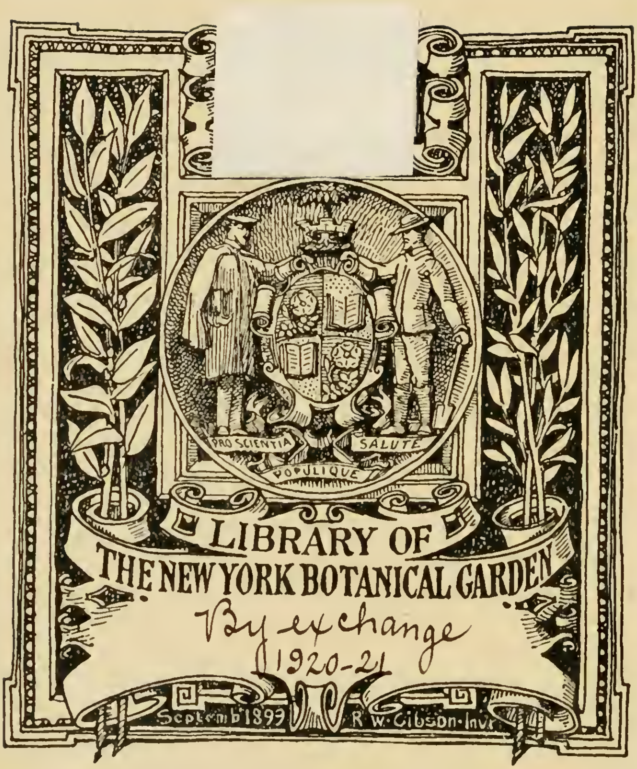
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Proceedings of the

Indiana Academy of Science

1918

PROCEEDINGS

OF THE

Indiana Academy of Science

1918

LEE F. BENNETT, Editor

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING
1919

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CONSTITUTION.

ARTICLE I.

SECTION 1. This association shall be called the Indiana 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 men engaged in scientific work, especially in Indiana; 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 investigation and discussion as may further the aims and objects of the Academy as set forth in these articles.

WHEREAS, The State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

SECTION 1. Members of this Academy shall be honorary fellows, fellows, non-resident members, and active members.

SEC. 2. Any person engaged in any department of scientific work, or in any original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Application for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

Sec. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men, and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

Section 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a President, Vice-President, Secretary, Assistant Secretary, Press Secretary, Editor, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-Presidents of the Academy, shall constitute an Executive Committee. The President shall, at each annual meeting, appoint two members to be a committee which shall prepare the programs and have charge of the arrangements for all meetings for one year.

Sec. 2. The annual meeting of the Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past Presidents, together with the officers and Executive Committee, shall constitute the council of the Academy, and represent it in the transaction of any necessary business not especially provided for in this constitution, in the interim between general meetings.

Sec. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

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 President shall deliver a public address on the morning of one of the days of the meeting at the expiration of his term of office.

3. The Press Secretary shall attend to the securing of proper newspaper reports of the meetings and assist the Secretary.

4. No special 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 arrearage by the Treasurer, shall have their names stricken from the roll.

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

8. An Editor shall be elected from year to year. His duties shall be to edit the annual Proceedings. No allowance shall be made to the Editor for clerical assistance on account of any one edition of the Proceedings in excess of fifty ($50) dollars, except by special action of the Executive Committee. (Amendment passed December 8, 1917.)

AN ACT TO PROVIDE FOR THE PUBLICATION OF THE REPORTS AND PAPERS OF THE INDIANA ACADEMY OF SCIENCE.

(Approved March 11, 1895.)

WHEREAS, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory board, assist in the direction and execution of any investigation within its province without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State; and,

WHEREAS, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form; and,

WHEREAS, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement; therefore,

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana,* That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

SEC. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such service, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less than 1,500 nor more than 3,000 copies of each of said reports shall be published, the size of the edition within said limits to be determined by the concurrent action of the editors and the Commissioners of Public Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

Sec. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage.

PUBLIC OFFENSES—HUNTING WILD BIRDS—PENALTY.

(Approved March 15, 1913.)

Section 1. *Be it enacted by the General Assembly of the State of Indiana*, That section six (6) of the above entitled act be amended to read as follows: Section 6. That section six hundred two (602) of the above entitled act be amended to read as follows: Section 602. It shall be unlawful for any person to kill, trap or possess any wild bird, or to purchase or offer the same for sale, or to destroy the nest or eggs of any wild bird, except as otherwise provided in this section. But this section shall not apply to the following named game birds: The Anatidae, commonly called swans, geese, brant, river and sea duck; the Rallidae, commonly known as rails, coots, mud-hens and gallinules; the Limicolae, commonly known as shore birds, plovers, surf birds, snipe, woodcock, sandpipers, tattlers and curlews; the Gallinae, commonly called wild turkeys, grouse, prairie chickens, quails, and pheasants; nor to English or European house sparrows, blackbirds, crows, hawks or other birds of prey. Nor shall this section apply to any person taking birds or their nests or eggs for scientific purposes under permit as provided in the next section. Any person violating the provisions of this section shall, on conviction, be fined not less than ten dollars ($10.00) nor more than fifty dollars ($50.00).

INDIANA ACADEMY OF SCIENCE.

OFFICERS, 1919.

President,
E. B. WILLIAMSON.

Vice-President,
CHARLES STOLTZ.

Secretary,
HOWARD E. ENDERS.

Assistant Secretary,
PHILIP A. TETRAULT.

Press Secretary,
FRANK B. WADE.

Treasurer,
WILLIAM M. BLANCHARD.

Editor,
LEE F. BENNETT.

Executive Committee:

ARTHUR, J. C.,
BENNETT, L. F.,
BIGNEY, A. J.,
BLANCHARD, W. M.,
BLATCHLEY, W. S.,
BRANNER, J. C.,
BURRAGE, SEVERANCE,
BUTLER, AMOS W.,
COGSHALL, W. A.,
COULTER, JOHN M.,
COULTER, STANLEY,
CULBERTSON, GLENN,
DRYER, CHAS. R.,
EIGENMANN, C. H.,
ENDERS, HOWARD E.,
EVANS, P. N.,
FOLEY, A. L.,
HAY, O. P.,
HESSLER, ROBERT,
JORDAN, D. S.,
McBETH, W. A.,
MEES, CARL L.,
MOENKHAUS, W. J.,
MOTTIER, DAVID M.,
MENDENHALL, T. C.,
NAYLOR, JOSEPH P.,
NOYES, W. A.,
STOLTZ, CHARLES,
TETRAULT, P. A.,
WADE, F. B.,
WALDO, C. A.,
WILEY, H. W.,
WILLIAMSON, E. B.,
WRIGHT, JOHN S.

Curators:

BOTANY.......................................J. C. ARTHUR.
ENTOMOLOGY...................................W. S. BLATCHLEY.
HERPETOLOGY
MAMMALOGY ....A. W. BUTLER.
ORNITHOLOGY
ICHTHYOLOGY..................................C. H. EIGENMANN.

Committees Academy of Science, 1919.

Program.

C. C. Deam, Bluffton.
Frank B. Wade, Shortridge High School, Indianapolis.
John S. Wright, Indianapolis.

Nominations.

Stanley Coulter, Lafayette.
W. J. Moenkhaus, Bloomington.
J. P. Naylor, Greencastle.

State Library.

W. S. Blatchley, 1558 Park Ave., Indianapolis.
A. L. Foley, Bloomington.
Amos W. Butler, State House, Indianapolis.

Biological Survey.

Herbert S. Jackson, Agricultural Experiment Station, West Lafayette.
Richard M. Holman, Crawfordsville.
M. S. Markle, Richmond.
Will Scott, Indiana University, Bloomington.

Distribution of Proceedings.

Howard E. Enders, West Lafayette.
Wm. M. Blanchard, Greencastle.
U. O. Cox, State Normal, Terre Haute.
George Osner, West Lafayette.

Membership.

F. M. Andrews, Bloomington.
M. L. Fisher, West Lafayette.
Mason L. Weems, Valparaiso.

Auditing.

Glenn Culbertson, Hanover.
Rollo Ramsey, Bloomington.

Relation of the Academy to the State.

R. W. McBride, 1239 State Life Building, Indianapolis.
Glenn Culbertson, Hanover.
H. E. Barnard, State House, Indianapolis.
John S. Wright, 3718 Pennsylvania St., Indianapolis.
W. W. Woollen, 1628 Pennsylvania St., Indianapolis.

Publication of Proceedings.

Lee F. Bennett, Janesville, Wis.
Robert Hessler, Logansport.
George N. Hoffer, West Lafayette.
R. R. Hyde, Terre Haute.
James Brown, 5372 E. Washington St., Indianapolis.

Advisory Council.

John S. Wright.
R. W. McBride.
Glenn Culbertson.
Stanley Coulter.
Wilbur Cogshall.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

Years.	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885-1886	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886-1887	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887-1888	J. P. D. John*	Amos W. Butler			O. P. Jenkins.
1888-1889	John C. Branner	Amos W. Butler			O. P. Jenkins.
1899-1890	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890-1891	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891-1892	J. L. Campbell*	Amos W. Butler			C. A. Waldo.
1892-1893	J. C. Arthur	Amos W. Butler	Stanley Coulter W. W. Norman		C. A. Waldo.
1893-1894	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894-1895	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895-1896	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896-1897	Thomas Gray*	John S. Wright	A. J. Bigney		W. P. Shannon.
1897-1898	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.*
1898-1899	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton.	J. T. Scovell.
1899-1900	D. W. Dennis*	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900-1901	M. B. Thomas*	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901-1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine*.	Geo. W. Benton	J. T. Scovell.
1902-1903	W. S. Batchley	John S. Wright	Donaldson Bodine*.	G. A. Abbott	W. A. McBeth.
1903-1904	C. L. Mees	John S. Wright	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1904-1905	John S. Wright	Lynn B. McMullen.	J. H. Ransom	G. A. Abbott	W. A. McBeth.

1905–1906	Robert Hessler	Lynn B. McMullen	J. H. Ransom	Charles R Clark	W. A. McBeth.
1906–1907	D. M. Mottier	Lynn B. McMullen	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1907–1908	Glenn Culbertson	J. H. Ransom	A. J. Bigney	G. A. Abbott	W. A. McBeth.
1908–1909	A. L. Foley	J. H. Ransom	A. J. Bigney	G. A. Abbott	W. A. McBeth.
1909–1910	P. N. Evans	Geo. W. Benton	A. J. Bigney	John W. Woodhams	W. J. Moenkhaus.
1910–1911	C. R. Dryer	A. J. Bigney	E. B. Williamson	Milo H. Stuart	W. J. Moenkhaus.
1911–1912	J. P. Naylor	A. J. Bigney	E. B. Williamson	Milo H. Stuart	W. J. Moenkhaus.
1912–1913	Donaldson Bodine*	A. J. Bigney	C. M. Smith	F. B. Wade	W. J. Moenkhaus.
1913–1914	Severance Burrage	A. J. Bigney	Howard E. Enders	F. B. Wade	W. A. Cogshall.
1914–1915	Wilbur A. Cogshall	A. J. Bigney	Howard E. Enders	F. B. Wade	Wm. M. Blanchard.
1915–1916	A. J. Bigney	Howard E. Enders	E. B. Williamson	F. B. Wade	Wm. B. Blanchard.
1916–1917	W. J. Moenkhaus	Howard E. Enders	P. A. Tetrault	F. B. Wade	Wm. M. Blanchard.
1917–1918	E. B. Williamson	Howard E. Enders	P. A. Tetrault	F. B. Wade	Wm. M. Blanchard.
†1918–1919	E. B. Williamson	Howard E. Enders	P. A. Tetrault	F. B. Wade	Wm. M. Blanchard.

*Deceased. †Officers continued—Annual meeting not held because of influenza epidemic.

MEMBERS.*

FELLOWS.

Andrews, F. M., 901 E. 10th St., Bloomington .... †1911
Associate Professor of Botany, Indiana University.
Plant Physiology, Botany.

Arthur, Joseph C., 915 Columbia St., Lafayette 1893
Professor Emeritus of Botany, Purdue University.
Botany.

Badertscher, J. A., 312 S. Fess Ave., Bloomington 1917
Professor of Anatomy, Indiana University.
Anatomy.

Beede, Joshua W., 404 W. 38th St., Austin, Texas 1906
Bureau of Economic Geology and Technology, University of Texas.
Geology.

Behrens, Charles A., 217 Lutz Ave., West Lafayette 1917
Professor of Bacteriology, Purdue University.
Bacteriology.

Bennett, Lee F., Janesville, Wis 1916
With The H. W. Gossard Company.
Geology, Zoology

Benton, George W., 100 Washington Square, New York, N. Y..... 1896
Editor in Chief, American Book Company.

Bigney, Andrew J., Syracuse, N. Y 1897
Professor of Physiology, Syracuse University.

Blanchard, William M., 1008 S. College Ave., Greencastle, Ind..... 1914
Professor of Chemistry, DePauw University, Greencastle, Ind.
Organic Chemistry.

Blatchley, W. S., 1558 Park Ave., Indianapolis 1893
Naturalist.
Botany, Entomology, and Geology.

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* Every effort has been made to obtain the correct address and occupation of each member, and to learn in what line of science he is interested. The first line contains the name and address; the second line the occupation; the third line the branch of science in which he is interested. The omission of an address indicates that mail addressed to the last printed address was returned as uncalled for. Information as to the present address of members so indicated is requested by the secretary. The custom of dividing the list of members has been followed.

† Date of election.

Breeze, Fred J., Muncie....................................1910
Branch State Normal School.
Geography.

Bruner, Henry Lane, 324 S. Ritter Ave., Indianapolis............1899
Professor of Biology, Butler College.
Comparative Anatomy, Zoology.

Bryan, William Lowe, Bloomington..............................1914
President Indiana University.
Psychology.

Butler, Amos W., 52 Downey Ave., Irvington....................1893
Secretary, Indiana Board of State Charities.
Vertebrate Zoology, Anthropology, Sociology.

Cogshall, Wilbur A., 423 S. Fess Ave., Bloomington..............1906
Associate Professor of Astronomy, Indiana University.
Astronomy.

Coulter, Stanley, 213 S. Ninth St., Lafayette....................1893
Dean School of Science, Purdue University.
Botany, Forestry.

Cox, Ulysses O., P. O. Box 81, Terre Haute.....................1908
Head Department Zoology and Botany, Indiana State Normal.
Botany, Zoology.

Culbertson, Glenn, Hanover......................................1899
Chair Geology, Physics and Astronomy, Hanover College.
Geology.

Cumings, Edgar Roscoe, 327 E. Second St., Bloomington..........1906
Professor of Geology, Indiana University.
Geology, Paleontology.

Deam, Charles C., Bluffton......................................1910
Druggist, Botanist, State Forester.
Botany.

Dryer, Charles R., Oak Knoll, Fort Wayne.......................1897
Geography.

Dutcher, J. B., 1212 Atwater St., Bloomington..................1914
Associate Professor of Physics, Indiana University.
Physics.

Eigenmann, Carl H., 630 Atwater St., Bloomington..............1893
Professor of Zoology, Dean of Graduate School, Indiana University.
Embryology, Degeneration, Heredity, Evolution and Distribution of American Fish.

Enders, Howard Edwin, 107 Fowler Ave., Lafayette..............1912
Professor of Zoology, Purdue University.
Zoology.

Evans, Percy Norton, 302 Waldron St., West Lafayette...........1901
Director of Chemical Laboratory, Purdue University.
Chemistry.
Foley, Arthur L., Bloomington.................................1897
Head of Department of Physics, Indiana University.
Physics.
Hessler, Robert, Logansport...................................1899
Physician.
Biology.
Hoffer, George N., Littleton St., West Lafayette..................1913
Federal Agent, Purdue University Experiment Station.
Hufford, Mason E., Bloomington................................1916
Physics.
Hurty, J. N., Indianapolis.....................................1910
Secretary, Indiana State Board of Health.
Hygiene and Chemistry.
Hyde, Roscoe Raymond, 636 Chestnut St., Terre Haute...........1909
Assistant Professor Physiology and Zoology, Indiana State Normal.
Zoology, Physiology, Bacteriology.
Kenyon, Alfred Monroe, 315 University St., West Lafayette.......1914
Professor of Mathematics, Purdue University.
Mathematics.
Kern, Frank D., State College, Pa..............................1912
Professor of Botany, Pennsylvania State College.
Botany.
Koch, Edward W., Buffalo, N. Y................................1917
Care of University of Buffalo Medical School.
Pharmacology.
Logan, Wm. N., 924 Atwater St., Bloomington....................1917
Professor of Economic Geology, Indiana University.
State Geologist.
McBride, Robert W., 1239 State Life Building, Indianapolis.......1916
Lawyer.
Middleton, A. R., 629 University St., West Lafayette.............1908
Professor of Chemistry, Purdue University.
Chemistry.
Morrison, Edwin, 80 S. W. Seventh St., Richmond................1915
Professor of Physics, Earlham College.
Physics and Chemistry.
Mottier, David M., 215 Forest Place, Bloomington................1893
Professor of Botany, Indiana University.
Morphology, Cytology.

Naylor, J. P., Greencastle....................................1903
Professor of Physics, DePauw University.
Physics, Mathematics.

Nieuwland, J. A..1914
Notre Dame University.
Botany and Organic Chemistry.

Payne, F., 620 S. Fess Ave., Bloomington........................1916
Associate Professor of Zoology, Indiana University.
Cytology and Embryology.

Pohlman, Augustus G., 16 Yale Ave., University City, St. Louis, Mo..1911
Professor of Anatomy.
Embryology, Comparative Anatomy.

Ramsey, Rolla R., 615 E. Third St., Bloomington.................1906
Associate Professor of Physics, Indiana University.
Physics.

Ransom, James H., 2015 West End Ave., Nashville, Tenn.........1902
Professor of Chemistry, Vanderbilt University.
General Chemistry, Organic Chemistry.

Rettger, Louis J., 31 Gilbert Ave., Terre Haute..................1896
Professor of Physiology, Indiana State Normal.
Animal Physiology.

Rothrock, David A., Bloomington...............................1906
Professor of Mathematics, Indiana University.
Mathematics.

Schockel, Barnard, Terre Haute................................1917
Professor of Physical Geography, State Normal School.

Scott, Will, Bloomington.......................................1911
Assistant Professor of Zoology, Indiana University.
Zoology, Lake Problems.

Shannon, Charles W., 518 Lahoma Ave., Norman, Okla............1912
With Oklahoma State Geological Survey.
Geology.

Smith, Albert, University St., West Lafayette (Army Service).....1908
Professor of Structural Engineering.
Physics, Mechanics.

Smith, Charles Marquis, 152 Sheetz St., West Lafayette...........1912
Professor of Physics, Purdue University.
Physics.

Stone, Winthrop E., Lafayette..................................1893
President of Purdue University.
Chemistry.

Van Hook, James M., 939 N. College Ave., Bloomington..........1911
Assistant Professor of Botany, Indiana University.
Botany.

Wade, Frank Bertram, 1039 W. Twenty-seventh St., Indianapolis...1914
Head of Chemistry Department, Shortridge High School.
Chemistry, Physics, Geology, and Mineralogy.

Williamson, E. B., Bluffton....................................1914
President, The Wells County Bank.
Dragonflies.

Woollen, William Watson, Indianapolis..........................1908
Lawyer.
Birds and Nature Study.

Wright, John S., 3718 N. Pennsylvania St., Indianapolis..........1894
Manager of Advertising Department, Eli Lilly Co.
Economic Botany.

NON-RESIDENT MEMBERS AND FELLOWS.

Abbott, G. A., Grand Forks, N. Dak., Fellow.....................1908
Professor of Chemistry, University of North Dakota.
Chemistry.

Aldrich, John Merton, Washington, D. C..........................1918
Custodian of Diptera, U. S. National Museum.
Dipterologist.

Aley, Robert J., Orono, Me., Fellow.............................1908
President of University of Maine.
Mathematics and General Science.

Branner, John Casper, Stanford University, California.
President Emeritus of Stanford University.
Geology.

Brannon, Melvin A., President Beloit College, Beloit, Wis.
Plant Breeding, Botany.

Burrage, Severance, Denver, Colo................................1898
United States Public Health Work.

Campbell, D. H., Stanford University, California.
Professor of Botany, Stanford University.
Botany.

Clark, Howard Walton, U. S. Biological Station, Fairport, Iowa.
Scientific Assistant U. S. Bureau of Fisheries.
Botany, Zoology.

Cook, Mel T., New Brunswick, N. J., Fellow.....................1902
Plant Pathologist, New Jersey Experiment Station.
Botany, Plant Pathology, Entomology.

Coulter, John M., University of Chicago, Chicago, Ill., Fellow......1893
Head Department of Botany, Chicago University.
Botany.
Davis, B. M., Oxford, Ohio.
Professor of Agricultural Education.
Miami University.
Duff, A. Wilmer, 43 Harvard St., Worcester, Mass.
Professor of Physics, Worcester Polytechnic Institute.
Physics.
Evermann, Barton Warren, Director Museum.
California Academy of Science, Golden Gate Park, San Francisco, Cal.
Zoology.
Gilbert, Charles H., Stanford University, California.
Professor of Zoology, Stanford University.
Ichthyology.
Goss, William Freeman M., 61 Broadway, New York, Fellow......1893
President The Railway Car Manufacturers Association.
Greene, Charles Wilson, 814 Virginia Ave., Columbia, Mo.
Professor of Physiology and Pharmacology, University of Missouri.
Physiology, Zoology.
Hargitt, Chas. W., 909 Walnut Ave., Syracuse, N. Y.
Professor of Zoology and Director of the Laboratories, Syracuse University.
Hygiene, Embryology, Eugenics, Animal Behavior.
Hay, Oliver Perry, U. S. National Museum, Washington, D. C.
Research Associate, Carnegie Institute of Washington.
Vertebrate Paleontology, especially that of the Pleistocene Epoch.
Huston, H. A., New York City, Fellow..........................1893
Secretary, German Kali Works.
Jenkins, Oliver P., Stanford University, California.
Professor of Physiology, Stanford University.
Physiology, Histology.
Jordan, David Starr, Stanford University, California.
Chancellor Emeritus of Stanford University.
Fish, Eugenics, Botany, Evolution.
Kingsley, J. S., University of Illinois, Urbana, Ill.
Professor of Zoology.
Zoology.
KleinSmid von, R. B., President University of Arizona, Tucson, Ariz.
Knipp, Charles T., 915 W. Nevada St., Urbana, Ill.
Professor of Experimental Physics, University of Illinois.
Physics, Discharge of Electricity Through Gases.

Marsters, V. F., Kansas City, Mo., care of C. N. Gould, Fellow....1893
Geologist.

McDougal, Daniel Trembly, Tucson, Ariz.
Director, Department of Botanical Research, Carnegie Institute, Washington, D. C.
Botany.

McMullen, Lynn Banks, State Normal School, Valley City, N. D.
Head Science Department and Vice-President State Normal School.
Physics, Chemistry.

Mendenhall, Thomas Corwin, Ravenna, O.
Retired.
Physics, "Engineering," Mathematics, Astronomy.

Miller, John Anthony, Swarthmore, Pa., Fellow..................1904
Professor of Mathematics and Astronomy, Swarthmore College.
Astronomy, Mathematics.

Moore, George T., St. Louis, Mo.
Director Missouri Botanical Garden.
Botany.

Noyes, William Albert, Urbana, Ill., Fellow......................1893
Director of Chemical Laboratory, University of Illinois.
Chemistry.

Reagan, A. B.
Superintendent Deer Creek Indian School, Ibopah, Utah.
Geology, Paleontology, Ethnology.

Smith, Alexander, care Columbia University, New York, Fellow....1893
Head of Department of Chemistry, Columbia University.
Chemistry.

Springer, Alfred, 312 E. Second St., Cincinnati, O.
Chemist.
Chemistry.

Swain, Joseph, Swarthmore, Pa., Fellow........................1898
President of Swarthmore College.
Science of Administration.

Waldo, Clarence A., 401 W. 18th St., New York City.............1893
Mathematics, Mechanics, Geology and Mineralogy.

Wiley, Harvey W., Cosmos Club, Washington, D. C., Fellow......1895
Professor of Agricultural Chemistry, George Washington University.
Biological and Agricultural Chemistry.

Zeleny, Chas., 1003 W. Illinois St., Urbana, Ill.
Professor of Experimental Zoology.
Zoology.

ACTIVE MEMBERS.

Acre, Harlan Q., Denison, O.
Botany.
Allen, William Ray, 212 S. Washington St., Bloomington.
Zoology, Indiana University.
Allison, Luna E., 435 Wood St., Lafayette.
Care Agricultural Experiment Station.
Botany.
Anderson, Flora Charlotte, Route No. 5, Crawfordsville.
Botany.
Atkinson, F. C., 2534 Broadway, Indianapolis.
Chemistry, American Hominy Company.
Baker, William Franklin, Indianapolis, care St. Vincent's Hospital.
Medicine, Roentgenology, Pathology.
Barnhill, Dr. T. F., Indianapolis.
Professor of Surgery, Indiana University School of Medicine.
Barr, Harry L., Stockland, Ill.
Botany and Physics.
Bates, W. H., 403 Russell St., West Lafayette.
Associate Professor of Mathematics, Purdue University.
Mathematics.
Beals, Colonzo C., 103 Russell St., Hammond.
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Berteling, John B., 228 W. Colfax Ave., South Bend.
Medicine.
Binford, Raymond, Guilford, N. C.
President of Guilford College.
Zoology.
Bishop, Harry Eldridge, 551 E. 40th St., Indianapolis.
Food Chemist, Indiana State Board of Health.
Black, Homer F., 2719-2721 Michigan Ave., Chicago, Ill.
Professor of Mathematics, Chicago Technical College.
Mathematics.
Bliss, G. S., Fort Wayne.
Medicine, State School for Feeble Minded.
Blose, Joseph, Spiceland.
Physics.
Bond, Charles S., 112 N. Tenth St., Richmond.
Physician.
Biology, Bacteriology, Physical Diagnosis and Photomicrography.
Bond, Dr. George S., Indianapolis.
Professor of Medicine, Indiana University School of Medicine.

Bonns, Walter W., Indianapolis, care of Eli Lilly & Co.
Plant Physiology.
Director of Botanical Department.
Bourke, A. Adolphus, 2304 Liberty Ave., Terre Haute.
Instructor, Physics, Zoology, and Geography.
Botany, Physics.
Brossman, Charles, 1503 Merchants Bank Bldg., Indianapolis.
Consulting Engineer.
Water Supply, Sewage Disposal, Sanitary Engineering.
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Professor of Chemistry, Indiana State Normal.
Chemistry.
Bybee, Halbert P., University Station, Austin, Texas.
Adjunct Professor of Geology, University of Texas.
Canis, Edward N., Route A-2, Box 372-A, Indianapolis.
Nature Study.
Caparo, Jose Angel, Notre Dame.
Professor of Physics and Mathematics, Notre Dame University.
Mathematics, Physics and Electrical Engineering.
Carr, Ralph Howard, 27 N. Salisbury St., West Lafayette.
Professor of Agricultural Chemistry, Purdue.
Carter, Edgar B., 2615 Ashland St., Indianapolis.
Director of Scientific Work, Swan-Myers Company.
Chemistry and Bacteriology.
Chandler, Elias J., Bicknell.
Farmer.
Ornithology and Mammals.
Chapman, Edgar K., 506 S. Grant St., Crawfordsville.
Professor of Physics, Wabash College.
Clark, Jediah H., 126 E. Fourth St., Connersville.
Physician.
Medicine.
Cloud, J. H., 608 E. Main St., Valparaiso, Ind.
Professor of Physics, Valparaiso University.
Physics.
Collins, Anna Mary, 5248 Kensington Ave., St. Louis, Mo.
Zoology.
Collins, Jacob Roland, 711 Vine St., West Lafayette.
Instructor in Physics, Purdue University.
Conner, S. D., 204 S. Ninth St., Lafayette.
Chemistry, Experiment Station.
Coryell, Horace N., New York City.
Columbia University.
Geology.

Cromwell, Hobart, Salem, Ind.
Zoology.
Cullison, Aline, East Chicago, Ind., Box 404.
Instructor, Botany, in East Chicago High School.
Daniels, Lorenzo E., Rolling Prairie.
Retired Farmer.
Conchology.
Dean, John C., University Club, Indianapolis.
Astronomy.
Denny, Martha L., Manhattan, Kan.
Kansas Agricultural College.
Zoology.
Deppe, C. A., Franklin.
Franklin College.
Dietz, Harry F., Washington, D. C.
Federal Horticultural Board.
Entomology.
Doan, Martha, Richmond.
Professor of Chemistry, Earlham.
Dolan, Jos. P., Syracuse.
Douglas, Benjamin W., Trevlac.
Fruit Culture.
Downhour, D. Elizabeth, 2307 Talbott Ave., Indianapolis.
Zoology and Botany, Teachers College.
Driver, Chas. C., 808 Atwater Ave., Bloomington.
Graduate Student in Zoology, Indiana University.
DuBois, Henry M., 1408 Washington Ave., LaGrande, Ore.
Paleontology and Ecology.
Dukes, Richard G., Corner Seventh and Russell Sts., West Lafayette, Purdue University.
Engineering.
Earp, Samuel E., 643 Occidental Bldg., Indianapolis.
Physician.
Medicine.
Edmonson, Clarence E., 822 Atwater St., Bloomington.
Graduate Student, Physiology, Indiana University.
Physiology.
Emerson, Charles P., 602 Hume-Mansur Bldg., Indianapolis.
Dean Indiana University Medical College.
Medicine.
Epple, Wm. F., 311 Sylvia St., West Lafayette.
Assistant in Dairy Chemistry, Experiment Station, Purdue University.

Estabrook, Arthur H., 219 E. 17th St., Indianapolis.
Genetics, with State Board of Charities.
Evans, Samuel G., 1452 Upper Second St., Evansville.
Merchant.
Botany, Ornithology.
Felver, William P., 325½ Market St., Logansport.
Railroad Clerk.
Geology, Chemistry.
Fisher, Homer Glenn, Johns Hopkins Medical School, Baltimore, Md.
Student in Medicine.
Fisher, L. W., Rossville.
Zoology.
Fisher, Martin L., Lafayette.
Professor of Crop Production, Purdue University.
Agriculture, Soils, Crops, Birds, Botany.
Foresman, George Kedzie, 110 S. Ninth St., Lafayette.
Instructor in Chemistry, Purdue University.
Fuller, Frederic D., 4520 W. 28th St., Bryan, Texas.
Experiment Station.
Chemistry, Nutrition.
Funk, Austin, 519 E. Ninth St., New Albany.
Physician.
Diseases of Eye, Ear, Nose and Throat.
Galloway, Jesse James, Geology Department, Columbia University, New York City.
Geology, Paleontology.
Gatch, Willis D., Indianapolis, Indiana University Medical School.
Professor of Surgery.
Gates, Florence A., 3435 Detroit Ave., Toledo, O.
Teacher of Botany.
Botany and Zoology.
Gidley, William, 250 Hillside Ave., Jamaica, N. Y.
Pharmacy, with E. R. Squibb & Sons, New York.
Gillum, Robert G., Terre Haute.
State Normal School.
Gingery, Walter G., Shortridge High School, Indianapolis.
Mathematics.
Glenn, Earl R., New York City.
The Lincoln School of Teachers College, Columbia University.
Physics.
Goldsmith, William Morton, Gunnison, Colo.
Colorado State Normal School.
Biology.

Gray, Harold, 2813 Ruckle St., Indianapolis.
Research Chemist, Eli Lilly & Co.
Chemistry.

Greene, Frank C., 30 N. Yorktown St., Tulsa, Okla.
Geology.

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Physician.
Surgery.

Hanna, U. S., Bloomington.
Professor of Mathematics.

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Graduate Student in Botany, Indiana University.

Happ, William, South Bend.
Botany.

Harding, C. Francis, 503 University St., West Lafayette.
Head of Electrical Engineering, Purdue University.

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Physiology.

Heimburger, Harry V., St. Paul, Minn.
Instructor in Biology in Hamline University.

Heimlich, Louis Frederick, 495 Littleton St., West Lafayette.
Instructor in Botany, Purdue University.

Hemmer, Edwin John, Somerville.
Botany.

Hendricks, Victor K., 1273 Railway Exchange Bldg., St. Louis, Mo.
Assistant Chief Engineer, St. L. & S. F., Mo., Kan. & Texas; Mo., Okla. & Gulf Railroads.
Civil Engineering and Wood Preservation.

Hess, Walter E., Greencastle.
Professor of Biology, DePauw University.

Hetherington, John P., 417 Fourth St., Logansport.
Physician.
Medicine, Surgery, X-Ray, Electro-Therapeutics.

Hinman, Jack J., Jr., State University, Iowa City, Iowa.
Senior Water Bacteriologist and Chemist, Laboratories for State Board of Health.
Chemistry and Biology.

Hoffman, George L., care of Western Pennsylvania Hospital, Pittsburgh, Pa.
Bacteriology, Serology.

Hole, Allen D., 615 National Road, Richmond.
Professor Earlham College.
Geology.

Holman, Richard M., Crawfordsville.
Professor of Botany, Wabash College.
Houseman, H. V., 300 S. Bradford St., Platteville, Wis.
Chemistry and Physics.
Huber, Leonard L., Hanover.
Hanover College.
Chemistry and Biology.
Huchinson, Emory, Norman Station, Ind.
Zoology.
Hutton, Joseph Gladden, Brookings, S. Dak.
Associate Professor of Agronomy, State College.
Agronomy and Earth Science.
Hyslop, George, 65 Nagle St., New York City.
Cornell Medical School.
Irving, Thos. P., Notre Dame.
Physics.
Jackson, Herbert Spencer, 940 Seventh St., West Lafayette.
Botany, Agricultural Experiment Station.
Jackson, Thos. F., Carter Oil Co., Tulsa, Okla.
Geology.
Jacobson, Moses A., West Lafayette, care of Teknion House.
Instructor in Bacteriology, Purdue University.
Jopling, John C., 421 Emerson St., Princeton.
Chemist.
Jordan, Charles Bernard, West Lafayette.
Director School of Pharmacy, Purdue University.
Kaczmarek, Regidius M., Notre Dame.
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Nature Study.
Kohl, Edwin J., 105 Salisbury St., West Lafayette.
Biology, Purdue University.
Lee, C. O., Russell St., West Lafayette.
Pharmacy, Purdue University.
Liston, Jesse G., R. F. D. No. 2, Lewis.
High School Teacher.
Geology.
Ludwig, C. A., R. R. 1, Brookville.
Agriculture, Botany.
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Plant Pathology and Mycology.
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Physiography and Geology.
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Geology.
Markle, M. S., Richmond.
Professor of Botany, Earlham College.
Martin, Dr. H. H., Laporte, Ind.
Surgery and Urology.
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Instructor Mathematics, Purdue University.
Mathematics.
McCarty, Morris E., 224 Fowler Ave., West Lafayette.
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U. S. Department of Agriculture, Bureau of Entomology.
Insect Physiology.
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Graduate Student in Botany, Indiana University.
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Physics, University of Cincinnati.
Montgomery, Dr. H. T., 244 Jefferson Bldg., South Bend.
Geology.
Morrison, Harold, Bureau of Entomology, Washington, D. C.
Entomology.
Morrison, Louis, 80 S. West St., Richmond.
Munro, G. W., 202 Waldron St., West Lafayette.
Mechanical Engineering.
Myers, B. D., 321 N. Washington St., Bloomington.
Professor of Anatomy, Indiana University.
Nelson, Ralph Emory, 112 W. Wood St., West Lafayette.
Chemistry, Purdue University.
Nothnagel, Mildred, Gainesville, Fla.
Assistant Plant Physiology, Experiment Station, University of Florida.

Noyes, Harry A., Mellon Institute, Pittsburgh, Pa.
Research Chemist and Bacteriologist.
Oberholzer, H. C., National Museum, Washington, D. C.
Biology.
O'Neal, Claude E., 247 W. Lincoln Ave., Delaware, O.
Botany and Bacteriology.
Orahood, Harold, West Middleton, Howard County.
Geology.
Osner, G. A., Broadview, Mont.
Plant Pathology.
Owen, D. A., 200 S. State St., Franklin.
Professor of Biology. (Retired.)
Biology.
Papish, Jacob, Ithaca, N. Y.
Department of Chemistry, Cornell University.
Chemistry.
Peffer, Harvey Creighton, 412 N. Salisbury St., West Lafayette.
Head of Chemical Engineering, Purdue University.
Petry, Edward Jacob, 210 Ingalls St., S. Ann Arbor, Mich.
Botany, University of Michigan.
Botany, Plant Breeding, Plant Pathology, Bio-Chemistry.
Pickett, Fermen L., Pullman College Station No. 36, Washington.
Botany.
Pinkerton, Earl, Hutsonville, Ill.
Biology and Agriculture.
Pipal, F. J., 114 S. Salisbury St., West Lafayette.
Botany, Agricultural Experiment Station.
Prentice, Burr N., 400 Russell St., West Lafayette.
Assistant Professor of Forestry, Purdue.
Ramsey, Glenn Blaine, Orono, Me.
Botany.
Richards, Aute, 307 E. Jefferson St., Crawfordsville.
Professor of Zoology, Wabash College.
Richards, Mrs. Mildred Hoge, 307 E. Jefferson St., Crawfordsville.
Zoology.
Rifenburgh, S. A., Valparaiso, Ind.
Instructor Botany, Valparaiso University.
Botany.
Riley, Katherine, Robert W. Long Hospital, Indianapolis.
Roark, Louis, Box 1162, Tulsa, Okla.
Roxana Petroleum Company.
Petroleum Geologist.
Scott, W. R. M., West Lafayette.
Agricultural Botany, Purdue University.

Sheak, William H., 703 N. 19th St., Philadelphia, Pa.
Mammalogy.
Showalter, Ralph W., Indianapolis.
Director Biological Department, Eli Lilly & Co.
Biology.
Silvey, Oscar W., College Station, Texas.
Physics, University of Texas.
Smith, Chas. Piper, Hyattsville, Md.
State Seed Inspection Officer.
Systematic Botany.
Snodgrass, R. E., 2063 Park Road, Washington, D. C.
U. S. Bureau of Entomology, Extension Division.
Entomology.
Spitzer, George, 1000 Seventh St., West Lafayette.
Dairy Chemist, Purdue University.
Chemistry.
Spong, Philip, 3873 E. Washington St., Indianapolis.
Biology.
Stoltz, Charles, 530 N. Lafayette St., South Bend.
Physician.
Stone, Ralph Bushnell, 307 Russell St., West Lafayette.
Mathematics, Purdue University.
Sulzer, Elmer G., Madison.
Geology.
Taylor, Joseph C., 117 Ninth St., Logansport.
Student in University of Wisconsin.
Terry, Oliver P., State St., West Lafayette.
Professor of Physiology, Purdue University.
Tetrault, Philip Armand, 607 University St., West Lafayette.
Assistant Professor of Biology, Purdue University.
Tevis, Emma Louise, 122 W. 18th St., Indianapolis.
Department Experimental Medicine, Eli Lilly & Co.
Thompson, Clem O., 105 N. High St., Salem.
Superintendent of Schools.
Biology.
Thornburn, A. D., Indianapolis, care Pitman-Moore Company.
Chemistry.
Toole, E. H., 719 N. Main St., West Lafayette.
Assistant Professor of Botany, Purdue University.
Botany, Plant Physiology and Pathology.
Troop, James, West Lafayette.
Professor of Entomology, Purdue University.
Tucker, William Motier, Apartment 33, Alhambra Court, Columbus, O.
Ohio State University, Department of Geology.

Turner, B. B., 1017 Park Ave., Indianapolis.
Associate Professor of Pharmacology, Indiana University School of Medicine.
Turner, William P., 222 Lutz Ave., Lafayette.
Professor of Practical Mechanics, Purdue University.
Vallance, Chas. A., R. R. J-1, Box 132, Indianapolis.
Instructor Emmerich Manual Training School.
Chemistry.
Van Doren, Dr. Lloyd, Earlham College, Richmond.
Chemistry.
Van Nuys, W. C., Box No. 34, Newcastle.
Superintendent Indiana Epileptic Village, Fort Wayne.
Voorhees, Herbert S., 804 Wildwood Ave., Fort Wayne.
Instructor in Chemistry and Botany, Fort Wayne High School.
Chemistry.
Wildman, E. A., care of Eli Lilly & Co., Indianapolis.
Director of Chemical Research.
Chemistry.
Watson, Carl G., 120 Thornell St., West Lafayette.
Instructor in Physics, Purdue University.
Weatherwax, Paul, Athens, Ga.
Associate Professor of Botany, University of Georgia.
Botany.
Weems, M. L., 102 Garfield Ave., Valparaiso.
Professor of Botany.
Botany and Human Physiology.
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Teacher of Physics, Shortridge High School and Indiana Dental College.
Physics.
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Veterinary Department, Purdue University.
Wiancko, Alfred T., 230 S. Ninth St., Lafayette.
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Agronomy.
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Hydraulic Engineering, Purdue University.
Williams, A. A., Valparaiso.
Mathematics, Valparaiso University.
Mathematics, Astronomy.
Wilson, Charles E., Brazil.
Zoology and Economic Entomology.

Wilson, Mrs. Etta L., 2 Clarendon Ave., Detroit, Mich.
Botany and Zoology.
Wood, Harry W., 1538 Rosemont Ave., Chicago, Ill.
Geography and Geology.
Woodbury, C. G., 615 University St., West Lafayette.
Director of Experiment Station.
Wynn, Frank B., Hume-Mansur Bldg., Indianapolis.
Professor of Pathology, Indiana University School of Medicine.
Young, Gilbert A., 739 Owen St., Lafayette.
Head of Department of Mechanical Engineering, Purdue University.
Zehring, William Arthur, 303 Russell St., West Lafayette.
Assistant Professor of Mathematics, Purdue University.
Mathematics.

Fellows	58
Members, Active	186
Members and Fellows, Non-resident	38
Total	282

Minutes of the Spring Meeting.

INDIANA ACADEMY OF SCIENCE.

May 24 and 25, 1918.

The Illinois Academy of Science joined the Indiana Academy of Science in its Spring Meeting on Friday and Saturday, May 24 and 25, 1918, in the new State Park, Turkey Run, in Parke County, and at The Shades, in Montgomery County. Seventy-two members and guests of the two Academies were in attendance at the meeting.

Touring parties were organized at the park entrance under competent guides as groups of individuals arrived by automobile. They devoted the forenoon of Friday to exploring the magnificent forest, the rugged trails, picturesque ravines and the watercourses of the park. A basket-luncheon at noon afforded opportunity to renew old acquaintances and to make new ones among kindred spirits.

After luncheon the groups were reassembled for the trip across the swaying suspension bridge and a tramp into Rocky Hollow to the rugged, moss-covered gorges where giant kettle-holes and eroded or broken rocks indicate, of the past, a rush of water quite out of proportion to the amount that now trickles over the same ledges on its way into Sugar Creek. Enthusiastic groups of individuals explored the narrow ravines and slippery trails to study the geological formations or to try the cool waters of an isolated kettle-hole.

About four o'clock a long procession of automobiles carried the Academy party over the intervening fifteen miles of rugged country covered with magnificent forests and beautiful streams to The Shades, where dinner was provided in the spacious dining-room of The Shades Hotel. The freedom of the park was extended through the courtesy of Mr. Frisz, the proprietor and manager.

A general session of the Academies was held in the grove after the dinner.

The broad verandas and beautiful grove about the hotel afforded opportunity for further visiting until long after the more sedate members had gone into slumber-land.

Saturday, May 25, 1918.

After breakfast at The Shades Hotel, tramping-parties were quickly organized to explore the beauties of The Shades Park, the waterfalls and eroded ravines, the Devil's Punchbowl and other geological formations of unusual interest. The fantastic shapes of rocks seem to have appealed to some imaginative soul who believed they could have had no use but to the devil, therefore ascribed them to his satanic majesty as articles of domestic use. The Devil's Backbone then became the objective point of others who followed the narrow, beaten trail along Sugar Creek to the interesting high ridge of exposed rocks that bears this name. The return to the hotel afforded opportunity to see the points of interest that had been missed on our way. After a hearty luncheon and a brief exchange of experiences the groups dispersed with the feeling that the 1918 Spring Meeting had brought a new outlook and new experiences.

The following members of the Illinois and Indiana Academies and their guests attended the Spring Meeting:

Flora Anderson, Bloomington.
W. S. Bayley, Urbana, Ill.
Mrs. W. S. Bayley, Urbana, Ill.
Miss E. E. Bayley, Urbana, Ill.
C. A. Behrens, West Lafayette.
Elliot Blackwalder, Urbanå, Ill.
Mrs. Elliot Blackwalder, Urbana, Ill.
W. S. Blatchley, Indianapolis.
F. J. Breeze, Terre Haute.
Edwin M. Bruce, Terre Haute.
Stanley Coulter, Lafayette.
Ulysses O. Cox, Terre Haute.
Mrs. Kate Meehan Cox, Terre Haute.
M. K. Davis, Terre Haute.
Mrs. Davis, Terre Haute.
Chas. C. Deam, Bluffton.
Chas. S. Driver, Bloomington.
Howard E. Enders, West Lafayette.
Arthur L. Foley, Bloomington.
Mrs. Loretta Foley, Bloomington.
L. W. Fisher, West Lafayette.
M. L. Fisher, West Lafayette.
W. G. Gingery, Indianapolis.
W. F. Gidley, West Lafayette.
Richard M. Holman, Crawfordsville.
Geo. N. Hoffer, West Lafayette.
H. S. Jackson, West Lafayette.
L. E. Kennedy, Urbana, Ill.
Chas. T. Knipp, Urbana, Ill.
Mrs. Knipp, Urbana, Ill.

Miss Knipp, Urbana, Ill.
P. L. Knipp, Urbana, Ill.
Wm. A. McBeth, Terre Haute.
Mrs. Wm. McBeth, Terre Haute.
J. W. McCarty, Lafayette.
Eula D. McEwan, Washington, D. C.
M. S. Markle, Richmond.
A. R. Middleton, West Lafayette.
C. F. Miller, Urbana, Ill.
W. J. Moenkhaus, Bloomington.
Edwin Morrison, Richmond.
W. A. Noyes, Urbana, Ill.
Mrs. Noyes, Urbana, Ill.
F. Payne, Bloomington.
Burr N. Prentice, West Lafayette.
R. R. Ramsey, Bloomington.
Mrs. Clara Ramsey, Bloomington.
R. D. Reed, Urbana, Ill.
A. Richards, Crawfordsville.
Mildred H. Richards, Crawfordsville.
Katherine Riley, Indianapolis.
R. D. Salisbury, Chicago, Ill.
Will Scott, Bloomington.
Mrs. E. L. Stevens, St. Louis, Mo.
Charles Stoltz, South Bend.
W. E. Stone, West Lafayette.
Mrs. Stone, West Lafayette.
Oliver P. Terry, West Lafayette.
Mrs. O. P. Terry, West Lafayette.
P. A. Tetrault, West Lafayette.
Emma L. Tevis, Indianapolis.
W. Tomlinson, Urbana, Ill.
E. H. Toole, West Lafayette.
Frank B. Wade, Indianapolis.
Mrs. F. B. Wade, Indianapolis.
L. D. Waterman, Indianapolis.
John S. Wright, Indianapolis.
——— Wright, Indianapolis.
Frank B. Wynn, Indianapolis.
Mrs. F. B. Wynn, Indianapolis.
Charles Zeleny, Urbana, Ill.

BUSINESS MEETING AND GENERAL SESSION, FRIDAY, MAY 24, 1918.

A business meeting of the Indiana Academy of Science and a general meeting of the Indiana and Illinois Academies of Science was called to order by the Vice-President, Dr. Charles Stoltz, in the grove near The Shades Hotel.

The Membership Committee proposed the following names of persons for membership:

Harlan Q. Acre, Shoals, Botany.

Walter G. Gingery, Indianapolis, Mathematics.

Howard M. Lahr, Markle, Botany and Chemistry.

On motion, duly passed, they were elected to membership in the Indiana Academy of Science.

On motion the reprints from the Proceedings are to have the imprint of the volume, date of publication, and paging of the issue from which they are taken.

The matter is referred to the Publication Committee with power to act.

On motion the Secretary is ordered to telegraph President E. B. Williamson an expression of keen regret in his absence from the Spring Meeting, and to extend greetings and best wishes of the Academy for his speedy recovery to good health.

Vice-President Stoltz then appointed Stanley Coulter to take charge of the informal meeting that followed and to call upon various persons for addresses.

Dr. Coulter gave a brief history of the Indiana Academy of Science and its relation to the scientific activities of the State. He expressed our appreciation of the presence of so large a number from the Illinois Academy, and pointed out that a number of these persons formerly were members of the Indiana Academy and had an important part in its early achievements and activities.

A number of persons then were called upon to speak.

Dr. Frank B. Wynn of Indianapolis: "Why I am a pathologist rather than a naturalist." He pointed out the force of *curiosity* in the life of the investigator, and by means of a number of striking examples emphasized the fact that curiosity is a driving power in achievement.

Doctor W. A. Noyes of the University of Illinois expressed pleasure of the opportunity to attend this meeting and to renew acquaintances in the Indiana Academy of Science, of which he was a charter member. He spoke of the early years of the Academy and of its influence in academies and institutions of the country.

John S. Wright of Indianapolis spoke on the needs of an endowment for the promotion and publication of research in the Academy. A portion of this endowment very properly should come from the State. The effect of the war upon the matter of giving will mean much for the financial future of the Academy.

Doctor R. D. Salisbury of the University of Chicago, representing the Illinois Academy of Science, spoke on: "The effect of the war to bring about a revaluation of the things which we have regarded as unimportant." The academies of science, represented by their chemists, physicists, biologists, and others, are interested in the public health of the army at home and in the service. Geologists have been used by our enemies to aid in a determination of the nature and kind of trenching, the tools required, etc., and the water supply for any given region. Our government has come to realize the service which its scientists in every branch may perform, and it is to be hoped that enlarged support of scientific work by the government will come as a result of such revaluation of the services of science.

Professor M. L. Fisher of Purdue University reported for the bird-study group that fifty-five species of birds had been observed during the day.

Professor Wm. McBeth of the State Normal School, Terre Haute, discussed the geological formations in the State Park, at Turkey Run, and outlined the chief points of interest in the geology of The Shades Park.

Professor S. H. Jackson of the Agricultural Experiment Station, Purdue University, reported on the species of rusts found, and made a special appeal for the eradication of the barberry, the intermediate host of our destructive grain rust. He urged the importance of its eradication as a war-measure that is being undertaken by every State in the Union.

Miss Flora Anderson, student in zoology in Indiana University, reported upon the number of snakes observed or collected during the day.

A rising vote of thanks was tendered Mr. J. W. Frisz, manager and proprietor of The Shades Park, for his numerous courtesies and the freedom of the park.

Adjournment.

Charles Stoltz, Vice-President.
Howard E. Enders, Secretary.

Program of the Thirty-Fourth Annual Meeting*

of

THE INDIANA ACADEMY OF SCIENCE,

held at

The Claypool Hotel, Indianapolis,

Thursday, Friday and Saturday, December 5, 6 and 7.

OFFICERS.

E. B. Williamson, President.
Charles Stoltz, Vice-President.
Howard E. Enders, Secretary.
William M. Blanchard, Treasurer.
P. A. Tetrault, Assistant Secretary.
Frank B. Wade, Press Secretary.
Lee F. Bennett, Editor.

PROGRAM COMMITTEE.

C. C. Deam. John S. Wright.
Frank B. Wade.

GENERAL PROGRAM.

Thursday.

Meeting of the Executive Committee, Claypool Hotel....... 8:00 p. m.

Friday.

Business Session .... 9:30 a. m.
General Session ....10:00 a. m.
Sectional Meetings .... 2:00 p. m.
Informal Dinner at the Claypool Hotel.................... 6:30 p. m.

The address of the retiring President, E. B. Williamson, of Bluffton, will be delivered at this time. Title, "How Should the Student Body Be Recruited?"

Principal Business Session........................8:00 to 8:30 p. m.

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* The fall meeting was cancelled because of the influenza epidemic. The business session was held in the Claypool Hotel, Indianapolis, December 7, 1918.

Friday, 8:30 p. m.

Assembly Room, Claypool Hotel.

Symposium on Important Contributions of Science to Military Efficiency.

Leaders.

For Astronomy..............Prof. W. A. Cogshall, Indiana University
For Bacteriology..................................Dr. Will Shimer
Director State Laboratory of Hygiene
For Botany.....................Prof. R. M. Holman, Wabash College
For Chemistry...F. R. Eldred
Director of Scientific Department, Eli Lilly & Co., Indianapolis
For Geology...............Prof. L. F. Bennett, Valparaiso University
For Physics.................Prof. Chas. M. Smith, Purdue University
For Physiography...Prof. W. A. McBeth, Indiana State Normal School
For Zoology......................Prof. H. L. Bruner, Butler College

Saturday.

Business Session ....9 a. m.

GENERAL SESSION.

Friday 10:00 a. m.

1. The Proposed Conservation Bill—Governor Goodrich. To be given on arrival of Governor Goodrich.
2. The Barberry and Its Relation to the Stem Rust of Wheat in Indiana, 20 minutes—F. J. Pipal, Purdue University.
3. Evolutionary Philosophy and the German War—A. Richards, Wabash College.
4. Geography in Colleges and Universities of the United States, 20 minutes—F. J. Breeze, Indiana State Normal School.
5. The Life of the Late Dr. Luther D. Waterman—A. L. Foley, Indiana University.
6. In Memoriam, Prof. Geo. D. Timmons—L. F. Bennett, Valparaiso University.
7. Biography of the Scientific Work of William James Jones, Jr.—S. D. Conner, Associate Chemist, Agricultural Experiment Station, Purdue University.
8. Observations on 1,500 Registrants of the First Conscription, 30 minutes—Dr. Chas. Stoltz, South Bend.

9. Mental Defectives; the Problem; Conditions in Indiana, 20 minutes—Miss Edna R. Jatho, Psychologist, Philadelphia Public Schools.
10. Textbook Treatments of Diffusion and Osmosis, 15 minutes—Paul Weatherwax, Indiana University.

CONTINUATION OF GENERAL SESSION, FOLLOWED BY SECTIONAL MEETINGS.

FRIDAY 2:00 P. M AND SATURDAY 9:30 A. M.

Bacteriology.

11. Number of Colonies for a Satisfactory Soil Plate—H. A. Noyes and G. L. Grounds, Agricultural Experiment Station, Purdue University.
12. The Length of Time to Incubate Petri Plates—H. A. Noyes, J. D. Luckett and Edwin Voigt, Agricultural Experiment Station, Purdue University.
13. Bacteria in Frozen Soil—H. A. Noyes, Agricultural Experiment Station, Purdue University.

Botany.

14. Reproduction in Coleochaete Scutata, 8 minutes (lantern)—M. S. Markle, Earlham College.
15. Some Abnormalities in Plant Structure, 2 minutes—M. S. Markle, Earlham College.
16. Plants of Boone County, Kentucky (by title)—James C. Nelson.
17. Plants New or Rare to Indiana, VIII, 10 minutes—Chas. C. Deam, Acting State Forester.
18. The Morphological Basis of Certain Problems in Inheritance in Maize, 12 minutes—Paul Weatherwax, Indiana University.

Chemistry.

19. Analysis of 100 Soils in Allen County, Indiana—R. H. Carr and V. R. Phares, Purdue University.
20. Relation of Nitrogen, Phosphorus and Organic Matter to Corn Yield in Elkhart County, Indiana—R. H. Carr and LeRoy Hoffman, Purdue University.
21. Flame Reactions of Thallium, 10 minutes—Jacob Papish, Purdue University.
22. Sulphur Dioxide as a Source of Volcanic Sulphur, 5 minutes—Jacob Papish, Purdue University.

Geology.

23. A Preliminary Report on the Origin of Indianaite in Indiana, 10 minutes—Wm. N. Logan, Indiana University.
24. The Occurrence of Coal in Monroe County, Indiana, 5 minutes—Wm. N. Logan, Indiana University.
25. The Occurrence of Indianaite in Monroe County, Indiana, 5 minutes—Wm. N. Logan, Indiana University.
26. Notes on the Paleontology of Certain Chester Formations in Southern Indiana, 10 minutes—Allen D. Hole, Earlham College.
27. Soil Survey of Cass County, 10 minutes—Colonzo C. Beals, Indiana University.

Physics.

28. A New Method of Measuring the Velocity of Sound, 15 minutes (lantern)—A. L. Foley, Indiana University.
29. The Instantaneous Velocity of Sound at Points Near the Source, 5 minutes (lantern)—A. L. Foley, Indiana University.
30. An Experimental Determination of the Relation Between Sound Velocity and Intensity, 5 minutes (lantern)—A. L. Foley, Indiana University.
31. An Experimental Determination of the Duration and Luminosity of an Electric Spark, 10 minutes (lantern)—A. L. Foley, Indiana University.
32. A Simple Method of Determining the Character and Frequency of the Oscillation of Machine Parts, 5 minutes (lantern)—A. L. Foley, Indiana University.
33. Energy Losses in Commercial Hammers, 5 minutes—Edwin Morrison, Earlham College.
34. New Surface Tension Apparatus, 5 minutes (lantern)—Edwin Morrison, Earlham College.
35. Effect of Certain Dissolved Salts Upon the Surface Tension of Water, 10 minutes (lantern)—Edwin Morrison, Earlham College.

Physiography.

36. The Chester Series of Indiana and Their Correlation with Those of Kentucky, 10 minutes—Clyde A. Malott and James D. Thompson, Jr.
37. A Peculiar and Remarkable Adjustment of Drainage—the Case of "The American Bottoms" of Greene County, Indiana, 10 minutes—Clyde A. Malott and Frederick J. Breeze.
38. A Notable Case of Successive Stream Piracy, 10 minutes—Clyde A. Malott.

39. Monadnocks and Similar Physiographic Features, 10 minutes—Clyde A. Malott.
40. A New Explanation of the Valley Filling of Southwestern Indiana and Associated Regions, 10 minutes—Clyde A. Malott.

Zoology.

41. The Crustaceans of Lake Maxinkuckee—Barton W. Evermann, Director of the Museum of the California Academy of Sciences, and Howard W. Clark, Scientific Assistant, U. S. Bureau of Fisheries Biological Station, Fairport, Iowa; 20 minutes.
42. The Insects of the Lake Maxinkuckee Region—Barton W. Evermann, Director of the Museum of the California Academy of Sciences, and Howard W. Clark, Scientific Assistant, U. S. Bureau of Fisheries, Biological Station, Fairport, Iowa.
43. Aphids on Fruit Trees, 5 minutes—S. D. Conner, Associate Chemist, Agricultural Experiment Station, Purdue University.
44. Some Further Experiments for Low and High Bristle Number in a Mutant Strain of Drosophila Ampelophila, 10 minutes—F. Payne, Indiana University.
45. A Memorial, Albert Homer Purdue—George H. Ashley, Washington, D. C.
46. A Memorial, Prof. M. J. Golden—R. B. Trueblood, Purdue University.
47. Some Trees of Indiana—F. M. Andrews, Indiana University.
48. Ascomycetes New to the Flora of Indiana—Bruce Fink and Sylvia C. Fuson, Miami University.
49. The Dormant Period of Timothy Seed After Harvesting—M. L. Fisher, Purdue University.
50. The Birds of the Sand Dunes of Northwestern Indiana—C. W. G. Eifrig, Oak Park, Ill.
51. A Synopsis of the Races of the Guina Flycatcher—Harry C. Oberholser, the U. S. National Museum.
52. Erosional Freaks of the Saluda Limestone—Elmer G. Sulzer, Madison.
53. Remnant Monuments Near Madison—Elmer G. Sulzer, Madison.
54. A Kinetic Model of the Electron Atom—R. R. Ramsey, Indiana University.
55. New Methods of Measuring the Speed of Sound Pulses Near the Source—Arthur L. Foley, Indiana University.

MINUTES OF THE FALL MEETING,

INDIANA ACADEMY OF SCIENCE,

CLAYPOOL HOTEL, INDIANAPOLIS, IND., DECEMBER 7, 1918.

The Executive Committee of the Indiana Academy of Science met at the Claypool Hotel and was called to order by the President, E. B. Williamson. The following members were present: F. M. Andrews, L. F. Bennett, Wm. Blanchard, A. W. Butler, W. Cogshall, S. Coulter, C. C. Deam, R. W. McBride, J. P. Naylor, C. Stoltz, P. A. Tetrault, F. B. Wade, E. B. Williamson and J. S. Wright.

The reports of the standing committees were first taken up.

Program Committee—Oral reports by C. C. Deam and F. B. Wade. On account of the influenza epidemic, the printed report was not carried out, but all papers submitted will be printed in the regular Proceedings.

Committee on Biological Survey—Written report submitted to the President by the Chairman, H. S. Jackson, was read by the Secretary. A number of investigations are in progress, and it is hoped that the work under way will be in shape for publication in the Proceedings of the Academy at an early date.

Committee on Distribution of Proceedings—Due to the absence of the Chairman, H. E. Enders, the report was given by Wm. Blanchard. The delay in the distribution of the Proceedings was explained.

Committee on Amendments—Work being completed, the committee was discharged.

Committee on Relation of Academy to State—On motion a special committee of five was appointed by the President, the President acting as Chairman, to consider the publication of the Evermann Report on the Biology of Lake Maxinkuckee.

Adjourned at 1:00 p. m. for luncheon.

Meeting reopened at 2:00 p. m.

On motion a committee was appointed to confer with the Senator and Representative appointed by the Governor to frame the bill for the naming of a Conservation Commission. The object is to have the following embodied in the bill:

Three men appointed from each of the following institutions: Indiana Academy of Science, Indiana Horticultural Society, Indiana Sportsmen's

Association, the higher institutions of the State, including universities, colleges and normal schools, who shall constitute a committee to nominate the director of the commission.

The following committee was appointed by the President: R. W. McBride, J. S. Wright, F. B. Wynn, W. Cogshall, S. Coulter.

Wm. M. Blanchard, Treasurer, reported as follows:

Balance in treasury December 2, 1917	$524 58
Dues collected during the year	224 00
Total	$748 58
Expenditures	286 51
Balance in treasury December 1, 1918	$462 07

The report was received and referred to the Auditing Committee.

The Membership Committee proposed the following names of persons for membership:

Frank G. Bates, 908 E. Atwater Ave., Bloomington—Political Science.

Walter W. Bonns, care of Eli Lilly & Co., Indianapolis—Plant Physiology.

Edgar Brock Carter, 2615 Ashland Ave., Indianapolis—Chemistry and Bacteriology.

Frank R. Eldred, 3325 Kenwood Ave., Indianapolis—Chemistry.

Harold Gray, 2813 Ruckle St., Indianapolis—Chemistry.

Aubrey Chester Grubb, 427 Russell St., West Lafayette—Chemistry.

Jas. Wm. Jackson, Shortridge High School, Indianapolis—Chemistry.

John C. Jopling, 421 —. Emerson Ave., Indianapolis—Chemistry.

Daniel B. Luten, 1056 Lemcke Annex, Indianapolis—Civil Engineering.

Thomas E. Nicholson, N. Park Ave., Bloomington—Psychology.

Mrs. L. W. Pressey, N. Park Ave., Bloomington—Psychology.

S. L. Pressey, N. Park Ave., Bloomington—Psychology.

Paris Stockdale, 425 S. Grant St., Bloomington—Geology.

Elmer G. Sulzer, Madison—Geology.

Myron W. Tatlock, Shortridge High School, Indianapolis—Physics and Chemistry.

David H. Thompson, Dayton—Biology.

E. A. Wildman, care of Eli Lilly & Co., Indianapolis—Chemistry.

Committee on Academy Foundations—The report was laid on the table.

Printing Committee—Report was accepted, and on motion the Editor's bill is to be included in this year's expenses.

Professor J. M. Aldrich was elected a Fellow of the Academy.

On motion Professor J. M. Aldrich's name was transferred to the non-resident list.

On motion it was decided that only paying Fellows and members, both resident and non-resident, are to receive the Proceedings.

On motion the Secretary and Treasurer are instructed to nominate Fellows and members to be placed on the non-resident list, such Fellows and members to be chosen from those who remain in active scientific work. These same are to be voted on at the regular meeting of the Executive Committee, subject to the approval of the Academy.

Nominating Committee—The report of the committee was to the effect that the present officers should continue in office till the next regular meeting. The canceling of the annual meeting of the Academy has brought about conditions which make it impossible to hold an election at this time.

Adjourned 3:45 p. m.

E. B. Williamson, President.
P. A. Tetrault, Assistant Secretary.

President's Address.

E. B. Williamson.

HOW SHOULD THE STUDENT BODY BE RECRUITED?

Some time after the English blockade went into effect, a public official learned to his surprise that there was some relation between fats and explosives. The relation was not clear in his mind, but he said he understood it was a recent discovery. Since then there has been a more or less insistent demand in England that more science should be included in the university curricula offered those who were to become the public men of the British Empire.

Prior to the war these curricula have been much debated in all countries. During the past twenty-five years high school courses have gone to the maximum of subjects and the minimum of thoroughness. The requirements generally in the science course in universities specify that the student must study French *or* German, overlooking the obvious fact that a student who progresses to a point where either foreign language is essential requires both. To a dispassionate observer, therefore, it seems that the making over of curricula has resulted in small if any improvement. Certainly the present curricula are giving us no products of a more gigantic stature than the Huxleys, Kelvins and Haeckels of a past generation, themselves often critics of these very curricula.

Is it not possible that some other more important factor is involved here? May it not be the composition of the student body which is at fault? Through elective courses and studies students dictate the curricula to a considerable extent. For on their selection depends largely the relative strength of the various departments in every university. It seems, therefore, that the composition of the student body is of more immediate concern than the subject-matter studied. Professors cannot select or make students. Students can determine their professors; and it was an old Scotch professor who said: "The university is a fine place if it were not for the students."

Universities, their faculties and students are an economic burden to be borne only as society receives a commensurate return for their activities. There is every reason to believe that following the war such institutions will be scrutinized as possibly they have never been in the past. The composition of the student body will, I believe, largely determine the verdict under which such institutions must prosper or decline.

How is the composition of the student body determined, or, in other words, how is the student body recruited?

In the early winter of 1917 a leading weekly naively remarked that the criticism sometimes made that the sons of the rich and well-to-do were not doing their part in the war was disproved by the decreased university enrollments. Or, to put it bluntly, the institutions dependent on taxes or on endowments made valuable through the labors of society as a whole were attended by the children of only a portion of this society, parental wealth being the determining factor. High school teachers of experience will know exactly what I mean. The matter is as obvious as it is objectionable. Under unsettled social conditions it is a matter that might determine the very life of the institutions we all wish to see prosper, believing as we do that the salvation of the world is in their hands.

The answer to our problem is so easy and so just that one can only wonder why so plain a reform has been so long delayed. It is not to be solved by the wholesale education of all high school graduates of a certain age as the government has recently undertaken as a war measure. Rather it is to be solved along the lines of the following tentative plan:

The faculty of each commissioned and certified high school, the county superintendent, the superintendent of each school, and the township trustees or board of education shall at commencement designate 20% or 25% of the graduates of each school as beneficiaries under this plan. The basis of selection of beneficiaries shall be the class record of graduates during their high school course. Each beneficiary shall be permitted to select any course of study desired in any school in the State approved by the State Board of Education, provided that any course so selected must be in advance of high school work. Each beneficiary shall be paid for work done in any such school as follows: $325 for the first year, $350 for the second year, $375 for the third year, and $400 for the fourth year, provided that during his course he shall carry at least fifteen hours recitation, or its equivalent, per week. Payment shall be made to the beneficiary at the end of each month or term in which such collegiate work is done, subject to passing grades in each course of work pursued. Failure to make passing grades shall deprive beneficiary of further privileges under this plan; and in case of dismissal from his college for any cause all privileges are forfeited, subject to an appeal to the State Board of Education, which board may grant permission to enter another school, subject to the approval of such school, in which the beneficiary shall again be granted the privilege of this plan.

The funds for carrying out this plan shall be raised by a county tax in those counties in which commissioned and certified high schools are located. By taxation a fund shall be created and held by each county treasurer. Each beneficiary shall be paid by a draft drawn by him through the bursar of the college where said beneficiary is pursuing his work, and such draft shall be an order on the treasurer of the county in which the beneficiary resides to pay the amount of such draft.

The purpose of this plan, as thus tentatively outlined, is to give a stimulus to better high school work, resulting in a sharper differentiation of those capable of more advanced education from those less capable. It aims to make capacity and ambition rather than the accident of birth the criterion for higher education. It is believed that it will result in a serious and purposeful student body and, in a few years, in a more enlightened, moral and capable citizenship. To the exceptional few who are capable of educating themselves under present existing conditions this plan gives an added stimulus, permitting them to go farther than would otherwise be possible. Finally, it may be remarked that the economic burden of the student body on society would be less under this plan than under conditions now existing. Education of individuals selected after the usual four-year college course should be provided for by scholarships, which should be available only for post-graduate work.

This subject of financial aid to students may not appeal to you at first glance as a matter of fundamental importance. But I wish to insist that it is. Other things being equal, that family or tribe or nation which gets for the family, tribe or nation the benefit of what it breeds will succeed over its neighbors or competitors. Biology has contributed one fundamental idea or concept to human thought—the idea of evolution. And legislation can be in harmony with or conform to evolutionary trends. Education of the most fit at public expense is, I believe, such legislation. Such legislation would tend to give the nation the benefit of what it breeds, a condition now imperfectly realized because our college students are largely recruited from a numerically inferior portion of our population.

"Heredity may confer some advantage; but genius generally mocks at heredity, and the frequent rise by sheer ability of men from the ranks of manual workers seems to prove that brain power in the case of a fairly homogeneous race exists in due proportion in all classes. The object of national education must be to provide, so far as possible, equal chances for natural talent wherever it is to be found. Otherwise there must be loss of national efficiency. At the same time, it must be remembered that marked intellectual power will always be the possession of a minority, that real leadership will always be rare, and that training in all classes may be wasted if carried beyond the inherent capacity of the individual boy or girl. * * * Of about 600,000 children (in England) who now leave the elementary schools annually, only about 1 per 1,000 reaches a university. This is far too low a proportion, and it indicates the denial of that equality of opportunity which must be our ideal."[1]

"We are not limited, however, to a military objective, for when the war is over the international competitions of peace will be resumed. No treaties or leagues can prevent that, and it is not desirable that they should, for no nation can afford to be without the stimulus of competition.

"In that race the same power of science which has so amazingly increased the productive capacity of mankind during the past century will be applied again, and the prizes of industrial and commercial leadership will fall to the nation which organizes its science forces most effectively."[2]

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[1] Lord Sydenham, Science, N. S. Vol. XLVIII, pp. 482 and 483, 1918.

[2] Elihu Root, l. c. pp. 533 and 534.

Contributions of Botany to Military Efficiency.

R. M. Holman, Wabash College.

Certainly no science seems, at first thought, to be more remotely related to military pursuits than does the science which deals with plants. In chemistry we recognize at once one of Mars' chief servitors; for even in the days before men fought with deadly gases, the products of chemical research, leaders in military affairs were indebted to the science of chemistry for the development of more and more destructive explosives and for a great number of other essential though minor war materials. In physics, too, we recognize a science whose contributions to the business of warfare are scarcely to be enumerated. But so many and varied are the factors which play their part in the successful pursuit of modern warfare, and so extensive are the applications of the sciences today to practical problems, that every science has been called upon to make its contributions to military efficiency. Thus the science of botany has come to play a by no means inconsiderable part in the organization, equipment and operation of an army. In the time allotted to me it would not be possible to consider all the particulars in which this science has aided directly or indirectly in the pursuit of war, but I shall call to your attention two or three phases of botanical work which have been of rather direct assistance.

The very considerable shortage of cotton which existed during the greater part of the war period, and the great demand for this material for civilian and military clothing and for the manufacture of explosives, suggested late in 1914 a search for a suitable substitute for the cotton so extensively used in surgical dressings. The material which proved best fitted to this use was sphagnum moss, which grows so abundantly in peat bogs and by its accumulation has built up very largely the great deposits of peat which are utilized as sources of fuel in some parts of the world. This moss, which was in fact employed to a limited extent for surgical dressings in the Russo-Japanese War, has the two great virtues of being very abundant and of possessing a remarkable power of absorbing liquids. In this latter respect it is many times as efficient as cotton. By no means all species of the genus *Sphagnum* are suitable for use in the preparation of surgical dressings. The species which can be used for this purpose, and which are found in the United States, are: *Sphagnum imbricatum*, *S. palustre*, *S. papillosum*, and *S. magillanicum*. These species are not found in the numerous bogs in the region of the Great Lakes, but are restricted to the bogs of the North Pacific and North Atlantic coastal regions. The recognition of the numerous species of the genus *Sphagnum* is by no means easy, and on that account there has fallen to the few botanists of this country who are familiar with the genus the task of supervising the collection of suitable material for the use of the Red Cross. The British War Office, the Canadian Red Cross, and the American Red Cross have used large quantities of sphagnum moss for the making of dressings, and so satisfactory has it proven that it seems likely that, even in times of peace, it will continue to be extensively used for this purpose.[1]

In a symposium on War Problems in Botany at the meeting of the American Association for the Advancement of Science at Pittsburgh in December, 1917, an appeal was made by Dr. G. R. Lyman, pathologist in charge of the plant disease survey of the United States Department of Agriculture, for effective organization of botanists and correlation of their efforts toward the increase in food production and conservation of food so essential to the military success of ourselves and our allies. The principal practical outgrowth of this appeal was the organization at Pittsburgh of the War Board of American Pathologists by the members of the American Phytopathological Society there present. The War Board had as its object the increase of the product of land already under cultivation by means of emergency plant disease research, and by a more extensive application of the measures known to plant pathologists for the reduction of crop diseases; and the reduction of the losses by disease of fruits, vegetables and other plant products in transit or storage.

In the pursuit of these objects a number of measures were carried out by the War Board. A man-power survey was undertaken to determine what botanists, not already engaged in plant pathology, were prepared and willing to do emergency work on plant diseases. This survey was made necessary not only by the extensive program of work planned by the War Board but also by the large number of trained pathologists which had been lost for the time being to the science by reason of enlistment and conscription.

Estimates were prepared, showing more accurately than any previous estimates had shown, the losses due to diseases of the staple crops in the year 1917. These figures revealed that, in spite of the absence of any serious epidemic during that year, the loss in cereals alone, due to plant diseases largely preventable by already known methods, was over four hundred million bushels; and that the control of two diseases of wheat—

[1] For the facts in this paragraph the author is indebted to the article entitled, "Sphagnum as a Surgical Dressing," by J. W. Hotson, Science, N. S. Vol. XLVII, No. 1235.

loose smut and bunt—during that year would have resulted in saving thirty-three million bushels of that grain. This might have been added to the quantity furnished to our allies in Europe, and might well have been an important factor in the military situation. It is clear that these loss estimates were important in the execution of the plans of the War Board to reduce these losses in the interest of the armies and the civilian populations of the United States and her allies.

Early in 1918 conferences were held in the six districts into which the country had been divided for the organization of the emergency plant disease work. At these conferences the plant pathologists of each district met together with one or more of the commissioners of the War Emergency Board to discuss fully and informally the plant disease problems of the district. Leaders were elected for the work on each special problem, and co-operation for the earliest possible solution of such problems was arranged among the workers specially interested.

In addition to the man-power survey, the crop loss estimates and the emergency research organized at the district conferences, the War Emergency Board, through one of its commissioners, carried on a publicity campaign through all available channels for the wider dissemination of information as to the importance and methods of plant disease control. Provision was also made for the prompt exchange among pathologists of emergency information on methods of control. Thus it was sought, by means of mimeographed sheets mailed frequently to all workers, to make available at the earliest date important new facts which could be utilized in an intensive campaign against crop diseases. The delay which would have attended publication through the usual channels was thus avoided.

Another department of the work was concerned with the gathering and distribution of information as to supplies and prices of the important fungicides and spraying machinery. The production and marketing of these most important agencies of plant control had been greatly interfered with by war conditions in the industries and in transportation.

The early and unexpected termination of the war prevented the activities of the War Emergency Board from bearing the fruit in increased food supply for the allied nations which might have been expected in the second and subsequent years of its existence. Ten months from the conception of the plan the war was over, and the possibility of its making further contribution to military efficiency through adding to the food supply had ceased. This fact, and the impossibility of estimating the results secured after so short a period of operation, should not prevent us from recognizing the value of this unprecedented movement for co-operation in increasing knowledge in what is probably the most important field of applied botany, and for the effective application of this knowledge to the problems of the farmer, the fruit grower, the gardener, and the shipper.

Forestry is another branch of applied botany which has contributed to the successful prosecution of the war. Its contributions have been more direct in their bearing upon purely military affairs than have those of plant pathology.

Two regiments of engineers (forest) were organized during the year following our entry into the war. Trained foresters largely officered the first of these regiments, and the second drew about 25 per cent of its officers from the ranks of professional foresters. The companies making up these regiments were employed in the forests of France in the felling of trees, in the sawing of timbers and boards for military construction, in hewing ties for army railroads, and poles and props for use in the trenches and elsewhere. The forester officers found abundant opportunity to utilize their experience in supervising this work, for the French forests have in the past been managed with the highest skill and efficiency. It was necessary that the work of the forest engineer regiments be carried on with the least possible waste, and with due regard to the future of the forests worked.

The entry of the United States into the world war and the initiation of our ambitious aircraft construction program offered a great opportunity for service to that branch of forestry which is concerned with the study of forest products. On account of its virtues of lightness, strength and elasticity, wood is very largely employed in airplane construction. Different parts of the airplane in the construction of which wood is used call for lightness, strength and elasticity in varying degree. In the building up of the framework much more consideration may be given to the matter of lightness than in the case of a part such as the front of the fuselage, which, by reason of the weight of the motor, is subject to great shock in landing. Lightness must also be sacrificed to strength and resilience in choosing suitable wood for the tail skids and for the landing skids on the lower planes. Special demands are also made upon the material employed for the engine bed.[2]

The careful tests upon which was based the choice of the best woods for the purposes mentioned and for others in connection with airplane construction were made largely by or under the supervision of foresters trained in the study of forest products. A large part of this work and of other work on forest products connected with the airplane program was carried out at the Forest Products Laboratory, Madison, Wisconsin,

[2] The facts in this paragraph and many others used here were secured from an article entitled, "Our Air Fleet in the Making," by Samuel J. Record, Yale Forestry School News, July 1, 1918.

which is administered by the Forest Service of the Department of Agriculture in co-operation with the University of Wisconsin. How extensive was this work may be judged by the fact that on September 1, 1918, all or part of ten buildings were being utilized by the Forest Products Laboratory and approximately 400 persons were engaged in its work. At that time 75 per cent of the work of the laboratory was concerned directly with the airplane problems.[3]

The great demand for airplane woods rendered it impossible to depend upon the slow method of air drying and necessitated tests of different types of kilns, various kilning procedures, their suitability for different species, and the effect of kilning on strength. Satisfactory kiln drying methods were determined, and these were introduced into commercial kiln drying establishments engaged in the curing of airplane stock. Research was also undertaken upon the factors which determine the suitability of certain species for steaming and bending into the various bent wood parts employed in airplane construction, as well as upon the best conditions for bending and the effects of bending on the strength of the wood.

A particularly interesting feature of the work was that relating to the utilization of thin plywood for fuselage walls, the pontoons of flying boats, and eventually for the covering of the wings themselves. Since these were entirely new uses for laminated wood, tests were necessary for the best species and for the best combinations. It was also necessary to test the efficiency of various joints and splices, and the effect of vibration on plywood strength, and to determine the best methods for stamping and molding the new construction material. By September, 1918, tests on the strength of plywoods had been carried out with 56 series of panels, each series consisting of 40 panels and requiring 240 tests. Twenty-five species of wood were represented in these 56 series. Plywood was also found to be an excellent material for different parts of the airplane framework. For such uses a core of yellow poplar with thin layers of birch, mahogany or black walnut was shown to be satisfactory.

Laminated construction is also used in the airplane propeller, although here the laminations are of much greater thickness than in plywood. Six to ten layers of something less than one inch thickness each are used in building up the propellers. At the Forest Products Laboratory extended studies were made to determine what wood species are most suitable for this very exacting use, what types of construction are best, and what conditions of manufacture and what finish are most effec-

[3] For these and other statements relative to the aircraft work of the Forest Products Laboratory the writer is indebted to the "Aircraft Research Program" and other reports of the laboratory furnished through the kindness of the Acting Director.

tive in preventing loss of balance or change of shape under the strains of service and in varying humidities.

The species which proved to best combine the properties desirable in a propeller wood—i. e., relative freedom from checking, warping and splitting; good glueing qualities; moderate hardness; and ability to be pierced by a bullet without being split or shattered—are the Central American and African mahoganies and the black walnut. These are used on combat planes, where motors of great power are employed and the demands upon the propeller are particularly heavy. For training planes, however, white oak (quartered), cherry, birch, and the various species known in the trade as Philippine mahogany were found suitable.

There fell also to the Forest Products Laboratory the task of training many of the inspectors essential in the carrying out of the airplane program. It was necessary for these men to inspect material and parts after various steps in manufacture, such as kilning, glueing and finishing. Some of them must also identify wood species and discern defects in the wood, often very difficult to detect, but, if overlooked, sufficient to cause the destruction of a costly machine or even the loss of an aviator's life. Decay, knots and brittleness or brashiness are relatively easy to detect; but pitch pockets well below the surface are very difficult to make out, as are also the so-called heart breaks. The origin of the latter defect is still somewhat obscure, but it is probably due to injuries to the tree by high winds while still standing, or to damage in felling. In planing, the fibers are sometimes broken in such a way as to closely simulate a heart break, and thus it becomes more difficult for the inspector to detect this source of weakness. Diagonal and spiral grain are important sources of weakness in airplane stock. Spiral grain is due to a peculiar development of the tree itself, but diagonal grain is due to mistakes in sawing, a tapering log being cut not parallel to its outer surface but to the center line. In some woods the direction of the grain is easily detected, but in others it can be made out only with difficulty. For some purposes wood with a greater divergence than one inch in thirty must be rejected.

The extensive research carried out by the Forest Products Laboratory in connection with the airplane program which has been briefly summarized above does not constitute the only war work of the laboratory. Investigations undertaken in co-operation with the Chemical Warfare Section of the War Department had important results, the confidential nature of which prevent their publication. Work was also conducted bearing on wooden ship building, gun stock manufacture, and the construction of artillery wheels and various military vehicles. Thus the laboratory was called upon to investigate the seasoning of the treenails or wooden spikes employed in large numbers in fastening parts of wooden ships. For the turning of these treenails black locust is the preferred material, but the supply of this wood became so limited in certain districts that it was necessary to substitute live oak for it. The Emergency Fleet Corporation's specifications called for thoroughly air-seasoned treenails. Stocks of air-seasoned live oak were soon exhausted, and in a number of the shipbuilding districts green or incompletely cured material was used. As a result serious defects in the ships developed through shrinkage of the treenails and loosening of joints. On that account the services of the Forest Products Laboratory was sought and the whole situation was investigated by the experts of the laboratory. It was decided that the long time necessary for air drying of live oak made it impracticable to insist upon the Emergency Fleet Corporation's specifications as to curing of treenail stock. Recommendations were made for the kiln drying of such stock at central points in each producing region and for the best kiln drying procedure.

Difficulties encountered in the bending of heavy oak for the rims of artillery wheels were made the subject of experiments by the laboratory, which resulted in the development of satisfactory methods. These were introduced into the factories engaged in this work. A schedule prepared by the laboratory for the curing of walnut blanks for rifle stocks came to be widely used by the manufacturers.

The molding of stock for the construction of army vehicles of many sorts called for investigation of the fungi concerned and of the methods by which mold development might be prevented. Mold which developed during the period between the felling and the arrival at the factory was particularly troublesome in the case of wood for the manufacture of spokes. As a result of extensive experiments, one series of which involved the testing of forty-three different antiseptics, means were found which were largely effective in removing this trouble.

Not all the cases have been here mentioned in which experts in forest products gave direct aid in the solution of problems arising in the industries engaged in the production of equipment, munitions and ships. Other branches of applied botany than those touched upon here might be cited which have contributed no less truly, although less directly, perhaps, to that great complex of factors which made for the success of our army. Sufficient has been said, however, to indicate that a by no means unimportant place among the sciences in the matter of contributions to military efficiency belongs to the science of botany.

Geology and the War.

L. F. Bennett.

The geology of a country is one of the most important factors which determine the location of its cities, its various industries, its population both as to number and occupation, its political aspirations and possibilities, and its relation to the countries bounding it.

It is the geology of a country which determines its natural resources, and these have had a peculiar bearing upon the recent history of Germany. Very much of Germany's iron and coal and her petroleum and potash deposits lie close to her frontiers. This has compelled her to strongly fortify these frontiers, especially next to France, and for this reason the giving back of Alsace and Lorraine to France will be a great economic blow to Germany.

In the last analysis it was the geological factors that gave Germany her great commercial and political importance and which determined her plan of attack upon France and Russia.

A glance at the geological map of northern France gives the reason why Germany was compelled to attack France through Belgium if she expected to reach Paris quickly. The series of escarpments to the east of Paris were the best of natural fortifications. They were practically impossible to scale when well protected by Frenchmen and French cannon. The immortal Verdun, one of the gateways into France, was made such by the steep slopes on the west and the outlying ridges which could be easily fortified by the defending army. The rocky barriers of northeastern France were too much for the wonderful military machine of Germany. The geological "stars in their courses" were marshaled against the invading Huns and helped the gallant French. It was the geology of the region that made Paris so easily protected from the invading armies from the east. Its geological defenses are among the wonderful geological features of Europe.

In western Russia the geological features are of glacial origin. There are numerous lakes, extensive marshes and morainic ridges. The area is easily defended by an army well supplied with means for defense. "The Germans could not get past the Russian troops so long as they formed heroic fighting units instead of radical debating societies."

The retreat of the Russians was masterful. Their various positions were determined by the rivers, and the lakes and marshes formed other barriers to their foe.

The mountain passes of Galicia were the only practical ways into and out from the plains of Hungary on the east. The valley of the Danube was a most effectual barrier for Serbia until she was overwhelmed by the great armies of the Central Powers. The numerous mountain passes of the Balkan States, large and small, were alike helpful and harmful in offensive and defensive warfare.

The engineering feats of the Italian and Austrian troops as they fought in the high mountain barriers of their respective countries have won the admiration of the world. The wonderful bravery of these troops will ever be matters for historical comment like the defense of the immortal Greeks at the pass of Thermopylae.

How different would the political and economic history of the whole of southern Europe have been had the area been a great plain like much of Russia instead of the series of almost impassable mountain ridges.

It has been, it is now, and probably always will be mainly a geological question as to where many of the boundaries between countries will be located. It was thousands of centuries ago when the political history of Europe was largely determined. It was

"When you were a tadpole and I was a fish"

that the shores of the Paleozoic seas were very different from the present shore lines and thick sediments were deposited over the region that is now southern Europe, and it was much later that these sea beds were elevated and eroded into the mountains of today.

"The violation of Belgian neutrality was predetermined by events which took place in western Europe several million years ago. Long ages before man appeared on the world stage Nature was fashioning the scenery which was not merely to serve as a setting for the European drama but was, in fact, to guide the current of play into blackest tragedy. Had the land of Belgium been raised a few hundred feet higher above the sea, or had the rock layers of northeastern France not been given their uniform downward slope toward the west, Germany would not have been tempted to commit one of the most revolting crimes of history and Belgium would not have been crucified by her barbarous enemy."[1]

But what did the geologists do and what can geologists do in time of war? It is sure that, should there ever be another great war, the geologists would be a more important factor than ever before. They will be among the first of our scientists to be organized into an efficient working corps.

The following is an abstract of an article from "Economic Geology," July, 1918, entitled "The Geologist in War Times; the United States Geological Survey's War Work," by Philip S. Smith:

[1] Topography and Strategy in the War, Douglas Wilson Johnson.

"There are two hundred and sixteen members of the Survey in military service, one hundred and fifty of whom came from the topographer's branch. One of the Survey geologists in the Engineer Officers' Reserve Corps fills an important scientific post on General Pershing's staff that requires a knowledge of geology. One of the Survey topographic engineers was also assigned to General Pershing's staff, where he occupies a position that requires special knowledge of topographic engineering.

"As soon as war was declared every member of the Survey who could be spared took up war emergency work. They became members of various national committees necessary for the successful conduct of the war. The geologic branch was called upon to supply information concerning the mineral resources of the United States and of foreign countries. A systematic search of the United States has been made for the minerals which we have depended upon foreign countries to supply, and we congratulate ourselves upon the results of this search. Ores of manganese, chromium, tungsten, quicksilver and sulphur have been most sought. The results of the search for potash rewarded the Survey beyond expectations. There has been an attempt to bring consumers and producers of supplies closer together.

"Surveys containing topographic, geographic and geologic information have been made of the several cantonment districts. Different kinds of coal have been carefully investigated at the request of the Secretary of the Navy, and also for the War Minerals Committee. Over forty skilled topographic engineers have been sent to Europe. Camera mapping is being carefully studied.

"The water resources of the Survey, in addition to performing its routine work, has been called on to furnish much special information that is immediately pertinent to the work of the War and Navy Departments. In co-operation with the geologic branch, it furnished data concerning the camp water supplies of all the border States except those contiguous to Canada; made tests of the water and estimates of the quantity available at the sites of war industries plants to be erected in the eastern part of the country; reported to the Surgeon General's office on the quality of the water at thirty-three cantonments in twenty-three States; determined the quantity and quality of the ground water available at seven aviation camps; made a field survey of the water conditions along the Mexican border west of Nogales, Ariz.; made comparison of the quality of the water of European and American springs; made recommendations to solve the problem of contamination of the water supplies of the Kansas River by sewage below Camp Funston; and reported on available waterpower and quality of boiler water at Yorktown, Va.

"The war has emphasized the economic importance of geology in every branch of its science. It has done its work at home in the ways mentioned above, and on the battle front the geologist has been most important in determining the best possible places for camps, hospitals and the lines of defense."

May this emphasis not be forgotten. May the United States Government be always willing to contribute liberally to the Geological Survey for work in all of its departments. May the geologists themselves pursue all problems with the thought not only of developing their science but to promote the "general welfare of the people of the United States."

Physiography and War.

Wm. A. McBeth, Terre Haute, Indiana State Normal School.

The relation of physiography and war is clear and pervasive. Most of the wars of history have had their causes, have run their courses and have had their results determined under the influence of geographical environment. Raids were made into fertile territories for plunder or for permanent possession. Desert and mountainous regions have sent out their hungry hordes to conquest and pillage. Mountains, rivers and marshes have furnished favorable lines of defense. Mountain passes, valley ways and easy river crossings have been sought as points of attack. Climatically men prefer to march, go into battle, and carry on other activities of war in good weather. Winter often causes long and almost complete suspension of hostilities. Heavy rains turn fields and roads into quagmires, impede movement of troops, block transportation of munitions and food, and make impossible the handling of heavy artillery, causing unexpected delay, change of plan, and possibly disaster.

Military and naval strategy take into account, even build on the groundwork of natural features. An account of the campaigns of any war of recent times clearly shows this fact. The significance of the Hudson-Champlain Valley, with its nearly continuous line of water communication, in the French wars and in the War of the Revolution, is a striking illustration. The strategy of the Civil War in the United States centers in the Allegheny Mountain barrier, with the Ohio River as a secondary line of operations. The Mississippi River, the Chattanooga Gap, the Potomac River as lines of movement by either of the contending armies are familiar to all students of history. Naval operations to enforce a blockade were carried on along the Southern coasts by the Federal forces, while the Confederates sought to break through and destroy this sentinel cordon.

In the World War the armies of the Central Powers broke into and across Belgium because the smooth Flanders plain gave easier entrance into France than the way across the mountainous frontier between France and Germany farther south, where Verdun withstood shock after shock unconquered. The Somme, Aisne and Marne are names of rivers flowing west in France along which the invading armies undertook to make their way toward the channel ports or Paris, and Amiens, Soissons and Chateau-Thierry are important points of effective resistance, the last a crossing of the Marne, where the Huns were finally stopped and faced about to a last retreat and defeat. Numerous examples of the dependence of strategy on geographical conditions appear in all the other fields of operation in the war, and volumes on this aspect of the subject might be written.

The importance of physiographic knowledge and science in war is suggested by mention of a few of its contributions to war plans and work. Most countries have war colleges, general staffs, or other organizations for the study of strategical problems and the development and formulation of plans of attack and defense in war.

In our own country the leading geographers volunteered their services and organized in the national capital a Board of Geographical Information that gave valuable aid to the government in the prosecution of the war.

Accurate maps, indispensable for such study and planning, are prepared with great detail and accuracy in many countries. The Ordnance Survey, large scale maps of Great Britain and France, are marvels and models of the map maker's art. The relief of the country, its streams, lakes, railways, roads, canals, cities, villages and even farmhouses are accurately indicated. Outline and slope are shown in contours or shading, height by figures or contour intervals. Shores and off-shore waters are mapped, and depths, channels, shoals, lights and landings are indicated. Such maps are useful and instructive under peaceful as well as belligerent conditions, and, strange as it may seem, are easily obtainable by schools and the general public in and outside of the countries in which they are published. That such maps easily get into the hands of possible present or future enemies admits of no doubt, and those who want them get them by means of indirection or espionage if not openly. The United States Geological Survey maps and the maps of the Coast and Geodetic Survey and of the Mississippi Commission are most excellent in accuracy and execution, and, while not published primarily for military use, have a high value in that direction.

The army Signal Service calls to its aid the expert meteorologist, who observes the changes in the air and reports present and probable future weather conditions for the use of the various branches of the army. The infantry makes use of such information in timing attacks, such movements preferably being made in fair weather, unless in case of intended surprise. The artillery finds great advantage in knowing the air pressure, the direction and velocity of the wind, and even the temperature and humidity conditions of the atmosphere in finding ranges in firing.

Weather cbservations and predictions are even more important in the Flying Service. The strength and direction of the wind, the prevalence of cloud, or the probability of fog or cloud, are great factors in successful flight for either observation or combat. London came to expect an air raid on any still, clear night, and the Germans are reported to have taken care to have their best forecasters select the most favorable time and conditions for these attacks.

Many engineering problems are primarily geological or geographical problems, and the education of the civil or military engineer includes a knowledge of these subjects. The location of camps, with the associated matters of drainage, of transportation, food supply and equipment, require geographical knowledge. The location of coast defenses, the laying out of military roads, canals and lines of defense within a country, the improvement of waterways, and many other matters, are in the field of the geographer, and his knowledge and advice are essential to the engineer, whether in the interests of war or of peace.

The Barberry and its Relation to the Stem Rust of Wheat in Indiana.

F. J. Pipal, Purdue University.

It has now been over 250 years since the European farmers began to observe that the common barberry bush (*Berberis vulgaris*) had harmful effects upon the grain fields, particularly those of wheat, through severe rusting of the straw, and causing considerable shriveling of the grain. As early as 1660 a law was passed against it in the district of Rouen, France.[1] In later years, as the barberry was introduced into other European countries, frequent complaints were made by the farmers that the bush was responsible for a great deal of injury to the grain growing in its vicinity. One writer (Djörup[2]) remarks in this connection: "Many of the inhabitants reaped only straw, which, of course, could not be thrashed." In many instances the barberries were eradicated, either voluntarily or through force of law, or by the injured farmers themselves. There was no consensus of opinion, however, as to the guilt or the innocence of the barberry, and, as Lind relates in his article, a rather dramatic war was waged over the question. In 1863 DeBary finally demonstrated, through cross-inoculations, that one stage (*aecial*) of the stem rust of wheat (*Puccinia graminis*) passed its life on the leaves of the barberries. Even after this discovery, however, it was not agreed that the barberry was in any way responsible for the rust infection, and not until about thirty years ago was this fact generally accepted by the botanical profession.

During the seventeenth century the barberry was introduced into America, where it is now used extensively as an ornamental shrub. It is of interest to note that a law was passed against it in Connecticut in 1726, and in Massachusetts in 1755. It is doubtful, however, if the laws were ever enforced.

Owing to a lack of definite information regarding the extent to which the common barberry and its purple-leaved variety were responsible for the stem rust infection in this country, no special effort was made heretofore to bring about the eradication of this shrub. The great World War and the urgent need of food presented an opportunity to bring up the question of the eradication of the barberry, which, it was believed, would reduce stem rust infection and save millions of bushels of valu-

[1] J. Lind, Berberisbusken, og Berberisloven. Denmark, 1915.

[2] Quoted in Lind's article. See note [1].

able grains. The agitation of this question, enlivened by the fact that a very severe rust infection in 1916 caused a loss of over 200,000,000 bushels of wheat, resulted in the present barberry eradication campaign, comprising the upper Mississippi and the Western States, with Montana as the western and Ohio as the eastern limits. The campaign is conducted by the Office of Cereal Investigations, of the United States Department of Agriculture, in co-operation with the State Agricultural Colleges.

The barberry has been introduced into Indiana probably during the second half of the nineteenth century. Bushes have been found in the State which the owners claim to be over fifty years old. Most of the plantings, however, are of a more recent origin. The barberry scouts, who made a careful survey last spring and summer of the cities and larger towns in the northern thirty-six counties, located approximately 1,500 plantings. It is estimated that there are not less than 3,000 plantings within the State. The barberries are not so numerous in the counties south of the Indianapolis line, especially in the extreme southern end of the State, where they are very rare. Some of these plantings were very extensive, each containing several hundred bushes. Along the main line of the Pennsylvania Railroad, running from Chicago to Columbus, Ohio, there was a planting at nearly every station. Some were hedges several hundred to 1,000 feet long. At Valparaiso, Anderson and other cities large lots and even whole city squares were surrounded by barberry hedges. The country districts seem to be comparatively free from barberries, so far as can be judged from general observations. Several communities have been found, however, where bushes were growing on the farms and playing a very important role, as will be pointed out later, in starting local rust epidemics.

The earliest recorded mention of wheat rust causing serious injury in Indiana is found in the annual report of the Indiana State Board of Agriculture for 1868, pp. 364-365, in which Professor R. S. Brown, in discussing this disease and its control, makes this statement: "Cultivating early varieties of wheat, and immediately cutting, if the rust strikes the straw, are the only remedies we have to propose for this evil, which so often blasts, in a night, the brightest prospects of the farmer." The rust collection of the Department of Botany, Purdue University Agricultural Experiment Station, contains specimens of wheat stem rust from nearly every section of the State.

In 1892 Dr. Arthur[3] reported the following observation: "At one edge of a field of wheat on the Experiment Station farm at Lafayette, Indiana, were many large barberry bushes, forming a thicket some twenty-five by fifty feet. The season was favorable to the production

[3] Proc. Soc. Prom. Agric. Sci. 23d Ann. Rep.

of rust, and the barberry bushes were all covered with aecidia. By the first week in July the wheat field was also well rusted. * * *"

The survey made last summer in the northern part of the State and in a few districts of the southern part showed that prevalence of the stem rust of wheat followed closely the distribution of the barberries. In sections having large numbers of barberry bushes there was a comparatively heavy rust infection, while in sections where no barberries were found little or no rust was observed. In every instance where a severe rust infection was reported and investigated there was no difficulty in locating barberry bushes in the immediate or near vicinity of the damaged fields.

The following specific cases, investigated last summer, are presented to show the guilt of the barberry in spreading the stem rust of wheat in Indiana:

Case 1. Franklin County. A barberry bush was growing in the yard of Ed. Heap's farm near Drewersburg. Another bush was growing in the corner of a field across the road from the house. Mr. Heap's and two of his neighbors' wheat fields were very heavily rusted. The grain from these fields was refused by the local dealers as being worthless for milling purposes, and the County Agricultural Agent had to obtain a special permission from the County Food Administrator to allow the farmers to feed this grain to their stock. It was very noticeable in this case that practically all infection took place on the windward side of the barberries.

Case 2. Franklin County. Several barberries were found on the farm of Bradbury Hudson, several miles from Brookville. Other bushes are said to be growing in this neighborhood. All wheat in this community was reported by Mr. Hudson to be badly rusted.

Case 3. St. Joseph County. The following paragraph appears in the annual report, for 1918, of the Agricultural County Agent, J. S. Bordner: "In 1915 an urgent request came from Madison Township to come to the farm of Jonas Loucks, where an entire field of wheat had been ruined by some disease. Investigation showed the most pronounced attack of black rust which the writer had ever seen. Additional investigation showed infection in other fields, but not as pronounced, because most of the wheat of the neighborhood matured from four to ten days earlier than this particular field. Damage from red and black rust has been found each season in this community. This year an organized effort was made to locate the source of infection. The accompanying cuts speak for themselves. The barberry was found red-handed. One barberry hedge several rods in length has been responsible for the presence of rust in the entire surrounding country, the actual damage ranging from 2% to 50%, the field adjoining the barberry hedge sus-

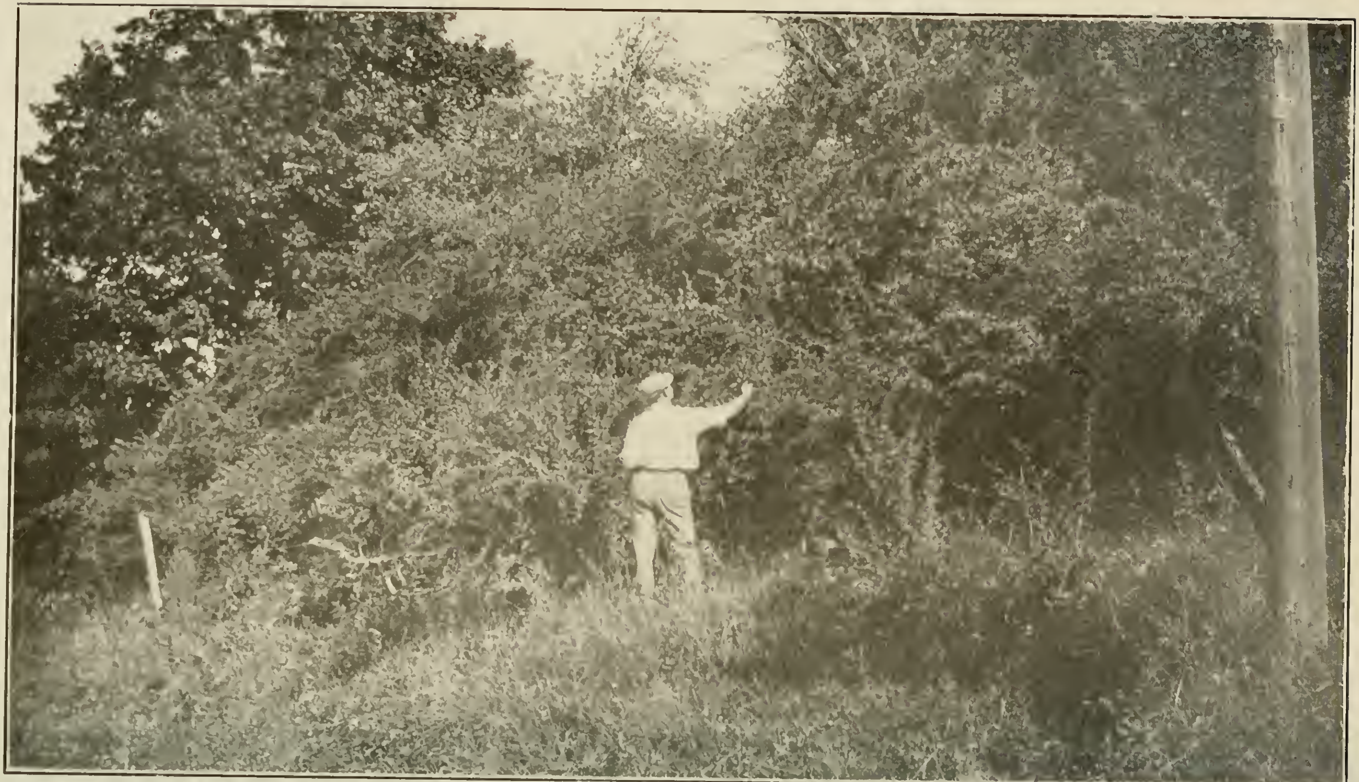

Fig. 1. Numerous barberry bushes covering a hillside in Wabash County. There bushes were responsible for a severe rust infection in the wheat field shown in Fig. 2. Read Case 13.

Fig. 2. The wheat field referred to under Fig. 1. The barberries are just across the road from the field, directly below the orchard.

taining the greatest loss." Infected barberry leaves were found when the field was inspected.

Case 4. St. Joseph County. Mr. Bordner also reports the following: "Another striking case of damage was found in the field of Charles Bunch near Lakeville, and upon thorough investigation we found barberry in the neighbor's back yard some ten rods away."

Case 5. Wayne County. A few miles east of Centerville stands a country church with a cemetery about eighteen rods from the building. A barberry hedge is growing on both sides of the walk leading from the church to the cemetery. Within a radius of about one-half of a mile from this hedge, especially on the windward side, all wheat fields were badly rusted. In the nearest field, on the McConaha farm, a prospective yield of thirty bushels of wheat to the acre was reduced to less than ten bushels.

Case 6. Wayne County. W. O. Seoney, Boston Township, suffered considerable losses from wheat rust for many years. A couple of years ago the crop was nearly ruined. Mr. Seoney wrote to the Agricultural Experiment Station and asked for a specialist to examine the crop and determine, if possible, the cause of the trouble. When the investigator found that the unusually heavy infection was due to the stem rust he searched the vicinity for barberry bushes and found a large one twenty rods from the wheat field. The bush was immediately removed. Last year Mr. Seoney's wheat was free from rust for the first time in many years, although a very heavy infection occurred in another section of the county not far from his farm.

Case 7. Jasper County. A barberry hedge was found on a farm two and a half miles north of Rensselaer. A wheat field across the road was heavily rusted. (Reported by W. E. Leer.)

Case 8. Rush County. The stem rust practically ruined the wheat crop in Orange Township on the farms of Jos. Brown, John Douthett, Chas. Owens and several others belonging to the same threshing ring. In one case the crop was a complete loss, as the grain did not even have any value as a stock feed. An investigation of the trouble resulted in locating an old abandoned nursery on a farm in the center of the affected community. Many barberry bushes formerly grew on this farm, but were dug up, as claimed by the owner, a couple of years ago. A further inquiry, however, disclosed the fact that a number of bushes were growing along the border of the farm woodlot which were not removed until last summer, after rust infection had already taken place. It is probable that there are other bushes growing wild in this community which have come up from seeds scattered by birds.

Case 9. Rush County. Two very severe cases of stem rust infection were found on the farms of T. A. Coleman and Wm. Garten, situated about two and a half miles northeast of Rushville. A careful search of the community resulted in locating a twelve-foot hedge of barberry bushes, most of which were over ten feet high. The infected fields were about three-quarters of a mile in direct line of the prevailing wind from the barberries.

Case 10. Jefferson County. A barberry hedge and several group plantings were found, late in the fall, about one and a half miles northeast of Madison. When the relation of the barberry to the stem rust of wheat was explained to one of the owners she recalled that a severe rust infection occurred last summer in a wheat field across the road from the barberries.

Case 11. Wabash County. Six infected barberries were found on the grounds of the Children's and Orphans' Home, three miles south of Wabash. Just across the fence from them was a wheat field in which the crop was badly rusted. (Reported by W. E. Leer.)

Case 12. An old planting of six large and several small barberry bushes was found on a farm eight miles southwest of North Manchester. The older bushes were about fifteen feet high, with stems several inches in diameter. A considerable rust infection was observed in wheat fields in this community within a radius of nearly two miles, especially in the windward direction. A field of oats and another of rye, about a quarter of a mile from the barberries, were also heavily rusted. (Reported by W. E. Leer.)

Case 13. Wabash County. A severe case of stem rust infection was reported by Nathan Gilbert on his farm five miles southwest of Wabash. Upon investigation it was found that numerous barberry bushes covered a hillside just across the road from the wheat field in question (see Fig. 2). The bushes showed abundant infection of the aecial stage of the rust. The entire wheat field was heavily infected, especially within a distance of about 100 feet of the road, where the grain was black with rust. Another wheat field situated about three-quarters of a mile from the barberries also had a considerable infection, but much less severe than the nearer field. The prospective yield of the first field was reduced by at least 60 per cent. A number of local farmers held a meeting at this field to see the havoc wrought by the barberries. The guilt of the bush was so firmly established in their minds that they went on record with the following resolution:

> We, the undersigned farmers of Wabash County, Indiana, at a meeting at the farm of Nathan Gilbert in Noble Township on July 19, 1918, called for the purpose of observing the ravages of the black stem wheat rust on the seventeen-acre wheat field, desire to go on record as follows:

1. We are fully convinced, after making these observations, that there is a connection between the common barberry and the black stem wheat rust. On the south side of this ruined field is a large planting of common barberry bushes, which have been badly infested by the rust. We have observed that the rust started on the side of the field next to these bushes and that now the worst infestation is on the side nearest the barberries.

2. We desire to go on record as favoring any legislation looking toward the complete eradication of the common barberry bush, believing it to be of no value, but on the other hand a serious menace to the wheat-growing industry.

(Signed)

Nathan Gilbert.	John Shambaugh.
N. L. Gilbert.	H. H. Behny.
David Flora.	L. R. Miller.
R. D. Flora.	W. Curtis.
S. A. Ungar.	Alvah DuBois.
Dan Cooper.	Jacob Stauffer.
E. E. Stouffer.	W. E. Walker.

Department of Botany, Purdue University Agricultural Experiment Station, Lafayette, Ind.

Evolutionary Philosophy and the German War.

A. Richards, Wabash College.

In the writings of the German intellectual classes during the early part of the war much was said about the biological justification for the conflict, and the German mind built up a biological argument which was faultless in logic, if the premises be granted. It is an argument which is readily comprehended in view of the historical development in Germany of the Darwinian doctrine of the survival of the fittest. This conception early took firm hold of the biological public of that country to the practical exclusion of those other explanations of the evolution process that have held scientific attention in other countries. The leading advocates of the principle of selection have been mostly eminent German scholars, many of whom have been even more ardent selectionists than Darwin himself. Owing to the stress they place upon selection as a factor of evolution, they comprise the school of Neo-Darwinians, and it is they who have carried Darwinism to the extreme in applying it to the problems of mankind. Obviously Darwin never anticipated such an application.

By selection the biologist means that of a race of individuals certain ones, especially desirable on the basis of some criterion established in the case, are chosen to be the parents of the next generation; and of the next progeny, those which show this same desirable character are chosen. In this way the domesticated races of animals and plants have been established, as is well known to the practical breeder. Natural selection, which Darwin assumed to be the chief factor in the evolution of species, behaves in the same manner that artificial selection in the hands of the breeder does; that is, the conditions of nature establish the criterion to which species must conform, and those members of the species which are best adapted to the conditions in which they are placed will be the ones that survive the inevitable struggle and give rise to the next generation. Whenever variations arise, however small in character they may be, if they give the individual possessing them any added advantage over its fellows, they will be perpetuated because of their usefulness. By the gradual accumulation of these small continuous variations the race is more and more adapted to its surroundings, and progress in evolution is made.

In spite of their zeal in the study of the selection factor, German scholars have not taken a leading part in the recent phases of investigation into evolutionary phenomena. It is true that since Darwin's original announcement, the most important single contribution to the understanding of these processes has been made by the leader of the Neo-Darwinians, Weismann. To him is due the conception of the continuity of the germ plasm, and the corrollary from this that body characters acquired in a single generation cannot be inherited. In other words, the germinal substance is carried from parent to offspring without interruption, and the variations which appear in the offspring are not inherited from the parent unless they are of such a nature that the germinal substance can carry them on. Thus an extra finger would be inherited, in all probability, but a bent one, due to an accident, would not be. The importance of Weismannism lies in this, that it is the foundation for the studies in genetics and eugenics which have occupied the center of the biological stage in this country and elsewhere for the last twenty years. To these subjects the active German investigators of the present time have contributed little. This fact should not minimize the contribution of Weismann, but, nevertheless, it does serve to explain to a certain degree the lack of German appreciation of the other factors of evolution, such as mutation, which are now known to be of the greatest importance in producing new species or races. German scholars are not now taking an active part in the modern studies of genetics; rather they explain most evolutionary phenomena on the basis of natural selection, and the German national philosophy is likewise based upon the acceptance of natural selection applied without modification to human life and society.

To the mind of most German biologist-philosophers, struggle is the rule among all the different groups of organisms, human groups included. Through all the ages that mankind has been developing, he owes his progress to the same factors that influence the evolution of other groups of animals and especially to the factor of natural selection. Selection is accomplished as the result of a bitter struggle for existence as ruthless in its outcome in the case of man as in that of beetles or snails or the beasts of the field. It follows that war is necessary that the best of the world's peoples may overcome their weaker neighbors and demonstrate their own superiority. The following paragraph from Kellogg explanatory of the German views helps to set before us the implicit Teutonic reliance in selection and in the irresistible consequences of the struggle for existence.

"This struggle not only must go on, for that is the natural law, but it should go on, so that this natural law may work out in its cruel, inevitable way the salvation of the species. By its salvation is meant its desirable natural evolution. That human group which is in the most advanced evolutionary stage as regards internal organization and form of social relationship is best, and should, for the sake of the species, be preserved at the expense of the less advanced, the less effective. It should win in the struggle for existence, and this struggle should occur precisely that the various types may be tested and the best not only preserved but put in position to impose its kind of social organization—its Kultur—on the others, or alternately, to destroy and replace them."

The so-called biological argument for the war, as it has shaped itself in the German mind, may, I believe, be formulated in three propositions. From these logically follows a conclusion, if the premises be granted, that abundantly justifies the German nation in carrying on the war for its own glory, and in taking measures of any nature whatever—no matter how horrible—which would make them dominant over the rest of the world. These propositions are the following:

1. In the evolution of any group of organisms natural selection is the chief, if not the exclusive factor in bringing about progress. Natural selection is effective because there must always be a struggle, either between individuals of the same group for space, food, etc., or between different groups for favorable living conditions, or between the individuals in question and the forces of nature, as climate, flood, etc. In the struggle for existence the individuals best fitted for the conditions of their environment will be selected to carry on the race and their characters preserved.

2. The principle of natural selection is applicable to the human race, to the nations of the world, just as it is to groups of lower animals, and there is to be expected a struggle for existence between the various nations. War is the usual form of struggle, and it offers an opportunity for the best among the nations to come to the front at the expense of the other less fortunate ones. There is something in the innate character of nations which finally makes them irreconcilable, and in the long run the principle of mutual aid, which is applicable to ameliorate the struggle within groups, cannot act to diminish the realness or the severity of the inevitable struggle.

3. The German nation is the mightiest and greatest nation upon the earth, and its social and political development has outstripped that of any other people. Since this is true, anything which operates to deprive Germany of her rightful place of dominance among the powers of the earth is wrong and cannot be allowed to stand. War is a worthy occupation for the German people, for it creates an opening by which their dominant traits are given the opportunity for full expression and development. The policy of terrorism is justified, for it aids the selected German nation to maintain itself over its weaker neighbors, and along with the natural results of war, it serves to remove the inferior and unfit peoples from the contest and thus make more room for the better fitted survivors.

That the points in the argument for war are not overdrawn as here formulated might easily be shown by quotations from many German writers. From eminent as well as from humble sources might be drawn proof that this point of view is part of the mental fabric of that nation. Many articles are available to show that the above propositions represent the average opinion of the dominant classes, while from Prussian sources come utterances that make the version here given seem woefully understated. Actual quotations here, however, appear unnecessary in view of the many statements in newspapers, magazines and authoritive publications of the years since the war began which depict plainly the German attitude.

The purpose of this discussion is to show that when critically examined this argument is not in every respect biologically sound. Indeed the points in the argument are only half truths, and as such can not be used as a basis from which to draw general conclusions. Not only is the biology of the present time set against war as an instrument of racial progress, but recent investigations go to show that, in some of its aspects at least, war tends to retard the development of the nations which pursue it. Biology has said nothing for which it merits the taint left upon it by this false argument. To grant the fallacious premises is possible only upon misinterpretation of the facts and teachings of nature.

Of the points advanced in the supposed biological argument for war, the first is the all importance of the factor of natural selection in evolution. Evidence for and against this view is familiar to all biologists and needs only be mentioned here. In Darwin's theory of evolution, natural selection was indeed the chief factor by which progressive development was thought to be accomplished; but he admitted that there might also be other factors of importance. Natural selection depends upon the usefulness of the character under consideration; that is, in the struggle for existence it is the character which is most useful, which is best fitted to the environment wherein the struggle is conducted, that is preserved. Darwin supposed that, as the small variations accumulated, they gradually fitted the individual possessing them more and more to its surroundings, and thus were passed to the next generations. Even the most minute, the continuous variations were to be interpreted thus. Discontinuous variations, by which offspring markedly different in some particular character are produced, were recognized occasionally to occur in nature, but they were thought to be rare and therefore insignificant. Darwin also recognized that his factor fails to account for the perpetuation of minute variations until they are sufficiently developed to be of importance to the organism. Natural selection without doubt plays its part in the case of a useful character. The white coat of the polar bear renders that animal inconspicuous on the snow fields of its habitat; but it is hardly to be supposed that the first patch of white hair that appeared upon the ancestral type of bear was perpetuated because it offered any great degree of security to its owner. Natural selection here loses its force, while discontinuous variations come into consideration. It is now known that the discontinuous type of variations, or mutations as they are called, is less rare than Darwin believed. To mutations is now attributed the larger share in the origin of races and species. The role played by mutations is illustrated by the recent experiments in the inheritance of the fruit fly, Drosophila. In laboratory cultures of these fruit flies there occur strains without eyes, other strains with vestigeal wings that can have no possible usefulness, as well as numerous other strains with characters widely different from those of the parent stock. If they had arisen in nature they would have been recognized without question as distinct sub-species at least, and probably as distinct species. Natural selection, as this and other cases that might be cited show, is not by any means all-powerful in producing new races and species.

In late years the selection problem itself has been attacked from many angles, and a great deal of experimental work has been done on it. The problem resolves itself into these questions: Are organisms indefinitely variable, and by constant selection can we hope to develop a character at will, or can we carry on our selection only to a certain point, beyond which it is not effective? As yet no definite answer has been made, and controversy has divided students of inheritance into two schools. Both agree that positive results come from selection, but one school holds that a limit is soon reached, after which selection is no longer effective. According to these geneticists, selection results in a sorting of the different strains of which any organism is composed into the original pure lines. Thus the bristles numbers on the thorax of a fly may be selected for perhaps thirty generations with an increase in the mean, but at length continued selection causes no further rise in the mean of the bristles number. If further selection is to be effective a new mutation must occur. Without some such change in the germ plasm selection cannot be responsible for continued progressive development.

According to the other school of biologists, germinal modifications are necessary before selection can bring about any real change in the organism, but these germinal changes are of such common occurrence that it is possible practically to continue development by selection in the direction desired. Between these two widely different viewpoints no decision can be reached, for sufficient experimental evidence is not at present available. Certainly there is not enough exact scientific data to justify relying solely upon natural selection, or making a fetish out of the conception of the struggle for existence.

One more important criticism of the narrow Darwinian interpretation should be pointed out. Evolutionists in the last quarter of a century have come to see that the struggle so much stressed in the years immediately following Darwin's life is by no means an unmitigated one, but that, on the other hand, those communities of animals that are most highly developed are the ones in which there is a division of labor and in which co-operation takes the place of bitter competition. Co-operation results in community prosperity and growth. This is the principle of mutual aid, and even a cursory examination of the facts of nature will show that it is not an unimportant one. It depends upon several observations which may be easily verified. There is not a vast number of species of animals that lead isolated lives, but there are numberless species that live in societies which seem to have their *raison d'etre* in better means for defense, for securing food, or for rearing offspring. A fairly keen competition and warfare may often be noted between animals which are members of different classes or species, or even between different tribes of the same species, but among individuals of the same community or tribe peace is the rule. And if an entire population is forced to struggle against the unfavorable conditions of drought, flood, famine, disease, wind or weather, the survivors, weakened by such a contest, can at best produce offspring with insufficient vigor to bring about the progressive development of the species. It is common knowledge that when a pestilence of any kind has swept an animal community, the remnant of the population is years in restoring its former numbers. Finally the degree of development of any group of animals is measured by the degree in which social life, co-operation for mutual good, and division of labor obtain, with the corresponding avoidance of severe competition. The social species prosper, while many of the unsocial ones tend toward decay. The principle of mutual aid presents another aspect of the story of development in the animal world which must not be overlooked, and shows that struggle is not in every case the chief characteristic of progress. This principle doubtless does not deserve the rank of the chief factor in evolution given it by Kropotkin, one of its proponents; but neither does the struggle for existence deserve the prominence which the German Neo-Darwinians have given it. The isolated species of animals struggling against his kin, his neighbors and his physical environment cannot longer be looked to for the entire cause of progressive evolution; rather we must look to both the social and unsocial, and remember that probably no single factor is broad enough to account for all the complexities of animal development.

These objections to and arguments against the Darwinian factor of natural selection, and especially the narrow Neo-Darwinian interpretation of it, constitute abundant reasons why it cannot be accorded the chief, the all-important place in the progressive development of animals.

They do not in any way constitute a denial that progressive development takes place, for that is a matter of common observation, but they do deny that natural selection is the all-powerful causal factor in bringing about that development.

The second point of the German war-biologists is that natural selection is applicable to the human race and the nations of the world just as it is to the lower animals. It must be admitted without question that there is a tendency for mankind to follow the same natural laws that the lower forms of life do, but this tendency is very often modified. Man does not owe his development to any one factor exclusively, whether it be natural selection or any other. Man differs from the lower animals in the degree to which the particular factor in question is applicable in his evolution. Most animals are forced to adapt their mode of life to the conditions in which they live, but man can by his superior intelligence and ability adapt the environment to his own needs. He has ameliorated the severity of the struggle with climate and other physical forces not by growing heavy fur or seeking caves, but by taking the skins of other animals or the product of the fields to make himself clothing, and by building shelters which render him almost completely master of the elements. The individual whose eyes are too weak to endure a severe struggle with unfavorable nature or more vigorous competitors is not at a disadvantage, for he, or rather those with whom he co-operates, have devised lenses by which the eyes are strengthened and he is enabled to occupy his rightful place among his fellows. The human individual is rendered superior to his environment; his form of adaptability to the conditions of nature consists in an ability to adapt them to himself. Furthermore, what is true of the individual is only true in a larger measure of whole nations.

Co-operation is the keynote in the life of mankind. Individuals organize themselves into communities, even among the most primitive of peoples, and the communities band themselves together for the mutual benefit of all their members. In each community there is a division of labor by which all of society is helped to a more successful life. The city nations of the Europe of the Middle Ages have given way to the state nations of the present time, and now peaceful and harmonious dwelling together prevails over large areas, to the increasing prosperity of the inhabitants, where formerly conflict and warfare was the rule between the subjects of separate cities or of neighboring feudal lords. As allegiance to cities gave way to allegiance to states, co-operation was extended. In no other nation was the principle of such organization more developed than in Germany. The Germany of Kaiser Wilhelm II owed its strength and efficiency to its organization and co-operation. German thinkers of the present time are fond of saying that no nation that does not have an extremely centralized form of government developed on the basis of a strict and complete organization can really become great and continue so. This is, of course, nothing more than the principle of mutual aid carried to a nation-wide extent. And if the life of a nation is made more effective by co-operation, does not the same rule apply to neighboring world powers? The logic that proves co-operation to be the best means to develop the people of a nation should be carried further and demand the co-operation of the nations themselves. Germany has not felt the full force of the logic of its own situation. There co-operation has worked effectively by removing competition and struggle from the inhabitants of an empire where formerly conflict was the rule and peace the exception. And this co-operation within the empire is completely at variance with the philosophy that regards conflict and struggle between nations, the downfall of one people and the exaltation of another, as the working out of natural law. The argument that natural selection and struggle for existence must be applied to peoples is most effectively disproven by the development and life of the German people itself. In every nation the highest development of its society is based upon the complete application of the principle of co-operation. And the highest development of the society of the world will await the co-operation of the nations which dominate and control the world's destiny.

The final point in the argument is the pre-eminence of the German people. Very few will be found to admit that this people represent the highest development of mankind and are the best fitted to rule, for such an admission would imply a very narrow understanding of the meaning of best fitted. At the beginning of the war Germany was certainly the best organized nation for military purposes; but when all is said, military strength will never give any people the first rank as the best developed of mankind. Intellectually Germany has stood well to the front, but it is noteworthy that this position is not due to the politicians and soldiers of Prussia but to the general interest in culture and learning that prevails in the south and west of Germany. Even Prussian Von Bülow remarked that "German intellect had already reached its zenith without the help of Prussia." Spiritually the life and performances of Germany will not stand close scrutiny. The misdeeds and moral corruption of the German military authorities are probably the most outstanding feature of the war. Certain it is that the life and deeds of the German nation do not stand in the eyes of the world as the finest and most fitted type of manhood. No attempt in the defense of this people can ever give them the place that they claim.

For all these reasons, therefore, biology cannot rightfully be charged with having furnished a foundation upon which to construct a philosophy of war.

November, 1918.

IN MEMORIAM.

George D. Timmons.

L. F. Bennett.

George Deming Timmons was born August 10, 1867, in Warren County, Indiana. He received his early education in the common schools of his county and in the Green Hill Seminary. He taught in the public schools from 1884 to 1895. He entered Valparaiso University in 1895 and graduated with honors from the Pharmacy class of 1897. Soon after graduation he was appointed Assistant Professor of Chemistry at Valparaiso. In 1909 he was promoted to the position of Head of the Department of Chemistry, and in 1912 he was made Dean of the School of Pharmacy. During this time he did graduate work in Chemistry in Chicago University.

Under Mr. Timmons' leadership the School of Pharmacy became one of the most important and most completely organized and best equipped departments of the University. His acquaintance with members of the profession, his activity to place the School of which he was Dean among the most efficient in the country, a constant and conscientious endeavor to be loyal to the best interest of the students, the University, the ethics of his chosen work, and the spirit of his subject, made of him a distinct personality.

A fellow teacher wrote of him: "A scholar without pedantry, a chemist whose world was not limited to chemical theories and formulæ, a teacher of a difficult subject who made it so attractive that even dull students got some insight into its laws and its poetry, a worker who never knew when to quit, a man with a heart big enough to feel the thrill of life intensely, its pathos, its heroism, its incongruities—such he seems as I try to set it down. Possibly, however, it was his amazing vitality and capacity for work that used to impress me most. So strong was this impression that he was the last man with whom I should have connected the idea of death. Of his remarkable gifts as a teacher I am not well qualified to speak, but I knew enough to be sure that he was a teacher born and made. He entered his classroom with a quick step of confidence and animation. He loved to teach—and to learn; and so it was that one would have sought far before finding a more alert, conscientious or inspiring teacher."

Mr. Timmons and I were colleagues for twenty years, and during all of this time we never had a single disagreement. I will always remember him for the many times he laid aside his own work in order that he might explain to me a chemical equation or reaction. He was never too busy to help me. I can recall now how he would reach for his numerous volumes of chemistry and would say, "We'll see what" this one or that one "says on the subject," and then he would tell me what he thought was the best explanation. And what he did for me he did for many others. His whole life was one of helpfulness. His greatest pleasure seemed to be to help his students. He had had a hard struggle to reach his present position and was very sympathetic toward one who was trying to learn. He was too tenderhearted for his own good. When he should have been resting he was off on a trip with his students or giving them extra help or writing a helpful letter to someone who needed encouragement.

He was never idle a minute. Between terms he would carefully inspect the laboratories and, if anything needed fixing, he would do it himself rather than not have it ready for the new term. His mechanical skill was second only to his ability as a teacher.

Mr. Timmons was not only a chemist; he was a student of many of the poets and prose writers. He was a lover of Riley. His colleagues will never forget the address he gave upon Riley and his poems. It would have done credit to a profound student of literature.

He was a member of the Indiana Academy but a few years and he never took an active part. He was an active member of the American Pharmaceutical Association and of the American Chemical Society. He was serving his third term as a member of the Valparaiso City Council at the time of his death.

Mr. Timmons published, in 1914, "Experiments in General Chemistry, I and II," and, in 1917, "Qualitative Chemical Analysis." At the time of his death he was engaged in gathering data for a further publication.

Last May Mr. Timmons was given a vacation for the summer and was advised to take a much-needed rest. Instead, he took a position made vacant by the draft in the offices of the Eli Lilly Company of Indianapolis. He died July 18th after a week's illness of typhoid fever. His funeral was held in the Auditorium of Valparaiso University and was largely attended by both students and townspeople.

A local paper paid the following tribute: "The death of Prof. G. D. Timmons has left a great vacancy in the life of the city and the University. To his duties as alderman he brought an unflinching loyalty to the cause of clean politics and efficient government. Whatever made for progress and advancement always received his whole-hearted support and devotion. No man ever deserved more justly to be called public spirited in the best sense. In his work at the University, where he was head of the Pharmacy Department, he was indefatigable. The unstinted admiration of all those who were in any way associated with him is a glowing tribute to his sincerity and earnestness."

William James Jones, Jr.

S. D. Conner, Purdue University.

William James Jones, Jr., was one of the most prominent officials in the United States in charge of fertilizer and feeding stuff inspection and control. His opinions were always given great weight in the meetings of the Association of Official Agricultural Chemists, of which he was a member. As an official of the Federal Food and Drug Department has stated, "We regarded him as a model of the efficient food control chemist."

Professor Jones was born at Watseka, Illinois, December 9, 1870. He studied in the public schools of Illinois until prepared for college. He took the science course at Purdue University, graduating with high honors in 1891. Immediately after graduation he became assistant to Dr. W. E. Stone, then head of the Chemistry Department. In 1892 he received the degree of Master of Science and in 1893 that of Analytical Chemist. In 1892 he was appointed Assistant State Chemist under Prof. H. A. Huston. Continuing in that department, he was made Chief Deputy in 1903 and State Chemist in 1907, holding that office until his death on August 31, 1917.

Professor Jones' high sense of honor and integrity, together with his thorough training and tireless energy, well fitted him as a leader against fraud in commercial fertilizer and feeding stuffs. He was instrumental in framing the Indiana Feedings Stuff Control Law of 1907, which has proved so satisfactory and successful that it has been used as a model by other States and the Federal Department in framing similar laws. This law was so administered by Professor Jones that it has proven of vast benefit to both consumer and the honest manufacturer. It may be safely said that both the feed and fertilizer sold in Indiana are now almost universally up to the guarantees.

His administration of the laws under his charge was without fear or favor. He forced the condimental stock food manufacturers to register and sell their products under the feeding stuff law. This ruling was disputed by the International Stock Food Company, who fought the case through all the courts until the United States Supreme Court decided in agreement with Professor Jones' interpretation of the law.

Professor Jones had a natural taste for investigation, and it is unfortunate that his regular duties prevented him from giving more time to research. While his publications of a research nature were few, he was of great assistance to his colleagues. His work on the Composition of Maize at different stages of its growth, published in collaboration with H. A. Huston in Bulletin 175, Purdue Experiment Station, is recognized as standard.

He designed the Indiana fertilizer sampler, which has been adopted as official by over twenty States. It is recognized as the most practical instrument made for the accurate sampling of commercial fertilizer and similar products. His feed sampler, which is a modification, is also widely used. He designed a stirring machine for the rapid precipitation of phosphorous and similar reactions. Professor Jones carried on extensive experiments in collaboration with Prof. H. A. Huston on the action of fertilizers on sugar beets and also on the effect of potash and other fertilizers on peat soil. This data is unpublished and it is to be hoped that it may be made available some time.

He was the author and contributor of over twenty fertilizer reports and ten feeding stuffs bulletins. Besides a report of inspection, his bulletins contained much valuable information upon the subject under consideration. Some of his compilations of feeding stuff definitions have been used as texts in college work. He helped form the Association of American Feed Control Officials and served as president and on the executive board of this association. He was a member of the American Chemical Society and the American Peat Society. He was a Fellow of the American Association for the Advancement of Science, and had long been a member of the Indiana Academy of Science. He was a charter member of the Purdue chapter of Sigma Xi.

Dr. W. E. Stone fittingly described his life when he said: "On every side he displayed the highest qualities, as a man, a citizen, a public officer, a scientist, and an alumnus of the University. Such men are rare. We shall long remember his exemplary life and mourn him as a staunch friend and a valued associate."

Feeble-Mindedness—The Problem—Conditions in Indiana.

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In the three-fold problem of Mental Defect we have Insanity, Epilepsy and Feeble-mindedness. Insanity and epilepsy, while not properly understood, are popularly recognized and are looked upon as explaining and excusing social irregularities and crime. But feeble-mindedness, which includes by far the largest proportion of mental defectives, is unrecognized, misunderstood and condemned.

The feeble-minded are adult children; their struggle to lead adult lives in competition with their normal fellows is a pitiful succession of social and economic failures. For a few minutes I want to discuss the problem of feeble-mindedness from its psychological basis and then proceed to the rehearsal of stories of real folks—stories that show how these adult children fall short in their effort to take a proper place in community life.

Feeble-mindedness, or amentia, is an absence of the quality that makes for normality. It is the place at which mankind loses his high birthright of reasoning power, and becomes something less than the man who has developed, through his years of childish growth and the struggles of adolescence, that perfect mind that makes him the highest of all creatures, a reasoning being. Amentia is a unit character, and represents a level of mentality lower than normal in all its manifestations. It does away with the old "faculty" psychology. A feeble-minded person could not be an idiot in powers of attention and have a good memory; nor will he reason well and perhaps fail to have imagination; nor will he have strong volition and lack judgment. His mental processes will be, on the whole, those of a normal child of the age at which his (the feeble) mind reached its level. In so far as any normal child will vary in special mental aptitudes, just so far will a feeble-minded person vary in ability for specific kinds of mental activity. But he will in no point rise above his mental level—he will do no more in other lines than a normal child of the same mental age, gifted with a one-sided talent. For example, a man of thirty, having a mentality of eight years, may be a very good reader. He has a peculiar aptness for the recognition of symbols and for stringing them together; but he will understand no more than a normal child of eight who, it happens, is better at reading than at anything else.

Believing with me that the mental level determines the ability of the feeble-minded individual, I may mention in passing the three great levels at which we classify subnormal mentality. There is first and lowest, the Idiot, who attains a mental ability equal to that of babies one and two years old. Some idiots can feed themselves and move about as smart babies do—others cannot. Many idiots of mature age are as helpless and as dirty as tiny babies. The Imbecile rises a little higher in the scale—he attains to a mind like that of normal children from three up to eight years of age. Low-grade imbeciles play a little, show interest in their surroundings and can make known their physical needs. As we come higher in the scale of imbecility we find these aments able to do simple routine tasks and run easy errands. Above the imbeciles are the Morons—those whose mental power resembles that of children from eight up to twelve years of age. These Morons can do simple tasks with only a little supervision—they make good household helpers (not managers)—they can run machinery and often work without supervision—but they cannot plan. The difference between the occupational ability in low, middle and high-grade Morons is almost as startling as the vivid contract between normal and defective.

Mental level or "mental age" is a result of a gradual slowing up and final and complete stoppage of mental development. The limitations manifest themselves between infancy and adolescence, leaving the subnormal individuals at a mental standstill somewhere between infancy and twelve years of age, while their bodies go on with the passing of the years, and the evolution of physical phenomena makes them men and women in the flesh while still they are children in the mind.

For nearly a year I have helped to search the highways and towns of certain counties of Indiana to find these defectives. They have not been hard to find, because they are to be found everywhere. Every State has them; no community escapes; no kind or amount of industry can free you from them; no legal rigor can expel them (except to some other community). Your State needs a farm colony—it needs more than one—for the feeble-minded. I can tell you of one place in a beautiful town where you would have a colony ready-made by building a fence around the slums. There is a section of about twelve blocks where in every one of the fifty houses there is defect of one kind or another—pauperism, syphilitic infirmities, and immorality walking hand in hand with feeble-mindedness. Some of the homes are clean, some are too filthy to talk about. There are about eight family names represented in this community and they all belong to each other somehow. As one old Moron woman said, "Yes, mom, we air all kin here. I jest found out after I took my second man that he were some kind of a cousin to my kids." The people who live in the beautiful homes of this fine town know they have these folks in their back yards, but they say, "What can we do?" And I repeat it, "What can they do?" I know another very beautiful and prosperous town in Indiana with a black spot like that in it—not so big, but one in which the problem of prostitution assumes alarming proportions.

The feeble-minded population of towns and accessible country districts shifts with the tides of business. In the woods about the lakes and in the isolation of river bottoms we find the defectives persisting, in spite of barrenness, starvation and inconvenience. Their wants are few and easily satisfied. In the lake community, in the northern part of the State, are found several groups of defectives who have lived in the same spot for two or three generations. One such family contained sixteen children, three of whom are normal, have married and have normal families. Two others are low-grade Morons, and the remaining eleven are idiots, resembling some of their paternal kinfolks, among whom idiocy and imbecility were not uncommon. Seven of these eleven idiots could not walk and none of them could talk. Only three of them are now living. The home that shelters them and their mother was left to them by their father. It is a tiny four-room cabin in the hills, inaccessible except by footpath. One room of this house has fallen away from the rest, and the other three rooms are small and dark, with wide cracks between the logs, through which the rain and snow drifts in on their beds.

You must hear about a family living in the river-bottoms in the southern part of the State. Because of the great number of adult feeble-minded we were finding in this community we often went two together, because we felt more sure of our judgment in a given case, when we could talk it over afterwards. The man who drove our car would try any kind of a road; but half a mile down the field towards this house he gave it up and walked with us through the fields until a turn in the path took him out of sight of the car, which he wanted to watch. Leaving him there to await our return, we went through the woods, across a freshly ploughed field, through a field of tall corn, and at last we reached the house of our search. We could never have found it had not the voices of the boys in the barn guided us to it. It was in the lowest and wettest part of the field, set like an ark on a scarcely dry mount. The vapor was so heavy that it kept us coughing. Here in dirt and disorder lived a family of five, all Morons. Twin boys are of low grade, the parents only middle grade, and an eighteen-year-old girl a little brighter than the others. Their isolation was as complete as if they were on another planet. The mother said her husband was not strong and no one would rent him a good farm. This farm is under water two months in the flood season, and in the winter they cannot get out because of snow. Yet they never try to better themselves—they accept their condition with calm indifference.

The broad highway of town and open country has its fascination for the feeble-minded just as it has for the rest of us. I cannot walk on the street at any time and fail to see defectives. But when, as in Indiana, it has been my "job" to hunt for them, I need only to select my section of the town and then go into house after house and talk with them. I like to talk with a Moron mother or father—they will tell so guilelessly just what I want to know: "Katy's baby ain't got no father. No, no, Katy never was real bright—she didn't learn nothing in school. John? He's fourteen and in the fourth grade—he's smarter than the others. John can write his name real nice. The old man, you say? Nope. He can't read. My first man could, though, but not the second one. This man can't keep no steady job; he's working on the coal bank now. Henry? Oh, Henry's in school in Indianapolis." I ask, "Is he in Plainfield?" "Yes, that's the place. Seems like he'll never get out. My least boy, he's ain't stout and he has red, sore eyes; the teacher can't learn him nothing 'cause he can't see. My other big girl, she's got red, sore eyes, too——" and so on.

Behind it and through it all I can read the old, old story of prostitution, illegitimacy, delinquency and general no-accountness of the feeble minds behind it. You may think I made up this story, but it is the story I heard from a gaudily dressed low-grade Moron mother, who did not know that I knew that she herself was a prostitute.

In the towns and cities the presence of the feeble-minded complicates our social service; it increases the number of accidents and adds to the list of the unemployed. The school system is corroded with the lower 3 per cent of its population mentally unfit to profit by its teaching. The administration of poor relief by the overseers of the poor lends almost all of its time and money to the feeble-minded of the township. I just had one township trustee tell me, with something like disgust, that two of his many paupers had married the only two paupers (widows) in a nearby township—thereby clearing one record and adding two families of feeble-minded children to his list. Later in the same day the trustee who had lost his two pauper women and their families told me the same story—but he thought it was funny! Poor farms are filled with feeble-minded folk who never did get along, and many of them entered the farm between twenty and forty years of age and have spent many years there. I talked with one woman in a county farm who had married four times, her last two husbands being inmates of the same poor farm. She had one epileptic daughter. That girl is now an inmate of the farm at twenty years of age, and last summer she gave birth to an illegitimate baby, which fortunately died at birth.

You may turn your head as you will, you still face mental defect, and the bulk of it is feeble-mindedness. We have established, as the result of the survey of ten counties in Indiana, that 2.2 per cent of the population is defective. Of this, 1.7 per cent is feeble-minded. Much of our crime, nearly all of our pauperism, a large proportion of school failures, practically all public prostitution, and a share of the gamut of ills that society is heir to, springs from among the feeble-minded. It is none of their fault. They stumble along the pathway of life, poorly prepared for the battle they fight. They are only grown-up children, and as such should not be blamed, imprisoned or cast aside, but sheltered, trained and supervised.

A Method of Teaching Diffusion and Osmosis in Connection with Biological Work.

Paul Weatherwax, Indiana University.

Osmosis and diffusion are processes met with in many lines of biological science, and the problem involved in an attempt to make the phenomena clear, especially to an elementary class, is often a difficult one. It is not proposed to add here anything new from the physical or chemical standpoint to the array of facts already clustered around these subjects; it is intended, rather, to give clear, concise definitions of the terms and to present a method of teaching the subjects which has been found successful in connection with elementary botany. The need of such presentation has been felt after the perusal of twenty-five or thirty text-books on general botany and plant physiology, most of which are noncommittal or inconsistent with facts when discussing these phenomena.

When the name *osmosis* was coined, the process was little understood and many irrelevant considerations were connected with it. Since then the process has been found to be of much more general occurrence than was at first supposed, and our definitions and explanations must be generalized to meet our better understanding of it. A brief history of the explanations of diffusion and osmosis that have been before biologists of the last few years will help to clear up the situation.

Pfeffer looked for the secret of osmosis in the behavior of solutions of cane sugar, potassium nitrate, etc., when separated from the pure solvent, usually water, by membranes of various kinds. He did much to bring the process to the attention of biologists, but he necessarily saw only a limited portion of the field to be covered.

Van't Hof attempted to generalize the problem and asserted that in dilute solutions the dissolved substance behaved approximately as it would in the gaseous form, the temperature and volume being the same as that of the solution, and osmotic pressure being substituted for gas pressure. But this hypothesis has been found to attempt to explain too much even for dilute solutions and is of no avail at all in connection with more concentrated solutions, which are also capable of demonstrating osmotic pressure. It also has the defect of not making sufficient allowance for membranes that are not perfectly semipermeable.

The kinetic theory offers an explanation based upon the assumption that certain molecules bombarding a membrane are able, because of some characteristic, presumably size, to make their way through even against a greater pressure than they themselves are exerting by their motion, while certain others fail to penetrate the membrane, even when aided by a difference of pressure. The most obvious objection to any consideration on this basis is found in the fact that certain liquids having large molecules—as some of the alcohols—are able to pass through certain membranes more readily than water.

Kahlenberg reports numerous experiments, both qualitative and quantitative, to show the fallacy of many of these theories. He makes no attempt to deal with the subject on a biological basis, but his results bring us near a working explanation for biological purposes. He attributes osmotic pressure to the relative affinities of two fluids for each other and for the separating membrane.

The report of the recent symposium of the Faraday Society on the subject of osmotic pressure was consulted in the hope that it would be of material aid; but it was found to contain little that is tangible or serviceable from our standpoint. Like Pfeffer's classic works, it was found to contain much about the mathematics of osmotic pressure and little about the process of osmosis.

The text-book definitions and discussions of osmosis and diffusion have been based upon one or a mixture of the theories here outlined. The prevailing influence of Pfeffer's work is evident in most of them, and, consequently, we see in them much about water and aqueous solutions of various densities. Osmotic pressure is too often emphasized at the expense of osmosis, and students of biology, who should be trying to understand the nature of the process and its relation to the plant, are still bored by having to read books and listen to lectures which emphasize the stupendous pressures exerted in cells; many a student finishes his course with a firmly fixed idea that relative density is the thing that makes the gases of the air and the water of the soil enter the plant body, and that density alone prevents all the sap of a plant from leaking out through the root hairs.

By means of a condensation and organization of what is known of the processes involved, there has been worked out a set of definitions and a method of presenting the subject which is believed to be superior to that given in most text-books of botany and plant physiology.

The first step in the teaching process is the well-known experiment of placing a crystal of some colored soluble salt, such as copper sulphate or sodium bichromate, in the bottom of a tall glass jar of water and watching the color ascend for a few days. The process is named *diffusion*, and the student is encouraged to work out his own definition. Diffusion is seen to consist of *the dispersal of the particles of one substance among the particles of another substance, without aid from external* *sources.* It is also pointed out that an energy transformation has taken place in the migration of the particles of the salt upward through the water; the source of this energy is in the chemical affinity between the salt and the water.

The next step is to demonstrate the existence of this energy in its static form. The ordinary osmosis experiment, in which a parchment diffusion shell filled with a thick sugar syrup is immersed in a jar of water, is set up. When the difference in level has been established, the process that has taken place is named *osmosis,* and a definition of osmosis is in order. It is seen that the syrup and water have tended to diffuse into each other through the membrane, but the water has been more successful than the syrup in getting through; in other words, the membrane is more permeable to the water than to the syrup. Osmosis may be defined, then, as *the diffusion of two fluids through a membrane that tends to be semipermeable.*

It is necessary to speak of two *fluids*, rather than two *liquids*, as many texts do, because the process is characteristic of gases also under proper conditions, and this phase of the process is a very important one in a biological connection. It is not deemed wise to complicate the definition or the explanation with reference to the few cases in which osmosis has been shown to take place between a solid and a liquid.

It seldom, if ever, happens in practical work that the membrane is perfectly semipermeable. If we were defining the ideal process, it might be well to speak of an ideally semipermeable membrane; but, after all, our aim is to make the situation clear to a student of biology, and he seldom has to deal with questions of complete semipermeability. To define osmosis as merely *diffusion through a membrane,* as some texts do, is insufficient, for a membrane equally permeable to both fluids would not demonstrate osmosis.

It will be noted that the student is not confused by the introduction of relative density into the definition here proposed. The density idea is a remnant of the day when the full application of the process was not understood—when combinations of solution and pure solvent, separated by a suitable membrane, constituted practically the only system that had been thoroughly investigated. Now osmosis is known to take place between numerous combinations of pure substances, and numerous examples are afforded where the old rule of density works the wrong way.

The reference to density is especially deceptive in certain cases where one of the diffusing substances is a gas. An interesting illustration of this is afforded by an experiment often made to show the "lifting power of evaporation." A thistle tube filled with water has a piece of wet bladder tied over the larger end in contact with the water, and the tube is supported in a vertical position with the smaller end dipping into mercury. As evaporation removes water from the wet membrane, water from the tube takes its place, and compensation is made for the decreased pressure by a rise of mercury into the lower end of the tube. But this is really a demonstration of osmosis. Evaporation in this case is merely the diffusion of water and air, and the process takes place through a membrane which allows water to pass more readily than air. It will be noted that the major flow is from water to air rather than from a less dense medium to a more dense.

It is true that when a solution and the pure solvent are considered, density may sometimes act, both qualitatively and quantitatively, as an indicator within certain limits; but we are by no means sure that it will work in all cases. It is probably worth mentioning that most of the experimental work that has been done with solutions and pure solvents have dealt with solutions whose density is greater than that of the pure solvent; but some combinations are possible in which the opposite is the case, and some interesting results might come from experiments with some of these. In the cases where the comparative density rule does work in determining the direction of the major flow and the ultimate pressure produced, color would probably serve as well for an indicator if a colored solute were selected and a sufficiently sensitive method of measuring intensity of color were devised; yet no one would think of connecting color with the fundamentals of the process. Density has about the same relation to the process as has color; chemical affinity is the driving force and the only consistent indicator of the qualitative and quantitative features of the process.

It will be seen that much depends upon the nature of the membrane through which the diffusion takes place, and to the physical chemist or the research student of physiology this is a very important thing. But to the student of the elementary aspects of biology, whose welfare is now being considered, the mechanism of the membrane is less important if he knows that for some reason it tends to be semipermeable. Whether the permeability of living membranes can be explained on a purely physico-chemical basis, or whether we must still have recourse to a vitalistic explanation until physics and chemistry have made sufficient progress to include these phenomena, is still an interesting problem of research.

It must be emphasized that, from the biological point of view, the effort expended in explaining diffusion and osmosis is lost if we fail to make clear their definite application to problems of plant and animal life, and many of our text-books fail to do this satisfactorily. Many of the texts examined make the assertion or leave the impression that the cell wall is the osmotic membrane concerned, and many leave with the student the impression that osmosis takes place only in root hairs and is concerned only with supplying the plant with water and mineral food. The student should be led to connect osmosis with his knowledge of cell structure and to see the general nature and importance of the process. All the living matter (protoplasm) in the plant or animal body is disposed in definite units (cells), whose unity is determined by the plasma membrane. The whole normal contact of the cell with its physiological environment—food, water, soil, air, digestive fluids, other cells, etc.—is defined and regulated, in so far as it is regulated at all, by this membrane. Thus, it is seen that all the life processes—respiration, photosynthesis, imbibition by living tissues, transpiration, secretion, excretion, etc.—which involve the exchange of fluids between the cell and its environment, depend upon the selective influence of semipermeable membranes.

I take this opportunity to acknowledge valuable assistance given me in the study of this problem by Professor O. W. Brown of the Department of Chemistry, Indiana University.

References.

It is not deemed necessary to give here a detailed bibliography Standard texts will illustrate the defects pointed out; the historical side of the question is given in most good texts on physical chemistry. Kahlenberg's work is described in the Journal of Physical Chemistry, Volume 10.

Number of Colonies for a Satisfactory Soil Plate.

H. A. Noyes and G. L. Grounds, Purdue University.

The uniformity between the number of colonies developing on petri plates carrying equal sized aliquots has been used as the basis for ascertaining the number of colonies satisfactory for one plate. Prucha[1] said in 1916: "Further study is needed to give sufficient basis for drawing definite conclusions, but the results so far point to the conclusion that the average of three plates from the same dilution approaches, reasonably closely, to the average of a hundred plates made from the same dilution, when that average is between one and two hundred colonies per plate."

The following points have served as the basis for determining the number of colonies satisfactory for a soil plate: Soil may be a medium for the growth of all kinds of micro-organisms; the rate at which different bacteria multiply varies considerably, and the antagonisms between organisms are affected by media, etc.

The plan for determining the number of colonies for a satisfactory soil plate was: First, to make many dilutions and platings of a prepared soil and study the numbers of colonies developing in three, seven and ten days incubation. Second, to compare the number of colonies developing from the different dilutions for evidence that plates from the higher bacterial dilution carried one-tenth the number of colonies of the lower dilution when the lower dilution did not give above the maximum number of bacteria that could be developed into colonies on the plates. Third, to give confirmation of the conclusions reached by routine laboratory data.

Unpublished results (obtained in this laboratory) show rather conclusively that practically all micro-organisms can be grown on a simple media. Differences in growth, in addition to being due to the virulence of the organisms and their natural characteristics, result from the media becoming unfavorable for growth, due to the presence of acid or basic reacting substances and specific end products of bacterial metabolisms. The importance of the proper conditions of aeration cannot be overemphasized. It has been noted that duplicate plates from pure cultures often agree well when even more than two hundred colonies are present per plate. Each organism in a pure culture multiplies under similar conditions and unfavorable media and end products stop rate and extent

[1] Prucha, M. J. Journal of Bacteriology, Vol. 1, No. 1, p. 92.

Fig. 1. Many colonies but all slow growing.
(Good plate.)

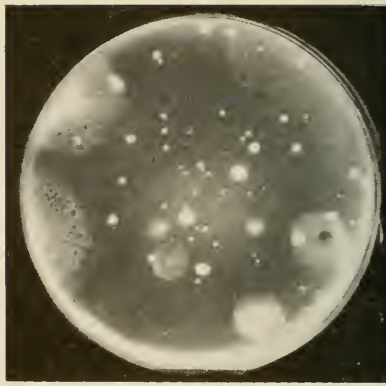

Fig. 2. Many colonies of many characters.
(Doubtful plate.)

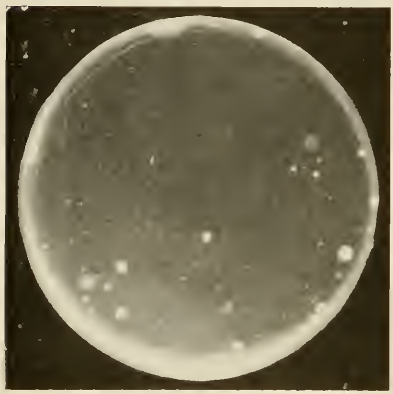

Fig. 3. Poor distribution on plate.
(Unsatisfactory plate.)

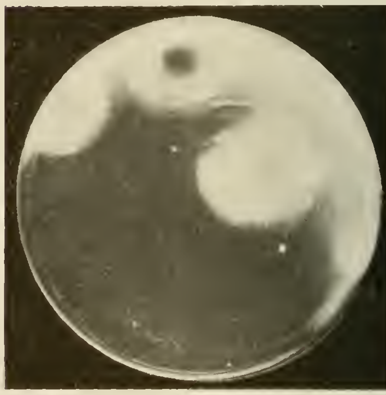

Fig. 4. Few colonies rapid growing and poorly distributed.
(Unsatisfactory plate.)

Fig. 5. Few rapidly growing and well distributed colonies.
(Good plate.)

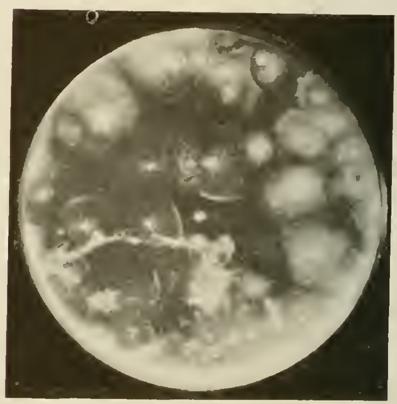

Fig. 6. Rapidly growing colonies.
(Doubtful plate.)

Plate I.

of growth rather than stop the growth of any individual organism. With mixed cultures the media may be suitable for the growth of all the organisms present, but the differences in rate of growth and specific end products cause uneven plates. (See Plate I.)

The literature does not furnish figures on duplicate and triplicate platings where the bacterial dilutions were made from large aliquots (10 cc. or more). In milk it has been noted that platings giving as low as forty colonies are satisfactory.[2] The soil is so much more ununiform than milk that the technic worked out at this station,[3] and depending on large aliquots for diluting and plating, was followed.

Experimental Work.

A black sandy soil was air dried and sieved to unify both the soil and its flora. Triplicate platings were made from 1–40, 1–400, 1–4,000, 1–40,000 and 1–400,000 bacterial dilutions. Counts were made after three, seven and ten days' incubation at 20° Centigrade. Especial care was taken in handling the plates to prevent contaminations. The check plates were in most cases entirely free from bacterial growth and their average has been deducted from the figures given. The results are given in Table I.

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[2] Conn, H. W. Public Health Reports. U. S. Public Health Service, Vol. 30, No. 33, August, 1915.

[3] Noyes, H. A., and Voigt, Edwin, in Proceedings of Indiana Academy of Science, 1916, pp. 272-301.

TABLE I.

Decreases in Numbers of Bacterial Colonies on Plates with Increasing Length of Time of Incubation.

No. of Sets of 3 Plates Compared.		Average Counts		
		3 days	7 days	10 days
1.	Colony numbers between.....2,900 and 3,000	2,905	2,045	1,680
1.	Colony numbers between ....2,000 and 2,100	2,030	1,790	1,610
2.	Colony numbers between.....1,700 and 1,800	1,750	1,570	1,003
1.	Colony numbers between ....1,600 and 1,700	1,600	1,050	860
1.	Colony numbers between ....1,500 and 1,600	1,590	1,400	960
4.	Colony numbers between.....1,400 and 1,500	1,456	1,256	1,021
1.	Colony numbers between ....1,300 and 1,400	1,380	1,150	840
1.	Colony numbers between ..1,200 and 1,300	1,240	960	820
2.	Colony numbers between ...1,100 and 1,200	1,135	918	830
1.	Colony numbers between ..1,000 and 1,100	1,070	1,010	940
1.	Colony numbers between.... 900 and 1,000	910	840	825
3.	Colony numbers between .... 800 and 900	852	778	677
6.	Colony numbers between ... 600 and 700	659	582	488
4.	Colony numbers between..... 500 and 600	541	480	440
6.	Colony numbers between .... 400 and 500	450	409	387
21.	Colony numbers between .... 300 and 400	340	327	308
11.	Colony numbers between .. 250 and 300	279	288	275
11.	Colony numbers between . 200 and 250	222	220	213
2.	Colony numbers between . 175 and 200	195	200	200
3.	Colony numbers between .. 150 and 175	163	168	172
3.	Colony numbers between ... 125 and 150	129	136	136
5.	Colony numbers between .. 100 and 125	115	125	128
5.	Colony numbers between . 90 and 100	95	108	109
8.	Colony numbers between . 80 and 90	83	91	92
5.	Colony numbers between ... 70 and 80	72	80	85
4.	Colony numbers between .... 60 and 70	65	71	79
3.	Colony numbers between . 50 and 60	54	57	57
7.	Colony numbers between .. 40 and 50	43	53	55
7.	Colony numbers between ... 30 and 40	35	44	46
9.	Colony numbers between .. 20 and 30	22	30	33
12.	Colony numbers between.... 10 and 20	11	19	24
6.	Colony numbers between .. 0 and 10	7	12	15

The table shows the following:

1. Increases in counts resulted from additional incubations when less than 200 colonies were present after three days' incubation.
2. Whether the counts increased or decreased, the counts after seven days' incubation fall between the three- and ten-day counts.
3. Two hundred or more colonies gave unreliable results.
4. The optimum number of colonies is probably much nearer 100 than 200 per plate.

The ratios between the number of colonies developing after ten days' incubation of the 1–40,000 and 1–400,000 bacterial dilutions of soils taken at different times from differently cropped areas are given in Table II. In carrying out the dilutings and platings the lower dilutions were made and plated before the higher dilutions were prepared, since it is believed that multiplications of the organisms have little effect on the higher dilutions under these conditions.

TABLE II.

Colony Counts on Plates of Different Bacterial Dilutions Cover Crop Investigations.

Plot Supporting	Average of Triplicate Plates.	
	Dilution 1-40,000	Dilution 1-400,000
Nothing		
Nov. 14, 1914	69.7 colonies	8.3* colonies
Feb. 6, 1915	73.0 "	11.6 "
Mar. 2, 1915	107.2 "	10.7* "
Mar. 27, 1915	62.0 "	7.7* "
April 15, 1915	94.0 "	6.0 "
Millett		
November 14, 1914	99.3 "	11.3* "
February 6, 1915	92.0 "	18.6 "
March 2, 1915	172.7 "	22.7 "
March 27, 1915	88.3 "	11.4 "
April 15, 1915	193.3 "	27.0 "
Soy Beans		
November 14, 1914	75.3 "	10.3 "
February 6, 1915	125.3 "	26.3 "
March 2, 1915	165.7 "	17.0* "
March 27, 1915	112.0 "	12.0* "
April 15, 1915	80.0 "	10.7 "
Nothing		
November 14, 1914	62.3 "	8.3 "
February 6, 1915	83 3 "	10.6 "
March 2, 1915	82.0 "	19.3 "
March 27, 1915	113.3 "	11.0* "
April 15, 1915	145.0 "	12 7 "
Hairy Vetch		
November 14, 1914	109.0 "	8.7 "
February 6, 1915	163.0 "	20.6 "
March 2, 1915	225.3 "	36.7 "
March 27, 1915	175.0 "	16.0* "
April 15, 1915	185.7 "	29 3 "
Winter Rye (Sown early)		
November 14, 1914	122.0 "	8.7 "
February 6, 1915	226.0 "	31.6 "
March 2, 1915	245.5 "	13.7 "
March 27, 1915	114 3 "	16.0 "
April 15, 1915	200.0 "	27.6 "
Nothing		
November 14, 1914	65.3 "	9.7 "
February 6, 1915	129.7 "	22.0 "
March 2, 1915	173.7 "	13.3 "
March 27, 1915	72.3 "	6.7* "
April 15, 1915	110.3 "	15.0 "
Winter Rye (Sown late)		
November 14, 1914	70.0 "	7.0* "
February 6, 1915	68.7 "	14.0 "
March 2, 1915	145.0 "	16.3 "
March 27, 1915	127.0 "	15.7 "
April 15, 1915	167.0 "	27.3 "
Crimson Clover		
November 14, 1914	44.7 "	3.3* "
February 6, 1915	91.0 "	15.6 "
March 2, 1915	254.3 "	23.3 "
March 27, 1915	46.0 "	6.7 "
April 15, 1915	122.2 "	16.7 "

TABLE II—Continued.

Colony Counts on Plates of Different Bacterial Dilutions Cover Crop Investigations.

Plot Supporting	Average of Triplicate Plates.	
	Dilution 1-40,000	Dilution 1-400,000
Nothing		
November 14, 1914	62.0 "	6.3* "
February 6, 1915	93.0 "	17.3 "
March 2, 1915	181.0 "	13.3 "
March 27, 1915	43.0 "	3.0* "
April 15, 1915	96.0 "	9.7 "
Buckwheat		
November 14, 1914	50.0 "	10.3 "
February 6, 1915	121.3 "	21.3 "
March 2, 1915	163.0 "	15.0* "
March 27, 1915	86.0 "	6.4 "
April 15, 1915	119.7 "	14.0 "
Natural Growth of Weeds		
November 14, 1914	54.7 "	5.7* "
February 6, 1915	100.3 "	23.3 "
March 2, 1915	152.5 "	33.6 "
March 27, 1915	82.3 "	11.0 "
April 15, 1915	108.0 "	13.7 "
Average of all 60 comparisons	117.15 "	14.8 "
Average of 15 comparisons*	94.4 "	9.4 "

These results show:

1. The ratio between the number of colonies on plates from the 1–40,000 and 1–400,000 bacterial dilutions is dependent on the number of organisms present rather than on the cropping system or the time of the year the soil samples were taken.
2. The averages show:
   (*a*) That the average of all comparisons for the 1–40,000 bacterial dilutions was too great for satisfactory plates.
   (*b*) That the results from the two dilutions tend to check when the number of colonies on the plates from the 1–40,000 bacterial dilutions is under 100.

Table III has been compiled to show the ratios between the counts of the two dilutions when the number of colonies developing on the 1–40,000 bacterial dilution is under 100. These results are the cases where the counts from twenty-four soil samples averaged under 100 on the 1–40,000 bacterial dilution.

TABLE III.

Colonies on 1-40,000 and 1-400,000 Bacterial Dilutions.
(Counts on 1-40,000 Bacterial Dilutions between 47 and 100.)

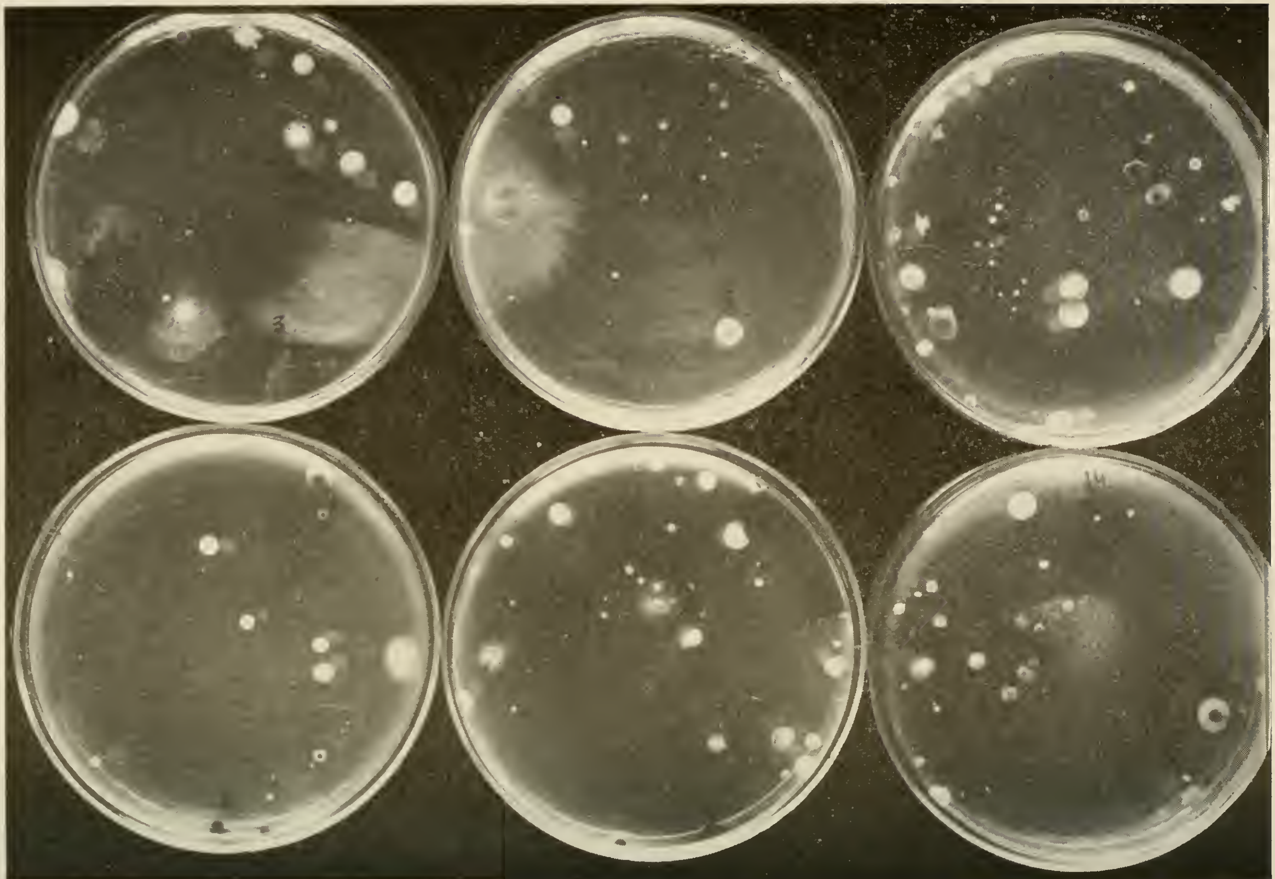
	DILUTIONS	
	1-40,000**	1-400,000
	94.5	12.0
	91.7	12.3
	88.0	13.5
	88.0	11.0
	86.3	9.0*
	80.3	7.8*
	74.0	8.0*
	65.3	8.0*
	65.0	5.3*
	56.0	7.0*
	51.0	4.0*
	48.0	5.0*
	47.0	5.3*
Average all	71.9	8.3
Average *	63.6	6.6

**Counts are averages of triplicate plates.

*These numbers multiplied by 10 are within 15 of the numbers obtained in the lower bacterial dilution.

Table III brings out that, while 100 colonies per plate are quite satisfactory, the 10 to 1 ratio is more nearly approximated when much less than 100 colonies were present per plate.

To further substantiate the evidence that results are reliable when relatively small numbers of colonies are present per plate, the ten-day counts from the 1–40,000 and 1–400,000 bacterial dilutions of a sandy soil, low in organic matter, are given in Table IV.



Pla'e II. Good Petri Plates.

TABLE IV.

Colonies on 1-40,000 and 1-400,000 Bacterial Dilutions.
(Colonies on 1-40,000 Dilutions number under 30.)

	Dilutions	
	1-40,000	1-400,000
	29.0	3.3* **
	26.7	2.3* **
	26.0	3.0* **
	25.3	3.0* **
	24.7	2.0* **
	23.0	3.0* **
	22.3	2.1* **
	20.7	3.3* **
	20.7	2.0* **
	20.3	3.0*
	20.0	3.0*
	19.0	3.0*
	17.7	2.0* **
	17.3	1.7* **
	16.0	3.0*
	16.0	2.3* **
	13.0	2.0* **
	11.7	2.0*
	11.3	3.3*
	11.0	1.0* **
	10.0	2.0*
Average of all	19 1	2.5
Average of *	19.5	2.5
Average of * **	21.0	2.2

All figures are averages of triplicate plates.
*Counts for 1-400,000 dilution are within 1.5 colonies of 0.1 of number on 1-40,000 dilution.
* **Counts for 1-400,000 dilution are within 0.7 colonies of 0.1 number on 1 40,000 dilution.

Summary.

1. These and other tests (of which these are representative) have shown that thirty is near the optimum number of colonies for a petri plate 100 mm. in diameter. Plate II.

2. The averages of a sufficient number of plates carrying between 10 and 100 colonies are satisfactory for computing bacterial numbers.

The Length of Time to Incubate Petri Plates.

H. A. Noyes, Edwin Voigt and J. D. Luckett, Purdue University.

Investigations of the steps entering into the plate method for the enumeration of the number of bacteria present in soil are few. So little agreement was observed in the procedures followed in different soil bacteriology laboratories that investigations were undertaken in this station to develop a reasonably accurate technic for the bacteriological examination of soils.[1] The present paper gives data in support of the ten-day period of incubation at 20° C. for soil plates. The work was done jointly with that on methods of sampling soil for bacteriological analysis[2] and the number of colonies satisfactory for a petri plate.[3] Among the soil factors considered in connection with the length of time to incubate plates were the kind of soil, the nature of its flora, temperature when sampled, the uniformity of sampling, the moisture content, and the condition of aeration.

It was early decided that probably the chief reason why confidence is lacking in the significance of plate counts is because the organisms have not usually been given the proper chance to develop into colonies.

Table I has been prepared to show how differently organisms develop into colonies under different periods of incubation. The technic followed was that previously described,[1] and the figures are based on the average of three plates in each case.

[1] Noyes, H. A., and Voigt, Edwin, in Proceedings of Indiana Academy of Science, 1916, pp. 272-301.

[2] Noyes, H. A., in Journ. Amer. Soc. of Agron., No. 5, 1915, pp. 239-249.

[3] Noyes, H. A., and Grounds, G. L., in Proceedings of Indiana Academy of Science, 1918.

TABLE I.

Cover Cropped Soils

*Percent Counts at 3, 5, and 7-Days Incubation are of 10-Days Counts.**

Cropped to	Bacterial Dilution							
	1-40,000				1-400,000			
	3	5	7	10 Days	3	5	7	10 Days
Nothing								
November 14, 1914	30.1%	55.9%	**%	100.0%	**%	52.2%	**%	100.0%
February 6, 1915	15.5	74.4	88.1	100.0	43.1	62.6	62.6	100.0
March 2, 1915	56.4	84.1	93 4	100.0	42.9	88.4	86.4	100.0
March 27, 1915	25.3	54.4	68.9	100.0	12.5	46.3	58.8	100.0
April 15, 1915	13.4	66.2	85.2	100.0	29.8	70.2	93.0	100.0
Average	27.8	67.0	83.9	100 0	32.1	63.9	75.2	100.0
Millet								
November 14, 1914	33.2	58.4	**	100.0	**	55.9	**	100.0
February 6, 1915	21.9	84.6	100.0	100.0	24.1	60.3	56.4	100.0
March 2, 1915	48.6	94.6	93.1	100.0	33.8	77.5	87.5	100.0
March 27, 1915	32.8	79.2	90.6	100.0	14.2	54.3	80.0	100.0
April 15, 1915	26.7	82.6	92.2	100.0	7.4	67.9	82.7	100.0
Average	32.6	80.0	94.0	100 0	19.9	63.2	76.7	100.0
Soy Beans								
November 14, 1914	18.6	42.9	**	100.0	**	54.8	**	100.0
February 6, 1915	33.0	65.4	80.8	100.0	18.5	54.2	66.7	100.0
March 2, 1915	40.4	88.2	99.4	100.0	36.5	74.6	88.8	100.0
March 27, 1915	30.0	70.9	88.2	100.0	22.6	61.3	58.1	100.0
April 15, 1915	12.5	85.7	98.2	100.0	11.1	75.0	91.5	100.0
Average	26.9	70.6	91.7	100.0	22.2	64.0	76.3	100.0
Nothing								
November 14, 1914	20.3	54.5	**	100.0	**	60.0	**	100.0
February 6, 1915	53.2	97.6	100.0	100.0	35.3	85.3	88.2	100.0
March 2, 1915	44.1	84.3	83.1	100.0	14 3	71.4	81.4	100.0
March 27, 1915	36.2	77.3	91.4	100.0	20.1	50.0	67.6	100.0
April 15, 1915	18.8	73.3	78.4	100.0	15.8	73.7	100.0	100.0
Average	34 5	77.4	88 2	100.0	21.4	68.1	84.3	100.0
Hairy Vetch								
November 14, 1914	19.6	40.1	**	100.0	**	42.3	**	100.0
February 6, 1915	30.7	63.8	84.4	100.0	20.3	54.7	85.9	100.0
March 2, 1915	43.8	83.2	97.2	100.0	20.2	73.7	88.5	100.0
March 27, 1915	28.1	71.4	100.0	100.0	28.5	69.4	89.1	100.0
April 15, 1915	15.3	84.9	94.1	100.0	29.5	68.2	88.6	100.0
Average	27.5	69.7	93.9	100.0	24.6	61.7	88.2	100.0
Winter Rye (Sown Early)								
November 14, 1914	26.5	55.2	**	100.0	**	35.5	**	100.0
February 6, 1915	46.1	48.9	75.1	100.0	16.5	49.5	53.6	100.0
March 2, 1915	46.5	63.2	79.4	100.0	43.4	84.9	84.9	100.0
March 27, 1915	30.3	76.4	86.9	100.0	22.4	44.9	65.3	100.0
April 15, 1915	24.5	84.8	88.0	100.0	10.8	63.8	86.8	100.0
Average	34.8	65.7	82.4	100.0	23.3	66.7	72.7	100.0
Nothing								
November 14, 1914	25.1	57.3	**	100.0	**	34.5	**	100.0
February 6, 1915	22.9	68.3	74.7	100.0	38.2	77.9	94.1	100.0
March 2, 1915	61.8	83.7	101.6	100.0	32.7	69.2	90 4	100.0
March 27, 1915	23.5	56.7	77 5	100.0	23.7	64.3	61.9	100.0
April 15, 1915	8.3	42.3	52.7	100.0	13.3	73.3	97.7	100.0
Average	28.3	61.7	76.6	100.0	27.0	63.9	86.0	100.0

TABLE I—Continued.

COVER CROPPED SOILS

*Percent Counts at 3, 5, and 7-Days Incubation are of 10-Days Counts.**

CROPPED TO	BACTERIAL DILUTION							
	1-40,000				1-400,000			
	3	5	7	10 Days	3	5	7	10 Days
Winter Rye (Sown Late)								
November 14, 1914	20.9	40.9	**	100.0	**	38.0	**	100.0
February 6, 1915	26.2	85.0	86.4	100.0	20.3	68.5	85.2	100.0
March 2, 1915	52.9	85.6	98.9	100.0	31.1	70.5	83.6	100.0
March 27, 1915	27.6	68.0	82.4	100.0	16.6	43.8	58.3	100.0
April 15, 1915	14.0	66.2	85.2	100.0	20.7	54.8	86.6	100.0
Average	28.3	69.1	88.2	100.0	22.2	55.1	78.4	100.0
Crimson Clover								
November 14, 1914	20.5	41.3	**	100.0	**	44.9	**	100.0
February 6, 1915	36.6	91.2	99.6	100.0	26.5	44.9	65.3	100.0
March 2, 1915	55.8	86.9	93.6	100.0	36.6	80.5	85.4	100.0
March 27, 1915	26.1	59.4	90.6	100.0	33.3	66.6	66.6	100.0
April 15, 1915	10.3	68.4	85.8	100.0	10.0	78.0	92.0	100.0
Average	29.9	69.4	92.4	100.0	26.6	63.0	77.3	100.0
Nothing								
November 14, 1914	24.7	47.3	**	100.0	**	42.0	**	100.0
February 6, 1915	18.6	86.7	93.5	100.0	9.2	62.9	79.6	100.0
March 2, 1915	50.0	76.5	83.0	100.0	34.6	76.9	73.5	100.0
March 27, 1915	31.7	62.8	95.4	100.0	36.9	44.4	66.7	100.0
April 15, 1915	16.0	76.8	92.3	100.0	17.2	55.2	89.6	100.0
Average	28.2	70.0	91.1	100.0	21.5	56.3	77.4	
Buckwheat								
November 14, 1914	12.0	50.0	**	100.0	**	64.5	**	100.0
February 6, 1915	19.2	94.7	105.2	100.0	25.7	65.1	69.7	100.0
March 2, 1915	40.5	80.7	87.1	100.0	40.5	80.7	91.2	100.0
March 27, 1915	26.7	53.5	77.1	100.0	20.0	55.0	55.0	100.0
April 15, 1915	21.2	77.2	84.1	100.0	11.9	86.6	83.3	100.0
Average	23.9	71.2	88.4	100.0	24.5	66.6	74.8	100.0
Natural Growth of Weeds								
November 14, 1914	22.5	53.1	**	100.0	**	64.7	**	100.0
February 6, 1915	31.2	85.0	100.0	100.0	31.9	75.0	84.7	100.0
March 2, 1915	55.1	73.7	85.8	100.0	35.4	70.8	72.6	100.0
March 27, 1915	27.1	71.3	88.3	100.0	20.5	55.9	73.5	100.0
April 15, 1915	22.5	81.7	96.0	100.0	17.1	85.3	97.6	100.0
Averages								
November 14, 1914	22.8	49.7	**	100.0	**	49.1	**	100.0
February 6, 1915	29.6	78.8	90.7	100.0	25.8	63.4	74.3	100.0
March 2, 1915	48.7	80.8	91.7	100.0	34.9	80.3	84.5	100.0
March 27, 1915	28.8	66.8	86.4	100.0	22.5	54.7	66.5	100.0
April 15, 1915	16.9	74.2	86.0	100.0	16.2	69.3	90.8	100.0
Averages of All	31.7	74.0	92.5	100.0	26.2	70.3	82.1	100.0

**Counts not made.

*Temperature of Incubation 20° C.

The variations between the per cent of the colonies that developed is from 7.4 to 43.4 per cent for the three days' incubation, 34.5 to 88.4 per cent for the five days' incubation, and from 53.6 to 100.0 per cent for the seven days' incubation. The figures are taken from the 1–400,000 bacterial dilutions, where the number of colonies was small enough to allow for all organisms to develop into colonies. The plates for the 1–40,000 bacterial dilutions in many cases had too many organisms for satisfactory counts, and this is shown in the general averages for this dilution as compared to those for the 1–400,000 bacterial dilution. The cropping system, the aeration of the soil and soil temperature very evidently influence the rate at which the organisms of soil develop into discernable colonies on petri plates.

One contention for the use of the bacteriologist's soil sampler[2] was that it sampled the soil accurately to the depth desired and kept the sample under field conditions of aeration until analyzed. Table II gives data showing how the methods of sampling can be compared by the relative distribution of the rapid and slow growing organisms present in the different samples.

TABLE II.

*Percent 3, 5, and 7-Day Counts of 10-Day Counts **.*
(Gravelly soil sodded and containing about 7% moisture.)

TIME OF INCUBATION		3	5	7	10 Days*
Bacteriologist's Soil Sampler	1	15.3%	20.8%	53.8%	100.0%
	2	11.8	39.4	49.0	100.0
	3	11.1	26.1	46.3	100.0
Average..........	....	12.7	28.8	49.7	....
P. E. Brown's Method	1	11.5	46.0	72.8	100.0
	2	29.2	43.8	65.7	100.0
	3	14.1	26.4	45.0	100.0
Average..........	....	18.3	38.4	61.2	....
Slice Method	1	20.5	48.2	64.0	100.0
	2	4.8	42.8	63.2	100.0
Average..........	....	12.7	45.5	63.6	....
Average of all....	....	14.8	37.7	57.4	....

*Counts after 10 days incubation at 20°C taken as 100% those at other times are stated as parts of this. Bacterial Dilution 1-400,000.

**Counts were about 3.0 million per gram of dry soil.

This test showed:

1. That the organisms present in this packed sodded land were principally slow growers.
2. That the uniformity of the development of colonies varied with the method by which the samples were drawn.

We have found by numerous tests that the number of organisms found in sodded soil at or below a depth of four inches is much less than nearer the surface; and, further, it has been observed that those organisms occurring at the lower depths do not usually multiply as rapidly on aerobic plates as those occurring nearer the surface. The samples procured with the bacteriologist's soil sampler evidently had near their proper proportions of slowly multiplying organisms.

In testing out the quantities of soil necessary for bacteriological examinations some tests were made with air-dry samples to show that even when samples were unified by air-drying a large quantity was necessary for accurate results. Table III gives the development of colonies after different periods of incubation on air-dry soil sieved to pass 1 millimeter, while Table IV gives results secured on the same sample of air-dry soil when further unified by using only that portion passing a sixty-mesh sieve.

TABLE III.

Percent 5 and 7-Day Counts are of 10-Day Counts.
(Air Dry Loam Soil, sieved C' pass 1 mm.)

Time of Incubation		5	7	10 Days*
Sample No.	Size of Sample			
1	50 grams	72 7%	92 1%	100 0%
2	50 grams	79 4	91 2	100.0
3	50 grams	73.0	88.6	100.0
4	10 grams	87 9	95.0	100.0
5	10 grams	95 4	96.8	100.0
6	10 grams	58.8	85 8	100 0
7	5 grams	71.2	91.8	100.0
8	5 grams	67 8	85 2	100.0
9	5 grams	75 8	97.1	100.0
10	1 gram	86 4	95.2	100.0
11	1 gram	72 1	80.5	100.0
12	1 gram	74.9	80 3	100.0
13	0.5 gram	64 7	85.0	100.0
14	0.5 gram	79.3	85.2	100.0
15	0.5 gram	62.5	79.4	100.0
	Average	74.8	88.6	100.0

*Counts after 10 days incubation at 20° C taken as 100.0%.
Other counts states as parts of these.
Bacterial Dilution 1-400,000.

TABLE IV.

Percent 5 and 7-Day Counts are of 10-Day Counts.
(Air Dry Loam sieved to pass 60 mesh.)

Time of Incubation		5	7	10 Days*
Sample No.	Size of Sample			
1	50 grams	79.9%	96.8%	100.0%
2	50 grams	67.0	100.0	100.0
3	50 grams	89.8	100.0	100.0
4	10 grams	63.7	72.1	100.0
5	10 grams	72.6	91.0	100.0
6	10 grams	74.7	100.0	100.0
7	5 grams	85.2	93.2	100.0
8	5 grams	90.8	95.7	100.0
9	5 grams	63.4	73.2	100.0
13	1.0 gram	93.7	100.0	100.0
14	1.0 gram	63.6	75.3	100.0
15	1.0 gram	62.8	85.8	100.0
16	0.5 gram	64.3	73.7	100.0
17	0.5 gram	66.5	100.0	100.0
18	0.5 gram	74.9	77.5	100.0
	Average	74.2	88.9	100.0

*Counts after 10 days incubation at 20°C taken as 100%.
Other counts stated as parts of these Bacterial dilution 1-400,000.

The results given in the previous tables show:

1. That the greater proportion of the organisms present in this air-dry soil develop into colonies after five days' incubation.
2. The larger the aliquot of soil used the more uniformity between the development of colonies on the plates.
3. In five cases out of the fifteen all the colonies were counted after seven days' incubation when the soil was sieved to pass a sixty-mesh sieve.

It has been observed, in soil bacteriology investigations in an apple orchard where different systems of soil management are practiced, that the organisms multiply into colonies at different rates, dependent on the system of management practiced. The results of this work are given in Table V.

TABLE V.

Average Percent 5 and 7-Day Counts are of 10-Day Counts.
(Silt Loam Subjected to Different Systems of Soil Management.)

Time of Incubation		5	7	10 Days*
Clean Cultivation	1	41.9%	100.0%	100.0%
	2	27.2	97.3	100.0
	3	23.5	100.0	100.0
Sod	1	42.3	82.3	100.0
	2	41.5	78.8	100.0
	3	33.3	79.0	100.0
Straw Mulch	1	65.1	85.3	100.0
	2	55.2	87.4	100.0
	3	65.2	81.7	100.0
Light Grass Mulch	1	67.3	88.2	100.0
	2	58.3	96.9	100.0
	3	37.0	82.2	100.0
Average All	....	46.5	88.3	100.0
Average Clean Cultivation	....	30.9	99.1	100.0
Average Sod	....	39.0	80.0	100.0
Average Straw Mulch	....	61.8	84.8	100.0
Average Light Grass Mulch	....	54.2	89.1	100.0

Table V shows:

1. The rate of development of colonies varies with the system of soil management.
2. Those conditions which unify differences in soil aeration are present where the rates of development of colonies check closest.
3. Short periods of incubation would not show the relative numbers of bacteria actually present in the soils.

Many sets of plates have been counted after twelve and fifteen days' incubation, but very rarely have counts increased at all after ten days' incubation. With suitable media the counts obtained after seven days' incubation have uniformly shown the comparisons between samples, and this does not mean that the increases from seven to ten days are numerically or proportionately the same.

Summary.

Counts made after ten days' incubation at 20° C. of petri plates, made from bacterial dilutions of soil, give reliable results as to the bacterial content of the soil, providing the number of colonies present per plate is small enough for all organisms to develop into colonies.

The rapidity with which bacteria develop into colonies has been shown to vary with the soil, and to be influenced by soil temperature, moisture and aeration.

Much of the lack of confidence in results obtained by the plate method is due to having too many colonies present per plate[3] and not allowing sufficient time of incubation of the petri plates.

Bacteria in Frozen Soil.

H. A. Noyes, Purdue University.

Two soil bacteriologists have published data as showing that the number of bacteria in soil increases when the soil is frozen. These reported increases in numbers are so contradictory to general belief concerning bacterial activities at low (about freezing) temperatures that not only the experimental data but abstracts of the technic followed are given below.

Figure 1 gives the data presented in Cornell University Agricultural Experiment Station Bulletin No. 338. The following is an abstract of the technic followed:

"Samples of soil were usually taken with an auger or by the combined use of an auger and pick when the ground was frozen. During the winter of 1909–1910 a pick alone was used. When an auger was employed the proceeds from two or three borings were combined, except in winter, when only one hole was made; but when the pick alone was used it was impossible to take any such pains in order to obtain a representative sample. * * * The depth of sampling was six to eight inches, although in winter 1909–1910 it varied more than during the remainder of the period. * * * The soil was carefully mixed, in summer by sieving through a sieve as fine as the moisture content would allow, in winter by stirring after thawing. Of this soil 0.5 gram was added to sufficient sterile water to make a volume of 100 cc. * * * The samples taken from any one of these four spots must have all been from within a circle of six-inch radius. The media used varied; the one most extensively used was soil extract gelatin containing 0.1 per cent dextrose. Plates were incubated seven days at 19° to 20° C. for gelatin and usually two weeks for agar."

The following statement is taken from the author's summary of the work[1]: "Quantitative determinations * * * have shown * * * an increase in numbers of bacteria in frozen soil."

Figure 2 gives the data presented in Research Bulletin No. 4 of the Iowa Experiment Station. The following is an abstract of the technic followed:

"The samples were drawn from the plot already described within an area of about five feet square. * * * They were taken to a

[1] Conn, H. J., in Centrab't fur Bakt II Abteil. 28 (1910), p. 422.

depth of 20 cm. by means of a 2.5-inch auger, except during the time that the soil was frozen, when it became necessary to substitute a mattock or grub hoe for the auger. The samples were collected on a sterile mixing cloth and then placed in sterile glass jars and taken to the laboratory and innoculations performed as quickly as possible. * * * In this work it was deemed inadvisable to permit such a multiplication of organisms to occur in the sample as would undoubtedly take place if they were allowed to stand long enough to thaw out completely. Consequently the frozen samples employed here were thoroughly comminuted by means of a sterile spatula, carefully mixed, and then subsampled for innoculations. The maximum time required to prepare the sample in this way was ten minutes. * * * 100 gram quantities of the soil prepared * * * were shaken for five minutes with 200 cc. portions of sterile distilled water. Lipman and Brown 'synthetic agar' was used and counts made after three days' incubation at 22° C. Results are averages of two dilutions which agreed closely in every case."

The author summarizes the results given in Figure 2 as follows:

1. "By means of the 'modified synthetic' agar plate method, bacteria are shown to be present in large numbers in a typical Wisconsin drift soil when it is completely frozen and the temperature is below zero degrees Centigrade; furthermore, increases and decreases in numbers of organisms occur during this period and larger numbers are found after the soil has been frozen for a considerable period than before it begins to freeze."

2. "During the fall season, the number of bacteria present in the soil diminishes gradually with the lowering of the temperature."

The methods of sampling and the technic employed in getting the results reported in the above mentioned publications were so different from those adopted in this laboratory, after much testing, that the results of data on bacterial counts obtained on different dates from samples of a silt loam variously cover cropped are given in Figure 3. The technic of sampling, diluting and plating is that previously described.[2]

It is to be noted that the numbers of bacteria found in the soil when the temperature was 32° or lower were greater than those found at other times during the winter. The soil thermometers were at a depth of nine inches and the samples were drawn to this depth. It had been found impracticable to take samples when the ground was solidly frozen, and samples were taken (on the dates) starred just as the soil had thawed enough so that the samplers[3] could be used. The question thus

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[2] Noyes, H. A., Voigt, Edwin, in Proceedings Indiana Academy of Science, 1916, pp. 272-301.

[3] Noyes, H. A., in Journ. Amer. Soc. Agron. Vol. 7, No. 5 (1915).

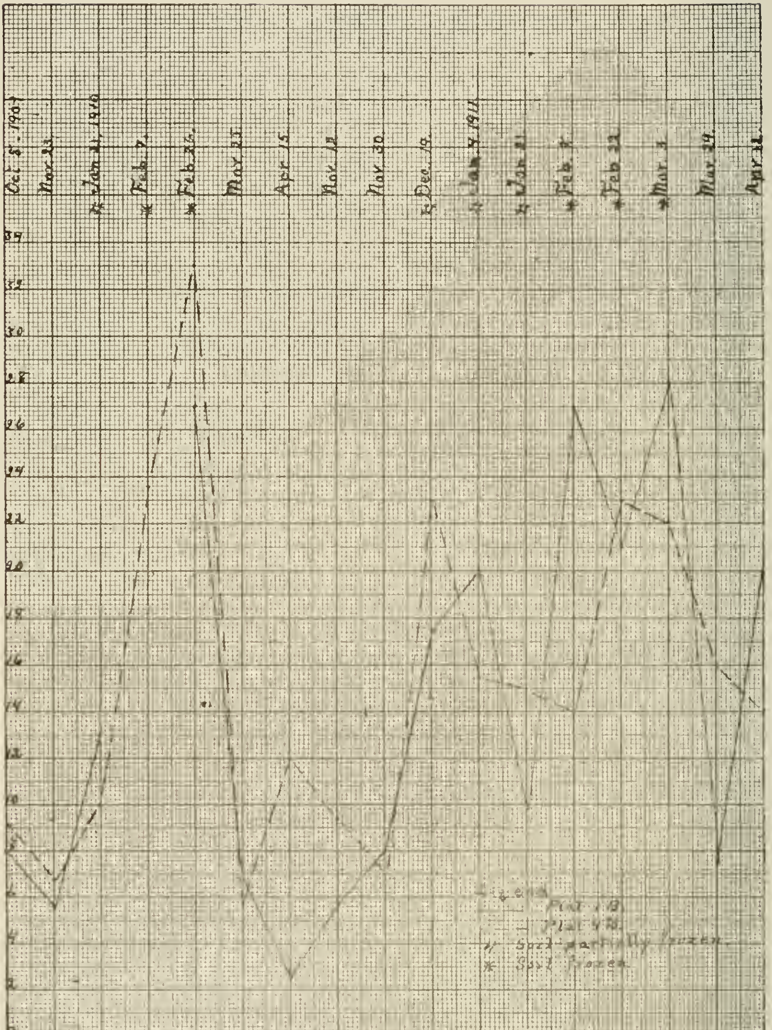

Figure 1. Bacteria Counts in million per gram of dry soil, New York.

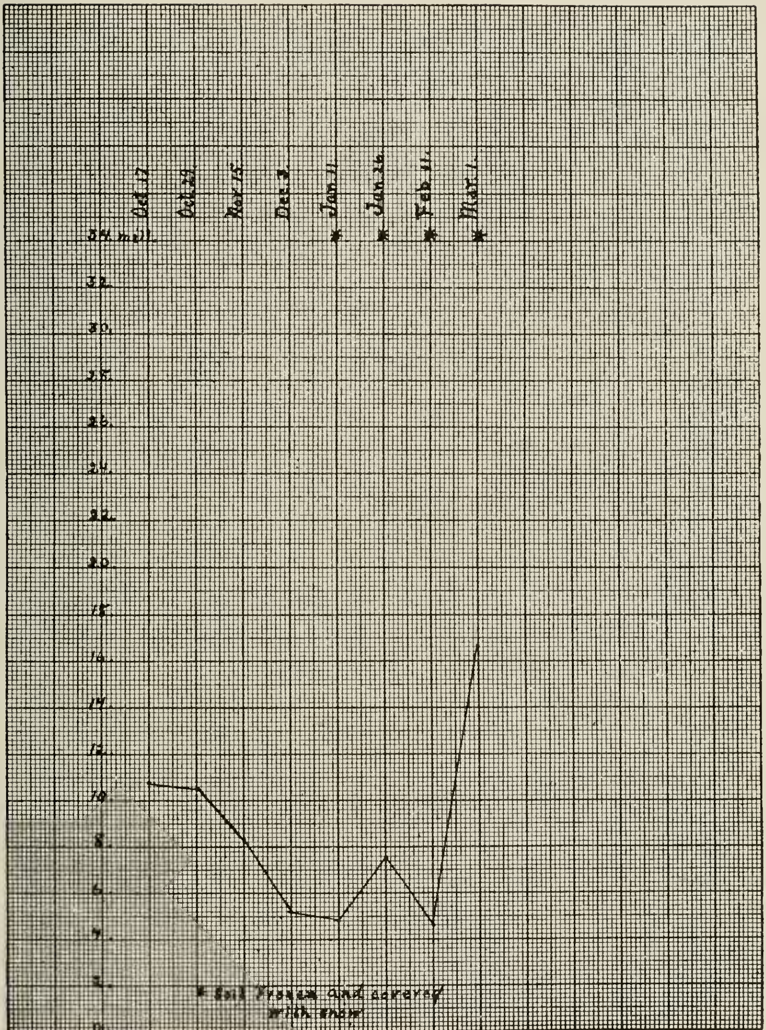

Figure 2 Bacterial Counts per gram of dry soil, Iowa.

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naturally arose as to whether the counts obtained in this and the previous work were not due to increased bacterial activities as the ground thawed.

To give more definite information, special experiments have been carried out. A special bacteriologist's soil sampler[3] reinforced with steel was secured and driven down into solidly frozen soil. The sampler containing the frozen soil was brought into the warm laboratory and in a half hour it was possible to push the core of frozen soil out of the sampler. This core was placed on a laboratory table. A wire was pushed into the core from time to time and it was found that thawing took place very slowly. It was forty-six hours from the time that the sample was laid out on the table before it had thawed enough for the wire to be thrust through it.

To see if the bacterial numbers in soil were not increased on the thawing out of the soil due to different layers of the soil being brought successively under more favorable conditions for bacterial development, the following test was made:

A sample of frozen loam soil was obtained, brought to the laboratory, pushed out of the sampler, then taken to a room having a temperature below 0° C., where it was halved lengthwise by chopping with an axe. One-half was chopped and mixed and fifty grams weighed out and analyzed *immediately* for its bacterial content. The other half was brought to the laboratory and allowed to stand twenty-four hours. It thawed out in this time. The sample was mixed and its bacterial content determined. The results of this test were that the sample allowed to thaw out before it was analyzed gave over three times the bacterial count that the one analyzed immediately did.

The following experiment is the latest one we have conducted on this subject, and it is left to the reader to judge from this in connection with the other work reported as to whether bacteria multiply in frozen soil. About twenty kilos of soil (silt loam) were procured by taking soil from between the depths of four and seven inches of a plot where millet had been plowed under each of the two preceding springs. This soil was mixed and sieved through a screen having eight meshes to the inch. The portion passing the screen was mixed thoroughly and then quartered. One quarter (about five kilos) was brought to the laboratory. Sterile 12-ounce bottles plugged with cotton had been previously prepared and 150 grams of the mixed and prepared sample were weighed out into each of twenty-six bottles. The soil in the bottles was then compacted by dropping them on the bench thirty times. The bottles were then divided into three groups and these groups were incubated in the following places:

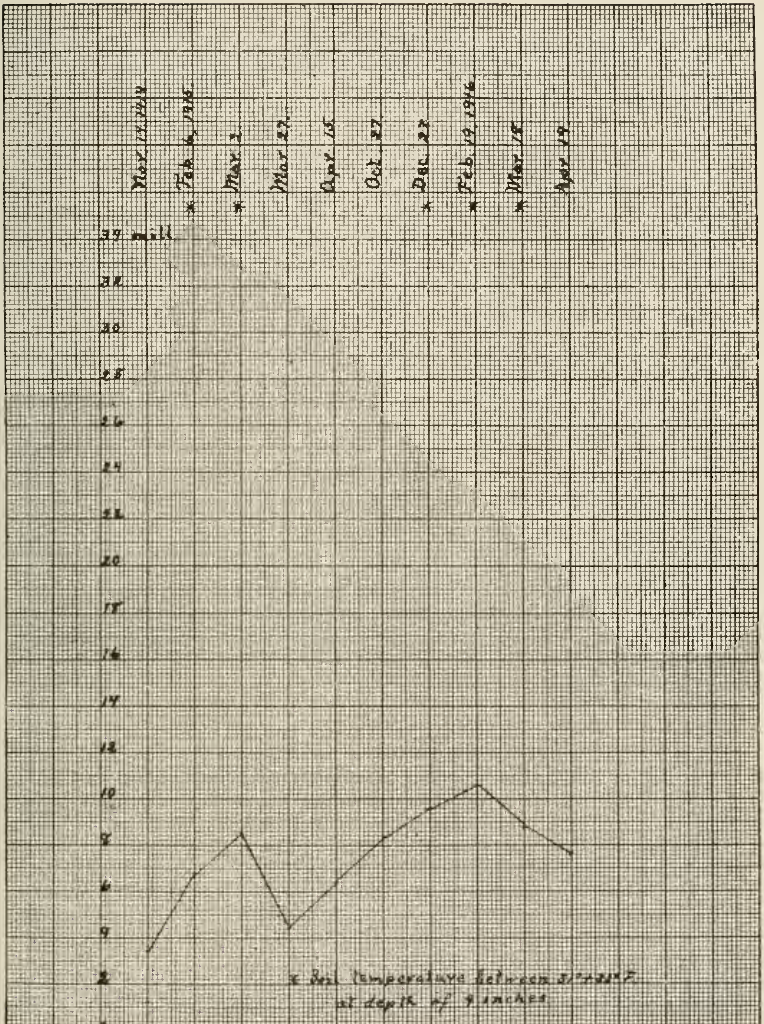

Figure 3 Bacterial Counts in millions per gram dry soil, Indiana.

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A. An ice box, temperature around 45° F.
B. In a cold storage room in a creamery, temperature 36° F. to 42° F.
C. Cold room in creamery, temperature between 27° F. and 30° F.

The counts obtained from these tests are given in Table I.

TABLE I.

Changes in Bacterial Content of Soil Stored in Different Refrigerating Rooms.

Lengths of Time of Incubation	Temp. 45° F	Temp. 39° F	Temp. 29° F
0 days	12.4*	12.4	12.4
21	11.7	9.5	5.5
78	0 7	4 8	4.5

*Figures are millions per gram of soil as used.

SUMMARY.

It is known to be difficult to get accurate figures of the numbers of bacteria present in frozen soil. It is not known that the layer of soil just below the constantly increasing layer of frozen soil is not very favorable for the multiplication of *certain* classes of bacteria.

The data reported in this paper, obtained in this laboratory and from the work of others does not prove that the number of bacteria present in soil is increased when the soil is frozen.

Some Abnormalities in Plant Structure.

M. S. Markle, Earlham College.

In looking over large numbers of microscopic slides made during the past few years, I have noted many instances of abnormalities in structure, some of which have not been reported, to my knowledge. Assuming that some of them may be of interest to members of the Academy, I submit drawings of a number of them.

In cutting some fern prothallia of an undetermined species collected in the Washington Park greenhouse at Chicago, I noticed large numbers of imbedded archegonia and a few instances of deeply imbedded antheridia. As will be seen from the drawings, these structures occurred several cells below the surface of the prothallium. An imbedded archegonium was generally associated with an ordinary one, though not always. The imbedded archegonium begins as a single cell, distinguishable by its larger nucleus and denser cytoplasm. The axial row develops like that of an archegonium of the usual type, except that there are usually two neck canal cells, if such they can be called here, instead of the usual single binucleate one. This is perhaps due to the differences in the pressure of the surrounding cells. A variation in the imbedded archegonia was found in one instance, in which there were two archegonia, with the position of the cells in the axial rows reversed, as shown in the figure.

Stages in the development of the imbedded antheridia were not found.

In sectioning some ovaries of Lilium of unknown origin, I found several sacs in which the four free nuclei following the second mitosis all gathered at one end of the sac, instead of two at each end, as usual. One instance of a mature embryo-sac that had evidently resulted from the further development of such a condition as that mentioned above showed six nuclei at one end of the sac completely surrounded by walls, while two nuclei remained free.

The "three-story" reproductive branch of Vaucheria shown in the figure was found in some material which was collected near Baton Rouge, Ala. The other, in which a secondary sexual branch was formed in the place of an oogonium, was collected near Earlham College, Richmond, Indiana.

The megaspore tetrad of Selaginella shown in the figure shows the outer wall of the spore continuous around the group of spores instead of surrounding the individual spores.

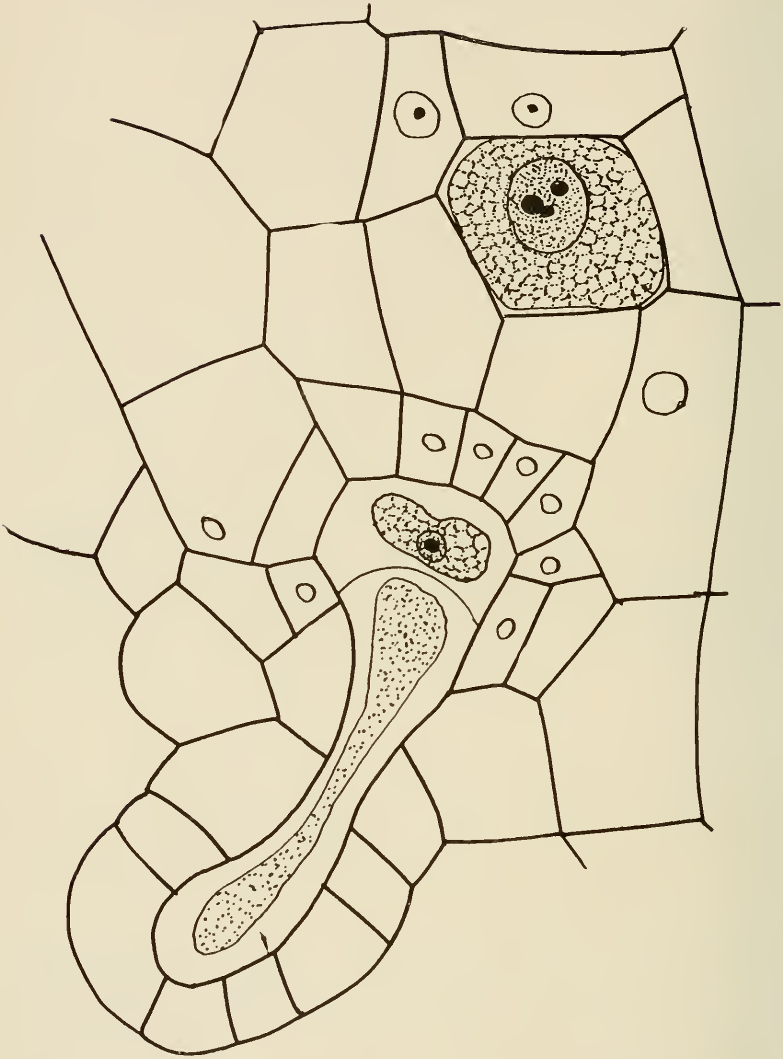


Fig. 1

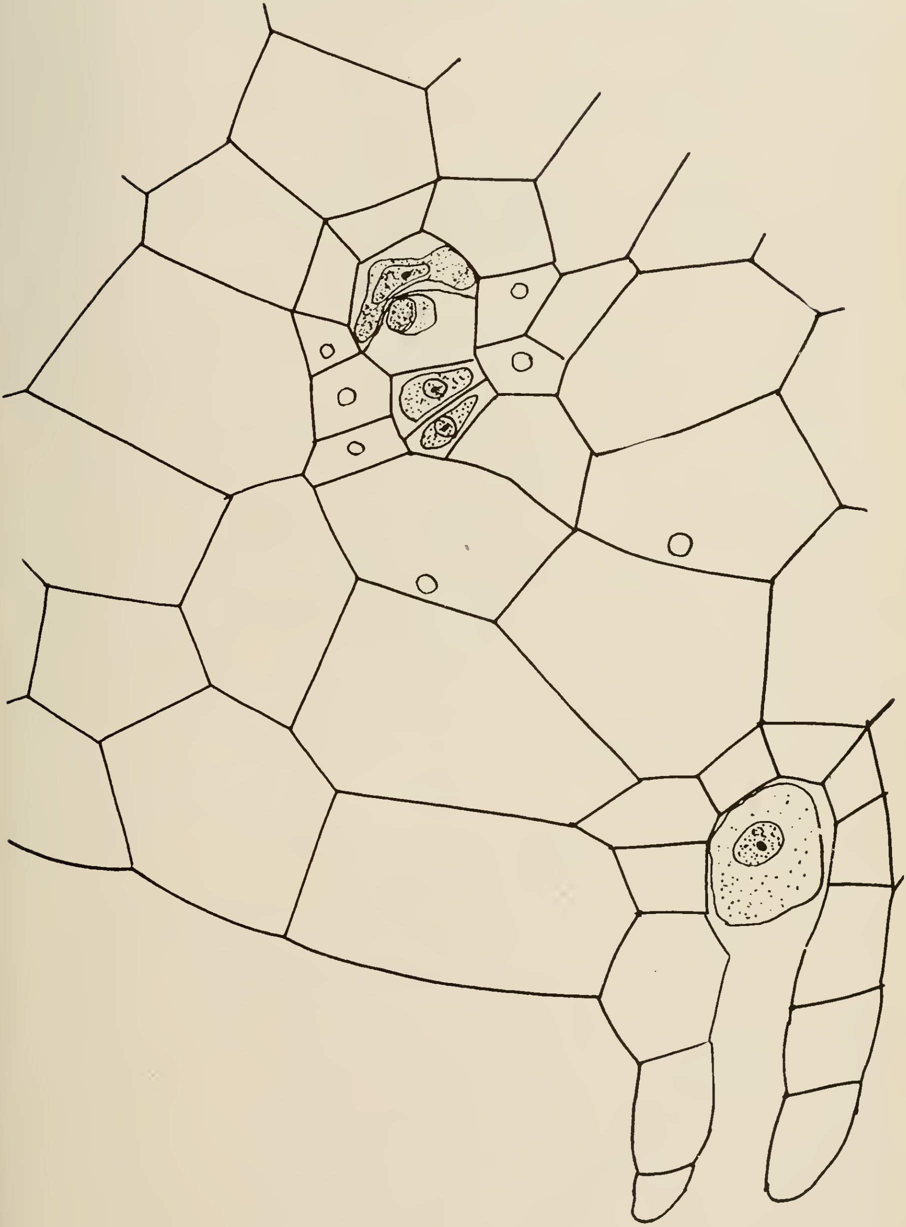


Fig. 2.

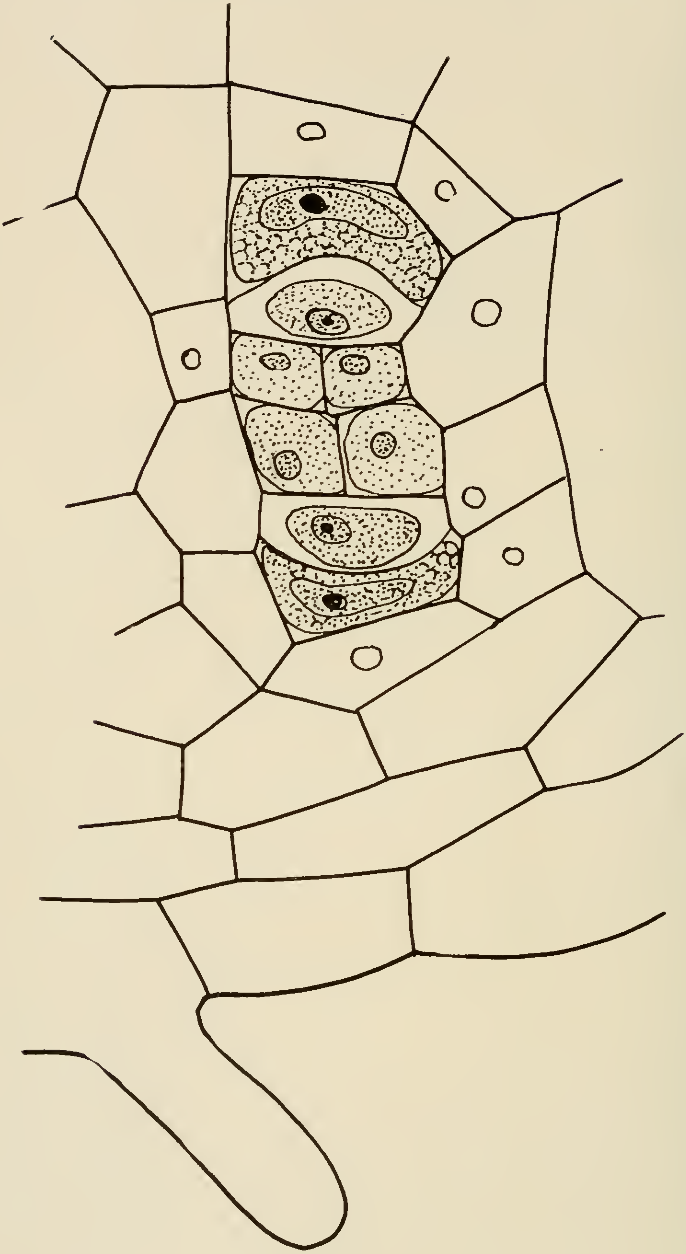


Fig. 3.

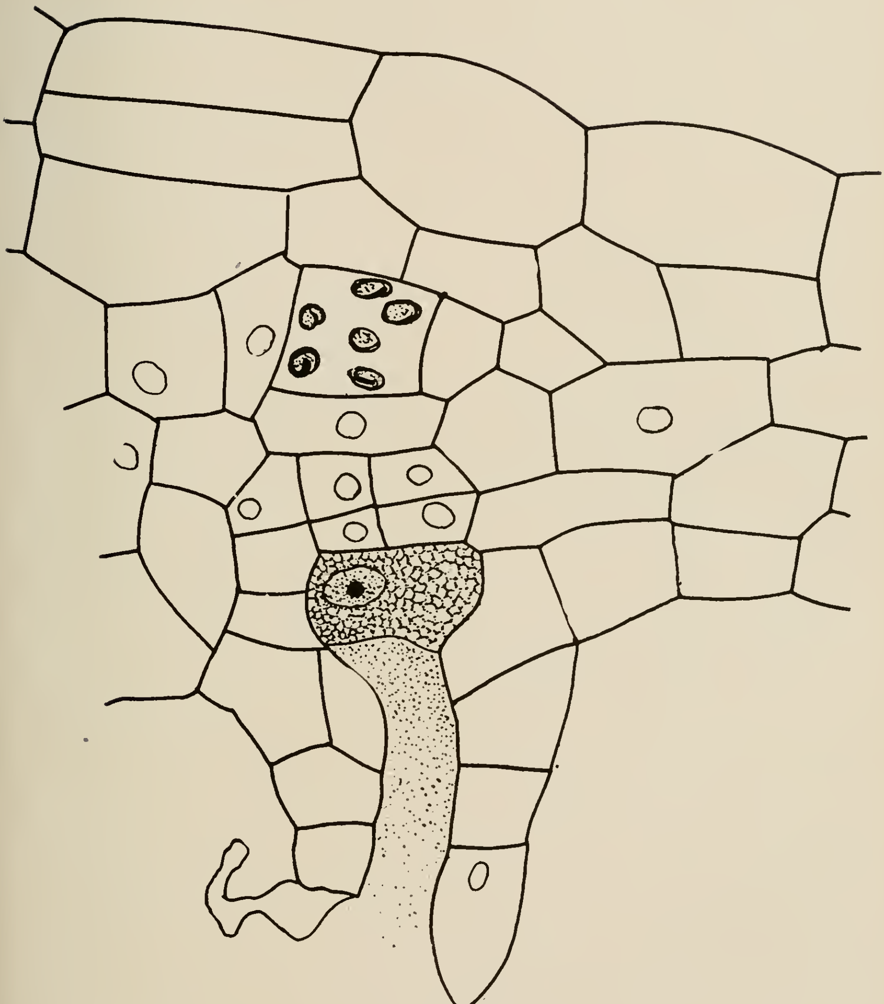


Fig. 4.

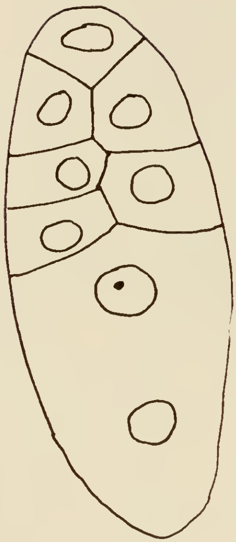


Fig. 5.

Fig. 6.

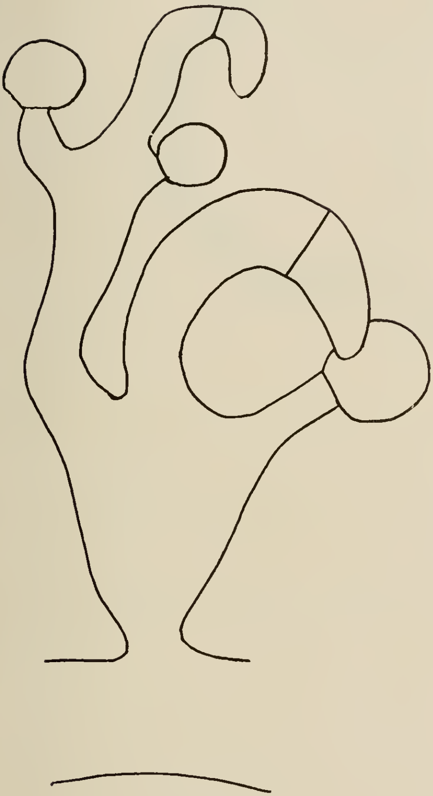


Fig 7.

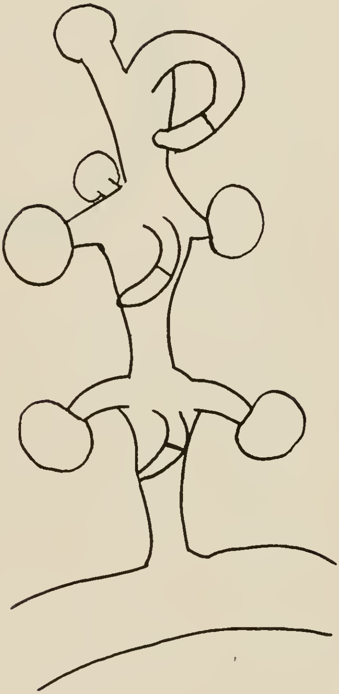


Fig. 8.

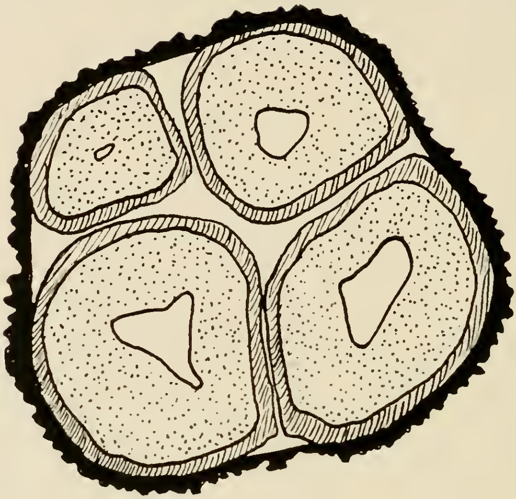


Fig. 9.

EXPLANATION OF FIGURES.

Fig. 1. Initial of imbedded archegonium.
Fig. 2. Completely formed imbedded archegonium.
Fig. 3. Two imbedded archegonia with axial rows reversed.
Fig. 4. Imbedded antheridium.
Figs. 5 and 6. Abnormal embryo-sacs of Lilium.
Figs. 7 and 8. Abnormal sexual branches of Vaucheria geminata.
Fig. 9. Abnormal megaspore tetrad of Selaginella.

Plants of Boone County, Kentucky.

James Carlton Nelson, Salem, Ore.

The following is a list of plants collected in that part of Boone County, Kentucky lying along the Ohio River opposite the Indiana counties of Ohio and Switzerland, extending along the river from the town of Grant to the mouth of Gunpowder Creek—some ten miles—and back from the river an average distance of seven miles. The region belongs geologically to the "Cincinnati Uplift," and is very hilly, except in the wide East Bend river-bottom. There is no exposed rock, such as forms the picturesque limestone cliffs farther down the Ohio, except a soft blue shale in deep stream-channels, and some large masses of conglomerate marking the terminal moraine of the Ice Age, which extends inland from the Ohio at "Split Rock," opposite the mouth of Laughery Creek, to a point about three miles west of the town of Union. The flora of this morainic district presents a marked contrast to that of the rest of the county. The region was originally covered with a dense forest of deciduous trees, which have been largely cleared away, leaving a very rich soil, which is rapidly washed away on the steep slopes, so that the prevailing soil is a tough yellow clay mixed with fragments of extremely hard blue fossiliferous limestone. The chief crop is tobacco, which has rapidly exhausted the soil and rendered it in many places sterile and unproductive. These collections were made during the years 1881–1893. I had no assistance in the work except such as was afforded by Gray's Manual, and the determinations represent in nearly every case simply my own unsupported opinion. The nomenclature is that of Gray's Manual, Seventh Edition. In making the determinations I used the Fifth and later the Sixth Edition of this Manual. I am indebted to Mr. Chas. C. Deam of Bluffton, Indiana, for his kindness in looking over the entire list and offering suggestions based on his own wide knowledge of the plants of Indiana. These suggestions I have in every case incorporated in the list. The region lies well within the limits of Gray's Manual, and there was little intrusion of extra-limital species. The Northern collector will note, however, the predominance of Southern types. Noteworthy is the total absence of Ericaceæ proper and Orchidaceæ, and the scanty representation of Umbelliferæ. No attempt was made to determine ferns, grasses and sedges.

POLYPODIACEAE:

Adiantum pedatum L. In rich woods, common.

(Two or three other members of this family occur, but I was unable to determine them.)

OPHIOGLOSSACEAE:

Botrychium virginianum (L.) Sw. Occasional in woods.

EQUISETACEAE:

Equisetum arvense L. Abundant in low ground.

Equisetum hyemale L., var. *robustum* (A. Br.) A. A. Eaton. Low ground, not common.

PINACEAE:

Juniperus virginiana L. Occasional on open hillsides.

TYPHACEAE:

Typha latifolia L. Not common, owing to absence of any large area of marshy ground in the district.

ALISMACEAE:

Sagittaria latifolia Willd. Moist river-shores, infrequent.

GRAMINEAE:

No attempt was made to determine these. The only species that I can positively affirm as growing in the district were:

Andropogon virginicus L. Common in sterile soil.

Panicum capillare L. Abundant in cultivated fields.

Echinochloa Crus-galli (L.) Beauv. Common in barn-yards and waste places.

Digitaria sanguinalis (L.) Scop. Common in door-yards.

Setaria viridis (L.) Beauv. Abundant in fields.

Phleum pratense L. A common escape.

Agrostis alba L. Not cultivated, but common.

Eleusine indica Gaertn. Common in door-yards.

Eragrostis hypnoides (Lam.) BSP. Abundant on river-shores.

Dactylis glomerata L. An occasional escape.

Poa pratensis L. Common in cultivation, and freely escaping.

Elymus virginicus L. Dry, open ground, common.

Hystrix patula Moench. Common in woods.

CYPERACEAE:

Here again nothing was done. The genera *Eleocharis*, *Cyperus*, *Scirpus* and *Carex* were all represented, but not fully, owing to the infrequency of marsh-land. The most characteristic *Carex* was a form with broad evergreen leaves, growing in woods. It evidently belonged to the section *Careyanae*, and I suspect was *C. platyphylla* Carey.

ARACEAE:

Arisaema triphyllum (L.) Schott. Common in woods.
Arisaema Dracontium (L.) Schott. With the last, but less common.
Acorus Calamus L. An occasional escape in dry ground.

COMMELINACEAE:

Tradescantia virginica L. Common in meadows.

JUNCACEAE:

Juncus bufonius L. Common along streams.
Juncus tenuis Willd. Abundant in dry soil.
Juncus effusus L. Less common than the other two.
Luzula campestris L. var. *multiflora* (Ehrh.) Celak. Occasional in woods.

LILIACEAE:

Uvularia grandiflora Sm. Rich woods, not infrequent.
Allium canadense L. Occasional in dry, stony ground.
Hemerocallis fulva L. A common escape.
Lilium canadense L. Very rare.
Erythronium americanum Ker. Rich woods, not common.
Erythronium albidum Nutt. With the last, but much more common. Rarely flowers.
Camassia esculenta (Ker) Robinson. Not common.
Ornithogalum umbellatum L. An occasional escape.
Asparagus officinalis L. Escaped to roadsides and meadows.
Smilacina racemosa (L.) Desf. Common in woods.
Polygonatum biflorum (Walt.) Ell. Common in woods.
Polygonatum commutatum (R. & S.) Dietr. Common in woods and grass-land.
Trillium sessile L. Very common in rich woods.
Trillium erectum L. With the last, but less common.
Smilax herbacea L. Occasional in woods.
Smilax rotundifolia L. Common in thickets.
Smilax glauca Walt. In thickets, scarce.
Smilax hispida Muhl. Rich woods, rare.

DIOSCOREACEAE:

Dioscorea villosa L. Common in thickets.

IRIDACEAE:

Sisyrinchium angustifolium Mill. Common in meadows.

SALICACEAE:

Salix nigra Marsh. Abundant on river-shores.
Salix alba L. var. *vitellina* (L.) Koch. A frequent escape.
Salix longifolia Muhl. Along streams, rather rare.

Salix discolor Muhl. River-banks, common.

Salix purpurea L. An occasional escape along the river, where it is cultivated for basket-work, etc.

Populus grandidentata Michx. Occasional along streams.

Populus deltoides Marsh. Abundant along the river.

JUGLANDACEAE:

Juglans cinerea L. Rich woods, less common than the next.

Juglans nigra L. Very common throughout.

Carya alba (L.) K. Koch. Rich hillsides, common.

Carya ovata (Mill.) K. Koch. With the last, but less common.

Carya glabra (Mill.) Spach. Open woods.

Carya cordiformis (Wang.) K. Koch. Low woods.

BETULACEAE:

Ostrya virginiana (Mill.) K. Koch. In woods, not infrequent.

Carpinus caroliniana Walt. Common in rich woods.

Alnus rugosa (Du Roi) Spreng. A single specimen on the river-shore.

FAGACEAE:

Fagus grandifolia Ehrh. Very common in rich woods.

Quercus alba L. The commonest species and our largest tree. Some specimens reached a diameter of eight feet.

Quercus macrocarpa Michx. In rocky woods.

Quercus Muhlenbergii Engelm. With the last.

Quercus rubra L. Common on dry hillsides.

Quercus palustris Moench. Low ground, not common.

Quercus velutina Lam. Rich soil, not common.

Quercus imbricaria Michx. At a few stations in the interior.

URTICACEAE:

Ulmus fulva Michx. Rich woods, less common than the next.

Ulmus americana L. Very common.

Celtis occidentalis L. Woods, especially along the river, common.

Cannabis sativa L. Occasional in waste places. Not cultivated.

Humulus Lupulus L. An occasional escape.

Morus rubra L. Rich woods, common.

Urtica gracilis Ait. Common in fence-rows, etc.

Laportea canadensis (L.) Gaud. Rich woods, common.

Pilea pumila (L.) Gray. Rich woods, common.

Boehmeria cylindrica (L.) Sw. Low ground along streams.

Parietaria pennsylvanica Muhl. Shaded banks, common.

LORANTHACEAE:

Phoradendron flavescens (Pursh) Nutt. Common, especially on *Ulmus* and *Gleditsia*.

ARISTOLOCHIACEAE:

Asarum canadense L. Common in rich woods.

Aristolochia Serpentaria L. In wooded districts, rare.

POLYGONACEAE:

Rumex Britannica L. In wet places, rather scarce.

(This probably should be *R. altissimus* Wood. Mr. Deam tells me that *Britannica* occurs in Ind. only in the northern counties, while *altissimus* is common along the Ohio R.)

Rumex crispus L. Abundant in fields and meadows.

Rumex obtusifolius L. Very common about dwellings.

Rumex Acetosella L. Common in poor soil.

Polygonum aviculare L. Abundant in door-yards, etc.

Polygonum erectum L. With the last.

Polygonum amphibium L. Occasional in wet places.

(This species has been found in Ind. by Mr. Deam but twice, while *P. Muhlenbergii* (Meisn.) Wats., which in Gray's 5th Ed. was not separated from *amphibium*, is abundant in the counties along the Ohio, so my report is doubtless an error, and should be changed to *Muhlenbergii.*)

Polygonum Hydropiper L. Wet ground, common.

Polygonum acre HBK. Abundant in waste places.

Polygonum orientale L. An occasional escape about dwellings.

Polygonum virginianum L. Rich thickets, common.

Polygonum sagittatum L. Occasional in low ground.

Polygonum Convolvulus L. Very common in cultivated fields.

Polygonum scandens L. Common in thickets.

CHENOPODIACEAE:

Chenopodium ambrosioides L. Common on river-shores and in waste places.

Chenopodium Botrys L. Sandy soil near the river, never inland.

Chenopodium hybridum L. Infrequent in waste places.

Chenopodium album L. Abundant about dwellings and in fields.

AMARANTHACEAE:

Amaranthus retroflexus L. Very common in cultivated ground.

Amaranthus hybridus L. With the last, but less common.

Amaranthus paniculatus L. Occasional near dwellings.

Amaranthus spinosus L. Waste ground near the river, infrequent.

Acnida tuberculata Moq. River-shores, common.

Acnida tuberculata Moq. var. *subnuda* Wats. With the last.

Acnida tuberculata Moq. var. *prostrata* (Uline & Bray) Robinson. With the last.

PHYTOLACCACEAE:

Phytolacca decandra L. Rich soil in low grounds, common.

ILLECEBRACEAE:

Anychia polygonoides Raf. Open places, rather scarce.
Anychia canadensis (L.) BSP. Dry woods, common.

AIZOACEAE:

Mollugo verticillata L. Sandy river-shores and tobacco-fields, common.

CARYOPHYLLACEAE:

Stellaria pubera Michx. Rocky woods, common.
Stellaria media (L.) Cyrill. Abundant about dwellings.
Cerastium vulgatum L. Common in fields and meadows.
Agrostemma Githago L. Common in grain-fields.
Silene antirrhina L. Occasional in cultivated ground.
Silene virginica L. Open woods, rather rare.
Silene stellata (L.) Ait. f. Shaded banks, not infrequent.
Saponaria officinalis L. An occasional escape.

PORTULACACEAE:

Claytonia virginica L. Common in woods.
Claytonia caroliniana Michx. With the last, but much less common.
Portulaca oleracea L. Abundant in cultivated and waste ground.

RANUNCULACEAE:

Ranunculus sceleratus L. Wet places, scarce.
Ranunculus abortivus L. Shady places, very common.
Ranunculus recurvatus Poir. In woods, common.
Ranunculus septentrionalis Poir. Moist ground, common.
Thalictrum dioicum L. Rocky woods, common.
Thalictrum polygamum Muhl. River-banks in rich soil.
Anemonella thalictroides (L.) Spach. In woods in early spring, common.
Hepatica acutiloba DC. Only on moraines, where it is common.
Anemone virginiana L. In meadows and fence-rows.
Anemone canadensis L. Low ground, especially in river-bottoms.
Clematis virginiana L. River-banks, not infrequent.
Isopyrum biternatum (Raf.) T. & G. Common in thickets.
Aquilegia canadensis L. Rocky woods, infrequent.
Delphinium tricorne Michx. Meadows and thickets, common.
Cimicifuga racemosa (L.) Nutt. Common in rich woods.
Actaea alba (L.) Mill. Not infrequent in rich woods.
Hydrastis canadensis L. In rich woods, rare.

MAGNOLIACEAE:

Liriodendron Tulipifera L. In river-bottoms, becoming scarce.

ANONACEAE:

Asimina triloba (L.) Dunal. Thickets and hillsides, common.

MENISPERMACEAE:

Menispermum canadense L. Thickets along streams, common.

BERBERIDACEAE:

Podophyllum peltatum L. Common in rich woods.
Jeffersonia diphylla (L.) Pers. Woods, common.
Caulophyllum thalictroides (L.) Michx. Woods, infrequent.

LAURACEAE:

Sassafras variifolium (Salisb.) Kuntze. In woods, becoming scarce.
Benzoin aestivale (L.) Nees. Damp woods, not rare.

PAPAVERACEAE:

Sanguinaria canadensis L. Open woods, common.
Stylophorum diphyllum (Michx.) Nutt. In rich woods, common locally.

FUMARIACEAE:

Dicentra Cucullaria (L.) Bernh. Common in woods.
Dicentra canadensis (Goldie) Walp. With the last.
Corydalis flavula (Raf.) DC. Rich soil, not uncommon.

CRUCIFERAE:

Lepidium virginicum L. Waste places and fields, common.
Capsella Bursa-pastoris (L.) Medic. Abundant in waste and cultivated ground.
Brassica alba (L.) Boiss. About dwellings, infrequent.
Brassica nigra (L.) Koch. With the last, but much more common.
Sisymbrium officinale (L.) Scop. var. *leiocarpum* DC. Common in fields.
Hesperis matronalis L. A rare escape.
Radicula palustris (L.) Moench. Common on river-shores.
Radicula Armoracia (L.) Robinson. An occasional escape.
Barbarea vulgaris R. Br. Roadsides, infrequent.
Iodanthus pinnatifidus (Michx.) Steud. Rich soil near the river.
Dentaria diphylla Michx. Woods, not common.
Dentaria laciniata Muhl. Very common in woods.
Cardamine bulbosa (Schreb.) BSP. Occasional in wet places.
Cardamine Douglassii (Torr.) Britton. Rich woods in early spring.
Cardamine pennsylvanica Muhl. Damp ground, rather scarce.
Arabis laevigata (Muhl.) Poir. Rocky woods, infrequent.

CAPPARIDACEAE:

Polanisia graveolens Raf. Gravelly river-shores, common.

CRASSULACEAE:

Penthorum sedoides L. Muddy shores, common.
Sedum ternatum Michx. Rocky woods, common.

SAXIFRAGACEAE:

Saxifraga virginiensis Michx. Steep wooded hillsides, local.

Heuchera americana L. Woods on moraine, local.

Mitella diphylla L. Rich woods, common.

Hydrangea arborescens L. Rocky hillsides, infrequent.

Ribes floridum L'Her. Thickets, not common.

PLATANACEAE:

Platanus occidentalis L. Common on river-banks.

ROSACEAE:

Aruncus sylvester Kost. Rocky woods on moraine.

Gillenia stipulacea (Muhl.) Trel. In dry soil by roadside near Verona, 20 miles from the river. The only station.

Pyrus Malus L. A frequent escape to thickets and roadsides.

Crataegus Crus-galli L. Infrequent in thickets.

Crataegus punctata Jacq. Open hillsides, not common.

Crataegus tomentosa L. Very common.

(I did not have the benefit of Eggleston's thorough revision of this genus. It is doubtful if *tomentosa* as now restricted occurs in Ind., and my plant, according to Mr. Deam, was probably *C. mollis* (T. & G.) Scheele.)

Fragaria virginiana Duchesne. Common on grassy slopes.

Potentilla monspeliensis L. Common in cultivated ground.

Potentilla canadensis L. Grassy places, infrequent.

Geum canadense Jacq. Borders of woods, common.

Geum virginianum L. With the last.

Geum vernum (Raf.) T. & G. Common in meadows, etc.

Rubus occidentalis L. Thickets and fence-rows.

Rubus allegheniensis Porter. Very common on open hillsides.

Rubus villosus Ait. Grassy open places, not common.

Agrimonia gryposepala Wallr. Rich soil in thickets, common.

Rosa setigera Michx. Borders of thickets, not common.

Rosa rubiginosa L. Pastures and roadsides, common.

Rosa humilis Marsh. In dry soil, scarce.

Prunus serotina Ehrh. In rich woods, rather common.

Prunus americana Marsh. In thickets, frequent.

LEGUMINOSAE:

Gymnocladus dioica (L.) Koch. Rich woods, infrequent.

Gleditsia triacanthos L. Very common, especially in low ground.

Cassia marilandica L. Rich soil, common.

Cassia Chamaecrista L. Sandy river-shores, not common.

Cercis canadensis L. Rich woods, common.

Baptisia australis (L.) R. Br. Gravelly river-shores, rare.

Trifolium pratense L. Common in meadows, and often cultivated.

Trifolium stoloniferum Muhl. Occasional in open ground.
Trifolium repens L. Abundant in meadows.
Melilotus alba Desr. Common on roadsides near the river, but not found farther inland.
Robinia Pseudo-Acacia L. Open hillsides, very common.
Astragalus canadensis L. Dry soil, not common.
Desmodium nudiflorum (L.) DC.
Desmodium pauciflorum (Nutt.) DC.
Desmodium canescens (L.) DC.
Desmodium bracteosum (Michx.) DC.
Desmodium Dillenii Darl.
Desmodium paniculatum (L.) DC.

(This genus seems to be the dominant one of the family here, much like *Astragalus* in the Rocky Mountain region and *Lupinus* on the Pacific Slope. All the species are in thickets and at the borders of woods, and are exceedingly troublesome on account of their burs.)

Lespedeza capitata Michx. On moraines, rare.
Apios tuberosa Moench. Rich woods, common.
Strophostyles helvola (L.) Britton. Abundant in river-thickets.
Amphicarpa monoica (L.) Ell. Rich woods, common.

OXALIDACEAE:

Oxalis violacea L. Rocky woods, not infrequent.
Oxalis corniculata L. Dry ground, very common.

GERANIACEAE:

Geranium maculatum L. Open woods and meadows, common.

RUTACEAE:

Zanthoxylum americanum Mill. Rocky woods, infrequent.

SIMARUBACEAE:

Ailanthus glandulosa Desf. An occasional escape.

POLYGALACEAE:

Polygala Senega L. Open, rocky soil; not common.

EUPHORBIACEAE:

Acalypha virginica L. Fields and waste places, common.
Phyllanthus caroliniensis Walt. In meadows, rare.
Euphorbia Preslii Guss. Dry soil, common.
Euphorbia maculata L. Open places, common.
Euphorbia humistrata Engelm. Not uncommon in rich soil.
Euphorbia corollata L. Rich soil, scarce.
Euphorbia dentata Michx. In rich soil, not common.
Euphorbia commutata Engelm. Dry woodlands, not common.
Euphorbia Cyparissias L. An occasional escape.

ANACARDIACEAE:

Rhus typhina L. Dry soil, common.
Rhus glabra L. With the last.
Rhus copallina L. Dry hillsides, not common.
Rhus Toxicodendron L. Thickets and fence-rows, very common.

CELASTRACEAE:

Evonymus atropurpureus Jacq. Thickets, common.
Evonymus obovatus Nutt. Low ground, not common.
Celastrus scandens L. Common in thickets.

STAPHYLEACEAE:

Staphylea trifolia L. Damp thickets, common.

ACERACEAE:

Acer saccharum Marsh. The commonest forest-tree of the district.
Acer rubrum L. Low woods, common.
Acer Negundo L. Low ground, common.

SAPINDACEAE:

Aesculus glabra Willd. Rich woods, common.
Aesculus octandra Marsh. With the last, but less common.

BALSAMINACEAE:

Impatiens pallida Nutt. Along streams in rich soil, common.
Impatiens biflora Walt. With the last.

VITACEAE:

Psedera quinquefolia (L.) Greene. Common in thickets.
Vitis aestivalis Michx. Thickets, common.
Vitis cordifolia Michx. River-banks, not infrequent.

TILIACEAE:

Tilia americana L. Rich woods, common.

MALVACEAE:

Abutilon Theophrasti Medic. Common in cultivated ground.
Sida hermaphrodita (L.) Rusby. A single station on river-bank.
Sida spinosa L. Common in cultivated ground.
Malva rotundifolia L. Common about dwellings.
Napaea dioica L. A single station on the bank of Gunpowder Creek.
Hibiscus militaris Cav. Wet river-shores, not common.

HYPERICACEAE:

Hypericum perforatum L. In fields, common.
Hypericum punctatum Lam. With the last, but less common.
Hypericum prolificum L. On moraines, rare.
Hypericum mutilum L. Damp river-shores, common.

VIOLACEAE:

Hybanthus concolor (Forster) Spreng. Rich woods, common.
Viola papilionacea Pursh. Meadows and thickets, very common.
Viola palmata L. Dry woods, infrequent.
Viola pubescens Ait. Rich woods, common.
Viola canadensis L. Rich woods, rather scarce.
Viola striata Ait. Meadows and borders of woods, common.

PASSIFLORACEAE:

Passiflora lutea L. Thickets, not common.

LYTHRACEAE:

Rotala ramosior (L.) Koehne. Wet river-shores, common.
Ammannia coccinea Rottb. With the last.
Lythrum alatum Pursh. A single station on the river-shore.
Cuphea petiolata (L.) Koehne. Dry fields, common.

ONAGRACEAE:

Ludvigia alternifolia L. Damp river-shores.
Ludvigia polycarpa Short & Peter. With the last, but less common.
Ludvigia palustris (L.) Ell. Wet places, very common.
Epilobium coloratum Muhl. Wet places, infrequent.
Oenothera biennis L. Open places, common.
Circaea alpina L. Rich woods, common.

(Since this species is rare in Ind., and *C. lutetiana* L. very common, I agree with Mr. Deam that my plant probably is to be referred to the latter species.)

ARALIACEAE:

Aralia racemosa L. Rich woods, infrequent.
Panax quinquefolium L. Rich woods, becoming rare.

UMBELLIFERAE:

Sanicula marilandica L. Open ground, common.
Sanicula canadensis L. Borders of woods, not so common as the last.
Erigenia bulbosa (Michx.) Nutt. Rich woods, common; the first spring flower.
Chaerophyllum procumbens (L.) Crantz. Moist woods, common.
Osmorhiza Claytoni (Michx.) Clarke. Rich woods, common.
Cicuta maculata L. River-banks, common.
Cryptotaenia canadensis (L.) DC. Shady places, common.
Taenidia integerrima (L.) Drude. Dry woods, infrequent.
Pastinaca sativa L. A common escape to roadsides, etc.
Daucus Carota L. An occasional escape.

CORNACEAE:

Cornus florida L. Common in woods.
Cornus Amomum Mill. River-banks, infrequent.
Nyssa sylvatica Marsh. Rich woods, infrequent.

ERICACEAE:

Monotropa uniflora L. Deep woods, rare.

PRIMULACEAE:

Samolus floribundus HBK. Occasional in wet places.
Lysimachia quadrifolia L. Moist soil, common.
Lysimachia terrestris (L.) BSP. Low ground, scarce.
Lysimachia Nummularia L. Escaped to roadsides and thickets.
Steironema ciliatum (L.) Raf. Low ground, common.
Steironema lanceolatum (Walt.) Gray. With the last, but less common.
Anagallis arvensis L. Sandy fields, rare.

EBENACEAE:

Diospyros virginiana L. Old fields, infrequent.

OLEACEAE:

Fraxinus americana L. Rich woods, common.

GENTIANACEAE:

Gentiana quinquefolia L. Along streams, not common.
Frasera carolinensis Walt. Dry hillsides, rare.

APOCYNACEAE:

Vinca minor L. A common escape about dwellings.
Apocynum androsaemifolium L. Dry thickets, not infrequent.
Apocynum cannabinum L. Borders of woods, common.

ASCLEPIADACEAE:

Asclepias tuberosa L. Dry soil, not common.
Asclepias incarnata L. Wet places, common.
Asclepias syriaca L. Alluvial soil, very common.
Asclepias quadrifolia Jacq. Dry woods, infrequent.
Asclepias verticillata L. Open ground, common.
Acerates viridiflora Ell. Dry soil, not common.
Gonolobus laevis Michx. River-banks and cultivated ground, very common.
Vincetoxicum hirsutum (Michx.) Britt. A single station in rocky oak woods.

CONVOLVULACEAE:

Ipomaea coccinea L. Waste places, rare.
Ipomaea hederacea Jacq. Common in cultivated fields.
Ipomaea purpurea (L.) Roth. An occasional escape.
Ipomaea pandurata (L.) Mey. Occasional on dry river-banks.

Convolvulus sepium L. Along streams, common.
Cuscuta arvensis Beyrich. Dry soil on various *Compositae*, common.
Cuscuta Gronovii Willd. River-shores on *Salix*, common.

POLEMONIACEAE:

Phlox divaricata L. Damp woods, common.
Polemonium reptans L. Rich woods, common.

HYDROPHYLLACEAE:

Hydrophyllum macrophyllum Nutt. Rich woods, common.
Hydrophyllum appendiculatum Michx. Damp woods, common.
Ellisia Nyctelea L. Damp thickets, infrequent.
Phacelia bipinnatifida Michx. Shaded banks, common.

BORAGINACEAE:

Heliotropium indicum L. A single station on sandy river-shore.
Cynoglossum officinale L. A common weed in pastures, etc.
Cynoglossum virginianum L. Open woods, not common.
Lappula virginiana (L.) Greene. Thickets and roadsides, very common.
Mertensia virginica (L.) Link. Rich soil in woods, rather scarce.
Lithospermum arvense L. Sandy roadsides, not common.
Onosmodium virginianum (L.) DC. Dry hillsides, occasional.
Onosmodium hispidissimum Mack. River-banks, rare.

VERBENACEAE:

Verbena urticaefolia L. Thickets and roadsides, common.
Verbena hastata L. Low ground, common.
(*V. bracteosa* Michx. was common on the river-shore at Rising Sun, Ind., but was never found on the Ky. side.)
Lippia lanceolata Michx. Damp river-shores, common.

LABIATAE:

Teucrium canadense L. Common in rich soil.
Isanthus brachiatus (L.) BSP. Dry soil on moraines, rare.
Scutellaria lateriflora L. Low ground, common.
Scutellaria versicolor Nutt. Rich woods, not infrequent.
Scutellaria canescens Nutt. In woods, rather scarce.
Scutellaria nervosa Pursh. Rich woods, not common.
Marrubium vulgare L. Dry soil, infrequent.
Agastache nepetoides (L.) Ktze. Borders of woods, common.
Nepeta Cataria L. Common about dwellings.
Nepeta hederacea (L.) Trevisan. Shady places, common.
Prunella vulgaris L. Fields and meadows, very common.
Synandra hispidula (Michx.) Britt. Rich woods, infrequent.
Leonurus Cardiaca L. Waste places, common.
Stachys tenuifolia Willd. Wet ground, common.
Stachys cordata Riddell. Dry thickets, rather common.

Monarda fistulosa L. Dry ground, common.
Blephilia ciliata (L.) Raf. Borders of woods, not infrequent.
Blephilia hirsuta (Pursh) Benth. Moist thickets, rare.
Hedeoma pulegioides (L.) Pers. Dry soil, very common.
Melissa officinalis L. An occasional escape.
Lycopus virginicus L. Moist soil, not infrequent.
Lycopus americanus Muhl. With the last.
Mentha spicata L. An occasional escape in dry ground.
Mentha piperita L. An occasional escape along streams.
Collinsonia canadensis L. Rich soil in woods, not infrequent.

SOLANACEAE:

Solanum nigrum L. Rich soil, common.
Solanum carolinense L. Sandy soil, common.
Physalis pubescens L. Open ground, common.
Physalis heterophylla Nees. Alluvial soil, common.
Nicandra Physalodes (L.) Pers. A single specimen on the river-shore.
Lycium halimiflorum Mill. An occasional escape in fence-rows, etc.
Datura Stramonium L. Waste places, less common than the next.
Datura Tatula L. Waste places, very common.

SCROPHULARIACEAE:

Verbascum Thapsus L. Dry fields and roadsides, very common.
Verbascum Blattaria L. Open places, common. (Only the white-flowered form.)
Linaria vulgaris Hill. Fields and roadsides, very common.
Scrophularia marilandica L. Fence-rows and borders of woods, common.
Pentstemon hirsutus (L.) Willd. Dry, rocky hillsides; not common.
Pentstemon laevigatus Ait. Rich soil, infrequent.
Chelone glabra L. Low ground, not common.
Mimulus ringens L. Wet places, common.
Mimulus alatus Ait. With the last, but less common.
Conobea multifida (Michx.) Benth. On muddy river-shores, infrequent.
Ilysanthes dubia (L.) Barnhart. On river-shores, common.
Gratiola virginiana L. Muddy places, common.
Veronica Anagallis-aquatica L. Wet places, rather scarce.
Veronica serpyllifolia L. Damp grassy places, common.
Veronica peregrina L. Cultivated ground, common.
Veronica arvensis L. With the last, and equally common.
Gerardia flava L. Occasional in oak woods.
Gerardia tenuifolia Vahl. In a single station on the river-shore.
Pedicularis canadensis L. Moist banks on moraine.

OROBANCHACEAE:

Epifagus virginiana (L.) Bart. Common in beech-woods.
Conopholis americana (L. f.) Wallr. In oak woods, scarce.

BIGNONIACEAE:

Tecoma radicans (L.) Juss. Common on river-banks.
Catalpa bignonioides Walt. Occasional in thickets near the river.

ACANTHACEAE:

Dianthera americana L. Gravelly river-shores, scarce.
Ruellia ciliosa Pursh. In dry soil, not common.
Ruellia strepens L. In rich soil, rather common.

PHRYMACEAE:

Phryma leptostachya L. Deep woods, not infrequent.

PLANTAGINACEAE:

Plantago major L. Door-yards and waste places, abundant.
Plantago lanceolata L. In meadows, common.
Plantago Purshii R. & S. Sandy soil, not common.
Plantago aristata Michx. Dry soil, scarce.
Plantago virginica L. Sandy soil, not common.

RUBIACEAE:

Galium Aparine L. Very common in thickets and fence-rows.
Galium circaezans Michx. In rich woods, not infrequent.
Galium asprellum Michx. Rich soil in thickets, not common.
Galium triflorum Michx. Rich woods, common.
Spermacoce glabra Michx. A single station on gravelly river-shore.
Mitchella repens L. Dry woods, not common.
Cephalanthus occidentalis L. Common in wet places.
Houstonia purpurea L. Borders of woods, not common.

CAPRIFOLIACEAE:

Lonicera sempervirens L. In thickets, not common.
Symphoricarpos orbiculatus Moench. Open hillsides, locally abundant.
Viburnum prunifolium L. Open woods, not common.
Sambucus canadensis L. In rich soil, common.

VALERIANACEAE:

Valeriana pauciflora Michx. Rich woods, scarce.
Valerianella radiata (L.) Dufr. In low ground, rare.

DIPSACACEAE:

Dipsacus sylvestris Huds. On barren hillsides, locally abundant.

CUCURBITACEAE:

Sicyos angulatus L. River-banks, common.
Echinocystis lobata (Michx.) T. & G. With the last, but less frequent.

CAMPANULACEAE:

Specularia perfoliata (L.) A. DC. In dry fields, common.

Campanula americana L. Borders of thickets in rich soil, common.

LOBELIACEAE:

Lobelia cardinalis L. Thickets on river-shores, scarce.

Lobelia siphilitica L. Low ground, rather common.

Lobelia inflata L. Dry fields, common.

COMPOSITAE:

Vernonia altissima Nutt. Rich soil in pastures, common.

Elephantopus carolinianus Willd. Low ground along streams, scarce.

Eupatorium purpureum L. Low ground, common.

Eupatorium serotinum Michx. Rich soil, rather common.

Eupatorium perfoliatum L. Low ground, common.

Eupatorium urticaefolium Reichard. Rich woods, common.

Eupatorium coelestinum L. In rich soil, not infrequent.

Solidago caesia L. In woods, rare.

Solidago ulmifolia Muhl. Rocky oak woods, scarce.

Solidago latifolia L. In woods, rather common.

Solidago canadensis L. Roadsides and pastures, very common.

(Revision of this species since the list was first made makes it probable that this should be referred to *S. altissima* L., according to Mr. Deam.)

Solidago rupestris Raf. Rocky river-banks, rare.

Solidago serotina Ait. Borders of woods, rather scarce.

Solidago graminifolia (L.) Salisb. Open hillsides, infrequent.

Aster divaricatus L. Woods, scarce.

Aster novae-angliae L. Stream-banks, scarce, but common in cultivation.

Aster patens Ait. Thickets, not frequent.

Aster Shortii Lindl. Wooded banks, not common.

Aster undulatus L. Thickets, rather frequent.

Aster cordifolius L. Woods, common.

Aster multiflorus Ait. Dry, open hillsides; common.

Aster vimineus Lam. Open ground, infrequent.

Aster prenanthoides Muhl. Along streams in woods, not common.

Aster umbellatus Mill. In thickets, scarce.

Erigeron pulchellus Michx. Moist banks, scarce.

Erigeron philadelphicus L. Rich soil, rather common.

Erigeron annuus (L.) Pers. An abundant weed in pastures.

Erigeron ramosus (Walt.) BSP. Common in fields and meadows.

Erigeron canadensis L. A very common weed.

Pluchea petiolata Cass. Occasional on river-shores.

Antennaria plantaginifolia (L.) Richards. Dry soil, common.
(Revision of the original species would probably throw my plant into *A. fallax* Greene, which, according to Mr. Deam, is very common in Ind., while he has but one authentic record of *A. plantaginifolia* as now understood.)

Gnaphalium polycephalum Michx. Dry soil, common.

Gnaphalium uliginosum L. Not infrequent on river-shores.

Inula Helenium L. An occasional escape to pastures, etc.

Polymnia canadensis L. Moist woods, common.

Polymnia canadensis L. var. *radiata* Gray. With the last, but much less common.

Polymnia uvedalia L. Fence-rows and roadsides, not common.

Silphium trifoliatum L. Dry banks, infrequent.

Silphium perfoliatum L. In rich soil along streams, common.

Ambrosia trifida L. Abundant in rich soil.

Ambrosia artemisiifolia L. A very common weed.

Xanthium spinosum L. Occasional in waste places near the river.

Xanthium canadense Mill. Sandy shores and fields, very common.

Heliopsis helianthoides (L.) Sweet. Wooded banks, not frequent.

Heliopsis scabra Dunal. Open ground, more common than the last.

Eclipta alba (L.) Hassk. Muddy river-shores, common.

Rudbeckia hirta L. Occasional in grass-land.

Rudbeckia laciniata L. Thickets near river, rather infrequent.

Lepachys pinnata (Vent.) T. & G. In dry soil, not uncommon.

Helianthus annuus L. An occasional escape.

Helianthus microcephalus T. & G. In rocky oak woods, scarce.

Helianthus tracheliifolius Mill. In thickets, rare.

Helianthus tuberosus L. An occasional escape.

Actinomeris alternifolia (L.) DC. Rich soil, common.

Bidens frondosa L. Low ground, common.

Bidens connata Muhl. Along streams, rather common.

Bidens cernua L. Wet places, common.

Bidens laevis (L.) BSP. River-shores.
(I have never felt that this was correct, because of being so far out of range. Mr. Deam thinks my plant was *B. aristosa* (Michx.) Britt., which occurs on river-banks in many parts of Ind.)

Bidens bipinnata L. Rich, damp soil; common.

Bidens trichosperma (Michx.) Britt. Frequent on river-banks after the great flood of 1884, but never found above high-water mark.

Galinsoga parviflora Cav. River-shores, scarce.

Helenium autumnale L. Low ground, common.

Achillea Millefolium L. A frequent escape.

Anthemis Cotula L. Abundant in barnyards, etc.

Chrysanthemum Leucanthemum L. var. *pinnatifidum* Lecoq & Lamotte. Common in waste places.

Tanacetum vulgare L. var. *crispum* DC. An occasional escape.

Artemisia biennis Willd. Not uncommon in waste places.

Artemisia annua L. River-banks and waste places, where it was common before 1881, though not mentioned in the Fifth Edition of Gray's Manual.

Erechtites hieracifolia (L.) Raf. Common in clearings.

Cacalia suaveolens L. Rich woods, rare.

Cacalia atriplicifolia L. Woods, rather common.

Senecio aureus L. In meadows and thickets, locally common.

Arctium minus Bernh. An abundant and troublesome weed.

Cirsium lanceolatum (L.) Hill. Very common in pastures.

Cirsium discolor (Muhl.) Spreng. Rich soil, not common.

Cichorium Intybus L. Roadsides, not common.

Krigia amplexicaulis Nutt. Wooded banks, not infrequent.

Taraxacum officinale Weber. Yards and pastures, abundant.

Sonchus oleraceus L. Cultivated ground near dwellings, common.

Sonchus asper (L.) Hill. Roadsides and waste ground, common.

Lactuca integrifolia Bigel. In thickets, not uncommon.

Lactuca villosa Jacq. Rich soil, frequent.

Lactuca spicata (Lam.) Hitchc. With the last, and equally common.

Hieracium scabrum Michx. Common in dry woods.

Hieracium Gronovii L. Sandy soil near river, not common.

The following species were collected in the vicinity of Hanover, Jefferson County, Indiana, during the years 1887–1890, but were never found in Boone County, owing perhaps to the complete change in geological horizon, although the two districts are less than sixty miles apart:

Pellaea atropurpurea (L.) Link.
Camptosorus rhizophyllus (L.) Link.
Oakesia sessilifolia (L.) Wats.
Muscari botryoides (L.) Mill.
Trillium recurvatum Beck.
Hypoxis hirsuta (L.) Coville.
Orchis spectabilis L.
Habenaria peramoena Gray.
Corallorhiza odontorhiza Nutt.
Aplectrum hyemale (Muhl.) Torr.
Saururus cernuus L.
Maclura pomifera (Raf.) Schneider.

Anemone quinquefolia L.
Clematis Viorna L.
Magnolia acuminata L.
Sullivantia Sullivantii (T. & G.) Britt.
Hamamelis virginiana L.
Liquidambar Styraciflua L.
Spiraea tomentosa L.
Pyrus arbutifolia (L.) L. f.
Amelanchier canadensis (L.) Medic.
Waldsteinia fragarioides (Michx.) Tratt.
Rhus canadensis Marsh.
Viola blanda Willd.
Aralia spinosa L.
Thaspium aureum Nutt.
Thaspium barbinode (Michx.) Nutt.
Cornus alternifolia L. f.
Obolaria virginica L.
Convolvulus spithamaeus L.
Lamium amplexicaule L.
Salvia lyrata L.
Orobanche uniflora L.
Houstonia caerulea L.
Triosteum perfoliatum L.
Triosteum angustifolium L.
Viburnum acerifolium L.

Plants New to Indiana. VIII.

Chas. C. Deam.

Specimens of the species reported are deposited in my herbarium under the numbers given. The Gramineae were determined at the U. S. Department of Agriculture; the Carices by K. K. Mackenzie; the Carya and Crataegus by C. S. Sargent; the Viola and Rubus by Brainerd; the remainder were checked at Gray herbarium.

Paspalum supinum Bosc.

Greene County, August 10, 1918. No. 26,090. Near the base of a wooded beech slope about one and one-half miles west of Stanford. Monroe County, August 9, 1918. No. 26,068. Growing on a slope with Hedeoma pulegioides and Vernonia altissima in a pasture field about three miles northeast of Bloomington. Orange County, August 14, 1918. No. 26,231. In a clover field between Paoli and Mitchell. Perry County, September 24, 1918. No. 26,735. Along a little used wagon road over the crest of a wooded sandstone ridge about eight miles southeast of Cannelton.

Andropogon Elliottii Chapman.

Clark County, October 30, 1918. No. 26,865. On the Forest Reserve in forest tract No. 16, near the border of the tract which borders the wooded slope of the "knobs."

Panicum yadkinense Ashe.

Perry County, June 4, 1918. No. 25,101. In Section 22 of Union Township at the base of a black oak slope, associated with Hydrophyllum macrophyllum, Tradescantia virginiana, etc.

Zizania aquatica L.

Lagrange County, August 30, 1914. No. 15,045. In Pigeon River about two miles east of Ontario. The base of the plant in water. Steuben County, August 19, 1916. No. 20,913. In shallow water on the north side of Lime Lake. This is the Zizania aquatica of Linnaeus, not of Authors.

Muhlenbergia glabriflorus Scribn.

Posey County, September 21, 1918. No. 26,645. Low, flat woods on the south side of Half Moon Pond, which is about ten miles southwest of Mount Vernon.

Sporobolus canovirens Nash.

Elkhart County, September 13, 1918. No. 26,362. On a sandy knoll along the roadside two and a half miles east of Bristol. Associated with Andropogon scoparius, etc.

Agrostis Elliottiana Schultes.

Floyd County, May 31, 1917. No. 23,298. In an alfalfa field along the Ohio River about six miles west of New Albany. Lawrence County, May 16, 1918. No. 24,808. About a quarter mile east of Tunnelton in an open woods pasture on an exposed point of the high bluff of White River. Associated with Sagina decumbens, Rumex Acetosella, Poa pratensis, etc.

Poa autumnalis Muhl.

Clark County, May 11, 1913. No. 12,706. On the Forest Reserve in a wooded ravine just north of forest tract No. 28. Jackson County, May 15, 1918. No. 24,762. Growing in the shade in a flat woods about five miles southwest of Seymour. Associated with Fagus, Liquidamber, Nyssa sylvatica, Quercus Michauxii (Gray's Manual, 7th ed.), etc. Jennings County, May 14, 1918. No. 24,748. In a flat woods about seven miles south of Vernon. In low ground with Fagus, Liquidamber, Impatiens biflora, Podophyllum, etc.

Bromus commutatus Schrad.

Warrick County, June 11, 1918. No. 25,308. Common on the sandy bank of the Ohio River about one and a half miles east of Newburg.

Scleria oligantha Michx.

Perry County, June 3, 1918. No. 25,069. Frequent over a small area on the dry, wooded slope of a spur of the sandstone ridge about eight miles southeast of Cannelton. Associated with Quercus velutina, Fagus, Fraxinus biltmoreana, Acer saccharum, etc.

Carex hormathodes var. Richii Fernald.

Harrison County, June 4, 1917. No. 23,417. In a swampy woods one and a quarter miles east of Palmyra. Associated with Carex Buxbaumii, Carex lanuginosa, etc.

Carex Shriveri Britt.

Whitley County, June 19, 1917. No. 23,704. Moist, sandy shore of the north side of New Lake, about ten miles northwest of Columbia City.

Carya alba subcoriacea Sarg.

Posey County, September 20, 1911. No. 10,182. A large tree on the east bank of the Cypress Swamp, about thirteen miles southwest of Mount Vernon.

Carya Buckleyi arkansana Sarg.

Knox County, August 28, 1915. No. 18,232. In the Knox sand on the ridge just east of what was formerly a cypress swamp, at Vollmer, or about two miles north of Decker.

Carya ovalis var. obcordata, forma vestita Sarg.

Knox County, October 5, 1917. No. 24,144. A very large tree in a low woods bordering Dan's Pond, which is 14.3 miles southwest of Decker.

Rynchospora corniculata (Lam.) Gray, var. interior Fernald.

Harrison County, October 13, 1916. No. 22,407. In a swampy woods one and a quarter miles east of Palmyra. Associated with Carex louisianica, etc.

Polygonum exsertum Small.

Greene County, October 2, 1917. No. 24,082. In low ground at the edge of a field where it borders Horseshoe Pond, about three miles southeast of Lyons. Associated with Chamaesyce Preslii, Eupatorium serotinum, Cyperus sp., etc.

Calycocarpum Lyoni (Pursh) Nutt.

Posey County, October 13, 1917. No. 24,323. Wooded border of a slough about twelve miles southwest of Mount Vernon. Also noted as common on the wooded bank of the east side of the cypress swamp about thirteen miles southwest of Mount Vernon. Spencer County, June 8, 1918. No. 25,210. In anthesis at this time. A common vine in a slough about six miles southwest of Rockport, climbing trees and shrubs to a height of eight to twelve feet. Noted also in Perry County about eight miles southeast of Cannelton, but no specimen was preserved.

Barbarea verna (Mill.) Aschers.

Jefferson County, May 1, 1918. No. 24,582. Frequent along the roadside and rocky adjoining bluff of the Ohio River about two miles west of Madison.

Crataegus arduennae Sargent.

Allen County, May 31, 1915. No. 15,834. A large tree on the south bank of the St. Mary's River just south of Fort Wayne.

Crataegus conjuncta Sargent.

Wells County, May 12, 1915. No. 15,625. On the border of a pond in a white oak woods on the south side of the lake in Jackson Township.

Crataegus Dodgei Ashe.

Lagrange County, May 17, 1915. No. 15,662. Roadside, about one mile northwest of Howe. Wells County, May 12, 1915. No. 15,624. A tree ten feet high and one and a quarter inches in diameter breast-high on the border of a pond in a white oak woods on the south side of the lake in Jackson Township.

Rubus Baileyanus x Enslenii.

Vanderburg County, May 10, 1917. No. 22,894. In clay soil on the slope of a roadside cut about one mile west of Darmstadt.

Lathyrus latifolius L.

Lawrence County, August 13, 1918. No. 26,215. In the vicinity of the site of the former dwelling house and in the deep adjoining woods on the Donaldson farm, about three miles southeast of Mitchell. There has been no dwelling here for at least fifteen years, and the plant has spread into the orginal forest, where several large colonies were noted. It is to be noted that Vinca minor has invaded the original forest here and forms a complete mat over several acres and is fast spreading in the dense forest.

Viola hirsutula x missouriensis.

Clark County, May 30, 1917. No. 23,261. On the slopes of a wooded ridge two miles northwest of Bennettsville. Associated with Quercus Prinus (Gray's Man., 7th ed.), Quercus velutina, Quercus alba, Pinus virginiana, Houstonia caerulea, etc. Prefers to grow in hard clay in exposed places.

Viola missouriensis Greene.

Clark County, May 30, 1917. No. 23,261. On a wooded slope two miles northwest of Bennettsville, associated with the preceding. Daviess County, May 3, 1917. No. 22,667. In a low, flat woods one mile west of Plainville. Also along the roadside six miles southeast of Elnora. Gibson County, May 6, 1917. No. 22,809. In a low, flat woods three miles northwest of Patoka. Greene County, May 2, 1917. No. 22,654. In alluvial soil along a creek four miles northwest of Bloomfield. Knox County, May 6, 1917. No. 22,741. In a low woods on the border of Claypole Pond about eleven miles southwest of Decker. Associated on the border of Claypole Pond with Quercus palustris, Ulmus americana, Liquidamber, Phlox divaricata, etc. Owen County, May 1, 1917. No. 22,622. Alluvial bank of Eel River on the road between Coal City and Worthington. Vigo County, May 12, 1917. No. 22,934. Alluvial soil along the bank of Wabash River, three miles west of Prairieton.

Viola missouriensis x sororia.

Knox County, May 3, 1917. No. 22,681. In a sandy black and white oak woods two miles east of Bicknell. Also taken in a sandy black and white oak woods four miles southeast of Vincennes. Sullivan County, May 11, 1917. No. 22,913. In a wooded creek bottom two miles west of Sullivan. Tippecanoe County, May 16, 1917. No.

23,061. Frequent on the white oak slope of the Wabash River terrace just north of the Soldiers' Home. Vanderburg County, May 10, 1917. No. 22,895. In a black and white oak woods one mile west of Darmstadt.

Viola missouriensis x triloba.

Daviess County, May 3, 1917. No. 22,679. Low woods one mile west of Plainville. Abundant here and associated with Ulmus americana, Betula nigra, Quercus bicolor, Phlox divaricata, Claytonia virginica, Cardamine bulbosa, etc. Greene County, May 2, 1917. No. 22,640. Associated with oak at the top of a beech slope about ten miles southeast of Bloomfield. Also in a sandy woods one mile north of Newberry. Associated with Fagus, Sassafras, Quercus alba, Quercus velutina, Podophyllum, Polygonatum biflorum, etc. Knox County, May 6, 1917. No. 22,733. In a low woods bordering Claypole Pond, about eleven miles southwest of Decker. Lawrence County, June 8, 1917. No. 23,556. In an old fallow field about three miles southeast of Mitchell. Associated with Rubus Enslenii, Panicum commutatum, Sassafras, etc.

Viola riarum Pollard.

Knox County, May 6, 1917. No. 22,719. In moist, sandy soil along the railroad, about four miles south of Vincennes. Closely associated with Viola affinis and Viola sororia.

Decodon verticillatus laevigatus T. & G.

Jackson County, August 16, 1913. No. 14,025. In a bog about a half mile south of Chestnut Ridge. Lagrange County, August 29, 1914. No. 14,979. On the west shore of Twin Lakes. Lake County, August 23, 1915. On the east shore of Cedar Lake. Owen County, September 22, 1917. No. 23,874. On the shore of Stogdill Pond, about four miles southeast of Spencer.

Oenothera triloba Nutt.

Jefferson County, May 1, 1918. No. 24,580. Common on a washed, sterile, sparsely wooded slope of the bluff of the Ohio River just east of Madison. Associated with Opuntia Rafinesque, Plantago virginica, etc. A specimen of this species was sent me from Washington County in June, 1917, from near Salem, by W. H. Rudder. Oenothera triloba parviflora Wats. was reported in Coulter's Catalogue for Blatchley from Monroe County, but Blatchley's original manuscript of the flora of Monroe County does not give this species, but does give Oenothera biennis parviflora. In Coulter's Catalogue the species was reported under a revised nomenclature, and it is believed an error was made in transferring it. Therefore it is here proposed to drop from our flora Oenothera triloba var. parviflora, which is as yet known only from the area west of the Mississippi.

Oxydendrum arboreum (L) DC.

Perry County, June 3, 1918. No. 25,071. A few trees on the lower slope of a beech-sugar maple spur of the sandstone wooded ridge about eight miles southeast of Cannelton. The largest tree was about six inches in diameter breast-high and about forty feet high. This species was closely associated with Fagus, Cornus florida, Nyssa sylvatica, etc.

Styrax americana Lam.

Posey County, June 15, 1918. No. 25,420. Frequent in a swampy place in a flat woods about ten miles southwest of Mount Vernon. A shrub four to six feet high. Associated with Cephalanthus occidentalis and the next.

Trachelospermum difforme (Walt.) A. Gray.

Posey County, June 15, 1918. No. 25,442. A vine climbing a button-bush to a height of six feet, in a swampy place in a low, flat woods about ten miles southwest of Mount Vernon. Closely associated with the last. This plant was detected by the fragrance of its flowers, which could easily be smelled for a rod distant.

Myosotis micrantha Pallas.

Parke County, May 24, 1918. No. 25,037. A common weed about the Administration Building in Turkey Run State Park.

Hedeoma hispida Pursh.

Putnam County, June 24, 1915. No. 1,094. Collected by Earl J. Grimes in a barren pasture field four miles east of Russellville. Uncommon.

Linaria minor (L.) Desf.

Vigo County, July 5, 1918. No. 25,791. Frequent in ballast along the Vandalia Railroad at the Haeckland switch, about four miles southeast of Atherton.

Veronica Tournifortii Gmelin.

Wells County, July 16, 1917. No. 23,761. Common in the lawn of Geo. T. Kocher on South Main street, Bluffton. Also common in a lawn on East Cherry street, Bluffton. This weed was kept under observation in 1918, and it appears that the lawn mower does not stop its progress, and it should be regarded as an aggressive weed.

Utricularia cleistogama (Gray) Britt.

This record was founded on a sheet in the Schneck herbarium which is now in my herbarium. I had the specimen examined by Dr. J. H. Barnhart, a specialist on this genus, and he says it is Utricularia gibba; that it is small and depauperate because it developed late in the season. It is here proposed to drop this species from our flora.

Lonicera japonica Thunb.

Clark County, September 7, 1915. No. 18,770. Roadside half a mile south of Charleston. In this county, near Sellersburg, this species was noted where it had invaded a clearing and had formed a complete mat over an acre. It climbed all of the shrubs of the area and was bending them down. This vine is already recognized in several counties as a great pest. Floyd County, June 8, 1913. No. 13,216. Common along the roadside about three miles west of New Albany. Jefferson County, May 28, 1911. Frequent on the rocky bluffs of the Ohio River between Madison and North Madison. Perry County, May 19, 1918. No. 24,910. Sandy roadside two and a half miles north of Tobinsport. A veritable pest here. Posey County, July 5, 1915. No. 16,852. Roadside one mile northeast of Poseyville.

Aster macrophyllus var. ianthinus (Burgess) Fernald.

Clark County, September 12, 1917. No. 23,794. On a white oak ridge on the Forest Reserve.

Eupatorium incarnatum Walt.

Perry County, September 24, 1918. No. 26,732. Along a woods road over the crest of the wooded sandstone ridge about eight miles southeast of Cannelton. Noted also near a spring at the base of the bluffs of the Ohio River about six miles east of Cannelton.

Taraxicum erythrospermum Anderz.

I thought this species had been reported many years ago, but I find no mention of it. It no doubt is found in lawns and fields in all parts of the State. I have specimens from the following counties: Grant County, May 23, 1916. No. 19,804. Roadside nine miles east of Marion. Huntington County, May 24, 1916. No. 19,774. Common in an open woods pasture two miles south of Mount Etna. Jasper County, May 8, 1916. No. 19,419. Abundant along the Pennsylvania Railroad about two miles east of Goodland. Newton County, May 8, 1916. No. 19,397. Frequent in a blue-grass pasture about one and a half miles east of Brook. Noble County, May 12, 1916. No. 19,624. Moist, sandy shore of the east side of Diamond Lake. Porter County, May 10, 1916. No. 19,496. In sandy soil along roadside two and a half miles south of Valparaiso. Randolph County, May 16, 1916. No. 19,630. Abundant in beech woods pasture five miles north of Winchester. St. Joseph County, May 10, 1916. No. 19,548. Along roadside eight miles west of South Bend. Wells County, May 23, 1916. No. 19,814. In an open woods about three miles south of Mount Zion. Noted also in many places in the county and very common in lawns. In many places it is more common than the other species of dandelion, especially in sandy soil.

Analyses of One Hundred Soils in Allen County, Indiana.

R. H. Carr and V. R. Phares, Purdue University.

The soils of Indiana present about as varied types and are as different in fertility as any that can be found. They include such famous areas as the sand dunes about Valparaiso, the peppermint fields of Mishawaka, and the limestone country about Bedford. There is quite a difference in soils not only between neighboring counties but even between adjacent farms, differences which the casual observer seldom notices, because to him all soils look alike and are "just dirt."

Calling the "Soil Doctor."

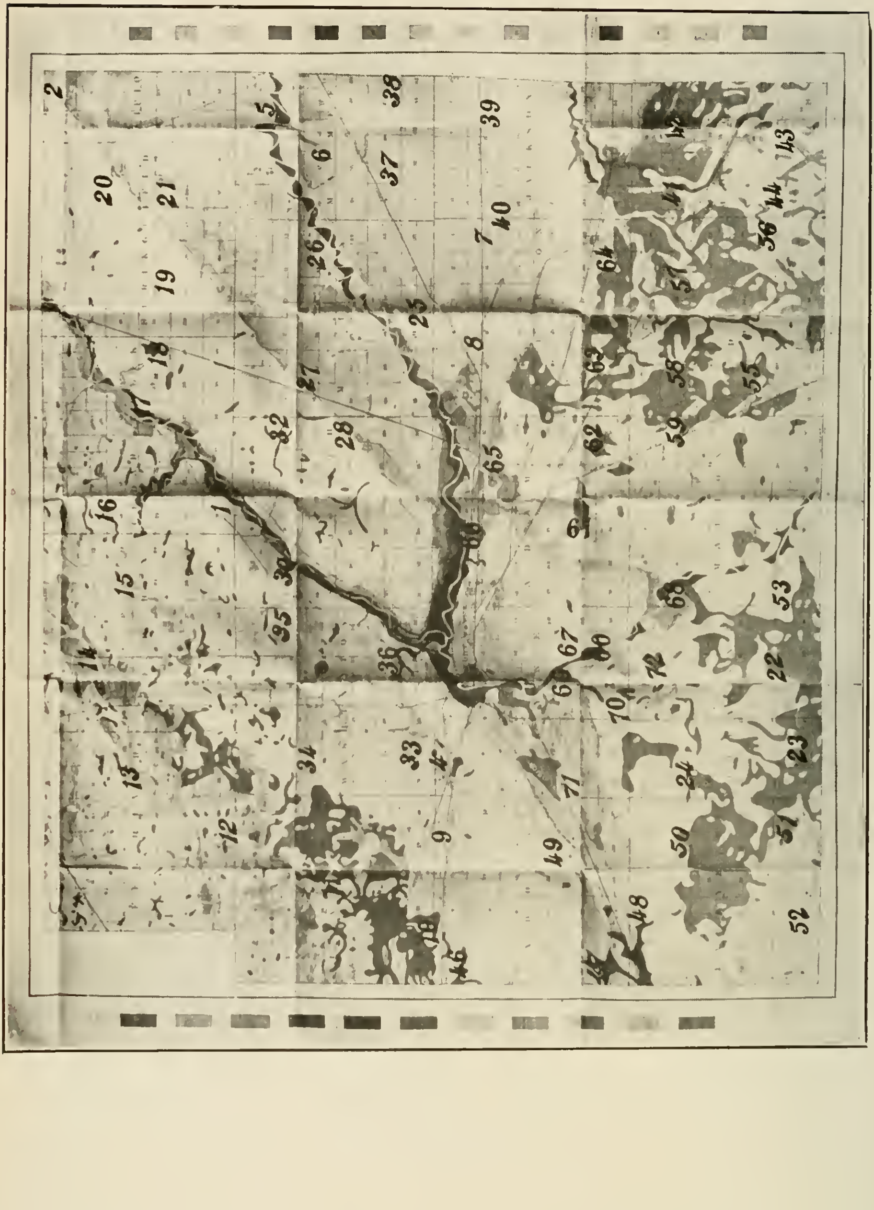
Soils are usually studied only after a series of failures of wheat, clover, etc., and the question naturally arises, "Why can I not grow crops like father used to?" It is at this stage of the soil's depletion that the "soil doctor" is called often to prescribe for the sick soil. The ability of the doctor to diagnose the case through analysis has been overestimated somewhat in the popular mind. Nevertheless it usually gives the best answer as to why the wheat or clover failed to do well. Of all the soils investigated in this county by the writers, it was found that, where the physical conditions permitted, the crop yield was closely related to the amount of organic matter and plant food present, as shown in the graphs which follow.

Value of Soil Analysis.

One reason for the questioning by many scientific men the value of analysis as a means of measuring fertility, is the varying results in pot and field work and the inability to correlate or interpret the results with the known composition of the soil. The conflicting results are often due to artificial surrounding conditions or to the use of seed of variable vitality, etc. Hence it was the purpose of this investigation to visit the growing plant, especially corn, in its natural home and there seek the reason of its good growth or the cause of its failure.

Plan of Investigation.

All the soils studied were secured in Allen County. They are of glacial origin, 70% belonging to the Miami series and 18.5% to the



Soil Map, Allen County, Indiana.

Clyde series. The samples, 100 in all, were taken from all parts of the county and from the various soil types. Many conditions were noted when the samples were taken (September, 1917), as the condition of the crops, prevalent weeds, trees, etc. Information as to the use of lime fertilizer, crop yield, was obtained from the man in charge of the farm. The following data was obtained by analysis: First, amount of volatile organic matter; second, per cent of phosphorus; third, per cent of nitrogen; fourth, presence of carbonates and acidity of the soil to litmus paper. The data from these soils is recorded in the tables which follow:

Discussion of Tables.

It will be noticed from the tables that there are many soils of this county quite high in organic matter, only 11% being below 4%, while 45% range from 4 to 7%; 37% range from 7 to 15%, and 6% are above that amount. It might be expected that this high organic content would carry a considerable amount of nitrogen, and this was found to be the case. Every per cent of increase in organic matter carried with it an increase of 519 pounds of nitrogen and 72 pounds of phosphorus per acre. This is much less phosphorus than is to be expected in these soils, and in most cases they would respond profitably to an application of that fertilizer. It is shown in Charts 1 and 2 that nitrogen has more to do with high corn yield than phosphorus. There is a serious lack of calcium carbonates in over half of the soils tested; 55% are acid to litmus. This condition makes a good clover stand nearly impossible and is the main cause of "clover sickness" frequently reported.

TABLE I.

Organic Matter 0 to 4%. Nitrogen and Phosphorus Content.

Sample No.	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nitrogen	Lbs. per Acre	Per Cent. Phosphorus	Lbs. per Acre
25	2.19	43,800	.0714	1,428	.0827	1,654
3°	4.00	80,000	.1834	3,668	.0781	1,562
35°	1.66	33,200	.2226	4,452	.0660	1,320
14°	1.75	35,000	.2002	4,004	.0946	1,892
16°	3.40	68,000	.1106	2,212	.0410	1,820
17°	4.00	80,000	.2122	4,244	.0990	1,978
235	3.81	76,200	.0840	1,680	.0754	1,508
27°	3.66	73,200	.1414	2,828	.0722	1,444
285	4.01	80,200	.0980	1,960	.0930	1,860
45°	3.72	74,400	.2525	5,050	.0740	1,480
475°	3.47	69,400	.2240	4,480	.0800	1,600
		68,433		3,667		1,696 ave.

This group constitutes 11% of total.
°—Acid condition.

TABLE II.

Organic Matter 4 to 5%. Nitrogen and Phosphorus Content of This Group.

Sample No.	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nitrogen	Lbs. per Acre	Per Cent. Phosphorus	Lbs. per Acre
1°	4.56	91,200	.1792	3,584	.0822	1,644
7s	5.04	100,000	.1064	2,128	.0647	1,294
11°	4.70	94,000	.4270	8,540	.0585	1,170
13	4.80	96,000	.2534	5,064	.1131	2,262
19s°	4.29	85,800	.3038	6,076	.0552	1,104
26s	4.97	99,400	.0602	1,204	.0808	1,616
32°	4.91	98,200	.1570	3,140	.0848	1,696
33	4.53	90,600	.1428	2,856	.0808	1,616
35°	4.91	98,200	.2030	4,060	.0849	1,698
36°	4.11	82,200	.1470	2,940	.0808	1,616
37s	4.91	98,200	.1498	2,996	.0808	1,616
41s°	4.43	88,600	.1939	3,878	.0740	1,480
56s°	4.78	95,600	.1386	2,772	.0657	1,314
65s	4.75	95,000	.0798	1,596	.0983	1,966
14s°	4.03	80,600	.0900	1,800	.0552	1,104
		92,914		4,312		1,671 ave.

s—Subsoil. This group constitutes 15% of total.
°—Acid condition.

TABLE III.

Organic Matter 5 to 6%. Nitrogen and Phosphorus Content of Group.

Sample No.	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nitrogen	Lbs. per Acre	Per Cent. Phosphorus	Lbs. per Acre
9°	5.49	109,800	.1624	3,248	.0754	1,508
15	5.17	103,400	.2688	5,376	.0768	1,536
18°	5.72	114,400	1909	3,818	.0916	1,832
20°	5.20	104,000	.1764	3,528	.0935	1,870
31°	5.21	104,200	.1796	3,592	.0889	1,778
34°	5.57	111,400	.1746	3,482	.0795	1,590
35s°	5.60	112,000	.2058	4,116	.0687	1,374
38s	5.22	104,400	.1232	2,464	0970	1,940
62°	5.04	100,800	.2366	4,732	.0949	1,898
64s	5.14	102,800	.1274	2,548	.1360	2,720
67°	5.41	108,200	.1092	2,184	.1104	2,204
67s	5.21	104,200	.0952	1,904	.1063	2,126
44°	5.91	118,200	.1890	3,780	.0957	1,914
53	5.46	109,200	.3052	6,104	.1582	3,164
25°	5.23	104,600	.1820	2,640	.0808	1,616
		108,018		3,658		1,764 ave.

s—Subsoil. This group constitutes 15% of total.
°—Acid condition.

TABLE IV.

Organic Matter 6 to 7%. Nitrogen and Phosphorus Content of Group.

Sample No.	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nitrogen	Lbs. per Acre	Per Cent. Phosphorus	Lbs. per Acre
2°	6.08	121,600	.2226	4,452	.1147	2,294
9s	6.33	126,600	.1008	2,016	.0741	1,482
23°	6.25	125,000	.2184	4,368	.1066	2,132
26°	6.99	139,800	.0644	1,288	.1082	2,164
60s°	6.49	129,800	.2100	4,200	.0902	1,804
62s°	6.06	121,200	.1848	3,696	.0687	1,374
64	6.00	120,000	.1694	3,388	.1360	2,720
70°	6.93°	138,600	.1484	2,968	.1010	2,020
41	6.63	132,600	.3164	6,328	.0701	1,402
43°	6.62	132,400	.2254	4,508	.2760	5,520
43s°	6.89	137,800	.0840	1,680	.0625	1,250
51°	6.95°	139,000	.1890	3,780	.0943	1,886
52°	6.77°	135,400	.1512	3,024	.1010	2,020
55	6.10	122,000	.2380	4,760	.1002	2,004
61°	6.39	127,800	.2212	4,424	.0833	1,266
		130,309		3,935		2,312

s—Subsoil. This group constitutes 15% of total.
°—Acid condition.

TABLE V.

Organic Matter 7 to 9%. Nitrogen and Phosphorus Content of Group.

Sample No.	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nitrogen	Lbs. per Acre	Per Cent. Phosphorus	Lbs. per Acre
7°	7.19	143,800	.3136.	6,270	.0016	1,832
19	7.37	147,400	.2828	5,656	....	....
21	7.46	149,200	.2590	5,180	.1065	2,130
28°	7 45	149,000	.2576	5,152	.0983	1,966
65°	7.63°	152,600	.1974	3,948	.1320	2,640
49°	7.78°	155,600	.2766	5,532	.0746	1,492
50	7.07°	141,400	.2100	4,200	.0956	1,912
8	8.79	175,800	.3094	6,188	.0867	1,734
4s	8.67	173,400	.2026	4,052	.1119	2,238
47	8.57°	171,400	.3220	6,440	.1015	2,030
52s	8.84°	176,800	.0826	1,652	.0741	1,482
54s	8.97°	179,400	.1604	3,208	.0680	1,360
56	8.46°	169,200	.2716	5,432	.0956	1,912
70s	8.63	172,600	.0840	1,680	.0875	1,750
72s	8.18°	163,600	.0826	1,652	.0875	1,750
22°	8.29	165,800	.2926	5,852	.1441	2,882
24°	8.28	165,600	.2226	4,452	.1199	2,398
29	8.57	171,400	.2828	5,656	.0983	1,966
		158,323		5,366		2,074 ave.

s—Subsoil. This group constitutes 18% of total.
°—Acid condition.

TABLE VI.

Organic Matter 9 to 11%. Nitrogen and Phosphorus Content.

Sample No.	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nitrogen	Lbs. per Acre	Per Cent. Phosphorus	Lbs. per Acre
5°	9.62	192,400	.3127	6,254	.1322	2,644
6	9.10	182,000	.3746	7,492	.0970	1,940
39	9.60	192,000	.2940	5,880	.1227	2,454
54	9.29	195,800	.2912	5,824	.1536	3,072
38	9.90	198,000	.3312	6,624	.1146	2,292
4	10.32	206,400	.5012	10,024	.1359	2,718
57°	10.00	200,000	.3808	7,616	.1110	2,220
60	10.34	206,800	.3038	6,076	.1150	2,300
72	10.44	208,800	.1876	3,752	.1027	2,054
50s	10.10	202,000	.1218	2,435	.0647	1,294
		196,911		6,615		2,410 ave.

s—Subsoil. This group constitutes 10% of the total.
°—Acid condition.

TABLE VII.

Organic Matter 11 to 15%. Nitrogen and Phosphorus Content.

Sample No.	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nitrogen	Lbs. per Acre	Per Cent. Phosphorus	Lbs per Acre
40	11.07	221,400	.3780	7,560	.1165	2,330
48	11.07	221,400	.1386	2,772	.1038	2,076
66	11.15	223,000	.2562	5,124	.1027	2,054
58	12.07	241,400	.2786	5,572	.0916	1,832
63°	12.21	244,200	.2968	5,936	.1388	2,776
10s	12.62	252,400	.3248	6,496	.0983	1,966
59	12.86	257,200	.3858	7,716	.1616	3,232
46	13.65	273,000	.4998	9,996	.2810	5,620
30	14.26	285,200	.4284	8,568	.1145	2,290
		245,850*		6,655		2,779 ave.

s—Subsoil. This group constitutes 9% of total.
*—1,000,000 lbs. per acre $6^2{}_3$ ins.
°—Acid condition.

TABLE VIII.

Organic Matter from 15 to 79%. Nitrogen and Phosphorus Content of Group.

Sample No.	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nitrogen	Lbs. per Acre	Per Cent. Phosphorus	Lbs. per Acre
69s	17.80	356,000	.0596	1,192	.1037	2,074
10	21.45	429,000	.4656	9,312	.1065	2,130
69	24.82	496,400	.6496	12,992	.1621	3,242
71	66.86	668,600	.5936	5,926	.1017	1,017
12	70.36	703,600	.9184	9,184	.1555	1,555
71s°	78.25	782,500	.4172	4,172	.0855	855
		574,400*		9,356		1,986

s—Subsoil. This group constitutes 6% of total.
*—1,000,000 lbs. per acre $6^2{}_3$ ins.
°—Acid condition.

Plate I

Relation of Nitrogen to Crop Yield

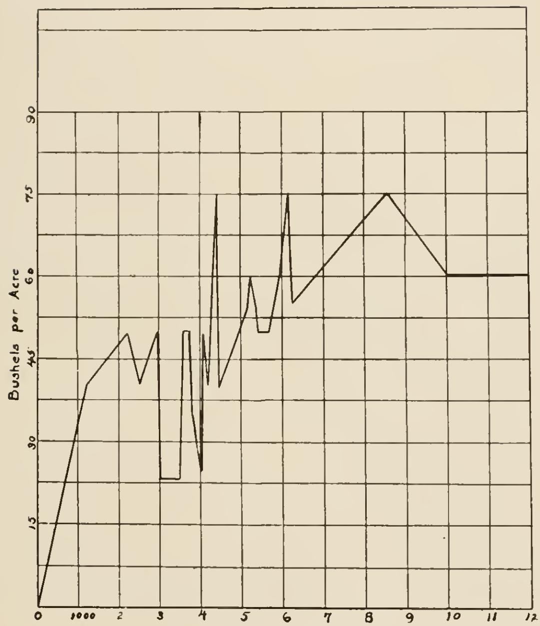


Plate II

Relation of Phosphorus to Crop Yield

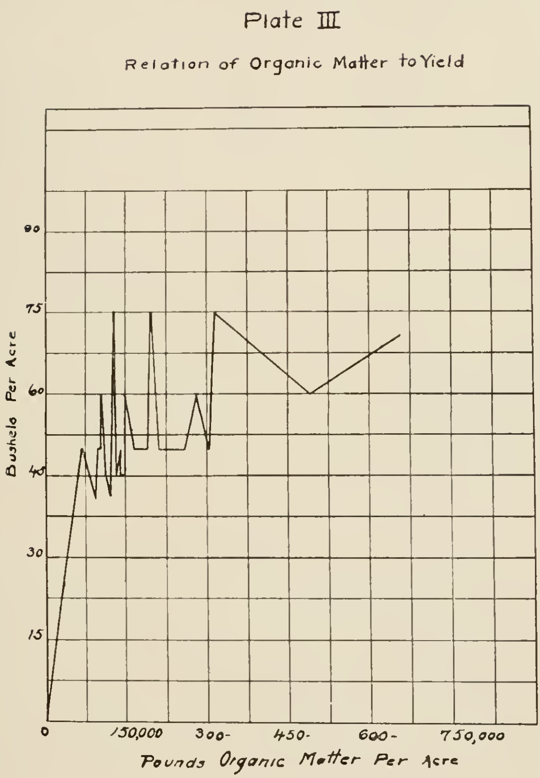


Plate III
Relation of Organic Matter to Yield
Bushels Per Acre
90
75
60
45
30
15
0
150,000
300-
450-
600-
750,000
Pounds Organic Matter Per Acre

The Relation of Nitrogen, Phosphorus and Organic Matter to Corn Yield in Elkhart County, Indiana.

R. H. Carr and Leroy Hoffman, Purdue University.

The fertility of the soil is so closely related to the progress of a community that any considerable increase in the productiveness of the soil from any cause is reflected in greater community prosperity. It is therefore important to study the soil and its needs.

Invoice of the Soil.

Just as an invoice of the stock of goods in a store aids the merchant in estimating his resources, so an invoice of the plant food in the soil enables the farmer to get a rating of his possible crop yield and enables him to plan intelligently for future soil improvement. A supply of plant food does not necessarily insure a good crop yield, as there are present sometimes counteracting conditions. Examples of such are found in Samples 1, 10 and 51. But these are usually evident, and the data to be presented shows that crops are generally produced where there is present sufficient plant food.

Release of the Soil's Food Supply.

The soil is composed of small fragments of rock particles mixed with more or less organic matter in various stages of decay. Only a small part of the plant food in the rock particles is available at any time. It is thought that the food elements contained in these rock particles alone, are not liberated fast enough from year to year to produce a paying crop. This is not so, however, with that stored in organic matter, especially the fresh organic matter, which not only releases its plant food rather rapidly, through bacterial action, but also aids materially in freeing that tied up in the rock particles of the soil. In view of this important part played by soil organic matter, it was thought best to classify all soils collected according to the amount of organic matter they contained.

Plan of Invoicing.

The samples of soil (total 57) from eleven soil types were collected late in September, 1917, in order to estimate more accurately the possible corn yield of that year. Much data was obtained relative to fertilizer treatment, kinds of weeds prevalent, the use of limestone, and especially the approximate crop yield as estimated by the man in charge of the farm. The following determinations were made on soil samples: First, total organic matter; second, total nitrogen; third, total phosphorus; fourth, presence of carbonates and acidity to litmus paper. The tables which follow will give a partial composition in per cent and pounds per acre (6.66 ins. 2,000,000 lbs.), together with the yield of corn per acre where the samples were secured:

TABLE I.

Content of Nitrogen, Phosphorus and Acre Yield. 0 to 2% Organic Matter.

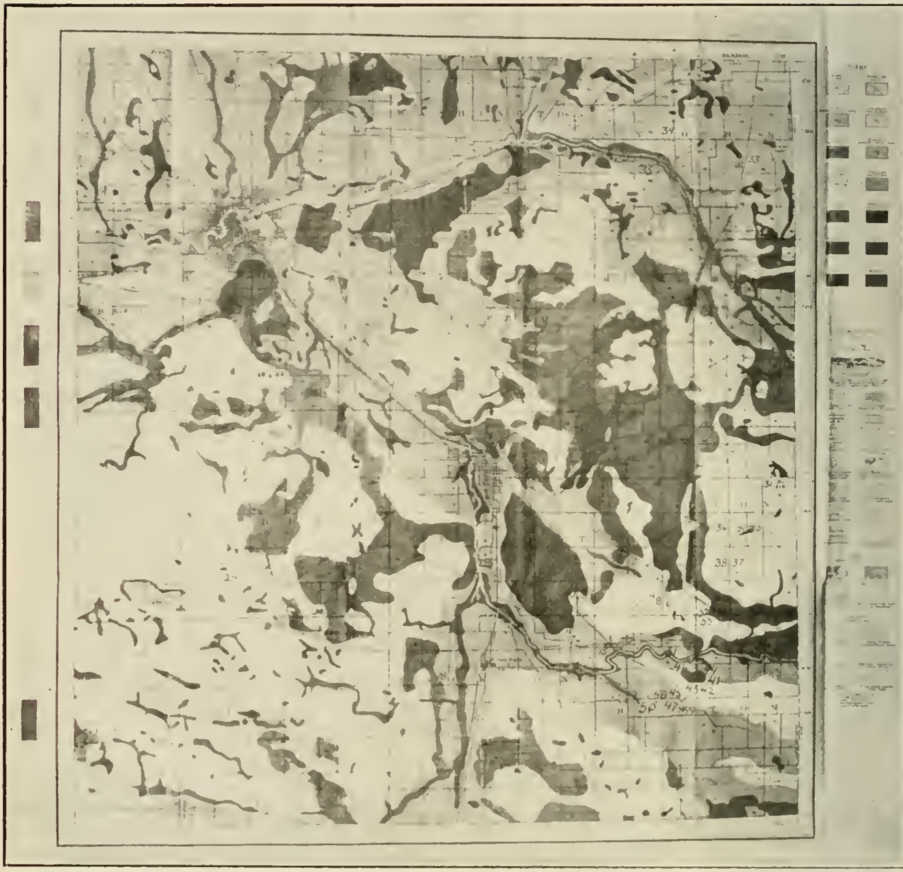
Sample No.	Bushels of Corn	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nit.	Lbs. per Acre	Per Cent. Phos.	Lbs. per Acre
32	18	1.75	35,000	.095	1,910	.062	1,242
33	0	1.32	26,400	.070	1,400	.079	1,580
34	0	.99	19,800	.039	785	.073	1,460
35	10	1.47	29,400	.030	612	.116	2,322
	14		27,650		1,177		1,651 ave.

TABLE II.

Content of Nitrogen, Phosphorus and Acre Yield. 2 to 4% Organic Matter.

Sample No.	Bushels of Corn	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nit.	Lbs. per Acre	Per Cent. Phos.	Lbs. per Acre
2x	30	2.53	50,600	.105	2,100	.210	4,212
13x	40	3.12	62,400	.113	2,267	.098	1,960
14	25	3.36	67,200	.110	2,204	.135	2,700
16x	25	3.25	65,000	.101	2,030	.078	1,566
15x	35	3.62	72,400	.140	2,800	.089	1,782
18	40	3.48	69,600	.105	2,100	.108	2,160
26x	35	3.30	66,000	.091	1,820	.012	2,056
27xs	....	2.58	51,600	.073	1,466	.124	2,480
35v	....	2.51	50,200	.066	1,330	.135	2,700
39x	40	3.67	73,400	.105	2,100	.129	2,592
56	15	2.23	44,600	.087	1,750	.480	2,970
5vs	....	3.79	75,800	.157	3,150	.132	2,656
	32.5		62,400		2,093		2,486 ave.

x—Soil acid.
v—Virgin soil.
s—Subsoil.



Reproduction of Soil Map made by U. S. Bureau of Soils of Elkhart County, showing areas of different type and places where samples were taken.

TABLE III.

Content of Nitrogen, Phosphorus and Acre Yield. 4 to 5% Organic Matter.

Sample No.	Bushels of Corn	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nit.	Lbs. per Acre	Per Cent. Phos.	Lbs. per Acre
3	40	4.63	92,600	.140	2,800	.135	2,700
9s	....	4.03	80,600	.077	1,540	.095	1,906
12	20	4.73	94,600	.108	2,160	.113	2,268
25x	35	4.53	90,600	.152	3,050	.116	2,322
40x	40	4.46	89,200	.140	2,800	.243	4,860
45x	30	4.08	81,600	.098	1,860	.078	1,586
46x	50	4.89	97,800	.124	2,485	.113	2,278
47x	30	4 70	94,000	.150	3,000	.086	1,728
53	....	4.53	90,600	.098	1,960	.107	2,140
54	40	4.10	82,000	.097	1,942	.103	2,060
	35.5		89,360		2,359		2,385 ave.

x—Acid soil.
s—Subsoil.

TABLE IV.

Content of Nitrogen, Phosphorus and Acre Yield. 5 to 6% Organic Matter.

Sample No.	Bushels of Corn	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nit.	Lbs. per Acre	Per Cent. Phos.	Lbs. per Acre
4	35	5.20	104,000	.161	3,220	.221	4,428
5x	35	5.45	109,000	.100	2,000	.099	2,000
17v	....	5.08	101,600	.186	3,720	.108	2,160
24	40	5.94	118,800	.141	2,834	.121	2,430
36x	0	5.71	114,200	.098	1,960	.129	2,592
41x	50	5.75	115,000	.122	2,450	.162	3,240
49	60	5.85	117,000	.175	3,450	.189	3,780
50	30	5.75	115,000	.129	2,580	.421	4,212
52	....	5.01	100,200	.119	2,380	.087	1,755
55	45	5.90	118,000	.144	2,880	.119	2,380
	42.14		111,280		2,748		2,898 ave.

x—Acid soil.
v—Virgin soil.

TABLE V.

Content of Nitrogen, Phosphorus and Acre Yield. 6 to 8% Organic Matter.

Sample No.	Bushels of Corn	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nit.	Lbs. per Acre	Per Cent. Phos.	Lbs. per Acre
6	50	7.20	144,000	.210	4,200	.145	2,916
7	75	7.05	141,000	.252	5,040	.272	5,454
8	35	7.10	142,000	.171	3,420	.094	1,890
10x	15	6.60	132,000	.157	3,140	.105	2,106
22x	40	6.87	137,400	.157	3,150	.183	3,672
29x	15	6.13	122,600	.098	1,969	.094	1,880
30v	....	7.02	140,400	.119	2,380	.113	2,278
37x	45	6.10	122,000	.132	2,650	.188	3,760
38	30	6.12	122,400	.165	3,305	.097	1,944
42	55	7.39	147,800	.192	3,840	154	2,916
1x	0	7.46	149,200	.260	5,200	.270	5,400
31x	35	7.06	141,200	.140	2,800	.143	2,862
48	40	7.11	142,200	.210	4,200	.124	2,482
	40.45		137,200		3,484		3,043 ave.

x—Acid soil.
v—Virgin soil.

TABLE VI.

Content of Nitrogen, Phosphorus and Acre Yield. 8 to 10% Organic Matter.

Sample No.	Bushels of Corn	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nit.	Lbs. per Acre	Per Cent. Phos.	Lbs. per Acre
11x	65	8.52	170,400	.218	5,260	.116	2,322
21	80	8.37	167,400	.252	5,040	.216	4,320
23	55	8.35	167,000	.226	4,524	.197	3,942
	66.6		168,230		4,941		3,528 ave.

x—Acid soil.

TABLE VII.

Content of Nitrogen, Phosphorus and Acre Yield. 10 to 15% Organic Matter.

Sample No.	Bushels of Corn	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nit.	Lbs. per Acre	Per Cent. Phos.	Lbs. per Acre
43	60	10.04	200,800	.297	5,950	.189	3,780
44	65	13.00	260,000	.267	5,346	.240	4,800
51x	0	12.54	250,800	.434	8,680	.259	5,184
	62.5		237,200		6,659		4,588 ave.

x—Acid soil.

TABLE VIII.

Content of Nitrogen, Phosphorus and Acre Yield. 15 to 85% Organic Matter.

Sample No.	Bushels of Onions	Per Cent. Organic Matter	Lbs. per Acre	Per Cent. Nit	Lbs. per Acre	Per Cent. Phos	Lbs. per Acre
19x	Onions	78.16	781,600*	2.800	28,000	.398	3,980
20x	Onions	81 18	811,800	3.010	30,100	.426	4,260
			796,700		29,050		4,120 ave.

*—Wt. muck soil, 1,000,000 lbs. per acre 6 ⅔ ins.
x—Acid soil.

Discussion of Results.

About 50% of the soils of Elkhart County are of the Miami loam and Miami sandy loam types, and about 27% are of the Plainfield sandy loam type. These soils are rather low in organic matter and 51% are acid. The crop yield as given by the man in charge of the farm and corroborated as to the possible yield when the samples were secured bears a close relation to the organic matter present, and this in turn is closely associated with the amounts of nitrogen and phosphorus present. There were only three samples—1, 10 and 51—which were exceptions to the general rule that high plant food content equals good corn yield. Sample 1 is a greenish ferrous iron soil turning brown when exposed to air on plowing. Sample 10 is a sandy soil, low in potassium. There may be other causes also for the corn on this soil turning yellow when it is about two or three feet high. The reason for the poor yield of Sample 51 has not been investigated. *Summarizing* the data in Tables 1–6, relating to plant food content and corn yield, it is noted that the difference in yield between the 0–2% and the 8–10% organic matter averages 25.6 bushels. Using this figure as a standard for organic matter increase, it is shown that on average field conditions for every increase of 2,672 pounds of organic matter, 71.6 pounds of nitrogen and 35.7 pounds of phosphorus per acre (2,000,000 pounds) there is an increase of *one bushel* of corn.

Flame Reactions of Thallium.

Jacob Papish, Purdue University.

The terms spectra of the *first* and of the *second order* were given by Plüker and Hittorf[1] to what are known now as *band* and as *line* spectra. Mitscherlich[2] proved that the *channeling* of the band spectrum is due to the existence of a compound of a metal in the flame, while the line spectrum is produced by the elementary metal. When halogen compounds of barium are introduced in the Bunsen flame they produce their own fugitive spectra, but on dissociation in the flame they all exhibit the band spectrum of barium oxide and also the λ-line (=5535.69) of the metal. Mitscherlich's work points to the fact that the final spectrum produced by a halogen salt of barium is the result of a chemical change that had been undergone by the salt in question.

The well-known luminescence of a flame charged with compounds of sodium is undoubtedly due to the existence of metallic sodium in the flame. Mendeléeff[3] arrived at this conclusion from the following experiments: If hydrochloric acid gas be introduced into a flame colored by sodium it is observed that the sodium spectrum disappears, owing to the fact that metallic sodium cannot remain in the flame in the presence of an excess of hydrochloric acid. The same thing takes place on the addition of ammonium chloride, which in the heat of the flame gives hydrochloric acid. If a porcelain tube containing sodium chloride (or sodium hydroxide or carbonate), and closed at both ends by glass plates, be so powerfully heated that the sodium compound volatilizes, then the sodium spectrum is not observable; but if the salt be replaced by sodium, then both the bright line and the absorption spectra are obtained, according to whether the light emitted by the incandescent vapor be observed, or that which passes through the tube. Thus the above spectrum is not given by sodium chloride or other sodium compound, but is proper to the metal sodium itself. If every salt of sodium, lithium and potassium gives one and the same spectrum, this must be ascribed to the presence in the flame of the free metals liberated by the decomposition of their salts.

Reference has been made from time to time to the fact that free

[1] Phil. Trans. 1885, 155.

[2] Pogg. Ann. 116, 419 (1862); 121, 459 (1863).

[3] "Principles of Chemistry", 1, 563 (1891).

carbon is found in the ordinary luminous flames[1] and that the luminescence is due to this carbon. Heumann[2] pointed out that when a feebly luminous hydrocarbon flame be charged with chlorine or with bromine, the luminosity of the flame is greatly increased. The chemical activity of chlorine and of bromine brings about the separation of carbon, which, on incandescence, increases the luminosity of the flame.

While investigating the structure of luminous flames, Smithells[3] proved that free carbon is found in the luminous portion of a hydrocarbon flame. His conclusion, which is in agreement with the view of Kersten,[4] is that the separation of carbon in a flame is due simply to the decomposition of the hydrocarbon by heat. He also asserts that the glow of carbon in the luminous region is due to the heat of its own combustion, and is increased probably by the concomitant combustion of hydrogen. Smithells[5] also succeeded in precipitating copper from a flame charged with cupric chloride.

Hodgkinson[6] obtained a deposit of sulphur from a moderate-sized sulphur flame.

Bancroft and Weiser,[7] who experimented with a number of metallic salts, proved that these salts dissociate at the temperature of the Bunsen flame, of the hydrogen-air flame and of the oxyhydrogen flame, the metals being set free.

Papish[8] investigated the behavior of compounds of selenium and of tellurium in the Bunsen flame and in the hydrogen-air flame. Elementary selenium and tellurium can be easily obtained by depressing the flames with a cold object.

In all cases mentioned above the luminescense can be traced back to the existence of an elementary substance in the flame. In some cases a particular luminescence is due to the existence or formation of a certain compound in a given zone of the flame. The work described in this paper was undertaken with the purpose of throwing more light on the nature of flame reactions in general and of the reactions of thallium in particular.

Thallous Chloride in the Bunsen Flame.—"Chemically pure" thallous chloride was distilled and redistilled in a hard glass tube. The final

[1] Hilgard: Liebig's Ann. **92**, 129 (1854); Liebig's Jahresb. 1854, 287; Landlot: Pogg. Ann. **99**, 389 (1856).

[2] Chem. Centrb. 1. 1876. 801.

[3] Jour. Chem. Soc. **51**, 223 (1892).

[4] J. prak. Chem. **84**, 290 (1861).

[5] Phil. Mag. (5) **39**, 127 (1895).

[6] Chem. News **61**, 96 (1890).

[7] Jour. Phys. Chem. **18**, 259 (1914).

[8] Ibid. **22**, 430 (1918); Ibid. p. 640.

product, which consisted of fine crystals, fused to a clear liquid on heating and sublimed without leaving any residue. On examination by means of the spectroscope it was found to give the thallium line and very faint sodium lines. This salt was introduced in a hard glass tube, one end of which was drawn to a capillary and inserted in a small hole bored in the stem of a Bunsen burner. The other end of the tube was connected with the air blast. A very slow current of air was turned on, the burner was lighted, and the thallous chloride in the hard glass tube was heated to volatilization. The vapors of this salt on entering the flame imparted to it the characteristic thallium green color. On depressing the flame with a cold object, such as an evaporating dish, a metallic mirror of a brownish appearance was obtained. That this mirror was due to the deposition of thallium was proved by moistening it with a drop of hydrochloric acid and impinging a Bunsen flame on it; the characteristic green color flashed up.

Thallous Chloride in the Hydrogen-Air Flame.—Resublimed thallous chloride was placed in a hard glass tube provided with a platinum tip. Hydrogen, generated from zinc and sulphuric acid and washed through a solution of silver nitrate, was passed through the tube and ignited above the platinum tip. The thallous chloride was now heated with a flattened Bunsen flame. The flame of the burning hydrogen, on becoming charged with the vapors of the thallium salt, was seen to consist of a long, slender inner cone, deep green in color, surrounded by a film which was almost colorless. The middle cone, which constituted the main part of the flame, was green for about two-thirds of its length, its lower third being blue. The outer cone, which formed the tip of the flame, was of an intense green color. The terms inner, middle and outer cones are used for the purpose of simplifying the description of the flame. Reference to the accompanying diagram will show that in practice the flame consists of five different zones, each zone having its own characteristic luminescence. On depressing the inner zone (*a*) with a cold object a lustrous dark metallic mirror of a brownish tinge was obtained. But no deposit of thallium was obtained when the part of the flame above the inner zone was depressed.

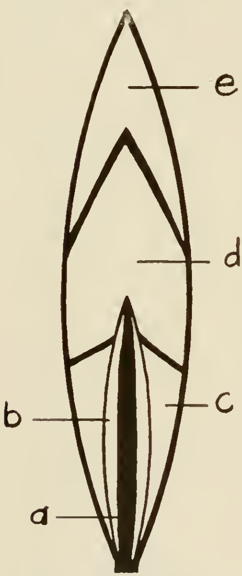


Diagram of the Hydrogen-Air Flame charged with Thallous Chloride.

a, deep green; b, almost colorless film; c, blue; d, green; e, deep green.

Conclusions.

Thallous chloride, when introduced in the Bunsen flame, dissociates, yielding the metal. This metal can be condensed on a cold object in the form of a brownish mirror. The characteristic luminescence of the flame is to be traced to the existence of the free metal in it.

When the hydrogen-air flame is charged with the vapor of thallous chloride, five different zones, each distinguishable by a different luminescence, can be observed. A lustrous metallic mirror of a brownish tinge can be obtained on a cold object by depressing the inner cone of the flame. The luminescence here again is to be traced to the element thallium. No deposit of thallium is obtained when the cold object is introduced in the outer zone; the luminescence in this region is undoubtedly due to the formation of an oxide or oxides of thallium.

Sulphur Dioxide as a Source of Volcanic Sulphur.

Jacob Papish, Purdue University.

The reaction expressed by the equation $H_2S + SO_2 = H_2O + 2S$ was investigated by Cluzel[1] as far back as 1812. This reaction was accepted by geologists and chemists[2] as being back of the origin of volcanic sulphur: hydrogen sulphide and sulphur dioxide gases, escaping from vents and fumaroles, come in contact and bring about the formation of sulphur. Brun[3] opposes this theory of the origin of sulfatara sulphur, and he, in turn, is opposed by others. The reader is referred to the literature on geochemistry for details.[4]

In case of sulphur deposition, where hydrogen sulphide is detected as a volcanic exhalation, it is supposed that the sulphur is formed as a result of the partial oxidation of the hydrogen sulphide.[5]

While investigating the flame reactions of the sulphur group of elements, I noticed that when a mixture of sulphur dioxide and illuminating gas is heated in a glass tube, an opalescence is produced due to the precipitation of sulphur. Illuminating gas is a mixture of different reducing gases, and, on the whole, the reaction resembles the one described by Berthelot,[6] which is expressed by the equation $SO_2 + 2CO = 2CO_2 + S$. Since volcanic exhalations contain carbon monoxide, as well as methane and hydrogen, then why not suppose that volcanic sulphur is formed from sulphur dioxide through a reaction of reduction, say, with carbon monoxide? The sulphur thus formed will have to cool and condense before it comes in contact with oxygen, otherwise it will burn back to sulphur dioxide. Some means of sudden cooling is especially favorable for its formation instantly upon reduction from sulphur dioxide. Such a means is to be found in the case of the sulphur recovered from Lake Ponto, which is a crater lake in the southwestern part of Kunashiri Island, Japan.[7] The water of this lake is strongly acid[8] and has a temperature of 40° C. Around the margins

[1] Ann. Chim. Phys. 84, 162 (1812); Jour. Phys. Chem. 15, 1 (1911).

[2] Ries' "Economic Geology", 4th ed., p. 293; Roscoe and Schorlemmer's "Treatise on Chemistry" 1, 365 (1905); Erdmann's "Lehrb. anorg. Chemie", 2nd ed., p. 235 (1900).

[3] Chem. Zeit. 15, 127 (1909).

[4] Clarke's "Data on Geochemistry", 3rd ed., pp. 270 and 575.

[5] Habermann: Zeit. f. anorg. Chem. 38, 101 (1904).

[6] Compt. rend. 96, 298 (1883).

[7] Y. Oinouye: Jour. of Geology 24, 806 (1916).

[8] Professor Oinouye, in a private communication dated April 29, 1918, informs me that the water smells of sulphur dioxide

through innumerable small fissures sulphur is deposited, and the country rock is strongly impregnated with it. The amount of gas emitted is ordinarily not very great, but is increased enormously when the atmospheric pressure is low. During periods of crater activity, paroxysmal eruptions of gas and water are noticed near the center of the lake at intervals of from one to three hours, and whenever the bubbling begins, workmen row to the spot. By means of a pulley attached to a framework resting upon two boats, the men lower an iron bucket in the center of the bubbling area to the bottom of the lake. When the bucket is withdrawn it is practically filled with sulphur grains. In this manner, while the crater is active, a hundred buckets of sulphur are easily brought up in a day. This sulphur is for the most part dark grey in color and consists of oolitic grains.

The process of sulphur deposition just described is not to be taken as typical, and Oinouye himself remarks[1] that the production of sulphur in crater lakes is very unusual even in sulfatara sulphur fields. But this particular process illustrates strikingly the possibility of sulphur coming from sulphur dioxide. The fact that the water of Lake Ponto is charged with sulphur dioxide bears unmistakable evidence of the existence of this gas as a volcanic exhalation. Its reduction to elementary sulphur can be assumed to take place through its interaction with carbon monoxide, which is very commonly found in volcanic exhalations together with other reducing gases. The freshly formed sulphur cools suddenly on coming in contact with the water in the lake and condenses in the form of oolitic grains.

The theory set forth in this paper is not meant to displace other accepted theories on the origin of sulphur, but rather to supplement them. No one theory can explain the origin of the different deposits of sulphur; each deposit has to be dealt with separately, and it is hoped that some cases of sulphur deposition can be explained on the basis of this theory.

The study of the origin of sulphur was undertaken at the suggestion of Dr. W. N. Logan of Indiana University, to whom my sincerest thanks are due.

Since this note has been written an article by J. B. Ferguson appeared on "The Equilibrium Between Carbon Monoxide, Carbon Dioxide, Sulphur Dioxide and Free Sulphur."[2] Mr. Ferguson states that he undertook his work with the purpose to shed some light on the role of sulphur gases in volcanic activity.

[1] Loc. cit.

[2] Jour. Amer. Chem. Soc. 40, 1626 (1918).

The Occurrence of Coal in Monroe County.

W. N. Logan, Indiana University.

(A Preliminary Report.)

The occurrence of coal in small outcrops has been known for three quarters of a century among a few inhabitants of the southwest part of the county. No reference to the occurrence of coal is mentioned in any of the geological reports, except that T. F. Jackson, in discussing the Pennsylvanian of the Bloomington quadrangle, says: "Carbonaceous layers varying in thickness from a thin streak to a few inches in thickness are found here and there in the sandstone shale part of the formation. None of these layers appear to have a very wide horizontal distribution."[1] In this report Jackson does not definitely locate any of these occurrences within Monroe County, though he may have intended to include such area. About twenty-five years ago Mr. Frank Coleman, living in Indian Creek Township, opened a coal prospect in the southeast quarter of Section 4. He first opened a drift and took out several tons of coal, which he sold to local blacksmiths. When the roof of the drift caved in during a rainy season, he went back about thirty feet from the mouth of the entry and put down a shaft, entered the coal vein and took out twenty-six bushels of coal from a hole about four feet square. Before he could get the shaft lined the upper part of it caved in and he abandoned the mining project. Coal was also found in the bottom of a well in the southeast quarter of Section 3 on the David Koontz farm.

In the late fall of 1917 Hall and Timberlake of Bloomington leased the Coleman farm and began prospecting for coal. They first opened up near the old drift and exposed a layer of coal about fourteen inches thick, a clay parting of the thickness of one foot, and a lower layer of coal sixteen inches thick.

As the entry was driven back under the hill the clay diminished in thickness and the coal increased in thickness to that extent. They also opened up the old shaft and found a thickness of twenty-six inches of good hard coal. They then drilled a well with a core drill midway between the occurrence on the Coleman place and the one on the Koontz place, and the well record which they kept shows six feet of coal at this point. On the David Koontz place they then sank a shaft to a

[1] See Thirty-ninth Annual Report, Geological Survey of Indiana, 1914, p. 227.

depth of seventeen feet and struck a vein of coal having a thickness of about two feet. In an entry running in the direction of the well above mentioned the coal shows evidence of thickening. The coal at this point underlies seventeen feet of grayish colored sandstone. Underlying the coal is a layer of fire clay.

The deep well above mentioned was drilled at an elevation of about 970 feet above sea level. The strata pierced are as follows:

	Feet.
Soil (top)	6
Ironstone	7
White shale	5
Ironstone	5½
Blue sandstone	34
Coal	6
Blue shale containing pyrite	22½
Blue sandstone	17
Ironstone and ore	27½
Limestone	3
Total	133

COMPOSITION OF MONROE COUNTY COAL.

A sample of the coal taken from the reopened shaft on the Coleman farm was analyzed by Mr. H. M. Burlage of the Chemical Department of Indiana University. The sample was obtained by taking a bushel of the mine-run coal, crushing and quartering down to about one pound of crushed coal, which was turned over to the analyst. The results obtained from the analysis are recorded below:

ANALYSIS OF MONROE COUNTY COAL.

	Per cent.
Volatile matter	42.74
Fixed carbon	52.96
Ash	4.3
Sulphur	2.76
B. T. U.	14,599.70

Comparing this analysis with the analyses of 115 samples of Indiana coals, this sample showed the highest amount of fixed carbon; only three samples run higher in volatile matter; only six are lower in ash; and it is the highest in recorded B. T. U.

Fig. 1. View along public road in Section 33, VanBuren Township, showing Mississippian sandstone with shales containing a thin layer of limestone. These rocks lie below the coal-bearing formation of this area.

Fig. 2. Ccal mine on the David Koonz Farm. Property of Hall and Timberlake. Shaft seventeen feet deep. Coal at rear of man on left hand.

The analysis of another sample taken from the same locality was made by Thomas J. Dee & Co., Chicago, Ill. The results recorded are as follows:

	Per cent.
Hydro carbon	44.90
Fixed carbon	43.20
Ash	3.00
Moisture	8.90
Sulphur	1.56

Coal is now being mined by Hall and Timberlake from the shaft on the David Koontz place. The coal is being used locally for domestic purposes and for blacksmithing.

Note on Occurrence of Indianaite in Monroe County, Indiana.

W. N. Logan, Indiana University.

During field work in 1917 the writer's attention was attracted to an outcrop of reddish colored clay containing fragments of a white clay near the public road in Section 3 of Indian Creek Township. A later examination of the white clay showed it to be Indianaite, a variety of halloysite.

In the spring of 1918, Mr. Dick Hall located a number of outcrops of the same kind of clay in the township. One of these outcrops is on the public road near the John Koontz place in Section 10. The section exposed consists at the bottom of a shale containing sandy layers near the upper part, overlying this is a layer of mahogany-colored clay of a thickness of thirty inches, containing fragments of Indianaite, and above is a five-foot layer of sandstone. The Indianaite occurs under and in most cases immediately in contact with the sandstone. Where the sandstone is compact and unfissured the Indianaite is more abundant. The thickness of the mahogany clay is variable, pinching and swelling. In some places it may have a thickness of four feet and pinch down to less than half that amount in less than ten feet.

At one point in Section 28 of Van Buren Township, in a sandstone layer, there is a thin layer made up of the fragments of Indianaite. This occurrence shows that the Indianaite had been formed, eroded and redeposited. Below the sandstone there occurs a layer of mahogany clay which contains small fragments of Indianaite. The mahogany clay rests on a thin bed of sandstone, which in turn rests on a bed of greenish colored shales. In the shale there are irregular, lens-like masses of limestone. Where exposed at the surface these limestone masses are surrounded with mahogany clay in which fragments of the white Indianaite were found.

Distribution.—In Van Buren Township, Indianaite has been found in Sections 27, 28, 33 and 34. The outcrops occur on the slopes of a ridge which rises about 900 feet above sea level and forms a part of the divide between Clear Creek on the east and Indian Creek on the southwest. On the road which connects West pike with the Rockport pike, passing through the center of Section 28 and intersecting the abovementioned ridge, there are a number of outcrops of Indianaite. On the northern slope of the ridge, at the point where the road crosses it, there

Fig. 1. Outcrop of mahogany clay with white kaolin at top. Sandstone above and shale below. Coal blossom just below note book and below mahogany.

Fig. 2. Sandstone forming ledge above the mahogany clay of Fig. 1. This sandstone forms a ridge-capping extending in a northeast-southwest direction through the southeast quarter of Section 28 in VanBuren Township.

is an outcrop of mahogany clay which contains a considerable quantity of Indianaite. Underlying the clay and separating it from a bed of shale is a thin layer of sandstone. A bed of sandstone having a thickness of twenty-five feet overlies the clay. The clay has a thickness of four feet at the outcrop, but pinches down to about half that in a distance of six feet. The Indianaite occurs in hard, irregular fragments and also as white plastic streaks in the red-colored clay. On the same slope, below this outcrop, there are some greenish gray shales containing irregular masses of limestone surrounded by mahogany clay. This clay also contains some fragments of the white Indianaite.

On the same ridge, farther east on the north side, there is an outcrop of Indianaite six feet thick on the side of a sinkhole. On the south side of this ridge, in the southeast quarter of Section 28, Indianaite occurs under the sandstone, capping the top of the ridge, at about the same elevation as that on the north side. West of the road above mentioned, in Section 33, there is an outcrop of mahogany clay containing considerable Indianaite. The clay occurs between layers of sandstone of very fine grain. The overlying sandstone has a thickness of about thirty feet. The mahogany layer is irregular in thickness, pinching and swelling. Similar outcrops have been found in Section 27, on the southwest side of the ridge, and in Section 34, on the east side.

Indian Creek Township.—Indications of the presence of Indianaite have been found at several places along the ridge which forms the divide between Indian Creek and Clear Creek in this township. In Section 3 outcrops occur in the west half of the section. In Section 10 outcrops of mahogany clay occur at several points, also in Sections 9 and 17. In the northwest corner of Section 10, near the public road, there is an outcrop of a layer of mahogany clay having a thickness of about thirty inches in places, but thinning down to about half that in other places. White Indianaite occurs in the clay in small, irregular fragments, which are most abundant under the compact and unfractured portions of the roof of sandstone. The underlying rock is shale, which passes into very sandy shale and lenses of sandstone just below the mahogany clay. The geological section exposed at this point is as follows:

	Feet.
No. 8. (Top.) Shale	5
No. 7. Sandstone in thin beds	5
No. 6. Shale, sandy	6
No. 5. Sandstone	5
No. 4. Shale	20
No. 3. Sandstone, thick layers	10
No. 2. Mahogany clay and Indianaite	2½
No. 1. (Bottom.) Shale, sandy toward top	12

Fig. 3. Tunnel of Hall and Timberlake kaolin mine in Section 27, VanBuren Township. White masses in front are fragments of kaolin taken from mine.

This mahogany clay lies near the unconformity in the Mississippian system of rocks. The shales above and below the mahogany belongs to the Mississippian.

State of Development.—Small pits have been dug at several places on the outcrop of the mahogany clay, but no serious attempt at development has been made. In order to determine whether the Indianaite occurs in sufficient quantities to warrant commercial development will require the drilling of wells along the sandstone ridge at some distance from the outcrop. Near the outcrop the clay is nearly always stained with oxides of iron.

The number and thickness of the outcrops offer promise of workable beds of the white clay. A tunnel has been driven at one point to a distance of 130 feet. Six feet of fairly white kaolin was found in this tunnel, and the indications are that a marketable quantity exists.

Notes on the Palaeontology of Certain Chester Formations in Southern Indiana.

Allen D. Hole, Earlham College.

In the course of an examination of the Chester formations of southern Indiana in the summer of 1918, especial care was taken at a few points to secure a representative collection of the fossils present. The study of the collections made at that time has not yet been completed, but enough has been done to make clear certain interesting relations between the formations exposed in Indiana and those which have been examined in southern and southwestern Illinois, and for this reason it has seemed worth while to record the results apparent in the work thus far.

The localities from which the largest number of species were collected are all in Orange County, and the horizons yielding the greatest abundance of well-preserved specimens were of limestone, three in number.

Renault Limestone.

The lowest of the three limestones referred to yielded the following forms:

Talarocrinus, somewhat abundant, one or two species.
Pentremites, somewhat abundant, including some very small forms.
Cup coral (Zaphrentis?).
Bryozoans (Archimedes rarely present).
Cliothyridina sublamellosa (Hall).
Composita sulcata, Weller.
Composita trinuclea (Hall).
Diaphragmus elegans (Norwood and Pratten).
Eumetria vera (Hall).
Girtyella (cf.) indianensis (Girty).
Orthothetes kaskaskiensis (McChesney).
Productus ovatus, Hall.
Productus parvus, Meek and Worthen.
Spirifer, sp. (near breckenridgensis, Weller).

The above fauna, considered in connection with the relation of this limestone to the other formations exposed, seems to afford sufficient evidence to justify the correlation of this horizon with the Renault of Illinois as defined by Weller.

Paint Creek Limestone.

The middle one of the three limestones examined, found in some places eighty to ninety feet higher stratigraphically than the lowest one, yielding the forms named below, and is consequently correlated with the Paint Creek formation of Weller in Illinois. The uncertainty recorded as to species in some cases is to be understood as indicating more or less difference from described forms; some of these may be new species, while others may deserve to be classed merely as variations marking less than specific divergence. The fauna as made out so far follows:

Gastropods sp?.

Cup corals (Zaphrentis?).

Crinoid stems, locally abundant, some of large size.

Pentremites numerous, larger than in the lowest limestone.

Archimedes, not numerous, but somewhat more abundant than in the lowest limestone.

Pygidia of trilobites. Phillipsia?.

Chonetes chesterensis, Weller.

Cliothyridina sublamellosa (Hall).

Composita sulcata, Weller.

Diaphragmus elegans (Norwood and Pratten).

Eumetria verneuiliana (Hall).

Girtyella (cf.) indianensis (Girty).

Martinia (cf.) sulcata, Weller.

Orthothetes kaskaskiensis (McChesney).

Productus (cf.) ovatus, Hall.

Pustula sp?.

Spirifer sp?.

Okaw Limestone.

The upper of the three limestones here referred to is found in some places within the areas examined seventy to eighty feet higher stratigraphically than the middle limestone, and on the basis of the fauna collected and the relations observed is correlated with the lower Okaw as defined by Weller from studies in Illinois. The fauna collected shows the following forms:

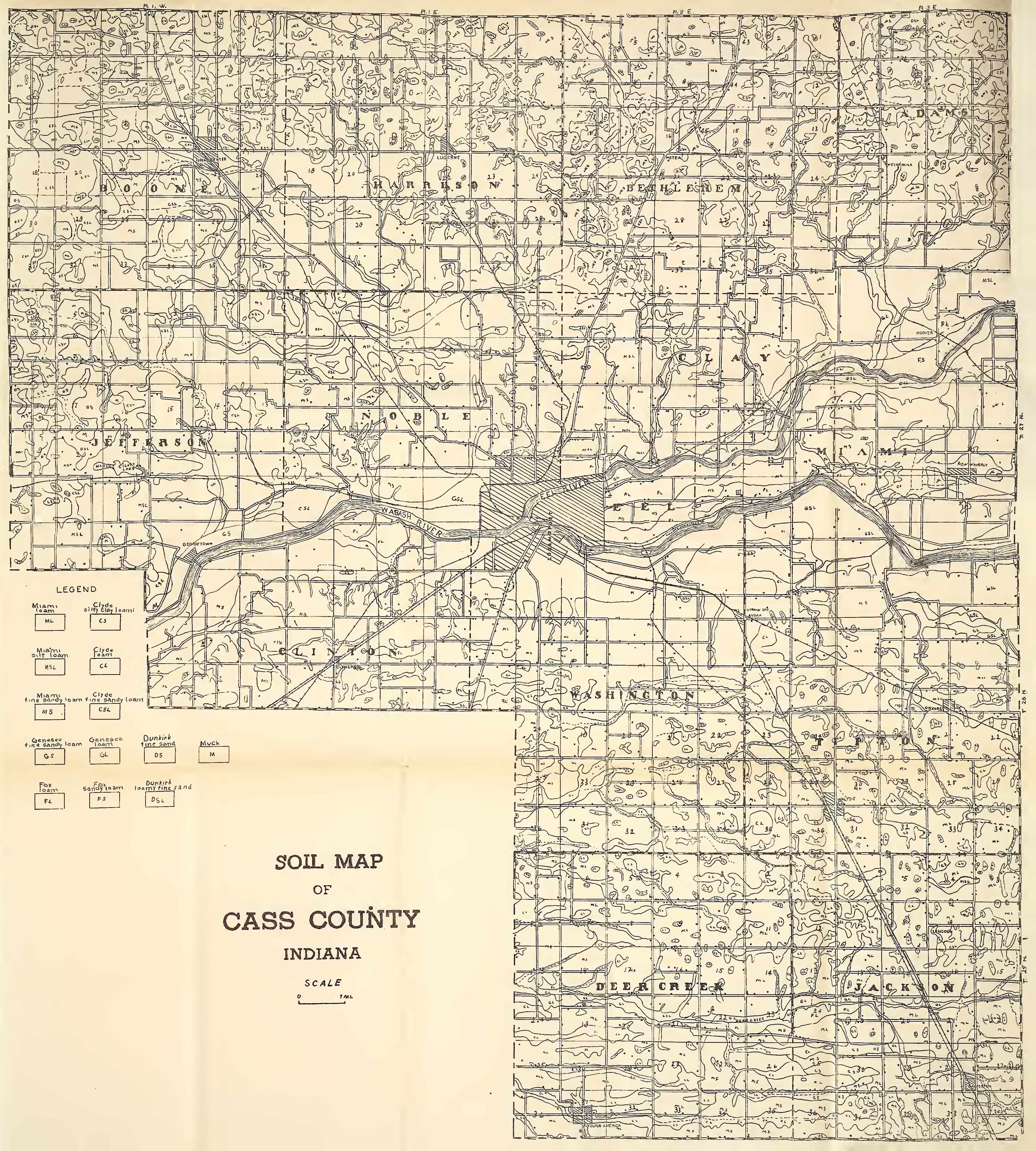
Gastropods sp?, a few.

Cup corals sp?, many partly silicified in places.

Bryozoans including abundant Archimedes.

Crinoids numerous; mostly in fragmental state including wing plates of Pterotocrinus sp?.

Pentremites abundant; some large forms.



SOIL MAP
OF
CASS COUNTY
INDIANA
SCALE
0 1 MI.
LEGEND
Miami loam ML
Clyde silty clay loam CS
Miami silt loam MSL
Clyde loam CL
Miami fine sandy loam MS
Clyde fine sandy loam CSL
Genesee fine sandy loam GS
Genesee loam GL
Dunkirk fine sand DS
Muck M
Fox loam FL
Fox sandy loam FS
Dunkirk loamy fine sand DSL
BOONE
HARRISON
BETHLEHEM
ADAMS
CLAY
NOBLE
JEFFERSON
MIAMI
EEL
CLINTON
WASHINGTON
TIPTON
DEER CREEK
JACKSON
WABASH RIVER
EEL RIVER

Trilobites; pygidia of Phillipsia?.
Camarophoria explanata (McChesney).
Cliothyridina sublamellosa (Hall).
Composita sulcata, Weller.
Composita trinuclea (Hall).
Productus sp?.
Pustula sp?.
Spirifer sp?.

In addition to the fauna listed and correlated above, a brief examination was made of the massive limestone beds lying below the formation interpreted as Renault limestone. In the best exposure found good specimens of fossils were not abundant, and the exact location of the lowest Chester bed was therefore not ascertained. Stems of Platycrinus huntsvillae, Wachsmuth and Springer, were, however, found at forty-five to fifty feet below the limestone named here Renault, thus indicating the presence of the Ste. Genevieve as defined by Weller, and fixing the lower limit of the Chester and therefore the upper limit of the Ste. Genevieve at a level not more than forty-five or fifty feet below the fossiliferous Renault limestone layer.

Soil Survey of Cass County, Indiana.

Colonzo C. Beals, Indiana University.

Description of the Area.—Cass County lies in the north central part of Indiana. It is bounded on the north by Pulaski and Fulton, on the east by Miami, on the south by Howard and Carroll, and on the west by Carroll and White counties. The greatest length north and south is twenty-four miles, while the maximum width is twenty-two miles. On the west boundary line it follows an irregular course. Commencing with the northwest corner of the county, it runs twelve miles south, three miles east, three miles south and eleven miles east to the southeast corner of the county. Cass County has a total area of 420 square miles and is divided into fourteen civil townships: Boone, Harrison, Bethlehem, Adams, Miami, Clay, Eel, Noble and Jefferson on the north side of the Wabash River, and Clinton, Washington, Tipton, Jackson and Deer Creek on the south side.

The county is roughly divided into a north and south portion by the Wabash River, which flows in a general east and west direction through the county. In the immediate vicinity of the Wabash and Eel rivers the country is undulating and broken. After leaving the rivers, to the south the surface is level. All the southern portion, in its natural state, was heavily timbered with hardwood, bottom and table land; the central portion is mostly bottom with high bluffs; the northern part is largely prairie.

The drainage of the county depends upon the large valley of the Wabash and Eel rivers, which extends in an east and west direction through the center of the county; the highland in Tipton and Washington townships south of the Wabash River; the highland in Jackson and Deer Creek townships, and the highland of Harrison and Boone townships. Deer Creek flows west near the central part of Jackson and Deer Creek townships, emptying in the Wabash River near Delphi. Rock Creek rises in the southwest part of Tipton Township, and flowing west through the southern part of Washington Township, empties into the Wabash River north of Rockfield in Carroll County. Pipe Creek rises in the southeast portion of Miami County near Xenia, and flowing

* The soil survey was done under the direction of Edward Barrett, State Geologist, in a similar way to the surveys of the past eight years. Mr. James Mathes assisted in making the survey which was done in the field season of 1917. Thanks are extended to those persons who assisted in making the survey a success.

in a south of northwest direction, enters Cass County about two miles below where the Wabash River enters, keeping the general direction until it is south of Lewisburg, when it turns sharply to the north, emptying into the Wabash River just below that town. Pipe Creek derives its name from the fact that for the greater part of its course in Cass County, the channel is carved in the limestone which comes to the surface at that place. Twelve Mile Creek drains the southern portion of Adams Township and a part of Bethlehem Township, emptying into Eel River. Indian Creek flows northwest, and Little Indian Creek drains west, both emptying into the Tippecanoe River. Crooked Creek rises in the southwest portion of Bethlehem Township and, after making many turns in flowing to the west, bends to the south and enters the Wabash River near Georgetown.

Lake Cicott is nine miles west of Logansport, a little to the southwest of the center of Jefferson Township. It is one mile long east and west and has an average width of one-fourth of a mile north and south, and its greatest depth is sixty-four feet. Bluffs twenty-five feet high surround it on all sides except the east, where during high water it drains by means of an old outlet through a former lake bed into Crooked Creek.

Abandoned Valleys.—A few well-marked abandoned valleys occur near the present Wabash Valley. The first one is around Waverly—in fact the town is in the valley. The channel enters the county in Sections 22 and 27, just east of Waverly, where it forms a valley almost a mile wide, narrowing to one-half of a mile near the Miami–Cass County line. Nearly a mile west of Waverly the valley turns to the south, entering the present Wabash Valley a short distance west of Lewisburg. The boundaries of the channel are rather uniform, except for a few gullies that enter on either side. Dr. M. N. Elrod and Mr. A. C. Benedict, in discussing the geology of Cass County in the nineteenth annual report of the Indiana Department of Geology and Natural Resources for 1894, say:

"This stream occupies a preglacial channel that starts west from the mouth of the Mississinewa, above Peru, and runs in a western direction until it reaches a point about one mile west of Waverly, where it turns south and intersects the Wabash one-half mile west of Lewisburg. At the time of our visit a diminutive streamlet was trickling over the rocks where once a volume of water poured."

We have shown that stream as an intermittent stream on the accompanying map.

Another interesting valley occurs west of Logansport in Clinton Township, where it roughly parallels the present channel of the Wabash River. This channel leaves the county one-fourth mile north of Clinton

Township, where it is about one-fourth of a mile wide. In places it has a width of about one-half of a mile. Near the east end as it approaches the river a large area of muck occurs. This channel seems to enter the Wabash Valley in the western edge of Section 36. Another deep valley enters the Wabash Channel in the eastern half of Section 31, heading toward the southeast. It starts just north of the present State insane institution at Long Cliff. Near the western end this valley has almost perpendicular walls and a width of over one-fourth mile. The southern escarpment of the two channels in Clinton Township, taken as a whole, show a very irregular outline with numerous gullies and V-shaped valleys, indicating very extensive erosion, while on the opposite side no indication of stream erosion exists. At present it is occupied by a few small streams, but no large ones.

Early History.—Until 1824 Cass County was included in Tippecanoe County. The organization of the county was completed April 13, 1829, under acts of the State legislature, passed December 18, 1828, and January 19, 1829. At that time it contained all that portion of the State now included in the counties of Miami, Wabash, Fulton, Marshall, Kosciusko and St. Joseph and parts of Laporte, Starke and Pulaski. The county seat was located at Logansport, August 10, 1829.

The first owners of the soil of Cass County were the Pottawottomie and Miami Indians. The former owned the land north of the Wabash, and the latter that upon the south. The first cessions of lands was made by the Miamis in the treaty of 1818, in which they gave up the land west of the mouth of Eel River. The Pottawottomies surrendered the land north of the Wabash in 1876 at the Mississinewa treaty and at subsequent times and by various other treaties.

Logansport was named in honor of Captain Logan, a Shawnee chief, who lost his life in November, 1812, because of his fidelity to the whites, and not for Logan the Mingo, as many suppose. The original plot of the town contained 111 lots, with streets 66 feet wide, except Broadway, which is 82½ feet wide.

Roads.—December 31, 1918, Cass County had 452½ miles of free gravel roads and 340 miles of unimproved roads. Rural free delivery extends to all parts of the county, which stimulates the extension of good roads.

Population.—The following table is based on the returns of the Federal Census, including estimated population for 1920:

	1910.	1900.	1890.	Estimated.
Cass County	36,368	34,535	31,152	38,200
Adams Township	984	974	962	.....
Bethlehem Township	999	1,047	1,113	.....
Boone Township, including Royal Center	1,802	1,807	1,680	.....
Royal Center, town	909	657	527	1,010
Clay Township	745	765	838	.....
Clinton Township	970	1,568	1,415	.....
Deer Creek Township	1,376	1,557	1,672	.....
Eel Township, including Logansport	20,239	17,237	14,052	.....
Logansport city	19,050	16,204	13,328	21,900
Harrison Township	1,231	1,258	1,189	.....
Jackson Township, including Galveston	1,748	1,725	1,655	.....
Galveston, town, incorporated in 1904	658	.....	.....	675
Jefferson Township	1,029	1,096	1,127	.....
Miami Township	854	926	938	.....
Noble Township	1,221	1,141	916	.....
Tipton Township, including Walton	1,975	2,038	2,015	.....
Walton, town	579	498	469	625
Washington Township	1,195	1,406	1,580	.....
Logansport, estimated in 1917....20,754	.....	.....	.....	.....
Hoover, estimated in 1910	100	.....	.....	.....
Lucerne, estimated in 1910	500	.....	.....	.....
Young America, estimated in 1910	600	.....	.....	.....
Lincoln, estimated in 1910	250	.....	.....	.....
Waverly, estimated in 1910	90	.....	.....	.....
Onward, estimated in 1910	250	.....	.....	.....
Lake Cicott, estimated in 1910	50	.....	.....	.....
Adamsboro, estimated in 1910	150	.....	.....	.....
Kennith, estimated in 1910	250	.....	.....	.....
Clymers, estimated in 1910	125	.....	.....	.....

The above table shows that the movement of population has been to build up the cities and larger towns at the expense of the rural districts. This is due to the fact that the younger generation, who replenish the working class, flock to the factories in town. The present (or just past) war conditions will cause the "from the farm to the city" exodus to continue.

Agriculture.—Cass County had 2,656 farms in 1900, while by 1910 the number had decreased to 2,443. In 1916 the number of farms containing over five acres amounted to 2,261, containing 256,229 acres.

The number of farms, classified according to size, were as follows in 1910:

Under 3 acres	4
3 to 9 acres	87
10 to 19 acres	113
20 to 49 acres	300
50 to 99 acres	765
100 to 174 acres	786
175 to 259 acres	212
260 to 499 acres	79
500 to 999 acres	6
1,000 acres and over	1

In 1910, the average farm contained 102.3 acres; 93.8 per cent of the total land area was in farms, and 82.7 per cent of this was improved; 35,392 acres were classed as wood land. In 1916 the waste land amounted to 4,067 acres.

Sixty-four and three-tenths per cent of all farms were operated by owners in 1910, which was a decrease of 1.4 per cent in ten years; twenty-three farms were operated by managers, a decrease of four in ten years. Eight hundred eighty-four of the farms operated by the owners were free from mortgage debt, while 669 had mortgages.

A crop that is on the increase is that of the soy bean—797 acres were devoted to it alone and 271 acres in combination with other crops. It can be used in the silo, thrashed for seed, or hogged down in the fall. Cow peas showed an acreage of seventy acres where grown alone and thirty-three acres where they were mixed with another crop or crops.

The crops cut for ensilage during 1917 amounted to 4,591 acres, which, we will suppose, were put in the 456 silos found in the county that fall. The greater percent of those crops consisted of corn, with some using part soy beans or cow peas.

The county had 934 acres devoted to white potatoes in 1917.

Most of the small fruit and truck crops occur in small farm gardens, but one acre was devoted to onions, two acres to tomatoes, five acres to cabbages, nine acres to watermelons, and fifteen acres to muskmelons (cantaloupes). Strawberries, blackberries and raspberries occupied sixty-four acres, while we find 43,849 bearing apple trees, 18,203 peach trees, and 11,455 pear trees.

Cass County is a grain-producing county, with a great deal of stock to consume the grain on the farm. Fifty-eight thousand six hundred three acres of corn were harvested in 1917, which did not give a normal yield that year because of the early frost.

During 1917 Cass County harvested 28,293 acres of wheat, but planted a larger acreage that year, amounting to 37,826 acres. The farmers planted 31,754 acres in oats, or a little more than the amount devoted to wheat.

A great deal of the rye planted was devoted to pasturage or plowed under in the spring as a green manure. Some may be used as a winter cover crop where land tends to erode. The crop for 1917 amounted to 5,493 acres, while almost double that area was sown in the fall, or 9,032 acres.

Some barley is grown in this region, eighty-four acres in 1917, and considerable land is devoted to buckwheat, for the seed principally, and secondarily to be used as a source for honey; and, last but not least, buckwheat is used as a restorer of fertility and friability of the soil; fifty-four acres were devoted to this crop alone.

The hay produced in Cass County is an important factor in the agricultural economy, the largest item of which was 10,298 acres of land growing timothy hay during 1917. Some of it is sold and leaves the county; the greater part of it is fed nearby and returned to the farms in the form of manure. Twenty acres of land were devoted to millet and Hungarian grasses.

A crop that has a great beneficial effect on the soil and should have a greater acreage is clover, of which 8,787 acres were used for hay, while 3,317 acres were cut and thrashed for seed. The combined acreage could easily be one-fourth of the combined acreage of the oats and wheat grown, and the farming interests would profit by the change.

In 1917 there were ten pure-bred horses and colts, fifteen milk cows, and 200 hogs in Cass County (reported to the township assessor). At that time there were 10,604 horses, 1,686 mules, 8,066 milk cows, 56,630 hogs and 5,923 sheep. There were 4,417 sheep sheared, yielding an average fleece of 7.2 pounds.

In 1917 Cass County had only 173 colonies of bees, which yielded 2,550 pounds of honey. It would be safe to say that more than that amount of honey was "wasted on the desert air" in the county because no bees were present to save it.

The farmers of Cass County bought 862 tons of fertilizers in 1917 and used a great deal of it on their wheat land.

The farmers had forty-two tractors on their farms the same year to aid in increasing the amount of their farm crops. They also had 1,491 cream separators in use on their farms.

Climatology.—In a general way Cass County has the same kind of climate that north central Indiana experiences. The following data is based on a record of twenty-eight years in the city of Logansport about two squares north of Eel River at an elevation of 620 feet. (The country is slightly rolling.) The average date of the last killing frost in the spring is April 27th, and the last killing frost in the fall is October

13th. The latest killing frost in the spring occurred May 16th, and the earliest killing frost in the fall was September 21st. The average growing season is 169 days, ranging from 144 days in 1895 and 1904 to 210 in 1902.

The prevailing direction of the wind is from the west throughout the year.

The only available data on average hourly wind movement (miles), mean relative humidity (percentage), and sunshine (percentage) is from Fort Wayne from a five-year record. (See table below.)

The precipitation of Cass County is adequate for all crop requirements of that region, and it is uniformly distributed over the growing season. The greatest amount of the year falls during the summer months. Dry and wet spells are not unknown, but they do not normally destroy the crops. The dry spells usually occur during the middle or late summer, while the wet season normally comes in the winter or spring, as the spring high water.

Months.	Snowfall.	Precipitation.	Average No. of Days with 0.01 or more of Prec.	Mean Temperature.	Mean Maximum Temperature.	Mean Minimum Temperature.	Highest Temperature.	Lowest Temperature.	Wind Movement.	Relative Humidity, 8 a. m.	Relative Humidity, 8 p. m.	Sunshine.
January	6.1	2.32	9.6	25.4	31.6	18.2	69	25	9.6	82	82	30
February	6.7	2.64	7.7	26.4	35.1	17.1	69	24	11.3	81	77	41
March	4.7	2.91	9.0	37.6	47.8	28.6	87	3	10.8	80	74	52
April	0.1	3.31	10.6	51.1	61.4	40.3	91	15	11.1	78	70	56
May	trace	4.31	11.5	62.3	74.1	50.2	101	28	9.3	78	68	59
June	0	3.73	9.3	71.5	83.7	58.7	103	37	8.1	76	62	70
July	0	3.25	8.3	75.5	87.7	62.4	106	43	7.2	78	64	67
August	0	3.11	6.9	72.5	85.4	60.2	103	41	7.5	85	68	61
September	0	3.22	7.2	66.3	78.9	53.6	102	30	7.7	85	73	62
October	trace	2.56	7.2	53.9	65.7	41.5	91	18	8.4	87	72	51
November	1.0	3.15	8.4	40.5	49.6	30.9	80	3	11.8	81	73	42
December	4.2	2.54	8.2	29.6	37.4	22.7	70	15	10.5	83	80	30
Season	23.1	37.5	10.4	51.0	61.8	40.4	106	25	9.6	82	72	52

Soils.

Definition.—Soils consist of the broken and decomposed portions of rocks mixed with more or less organic matter in various stages of decomposition. To the agriculturist it is that portion of the earth's surface into which the roots of plants may penetrate and obtain nourishment.

Physical Properties.—In former years it was thought that the chemical analysis of a soil was of the most importance; but since the subject has been better understood, the physical side has gained in emphasis. A factor of prime importance to the agriculturist is the absorbing capacity of a soil and its ability to retain and furnish moisture to the growing plant as needed. In fact the ability of a soil to furnish an adequate amount of water to the growing crop is of far more importance than its chemical ingredients. Pure sand holds water poorly, so that sand is ordinarily a dry soil. At the other extreme, clay holds moisture very tenaciously, so that a pure clay soil is soggy and apt to be very wet. A mixture of the two, forming a loam, is not subject to either objections and is an ideal soil.

Liberation of Plant Food.—Ground limestone and decaying organic matter are the principal materials which the farmer can utilize most profitably to bring about the liberation of plant food. The ground limestone corrects the acidity of the soil and thus encourages not only the nitrogen-gathering bacteria which live in the nodules found on the growing roots of the growing plants of clovers, cow peas, alfalfa and other leguminous plants, but also the nitrifying bacteria in the soil, which have the power to make into plant food the insoluble and unavailable organic products. At the same time the products of this decomposition also make available the insoluble minerals found in the soil, such as the potassium and magnesium, as well as the insoluble limestones and phosphates, which can be applied by the agriculturist in a very low-priced form.

One of the chief sources of loss of organic matter in the corn belt is the burning of the corn stalks. If the farmers would only realize the loss they incur they certainly would discontinue the practice. Probably no form of organic matter acts to form good tilth better than the plowing under of corn stalks. It is true they decay slowly, but that only prolongs the desired conditions of the soil. The nitrogen in a ton of stalks is one and a half times that of a ton of manure, while a ton of dry stalks when ultimately incorporated with the soil is equal to four times that amount of average farm manure, but when they are burned the humus-making element and nitrogen are both gone and lost to the soil.

Upland Soils.—The upland soils of Cass County are mapped in three series, namely: Clyde, Miami and Dunkirk types, and, in addition, the miscellaneous type known as Muck. These types are all due to a difference in soil content and color and to surface conditions resulting from erosion. The Miami and Clyde series occur side by side, perhaps coming from a similar glacial till, but those areas having a better natural drainage and smaller amount of organic remains for humus become the light-colored clay land or the Miami series, while the depressed areas with poor drainage, or no drainage, in swamp or marsh conditions, become the black or brown areas known as the Clyde series; or, where there was a great abundance of partly decomposed organic matter, they become Muck. The Dunkirk comprises the sand ridges and the loamy sand of a light yellowish brown color.

Alluvial Soils.—The alluvial soils of Cass County are the sediments deposited in the stream valleys by flood waters. A loam in the humid region always has a very luxuriant growth of vegetation where it has an adequate supply of water.

One of the effects of the presence of humus is to produce granules, forming a mellow, easily worked soil. Where a soil is cultivated without adding to the supply of humus, the soil becomes more compact and runs together, producing decreasing crops and reducing the moisture-retaining capacity. Cultivation loosens the soil, promoting aeration, and increases the amount of available plant food.

Chemical Properties.—A chemical analysis of a soil will show the amounts of the different plant foods, such as nitrogen, phosphorus, potassium, calcium, etc.; but the difficulty is that it does not even give a hint as to the form in which the elements occur in the soil. The analysis shows correctly the total organic carbon, but as a rule this represents about one-half the organic matter, so that 20,000 pounds of organic carbon in the upper six inches of an acre represent but twenty tons of organic matter. But this twenty tons is largely in the form of old organic residues that have accumulated during the centuries because they were so resistant to decay; so two tons of clover plowed under as a green manure would have greater power to liberate plant food for a growing crop than all the twenty tons of old residue of organic remains.

The sediments came from the uplands adjacent to the valleys of the different streams, and a certain kind of upland gave rise to a different type of alluvial soil. The overflow land is placed in the Genesee series. The Fox series consists of terrace soils, deposited perhaps by the glacial waters, which were a great deal more abundant than the waters of the present time. The meadow land has not been mapped, but much of the land along the smaller streams, classed as Genesee, belongs to this type.

Miami Silt Loam.

Characteristics.—The Miami silt loam consists of a dark gray or a light brown friable silt loam having an average depth of ten inches. It is usually deeper in depressed or level areas and somewhat shallower on the crest of ridges and on steep slopes. When moist the surface becomes almost uniformly grayish or yellowish brown, but when dry it becomes a light ashy gray.

The immediate subsoil consists of a yellow or yellowish brown silty clay loam having a depth of from twenty to thirty inches. This is immediately underlain by a yellowish clay or yellowish gritty or sandy loam with usually more or less amount of coarse sand, gravel and boulders. As a rule the material consists chiefly of fragments of limestone, a mixture of crystallines of various kinds.

The silt loam has a more brownish color near the streams, where the ground is more or less broken, and on the well-drained ridges. This is due to greater oxidation because of better drainage. The white clay knolls will take on a darker color when better drained and aerated.

The different soil areas mapped as the Miami silt loam will vary from the above description in one or more particulars, but will agree in the main. The Miami silt loam has a level to undulating or rolling surface and occurs throughout the country, with the Clyde series occurring in the depressions.

Origin.—The Miami silt loam, in common with other members of the Miami series, is due to the glaciation of the region in which it occurs. The retreating ice left the till with a very uneven surface, composed of numerous ridges and valleys or depressions. During the process of erosion and weathering since that time, the ridges have tended to become lower, thus filling the depressions with the organic remains and the finer sediments from the higher lands. The better natural drainage and lack of a large amount of humus would produce a light-colored soil with a high clay and silt content. This condition is well shown along the larger watercourses, where the surplus water rapidly drains away, producing a wide strip of the Miami series on either side without any or with very few areas of the Clyde series even in the largest depressions.

Drainage.—The fine texture and uniform structure causes ground water to move slowly and makes natural drainage inadequate in the Miami silt loam. This condition can be remedied by the use of tile drainage, but care should be taken by not using too small tile as lateral lines. The drains not only remove the surplus water in wet weather, thus lowering the ground water table, but also help to aerate the soil in dry weather. In most cultivated soils the pore space is from 25% to 50% of the volume, and this is the maximum water capacity or saturation capacity. The amount of this space occupied by water for the maximum development of most plants is from 40% to 50% of the pore space, which leaves one-half or more to be occupied by air. The presence of a large amount of oxygen in the soil is essential to the best growth of the plant crops as well as the liberation of the necessary plant food.

Tilth.—It is well to have in mind that, aside from fertility, drainage and tillage, one of the main factors of a good soil is good physical condition, or tilth. The Miami silt loam is in good tilth, but since it has a small percent of sand is very fine grained and easily injured by the tramping of live stock in the spring and fall on the stalk or stubble ground and by plowing or working the ground when too wet. Clods will result from these practices, and it usually requires considerable time and work to put the soil in good tilth again. An occasional application of ground limestone, followed with a crop of clover or some soiling crop, will produce good tilth. In fact good physical conditions depend to a large extent upon the amount of humus present in the soil.

Crops.—Corn, wheat, oats, clover and timothy do well on the Miami silt loam. It is not as good corn land as the Clyde, but it produces good crops where the soil is well cared for. To do the best a field should not be in corn two years in succession. Wheat and oats do well; in fact the Miami silt loam is better for wheat and oats than any member of the Clyde series, as it is apt to grow too rank and fall down when grown on the latter soils. Clover and timothy do well, but it is better not to grow the timothy alone, as it has a strong tendency to deplete the fertility of the soil. Some potatoes are grown on the Miami silt loam, but it does not give a high yield. Some orchards are grown on this type and seem to give good results.

Improvement.—As has been stated before, the Miami silt loam should be kept in good tilth by proper drainage, cultivation and the growing of crops for soiling purposes. All the manure produced on a farm should be carefully taken care of and spread over the land where it is most needed. It is well to follow a rotation where the corn is planted on clover sod. The number of crops and kinds used in rotation will depend on the size of the farm and the type of farming practiced, but should include one (two would be better) year of clover. Where the ground seems to be "clover sick" only an application of ground limestone is needed to insure a change. Commercial fertilizers may be resorted to under some conditions, but we believe that they should not be constantly used with all crops.

Miami Loam.

Properties.—The Miami loam is a transition between the silt loam and the sandy loam, and the boundary between them is usually arbitrary. It has a higher percent of sand and has perhaps a little darker color than the silt loam.

The subsoil of the Miami loam has a higher percent of sand and fine gravel than the silt loam and is variable in color and texture. On the one hand it grades into the silt to loam type, while on the other it may be sandy, grading into the sandy loam.

The difference in the character of the till as left by the glacier and the removal of the silt by the weathering and eroding agents are probably responsible for the present structure of the Miami loam. The topography is similar to that of the Miami silt loam.

Drainage.—The drainage of the Miami loam is usually good on account of the open, porous structure of the soil and the large amount of sand and gravel in the subsoil. In some cases, however, the subsoil is hard and compact, producing a poor natural drainage. In such cases artificial drainage would be beneficial and greatly increase the producing capacity of the soil.

Crops Grown.—The crops grown on this type are similar to those of the Miami silt loam and they yield as good crops. Owing to the presence of sand it can be more readily kept in a state of good tilth, but it quickly responds to good farming methods. The same farming methods will apply equally well in the Miami loam as in the silt loam types.

Location.—The Miami loam is about as extensive as the silt loam and is largely south of the Wabash and Eel rivers. It is valued about the same as the silt loam types.

Miami Sandy Loam.

Characteristics.—The upper six inches consist of a grayish to dark brown fine sandy loam or fine loamy sand. The subsoil is a yellowish brown heavy loam grading at about eighteen inches into a sticky fine sandy loam or clay loam. In some places it changes to a yellowish sand mixed with some clay.

Location.—It occurs in Cass County north of the Wabash River, becoming less sandy towards the river. A great deal of gravel occurs around Adamsboro and Georgetown. The sandy phase is associated with the sand ridges where the sand has been blown over the nearby land. The ridges are usually more sandy or gravelly, while the valleys contain a greater percent of clay. The topography ranges from level to undulating or rolling. Part has a morainic surface with more or less boulders.

Drainage.—The drainage of the Miami sandy loam is more abundant and is apt to be somewhat droughty in more sandy areas. The depressions usually develop swamps which have little or no drainage. A number of open ditches have been made, heading in the Muck and Clyde areas. Numerous wet quicksand areas occur on the hillside, where the water-bearing sands and gravel are exposed. These places are difficult to drain because of the continuous water supply.

Crops Grown.—This type produces good yields of corn, oats, wheat, clover and potatoes. Apples, pears, peaches, grapes and small fruits should do well on this type of soil. A few orchards have been planted and seem to do well.

Where sand ridges occur in the sandy loam, care should be taken to keep the sand from blowing in the spring of the year. The sand not only uncovers the young crops on the ridges but it covers up the plants in drifting. Blowing sand does great damage by lacerating the leaves. The more sandy ridges should have cover crops during the spring of the year, such as rye.

The fine sandy loam is easily cultivated and requires less labor to secure a good seedbed than the other upland soils. The yields are slightly below those of the heavier types.

Care should be taken not to cultivate sandy land when too wet. The water soon sinks down and the surface soon dries off, but below the first inch the soil is too wet. If stirred too wet, the soil loses too much water by evaporation.

The application of barnyard and green manures is very important. Clover and other leguminous crops should be grown for green manure. It is well to remember that sandy land loses fertility easier than clay soil from leaching.

Clyde Silty Clay Loam.

Characteristics.—The surface of the Clyde silty clay loam is a silty loam to a depth of from ten to sixteen inches. It then grades into a sandier brown clay loam having an average depth of sixteen inches. The subsoil consists of a drab or a dark blue, mottled with a yellowish to a rusty brown plastic clay loam. When wet its surface is dark brown or black, but when dry its surface becomes a grayish brown to brown. When dry the soil crumbles, forming cubical blocks. The surface forms deep cracks.

The Clyde silty clay loam grades on one side into the Peat and Muck series, while on the other side it merges into the surrounding Miami soils.

The topography is naturally level, with perhaps an occasional slight elevation on the surface.

Origin.—The Clyde silty clay loam, in common with the Clyde series, is due to depressions in the surface after the retreat of the glacier. The depressions had a very poor natural drainage and became marshes and swamps in the case of the glaciated regions. The areas are connected in most cases by long, narrow, usually parallel lines, where the water slowly drained from the higher swamps to the lower ones and finally reached the smaller tributaries of the streams. The swamps slowly filled with organic remains from the surrounding higher land in addition to the rank vegetation that flourished in the swamps themselves. The organic matter settled to the bottom, where it decayed and became mixed with the fine clay sediments that were washed into the depressions. The poor drainage produced the heavy phase, while the better and more free drainage gave rise to the silt loam with a bright yellow to reddish subsoil at a depth of two feet.

Drainage.—The Clyde series of soil types requires artificial drainage to lower the water level below the surface of the soil. In fact, when the country was first settled, the black land was all under water, but after thorough drainage it was considered the best soil type.

The Clyde silt clay loam contains a very high percent of humus, which, united with the clay, forms a porous, friable soil which absorbs moisture readily and is easily cultivated.

Crops Grown.—The Clyde soil is the leading corn land of the country. It yields fifty to seventy-five and sometimes eighty to ninety bushels per acre. Timothy is a good crop to grow on the more chaffy phases, where other crops have a tendency to dry up. Oats yields well and wheat does good, but both crops tend to produce too rank a growth of straw and consequently to lodge. Wet, open winters are bad for wheat. The open, loose texture admits water freely, and freezing heaves the soil, pulling the wheat out of the ground. A relatively dry winter season, with a few inches of snow for protection, is followed by good results.

The Clyde silty clay loam, or silty loam as it is sometimes called, occurs typically south of the Wabash River. The Muck is always associated with or surrounded by this soil type.

Clyde Loam.

Properties.—The Clyde loam is a grayish brown to a brownish black soil with an average depth of about ten inches. The subsoil is a grayish brown in color, increasing in clay content as it descends, and at about eighteen inches to two feet grading into a mottled bright yellow material. It is sometimes streaked with a reddish color and with the steel gray. This type occurs in shallower depressions, and the color of the surface soil is sometimes almost midway between the surrounding Miami soil and the darker Clyde silty clay loam.

Crops Grown.—The Clyde loam is well adapted to the growing of corn, clover, wheat, oats and timothy. It is first and last a corn soil; in fact, in some parts of the county that crop seems to be the only one grown.

A crop rotation should be practiced, including a crop of clover or some leguminous crop, every four or five years to enrich the soil. The farmers are planting the soy bean in the corn rows and also as separate crops. This will help to improve the soil.

Location.—The Clyde loam is developed throughout the county, but principally south of the Wabash.

Clyde Sandy Loam.

Properties.—The Clyde sandy loam consists of a variable black to a brownish black loam about sixteen inches deep. The subsoil is a light drab or sticky fine sandy or loam mottled with brown or drab and grading at about thirty inches into a gravelly yellowish clay.

Below this and along the border of the lake plain the subsoil and the substratum is often of heavier glacier till. In places the top soil is Muck but has the typical Clyde subsoil. In other cases the subsoil grades into a fine water-bearing sand.

Location.—This type occurs in the lake plain region and to the east north of the Wabash, where it occupies the low depressed areas between the more sandy ridges. It is intermingled with higher, island-like areas, usually of Miami sandy loam.

The surface is level or very slightly undulating. The Clyde sandy loam is due to an accumulation of an abundant growth of marsh grass mixed in with the sand and clay and washed in from the higher bordering ridges.

Formerly it was covered with water and marsh grass, but at present a system of dredge ditches and lateral drain tile form fairly adequate drainage. Care must be taken in the spring of the year, as numerous marshy or boggy places occur, due to the excess of water and probably the presence of quicksand near the surface. This is a great hindrance to farming operations. Perhaps one of the greatest factors is a lack of sufficient drainage, but this will be remedied in time.

The Clyde sandy loam is the most extensive and most important soil type of the lake region, in fact of northwestern Cass County. Between 80% and 90% of this is in cultivation.

Crops Grown.—Corn and oats are the principal grain crops grown, yielding as much as eighty bushels per acre. Some wheat is also grown.

Before the Clyde sandy loam was drained most of it was used for marsh hay and pasture.

Perhaps potash is the best fertilizer to use, as experiments have shown an increase of from ten to twenty bushels per acre of corn from its use.

This type is used for trading purposes more than any other type.

Fox Loam.

Properties.—The Fox loam has a surface of a gray to a brownish color with a friable loamy texture to an average depth of ten inches. The surface becomes lighter in color as the amount of sand increases. The subsoil becomes sandy, while in some cases, as near Hoover, it changes to gravel. The surface is level to slightly undulating.

The natural drainage of this type of soil is usually good, although during dry seasons it has a tendency to drought.

Crops Grown.—The crops grown and yield per acre are similar to those of the Miami series.

Fox Sandy Loam.

Properties.—The surface soil of the Fox sandy loam is a gray to brownish sandy loam. The subsoil is lighter in color and in the upper part has the same composition as the top soil, but becoming heavier with depth. At a depth of twenty-four inches it is a fine sandy clay, becoming lighter in color, often changing to a layer of sand in the three-foot section. Coarse gravel also may occur. This type occurs as a river terrace along the stream valleys. The surface is level or pitted and sometimes rolling, due to erosion.

The Fox sandy loam with the clay subsoil around Hoover holds the moisture during the dry, growing season, as the clay prevents evaporation. It yields from forty to fifty bushels of corn, fifteen to thirty bushels of wheat and about fifty bushels of oats per acre.

Genesee Loam.

Properties.—This soil consists of a light brown loam to a sandy or silty loam. The subsoil is very similar in texture to the soil, but is usually lighter brown in color. Below eighteen to twenty inches the substratum is frequently made up of horizontal beds of sand and clay.

The Genesee loam is an alluvial soil and its variation in structure is due to the same causes as in the case of the sandy loam. It has a level to somewhat broken topography and occurs along the sources of streams.

Agricultural Conditions.—The Genesee loam is used for the growing of grain crops, particularly corn. It is productive, easily cultivated, and readily kept in good condition. A great deal of the land is used for pasture purposes.

The drainage is usually good, but it does not stand dry weather as well as soils with a very high clay content.

Genesee Fine Sandy Loam.

Characteristics.—The Genesee fine sandy loam consists of a variable light brown to dark brown medium heavy fine sandy loam ranging from ten to twenty inches deep.

The subsoil has about the same texture, but usually of a lighter color. There are in places local variations from the typical Genesee, due to the variations of the flow of the depositing water. Sand and silt areas are due to erosion and depositing by the overflow waters. It is subject to frequent or annual overflow.

The Genesee forms the flood plains of all the streams. Some of the areas mapped as Genesee are the same as those usually called meadow land. The two were not separated. The boundary between the Clyde series and the Genesee series is not distinct. Since the Genesee fine sandy loam is an alluvial soil, it varies in short distances, owing to the changes in the current of the streams at various flood stages. Near the streams and across the sharper bends, where the currents were sharp, the coarser particles were deposited, and in many cases the soil has a large proportion of coarse sand. Near the larger bends, or where the water found settling basins, where the water was less turbulent, the finer material was deposited, giving rise to the heavier and more silty type, usually of a darker color. Mixture of the fine clay or silty material with the right proportion of sand is the basis of the Genesee fine sandy loam.

Agricultural Conditions.—The bottoms are flooded annually, or oftener, and in places are cut by smaller streams and branches tributary to the main stream. The drainage is usually good and the land dries rapidly after a rain. It is a soil that is friable, easy to till, and, where protected from overflow, is admirably adapted to corn, oats, clover or timothy. A great deal of the rougher land is in pasture.

The fertility of the Genesee fine sandy loam is renewed each time it is flooded by high water, making the growing of leguminous crops of less importance. Thorough cultivation is necessary to keep down the large number of weeds springing up from the seed brought in by high water.

The flood of 1913 took off all the top layer of soil of a field along the Wabash River. It was planted in corn that year and yielded ten bushels to the acre. Oats made ten bushels per acre the next year, but a good stand of clover was obtained. Two years later the field yielded eighty bushels of corn per acre. This goes to show the vital importance of clover on river-bottom land.

Dunkirk Loamy Fine Sand.

Characteristics.—The surface of this type is a yellowish gray to brown fine sandy loam. At six to ten inches it gradually changes to a fine yellowish sand, with perhaps a small amount of clay. The subsoil is variable, ranging from almost pure sand to a very sandy loam.

The topography of the Dunkirk fine loamy sand ranges from almost level to a rolling surface comprised of a series of sand ridges, the valleys holding the Clyde fine sandy loam. The Dunkirk loamy fine sand usually borders the muck patches, forming sand ridges.

Drainage.—The drainage is good, except in the narrow, depressed valleys, which are poorly drained.

Crops Grown.—Corn and oats do well on this type where the organic content is well supplied. Wheat does well when it has a favorable winter. Cow peas seem to be the best crop to supply plant food, as it can be grown more easily than clover. Most of the crop, however, should be plowed under. The agricultural practices given for the Miami series apply here.

Dunkirk Fine Sand.

Characteristics.—The Dunkirk fine sand occurs as a fine yellowish sand in ridges on the border of the lake plane region. These ridges are resting on a clay bottom. In some instances the clay seems to form the core of the ridge, the sand forming a sort of veneer. The loose drift sand was formed in unequal ridges by the wind blowing it in one direction, forming a gentle slope on the windward side and a sharp, abrupt slope on the leeward side.

The sand blows on the surrounding land, smothering the vegetation and beating the tender leaves to strings in the early spring. Care must be taken to keep a cover crop on all ridges and sandy areas that have a tendency to be moved by the wind. Rye is a good crop for this purpose.

Crops Grown.—Corn and oats do moderately well on this type. Wheat does very well, while navy beans are grown to some extent. A sand ridge is always damp just under the surface during the dryest weather. The crop yield is usually limited by the amount of available plant food. This is difficult to retain because of the bleaching power of the soil water. Clover is a good crop for green manure, or perhaps a better crop is cow peas.

MUCK.

Characteristics.—Muck is a dark brown to black mixture composed of the organic remains of swamp vegetation in various stages of oxidation, mixed with varying quantities of sand, clay and silt. It ranges from two or three feet to many feet in depth. On the outer margins the muck merges into the Clyde series.

Most of the muck occurs north of the Wabash and in many areas is bordered by sand ridges. The surface is level, and before it is drained it is covered with water, forming a marsh. Many of the areas were known as prairie by the early settlers. They were covered with a growth of sedges, marsh grass, etc. At the present time it is usually drained by dredge ditches. When it is properly drained and sown in grass it forms fine meadow or pasture land, in fact that seems to be the most satisfactory farm crop to use.

Crops Grown.—It produces good crops of corn where the frost does not get it in the late spring or early fall, but this land is affected most of all. Most muck is deficient in potash, which can be supplied by manure and potash salts. Grains grow too rank and lodge badly. Muck is well adapted to the growth of onions, celery, cabbage, lettuce, beets, turnips, cauliflower and Irish potatoes. It is especially used for gardening when close to town.

MEADOW.

Meadow represents the variable soil conditions encountered in the narrow, trough-like valleys of the streams. It consists of alluvial material, varying from almost pure sand to silt or clay, and is usually subject to overflow with very high water. Part of it is in cultivation, but most of it is in pasture, trees, underbrush and weeds. This type is not shown separately on the map, but is included with the Genesee series.

The Velocity of Sound Waves in Tubes.

Arthur L. Foley, Indiana University.

(Author's Publication No. 45.)

In 1862–63 Regnault, in Paris, made an elaborate series of experiments on the velocity of sound in newly laid water pipes. As sources of sound he used a pistol, explosions, and musical instruments. Both ends of the pipe were closed and the sound was produced at one end. Thus the wave passed back and forth through the pipe many times, its time of arrival at the ends being recorded on a chronograph drum by a stylus operated electrically when the sound wave impinged on a thin membrane and closed an electric circuit. Figure 1 shows graphically the results of Regnault's experiments.

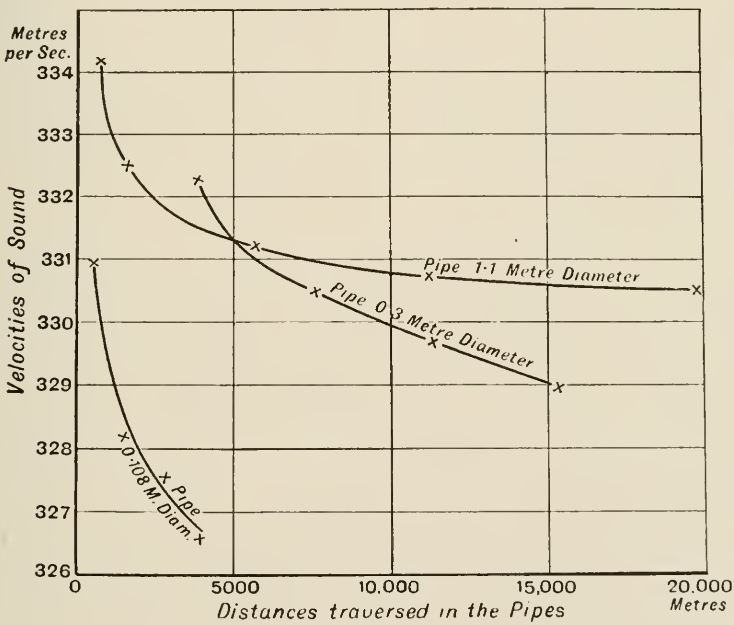


Fig. 1.

It will be noted that Regnault obtains a velocity of 334.2 m./sec. near the source in a pipe 110 cm. in diameter, and that the velocity at 2,000 m. from the source has decreased to 330.5 m./sec. A pipe 10.8 cm. in diameter gave a smaller initial velocity and a much more rapid variation of that velocity with distance from the source. (The curve indicates, too, a much greater total variation in the case of a small pipe.) Regnault concluded that: (1) The velocity of sound in pipes varies inversely with the diameter; (2) the velocity decreases as the distance from the source increases; (3) the limiting velocity is the same for all sources.

Rink objected to Regnault's deductions and explained the greater initial velocity as due to the fact that, during the first few coursings, the sound wave would be traveling in air moving bodily as the result of the explosion which produced the wave.

TABLE I.

Rink's Analysis of Regnault's Experiments.

No. of Experiment.	Charge of Gun Powder in Pistol in Gms.	Speed in cm. per Sec. of Each Passage of Sound Along Pipe 110 cm. Diameter.						Mean Speed for Given Charge of Powder
		3rd Passage	4th Passage	5th Passage	6th Passage	7th Passage	8th Passage	
1	0.5	330.02	330.29	330.15	330.21	330.11	330.13	330.152
2	1.0	330.36	330.59	330.57	330.61	330.44	330.42	330.498
3	1.5	330.29	330.57	330.54	330.47	330.47	330.53	330.433
4	2	330.60	330.51	330.84	330.44	330.44	330.30	330.513
5	1	330.04	330.26	330.26	330.23	330.15	230.22	330.193
6	1	330.36	330.37	330.50	330.67	330.55	330.50	330.492
Mean Speed for each Passage		330.278	330.428	330.477	330.452	330.360	330.350	

The above table gives the results of Rink's analysis of Regnault's experiments and appears to confirm Rink's contention that the true velocity of sound in a given pipe is constant, the result for a pipe 110 cm. in diameter being 330.5 m./sec. For a pipe 7 cm. in diameter LeRoux, using Regnault's methods, obtained a velocity of 330.66 m./sec.

Regnault, in 1865, by the reciprocal firing of guns, the explosion breaking an electrical circuit at the source, the wave—by moving a membrane—breaking another circuit at a distant point, both circuits making stylus records on the same chronograph, obtained velocities of 331.37 m./sec. and 330.7 m./sec. at distances respectively of 1,280 m. and 2,445 m. from the source. In all of Regnault's experiments efforts were made to determine and to correct for the time lag of the recording apparatus. The error due to this cause can not be entirely eliminated for two reasons. In the first place the lag depends on the intensity of the wave and is therefore a function of the distance from the source.

In the second place the sound produced by a pistol or cannon is, near the source, a pulse whose wave curve is short and steep. As the distance from the source increases the wave type changes. This change of wave form would of itself cause a variation in the time lag of the device. However, the unavoidable sources of error in Regnault's work are not sufficient to cast doubt on his conclusions that the velocity of sound decreases as the intensity decreases. Indeed, other experimenters using other methods have arrived at a similar conclusion, a conclusion in accord with theory.

Referring to Rink's table of Regnault's results from which Rink concludes that the velocity of sound in a pipe 110 cm. in diameter is practically constant, one may conclude that the apparent constancy is due to the fact that, in such a tube, the intensity of the sound wave varies very slowly with the distance from the source. In very small tubes and in tubes with rough walls or with walls of material capable of absorbing some of the energy of the waves, the intensity would vary more rapidly with increasing distance from the source, and one would expect a greater variation in the velocity. Experiments confirm this conclusion.

TABLE II.

Observer	Method	Frequency	Diameter and Material of Tube	Velocity m/sec.
Wertheim, 1844	Organ Pipe		1.0 cm. Brass 2.0 cm. Brass 2.0 cm. Glass 4.0 cm. Brass	329.12 330.11 330.23 332.10
Regnault. Mem. de l'Acad. Paris. 37. I. 3. 1868. C. R. B 66. s 209, 1868.	See Fig. 2 and explanation.			
Rink, Pogg. Ann. B 149 s 533. 1873.	See Fig. 2 and explanation.	Explosion	110 cm. Iron	330.5
Kundt. Pogg. Ann. B 135 s 333 u. 527. 1868.	Double Kundt's tube	?	3.5 cm. Glass 6.5 cm. Glass 13.0 cm. Glass	305.42 323.00 329.47
Seebeck. Pogg. Ann. B 139 s 104, 1870.	Kundt's tube	320 320 320 512 512 512	.34 cm. Glass .9 cm. Glass 1.75 cm. Glass .34 cm. Glass .9 cm. Glass 1.75 cm. Glass	317.26 328.02 329.24 322.98 328.44 330.92
Le Roux. Ann. Chem. Phys. (4) 12. 345, 1867	Similiar to Regnault's method	Explosion	7.0 cm.	330.66
Blaikley. Phil. Mag. V 16 p. 447, 1883.	Special form of organ pipe.	105	1.17 cm. Brass 1.95 cm. Brass 3.25 cm. Brass 5.41 cm. Brass 8.82 cm. Brass	324.56 326.90 328.78 329.72 330.13

TABLE II—Continued.

Observer	Method	Frequency	Diameter and Material of Tube	Velocity m./sec.
J. Muller. Ann. d. Phys. B 11, s 331. 1903.	Kundt's tube	903	.372 cm. Glass	317.2
		903	.678 cm. Glass	322 9
		902	1.552 cm. Glass	327.3
		2,482	.372 cm. Glass	323.0
			.678 cm. Glass	325.4
			1.552 cm. Glass	330.2
Schulze. Ann. d. Phys. B 13, s 1060. 1904.	Quincke's double tube	384	.101 cm. Glass	258
		384	.151 cm. Glass	282
		512	.101 cm. Glass	265
		512	.151 cm. Glass	290
		384	.099 cm. Brass	189
		384	.148 cm. Brass	230
		512	.099 cm. Brass	208
		512	.148 cm. Brass	253
		512	.150 cm. Rubber	195

In Table II, I have tabulated some of the results obtained by a few of the many observers who have determined experimentally the velocity of sound in tubes. The results shown are not uniform, but in general they tend to show that—

(1) The velocity of sound in tubes is less than in free air.

(2) The smaller the tube the smaller the velocity.

(3) The higher the frequency the less the retardation.

(4) The velocity depends more or less upon the material of the walls of the tube.

(5) The greater the intensity of the sound the greater is its velocity.

The last-named conclusion is not drawn from Table II, but from the original papers there referred to. It must be said, however, that the observers referred to are not a unit in supporting the five conclusions above named. Other observers are equally at variance. For instance, Violle and Vautier[1] after a study of the velocity of sound in a masonry conduit 3 m. in diameter, the sounds being produced by various musical instruments and ranging in frequency from 32 to 640, arrived at the conclusion that in such a pipe the velocity is constant to within one part in a thousand. Rink's analysis of Regnault's results, given in Table I, would seem to show a velocity independent of sound intensity.

As a whole, however, the conclusions given are supported by experi-

[1] Violle and Vautier. Ann. Chem. Phys. (8) 5. 208, 1905.

ment, and are in accord with the theoretical conclusions of Helmholtz,[1] Kirchoff,[2] Rayleigh,[3] and others who have attacked the subject. The equations of both Helmholtz and Kirchoff may be reduced to the form

$$v^1 = v\left(1 - \frac{c}{2r\sqrt{\pi n}}\right)$$

where v^1 is the speed of sound of frequency n in a pipe of radius r, and v is the velocity in free air. According to Helmholtz c is the viscosity of the gas, according to Kirchoff it is a term depending on the heat conduction between gas and pipe walls, according to Müller[4] the equation has no general validity, according to Schulze[5] the "constant" c was found to range between 0.0075 and 0.025, depending on the diameter and nature of the tube.

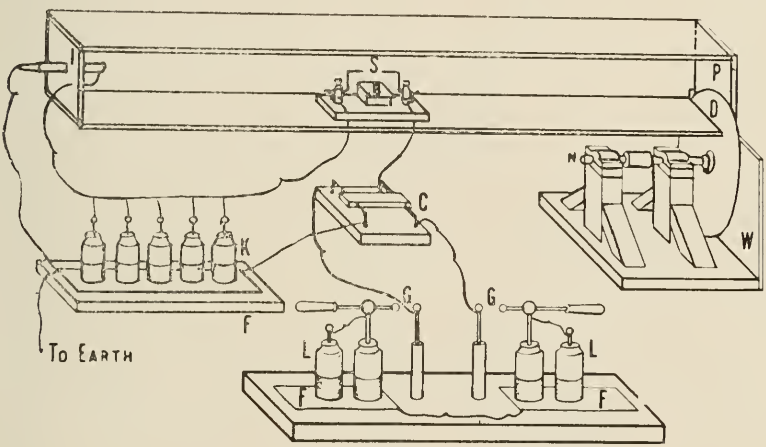


Fig. 2.

Sturm[6] found that Kirchoff's formula was not valid for different tubes and frequencies. On the other hand Wertheim's[7] results supported the equation, while Schneebele[8] and Seebeck[9] obtained results that sup-

[1] Helmholtz, Wessensch. Abhandl. B 1, s 383, 1882.

[2] Kirchoff, Pog. Ann. B 134, s 77, 1868.

[3] Rayleigh's Theory of Sound, Vol. —, p. —. Also Lamb's Dynamical Theory of Sound, p. 190.

[4] See Table II.

[5] See Table II.

[6] J. Sturm. Ann. d. Phys. B 14, s 822, 1904.

[7] Citation in Table II.

[8] Pogg. Ann. B 136, s 296, 1869.

[9] See Table II.

ported the equation only as far as concerns variation of speed with diameter of pipe, and were in disagreement as to the effect of pitch. There is therefore no consensus of opinion on any of the points concerning the velocity of sound waves in tubes. It will be noted, however, that in no case has an observer claimed a greater speed in pipes than in the open. The writer has obtained such results.

Figure 2 shows the general arrangement of the apparatus used in this experiment. The reader is referred to earlier papers[1] for a more detailed description and explanation. It will suffice here to say that two spark gaps S and I are in series and connected—through two variable gaps G, G—to the terminals of a powerful electrostatic machine. When the gaps G and G are shortened a discharge passes through the commutator C to the circuit including the sound gap S and the illuminating gap I, the latter spark being retarded slightly by a variable capacity K. By varying the capacity K and the length of the gap I, the light from the spark at I can be adjusted to cast a shadow on a photographic plate P of the sound wave produced by the spark at S.

Plate I shows such a wave. The sound spark was produced just behind the center of the circular screen (a hard rubber disk) D, the screen being used merely to prevent fogging the dry plate by the light of the sound spark. T is an end-on shadow of a portion of a piece of brass tubing 3 cm. in diameter and 5 cm. long. The projecting arms are four pieces of brass tubing, respectively 0.25 cm., 0.48 cm., 0.8 cm., and 1.15 cm. in internal diameter, each of them 2.4 cm. long. They were soldered radially in holes whose diameters corresponded respectively to the outside diameters of the tubes. Almost half of the side wall of the supporting tube was then cut away, to permit the sound wave to travel out on one side in free air, while on the other side the wave was arrested except for the portions passing through the four radial tubes. The sound gap was placed as accurately as possible at the center of the supporting tube and the point of intersection of the axes of the radial tubes.

In order to show at a glance just what has happened with the position of the sound gap as center I have drawn a broken line circle. To avoid confusion I have drawn the circle C just outside the main wave W. It will be noted that the waves through the tubes lie well without the circle, showing that the waves in the tube traveled more rapidly than the wave in free air, and that apparently the velocities in the several tubes were the same, although the tube diameters were in the approximate ratios of 1, 2, 3 and 5.

On the negative from which Plate I is a reduced print the waves

[1] Physical Review, Vol. 35, p. 373, 1912. Also Proceedings Indiana Academy of Science, p. 305, 1915.

through the tubes measured .48 cm. in advance of the free air wave and the tube length shadows were 4.56 cm. long. Assuming that the entire gain in space traversed occurred while the waves were inside the tubes (an assumption which I think is not entirely true) we would have a relative increase of velocity within the tubes of .48 ÷ 4.56, or 10.5 percent.

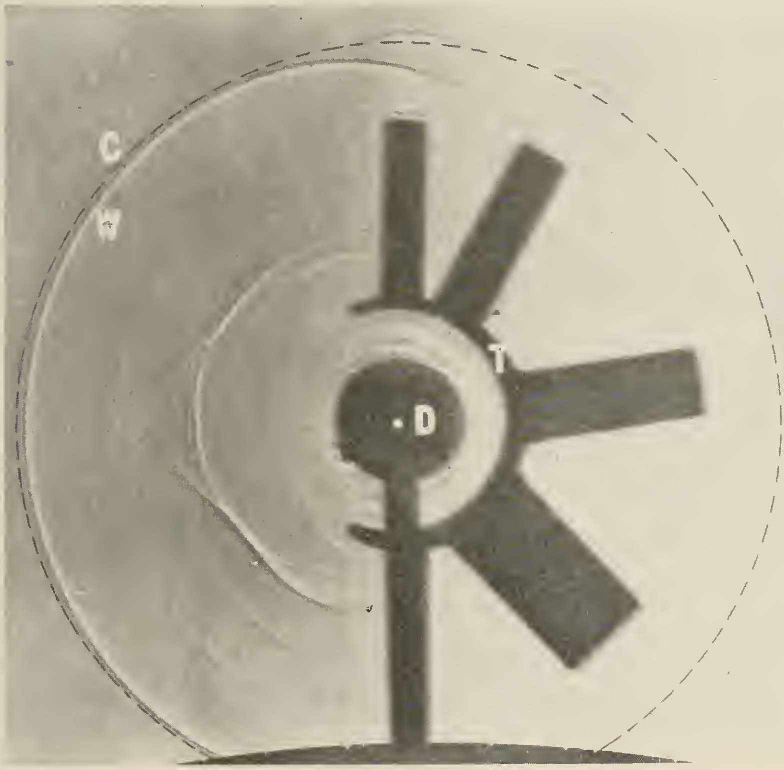


Plate I.

It happens that none of the observations of Table II was made with a tube of the same size as the smallest one used by the author. For a tube about 40 percent larger Seebeck and Müller obtained values approximately 5 percent less than the free air velocity—depending on the pitch of the sound. Thus it would appear that the total difference between their and the writer's results is in the neighborhood of 15 percent.

Plate II was obtained by replacing the four short tubes with two longer tubes, of internal diameter .25 cm. and 1.15 cm. respectively, each 10 cm. long, and adjusted radially as in Plate I. Note that in this case the wave through the small tube is actually slightly in advance of the wave through the large tube, the distances on the original plate

Plate II.

being .89 cm. and .84 cm. respectively. The wave near the gap is the reflected wave from the side of the box which enclosed the gaps and dry plate. The percent increase in velocity in this case is obtained as before by dividing .89 by 16.5, the length of the tube shadow on the negative. This gives 5.4 percent, about half the value obtained with the shorter tubes, which were about one-fourth as long as the two shown on Plate II. The gain in distance traversed was 0.48 cm. for the small tube when 2.4 cm. long, and 0.89 cm. when 10 cm. long. It would appear from this that more than half the gain was made in the first fourth of the tube's length, and that if the tube were long enough the velocity might drop to the values obtained by other experimenters, or even below —for their results are averages over considerable lengths of tubes.

The writer gives the calculations above—for Plates I and II—merely as an illustration of what occurred in these two cases, and not because he attaches any significance whatever to the numbers given. As a matter of fact, the numbers have no significance. In every case I have tried, the waves through the tubes have been in advance of those in free air, but the gain has been quite variable. I am now endeavoring to determine the cause of the increased velocity, and the reasons for its variation. I have secured a number of photographs of the waves through a 10 cm. and a 15 cm. tube placed side by side, with their ends at different distances from the sound spark. This investigation is not complete, but it has gone far enough for me to say that the velocity of a pulse through a tube is greatest when the end of the tube is nearest the sound spark, indicating that it is a question of sound intensity. The sound for a time travels faster in the tube than it does outside because the intensity of the wave in the tube decreases less rapidly than in free space.

This experiment appears to settle conclusively the question as to the dependence of sound velocity upon intensity independent of any variations caused by motion of air in a body, as contended by Rink in the case of Regnault's experiments. I shall discuss in a later paper the question of what happens to the air when a spark passes.

Physics Laboratory, Indiana University, January, 1919.

Dr. Luther D. Waterman.

Luther Dana Waterman.

Arthur L. Foley.

Dr. Luther Dana Waterman was born in Wheeling, West Virginia, November 21, 1830; died at Indianapolis, Indiana, June 30, 1918, age eighty-seven years, seven months and nine days. Dr. Waterman was the son of Joseph Aplin and Susan (Dana) Waterman, the father being a native of Cornish, New Hampshire, the mother of Belfry, Ohio. The mother died in 1837, leaving five young children, of whom Luther, the subject of this sketch, but seven years old, was next to the oldest. On the death of the mother Luther went to live with his grandmother at Oxford, Ohio. Although his father later remarried, Luther continued to make his home with his grandmother until he had completed the work of the public schools of Oxford and entered upon a college course at Miami University.

The father, Joseph Aplin Waterman, was a farmer in his earlier years. Later he became a physician and still later a Methodist minister. It appears that he was successful in each of these callings, particularly as a minister. It is said that he was not only a zealous expounder of the Gospel but that he was an earnest and capable biblical student. He died at Oxford, Ohio, at the age of fifty-five years.

Luther's maternal great-grandfather was Captain William Dana, who was in charge of one of the companies from New England that, under General Putnam, settled at Fort Marietta, now the city of Marietta, Ohio.

Dr. Waterman's early education was obtained in the public schools at Oxford, Ohio, where he was known as a very capable and ambitious lad. After completing the work of the public schools, he attended Miami University four years, and the Medical College of Ohio, at Cincinnati, two years. During his college work he was frequently obliged to drop out and teach a term to get money to continue his college work. At one time while a student in Cincinnati he got so near the end of his resources that his only alternative appeared to be to drop his medical work and seek employment. As a last resort he decided to try for a prize of fifty dollars offered by one of the Cincinnati papers for the best poem for the coming New Year's edition. By New Year's day young Waterman's funds were so low that he did not have money enough to buy a paper to see whether or not he had won the prize, and it was by accident that he learned of his success. He spent a part of the prize money to buy a pocket set of surgical instruments. He used these instruments during his forty years of surgical practice and it was with pride that he exhibited them to his friends, particularly after he and the instruments had "retired."

Dr. Waterman graduated from the Medical College of Ohio in 1853. For two years after graduation he practiced medicine in Cincinnati, and, like the usual young doctor, was not burdened with patients. Concluding that he could do better in a smaller town, he moved to Kokomo, Indiana, in 1855, and established a partnership with Dr. Corydon Richmond. The move proved to be a very wise one. The population of the town and surrounding country grew rapidly and with it the practice and reputation of the firm of Richmond & Waterman. For several years these doctors led a very strenuous life—with an office full of patients and constant calls for country trips through swamps and over corduroy roads. Although Dr. Waterman remained in Kokomo but six years, leaving there in 1861 to become a surgeon in the Union Army, nevertheless it was at Kokomo that he got the practical experience that made his work with the army so successful, and it was there that he secured the nucleus of his later fortune.

Being a man of strong idealism and patriotism, Dr. Waterman did not hesitate a moment, when the integrity of the Union was threatened, to sacrifice a large and lucrative practice to offer his services to the Government. In August, 1861, he was commissioned Surgeon of the Thirty-ninth Regiment, Indiana Volunteer Infantry. Although his total service in the Army extended over a period of three years and two months, nevertheless he was not with the Thirty-ninth Regiment much of the time, being frequently detailed to other companies and to hospitals. During his three years of service he was Surgeon of the Eighth Indiana Cavalry, Medical Director of the Second Division of the Second Army Corps, Army of the Cumberland, then Medical Director of the First Division of the same Corps, and during the absence of superior officers was Medical Director for a month of the Corps under General Phil Sheridan. He was Surgeon at the hospitals at Huntsville, Alabama, and at Bridgeport and Chattanooga, Tennessee. He was twice captured by Confederate forces, once at Harpeth Shoals, Tennessee, and again at Newman, Georgia. He was held for three weeks in the prison stockade at Macon, Georgia, and then transferred to the workhouse prison at Charleston, South Carolina. He was later released (exchanged) near Fort Sumpter.

At the conclusion of the war Dr. Waterman located at Indianapolis and once again began to build up a practice. He soon came to be recognized as a successful surgeon and one of the best general practitioners in the State. He was for several years one of the surgeons of the City Hospital and was one of the charter organizers of the old Indiana Medical College, in which he was Professor of Anatomy from 1869 to 1873, and Professor of Principles and Practice of Medicine from 1875 to 1877. With the consolidation of the several medical schools of the State into the Indiana University School of Medicine, Dr. Waterman became Emeritus Professor of Medicine. He was for many years an active member of the Indiana State Medical Society, and was Secretary and President of that organization. It was in May, 1878, as President of the Society, that he gave an address entitled "Economy and Necessity of a State Board of Health." The address was published by the Society and five thousand copies were distributed throughout the State. In that address his arguments were so conclusively presented that they caused a state-wide movement which resulted eventually in the establishment of a State Board of Health in Indiana. Up to that time but thirteen States in the Union had provided for state medical boards, and all these had been established within the previous decade.

Dr. Waterman retired from active practice in 1893, at the age of sixty-three years, after forty years of practice of medicine and surgery. Nowadays when a physician retires not many know about it or care. In this day of specialists, when a different one is employed for each and every ailment, physician and patient rarely know one another intimately; indeed, they may not even be acquaintances. Once each family had but one doctor, regardless of the nature of the case. Whatever such a physician lacked that the specialist possesses was balanced by the former's broad and comprehensive knowledge and experience, his understanding of the patient's history, habits and peculiarities, and a sympathy and personal interest that many times amounted to genuine affection. Dr. Waterman was such a physician, a family physician of the highest type, and there was sincere regret in thousands of homes when he announced his retirement from active practice.

Dr. Waterman was not only a progressive and successful physician and surgeon; he was a man of wide intellectual interests, a constant reader, all his life a student of science, language and literature, himself a writer of ability.

The writer remembers well the first time he met Dr. Waterman, then eighty years of age. He was attending a dinner of the Indiana Academy of Science and sat beside the writer—in order to discuss the electron theory. The last time the writer ever saw the Doctor alive was when the Doctor accompanied him on a two-hundred-mile auto trip to attend a meeting of the Indiana Academy at Turkey Run and The Shades—only a month before the Doctor's death. He was still interested in the electron theory. He was interested, too, in the research work of the Waterman Institute and discussed minutely the work in progress. But what impressed the writer even more than the aged Doctor's knowledge cf and continued interest in science was his knowledge of language, literature and history. He rarely faltered on Latin or Greek derivatives and he read Spanish readily. In fact, he was at that time reading a history of Mexico in Spanish. He had made an extended trip into Mexico in 1886 and had acquired some knowledge of the Spanish language. Thirty years later, at an age of more than four score, we find him reading Spanish and studying Mexican history. Here we find the secret of Dr. Waterman's success. He had the desire to know, and he had the perseverance and energy required to acquire the knowledge. In addition he had the instincts of the scientist, the faculty of observing details and appreciating their importance. This is strikingly illustrated in a paper presented to the writer a few years ago. It is a four-page description of an aurora witnessed by the Doctor when a young man, written as the display was taking place. For vividness of description and terse, straight-forward English it is superior to most of the studied memoirs published in our magazines of science. Dr. Waterman's ability was recognized by his alma mater, Miami University, by conferring upon him in 1892 the honorary degree M. A.

Dr. Waterman was originally a Whig, but became a Republican when that party came into ascendancy and remained a staunch Republican all his life. When Fremont was running for President the Doctor stumped Howard County in his behalf. Throughout his life he remained more or less active in his party's councils.

At the time of his visits to Europe, 1878 and 1881, also to Mexico, 1886, Dr. Waterman wrote a number of articles for the Indianapolis papers descriptive of his travels. He published a paper on "The Regimental Surgeon" in the Indiana Medical Journal, February, 1906, and a book of verse, entitled "Phantoms of Life," in 1883. In this little volume he "presented his philosophy of existence in stately phrasing. The ideals there shown are high, and those who knew him may well believe that he tried to fulfill them." Dr. Waterman, the son of a minister, was not himself an enrolled member of any church. Yet he was in thought and deed a deeply religious man. At his funeral both Jew and Gentile attested to the nobility of his character and the grief his death brought to them.

At a meeting of the Trustees of Indiana University, May 12, 1915, Dr. Waterman placed in their hands deeds to property amounting in value to one hundred thousand dollars for the purpose of founding an Institute for Scientific Research. This is the largest gift for scientific research ever made in Indiana. Dr. Waterman believed the highest form of charity is to discover useful truth, and for this purpose he gave the savings of a frugal and industrious life. The Luther Dana Waterman Institute for Research began its work in September, 1917. It is a satisfaction to know that Dr. Waterman lived to see the work inaugurated and to express interest in its progress. It is to be regretted that he did not live to see at least one publication from the Institute which with wisdom and generosity he had established.

At the Indiana University commencement exercises, June 23, 1915, President Bryan chose Dr. Waterman's life as a theme for his address to the senior class. No more fitting conclusion to this biography could be written. I therefore quote from President Bryan's address:

"I wish to say a few words to the oldest member of our faculty—Dr. Luther Dana Waterman, professor of medicine emeritus.

"Surgeon in the Federal Army, prisoner of war at Macon and Charleston, in civil life physician and professor of medicine, you have in eighty-four years won position and honors and fortune such that many would for them sacrifice everything else in the world. But I wish these my children to see that you have made your way up to a great practical success *without* sacrificing everything else in the world. You have not sacrificed your interest in the worlds that lie outside of your vocation of physician. Most men of every calling are caught within the trap of their own business. Not you. You have escaped that trap. You have traveled far among men and books and ideas. You are not of those who bear a title from the college of liberal arts and are yet aliens from its spirit. In the world of the liberal arts you are a citizen. You are friend with Plato and Virgil and Darwin and their kind. You know that these are not dead names in the academic catalogue, but living forces and makers of society. In that world you have spoken your own word in verses which are resolutely truthful, discriminating and brave. The joy of living as you have done in the wide, free and glorious world of the liberal arts is such that many for it have sacrificed everything else, including that practical success which you have not sacrificed.

"But besides your successes inside and beyond your calling you have had another fortune. Long ago there came to you an idea. You had lived from the days of the tallow candle and a thousand things which went with that to the days of the electric light and a thousand things which go with that. Within your lifetime you had seen an incredible access of power, enlightenment and freedom, from the discovery of truth of which all preceding generations had been ignorant. You had then the insight, the conviction that the Great Charity is the discovery of truth, which is thenceforth light and power and freedom for all men. This conviction became your deepest purpose. Thirty-two years ago you wrote:

He who would make his life a precious thing
Must nurse a kindly purpose in his soul.

"These lines were your confession. There was a great secret purpose which you were cherishing. You worked for that. You saved for that. For that you had the secret joy of living sparely, austerely as a soldier.

"Sir, you have no son. But the scholars who work upon the foundation which you have established here shall be your sons. Far down the years when all of us are in the dust your virile sons shall be here keeping alive your name and your hope. And so shall be fulfilled your saying that

They live longest in the future who
Have truest kept the purposes of life."

New Methods of Measuring the Speed of Sound Pulses Near the Source.

By Arthur L. Foley, Waterman Research Professor and Head of Department of Physics, Indiana University.

In the Proceedings of the Indiana Academy of Science for 1915 the writer showed that the relative speeds of sound pulses at some distance from the source and of different intensity are apparently the same. The experiments described threw no light on the question of the actual speed of a pulse at different distances from the source. This paper deals with a method, rather with two methods, of finding the actual and instantaneous speed of the pulse at any point less than a meter or so from the source. The method could be used for greater distances by increasing the intensity of the spark producing the sound pulse, so as to give the wave sufficient intensity to cast a "shadow" on a plate or film.

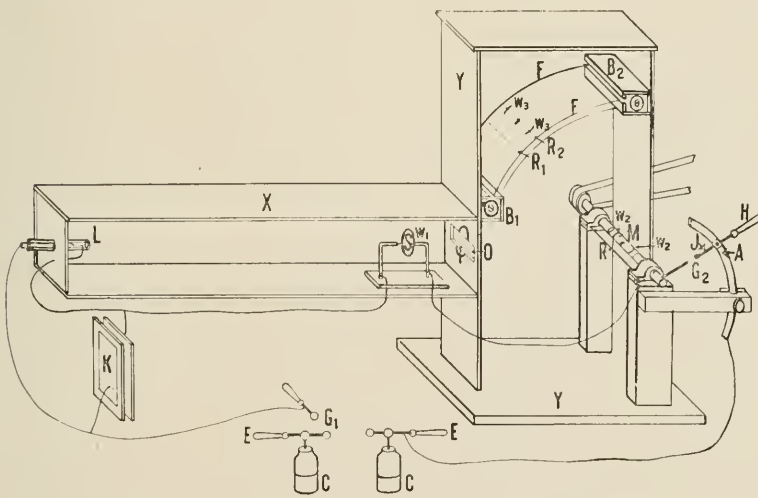


FIG. 1.

Figure 1 shows the arrangement of the apparatus used in this experiment. M is a plane steel mirror made by grinding and polishing the flat surface formed by cutting an axial longitudinal section 20 cm.

long from a piece of steel shafting about 5 cm. in diameter. The shaft was arranged for rotation at a high speed inside a light-tight box Y connecting with another light-tight box X, with a rectangular opening O, 2 x 15 cm. between them. B_1 and B_2 are boxes to hold the full and empty spools for photographic film. Guides F on each edge of the film caused it to lie, when unwound, on the surface of a cylinder with the rotating mirror M on the axis. Just in front of the mirror is a horizontal rod R, of small diameter. A spark from the terminals E of an electric machine jumps the gaps G_1, G_2, S and L, the spark at S occurring before the one at L. When the sound spark occurs the light passes through O, falls upon the mirror M, and is reflected on the film, the rod R producing a shadow R_1 on the film. Suppose that the sound pulse arrives at W_1 by the time the retarded light spark occurs. A part of the shadow of W_1 is intercepted by the wall of the box. A part passes through O, falls upon the mirror at W_2, W_2, and is reflected on the film at W_3, W_3, together with a second shadow of the rod R, now at R_2, due to the fact that the mirror has rotated through a measurable angle during the interval between the sound spark and the light spark. The distance between the shadows R_1 and R_2 together with the mirror speed and the distance from the mirror to the film, enable one to calculate the time interval between the sparks.

From the measured distance W_3—W_3, together with the distance from the light spark to the sound spark, and from the sound spark to the mirror, and thence to the film, one gets the true radius of the sound wave. The quotient of the radius by the time gives the average speed. If one plots radius by time for a considerable number of observations the tangent at any point on the curve gives the instantaneous speed at that point.

The films used were eight inches wide and four feet long, and included about sixty degrees of the arc about the mirror. As the image rotates twice as fast as the mirror it is evident that if the sparks were produced at random, there would be but one chance in twelve of the mirror being in the proper position to give a picture. To avoid this difficulty and to enable one to get several pictures on the same film a metal rod was fastened in such a position on the end of the mirror shaft that it shortened the gap G_2 to such an amount as to cause a spark to pass at the proper time. The position of the gap G_2 was varied by fixing the electrode J at different points along the arc A. J was arranged so it could be slid back and forth through a sleeve. When a spark was desired J was pushed forward and the gap G_2 thus shortened until a spark occurred. The gap was then lengthened before the electric machine had time to generate a sufficient potential for a second spark. In practice, however, this device was found to be somewhat erratic, probably due to the powerful air currents set up by the whirling electrode. Nevertheless it was possible to get three or four pictures on each film and to get sufficiently well defined sound pulse and rod shadows to permit of reliable speed calculations for waves of radius greater than 2 or 3 cm. The polish of the metal mirror was not sufficiently good to give well-defined wave pictures close to the source, where the wave is more or less confused with other spark effects. It was decided, therefore, to eliminate the mirror entirely and get the picture directly on a moving film. The mirror shaft was removed and in its stead was placed a shaft carrying an eight-inch flat-face steel pulley two feet in diameter. The film was fastened to the face of the pulley and rotated within 1 cm. of the opening O, across the center of which the rod R was fastened in a horizontal position and exactly in line with the sound and light sparks. The distance on the film between the sound spark and the light spark shadows of R together with the pulley speed gave the time interval between the sparks. From the radius of the wave shadow together with the distances from the light and sound sparks to the film the true radius of the sound pulse was calculated. As before, the quotient of radius by time gave the sound speed.

The definition of both sound wave and rod shadows was much better in this case than when the rotating steel mirror was used. However, the experiment did not yield better results for waves of small radius, because it was impossible to rotate the film fast enough to make the distance between the rod shadows sufficiently large to be measured with accuracy, when the time interval was small. The film was thrown off and torn to fragments whenever the speed exceeded some twenty-five revolutions per second, regardless of the precautions taken to hold the film on the pulley. Even when both the edges and the ends of the film were cemented to the pulley, the film was thrown off at a speed of some twenty turns per second. The highest rotational speed was obtained when the film was held on the pulley by placing over it a strip of strong cotton net of about 5 cm. mesh, with edges laced securely on the inside of the pulley rim. The string shadows were readily differentiated from the rod and wave shadows, and were not so objectionable as the writer feared they might be.

On account of the limited speed at which the film could be rotated, the increase in the accuracy of the time interval measurements resulting from the better definition of the rod shadows was offset by the fact that the distance between the shadows was much less than by the rotating mirror method. Both the rotating mirror method and the moving film method gave results that show that if there is any difference between the speed of a sound pulse of the intensity used and the speed of an ordinary sound wave, the difference is less than two per cent.

The writer is now at work on a third method which promises more accurate results than either of the ones described in this paper.

It may be noted that a photographic method of measuring sound speed eliminates sources of error found in all methods where the sense of hearing or any mechanical device is used to register the time of arrival of a sound wave, and where the distances traversed by the wave are large. There is no question as to personal error, time lag, wind velocities, differences in temperature, humidity, density, change of wave form, etc. The method gives the instantaneous speed at points up to the source of sound itself. These points will be discussed and data submitted in a later paper.

The writer wishes to thank Professor Cogshall of the Department of Astronomy, of Indiana University, for his kindness in grinding and polishing the steel mirror used in this experiment.

The Crustaceans of Lake Maxinkuckee.[1]

By Barton Warren Evermann,
Director of the Museum of the California Academy of Sciences,
and
Howard Walton Clark,
Scientific Assistant, U. S. Bureau of Fisheries Biological Station,
Fairport, Iowa.

During the physical and biological survey of Lake Maxinkuckee, Indiana, carried on more or less intermittently from July, 1899, to October, 1913, for the United States Bureau of Fisheries, considerable attention was given to the Crustaceans inhabiting the lake and its connecting waters. The full detailed report on those investigations will, it is hoped, be published elsewhere. In the present paper it is our purpose to present only the more important considerations and conclusions, largely omitting the vast body of details and observed facts upon which the present contribution is based.

A very comprehensive study of the Plankton was made by Professor Chancey Judah, now of the University of Wisconsin. It is hoped the results of Professor Juday's studies may be published soon. A similar thorough study of the Parasitic Copepods was made by Dr. Charles B. Wilson, a brief summary of whose report is made part of this paper.

Except during the summer of 1899 and 1900, the field work on Lake Maxinkuckee was nearly all done by one or two investigators only. This made it impossible to pay equal attention to all the groups of animals and plants; indeed, many groups could receive scarcely more than passing notice, while others had to be wholly neglected. Among those groups which received but slight attention are the worms, polyzoans, protozoans, smaller crustaceans, insects, and the like. Although considerable collections were made in some of these groups, insurmountable difficulty was experienced in finding specialists to work them up. Our reports on several of those groups are therefore necessarily brief and general in character.

Occasional notes and memoranda were made regarding various species which we did not have opportunity to observe regularly or methodically. Such of these as seem to possess some value or interest are given in the following pages.

[1] Published by permission of the U. S. Commissioner of Fish and Fisheries.

Collecting Stations.

Lake Maxinkuckee is in Marshall County, Indiana, 34 miles south of South Bend, 94 miles southeast of Chicago, and 32 miles north of Logansport. Its elevation above sea-level is 735 feet. It is about 2.6 miles long from north to south, about 1.6 miles wide, and its surface area is 1,854 acres. Its greatest depth is about 90 feet.

Observations were made and collections obtained in all sorts of places and situations in and about the lake. Certain localities mentioned specifically in this series of papers may be more definitely described as follows:

Arlington.—A flag station on the west side of the lake, at the base of Long Point.

Aubeenaubee Creek.—A small stream entering the lake near the middle of the east side.

Birch Swamp.—About two miles west of the lake.

Bruce Lake.—A small lake a few miles southwest of Lake Maxinkuckee.

Culver Inlet.—A small stream entering the lake at the northeast corner.

Drained Lake.—An old lake bed a mile northwest of the lake.

Farrar's Creek.—A small creek entering the lake at the southwest end.

Green's Marsh.—A few acres of wet ground between Long Point and the railroad on the west side of the lake.

Long Point.—A small peninsula projecting into the lake on the west side.

Lost Lake.—A small, shallow, muck-bottomed lake lying west a few rods from Lake Maxinkuckee.

Norris Boathouse.—On the southeast shore of the lake.

Norris Inlet.—The principal inlet of the lake, entering the lake at the southeast corner.

Outlet Bay.—A small bay on the north side of Long Point.

Outlet.—The small stream through which the water flows from Lake Maxinkuckee into Lost Lake.

Spangler Creek.—A small brook entering the lake from the east.

Walley's.—A farm on the outlet creek just below Lost Lake.

Weedpatch.—An east-and-west bar about 1,200 feet long and 500 feet wide, in Lake Maxinkuckee, in 10-foot water southeast of Arlington.

Winfield's.—On west side north of Outlet Bay.

For convenience of treatment, the Crustaceans of Lake Maxinkuckee may be divided into five groups, as follows: (1) the Plankton species;

(2) the Parasitic Copepods; (3) the Amphipods or Beach Fleas; (4) the Isopods or Sowbugs; and (5) the Crawfishes.

The Plankton Species.

The list of species contained in the Plankton collections of 1899 and 1900, and a discussion of their abundance, distribution and habits, will be found in Professor Juday's report. A few additional species were later obtained in the small ponds about the lake.

Of the individual species not much can be said; our studies were too general for that purpose. It may be stated, however, that plankton species of crustaceans constitute a large part, probably nearly all, of the first food of the young of many fishes, and much of the food of some species of fishes throughout their entire lives. The little Stickleback (*Eucalia inconstans*), for example, may be mentioned as one of such species. Examples of this species kept in an aquarium fed eagerly on any and all plankton crustaceans which we placed in the aquarium with them. We observed also that these small crustaceans are captured and eaten freely by those curious carnivorous plants, the bladderworts.

Of the whole group it can be said that they are present throughout the year in greater or less abundance. The abundance varies greatly, however, from time to time, as shown by Juday. On September 6, 1906, peculiar ripples were observed on the surface of the otherwise smooth lake. Upon cautiously approaching the spot it was found that the disturbance was caused by large schools of young black bass, circling about and feeding voraciously. Upon drawing a towing-net through the place great quantities of several species of plankton crustaceans were obtained.

On many occasions the lake surface in large areas was seen to be covered with a thin scum which, on examination, was found to consist chiefly of the cast-off skins of minute crustaceans.

On November 5, 1906, Entomostraca were present in such remarkable abundance at and near the surface of the lake that the water had the appearance and consistency of thick soup, the little animals actually crowding each other in the water. The next day great windrows of these crustaceans were found washed up on the shore at Long Point. Two days later they were again observed forming dense clouds at and near the surface of the lake off the Norris boathouse. A 4-drachm vial was simply dipped into the water and about 100 of the creatures were secured.

A quantity of plankton collected July 7, 1909, and examined qualitatively by Professor A. A. Doolittle of the department of biology, Washington, D. C., high schools, gave the following results:

Species.	Per cent.
Diaptomus oregonensis Lilljeborg..............	0.38
Cyclops leuckarti; (*edax* Forbes)..............	4.11
Diaphanosoma leuchtenbergianum Fischer......	0.40
Daphnia retrocurva Forbes, var...............	1.06
Daphnia hyalina Leydig......................	84.02
Total..................................	99.97

The Copepods (free-swimming species) frequently bear attached Protozoa, sometimes in such numbers as to make them appear bristly. They seem to be more abundant in winter when the lake is covered with ice. Whenever holes are cut through the ice these crustaceans often come crowding to the light and air.

The Cladocera are, generally speaking, the larger and more showy element of the crustacean plankton. Their stomach contents, which at times forms conspicuous masses, was found to be composed largely of phyto-plankton elements, especially *Botryococcus brauni*, which, because of its color, was easily recognizable. One of the smaller Cladocera, *Chydorus*, was found to constitute an important part of the food of the Unionidæ or mussels of the lake, as it also does of the small fishes.

One of the most notable species of the Zoo-plankton was *Leptadora hyalina*. This is usually a deep-water species, but on September 2, 1906, it was taken in quantities in a surface tow-net in Outlet Bay. Though one of the largest of the plankton crustaceans, this species was so transparent as to be quite invisible except by its movements among the associated individuals of *Lyngbya*.

Two other species of Entomostraca not usually classed as plankton were noted, namely, the fairy shrimps. One, *Branchippus serratus*, was found dead in large numbers floating on the surface in deep water July 11, 1899. Later in the same day considerable numbers were seined in shallow water off Norris Inlet. Again, on August 21 and 31, a few were seen floating.

Another species, *Branchippus vernalis*, was found abundantly in small temporary ponds west and south of the lake in the spring of 1901. A school of these curious crustaceans of delicate structure and pearly appearance. apparently usually swimming on their backs, their numerous gill-feet moving rapidly in the water, makes a very pretty sight.

The Parasitic Copepods are reported on by Dr. Wilson. It may be here remarked that, as compared with other bodies of water, these forms are comparatively rare in Lake Maxinkuckee. In certain rivers which we have examined, particularly the Kankakee, Maumee, and sloughs along the Mississippi, certain large species of *Lernasocera* are so abundant during the summer and fall that they infest most of the rock bass, crappies, and bluegills. They seemed to be worst on the rock bass, nearly every one of which was bleeding in one or more places where these parasites had fastened in their skin. At this season these fishes are said to be "wormy" and are rejected by anglers and others who chance to catch them.

The Isopods or *Sowbugs* are represented at the lake by two aquatic species, one in the lake proper, the other (*Porcellio scaber*) in the woodland ponds and in damp places. The lake species is abundant all the year round among the Chara, especially in Outlet Bay. It is one of the most important fish foods, particularly of rock bass and bluegills. It sometimes forms the greater part of the food of those species. Little or nothing was learned of the habits of the pond species. There are, of course, several land species of these curious crustaceans.

The Amphipods are represented by several species in the lake and the neighboring ponds. A large species (probably *Gammarus pulex*) was found near the shore, and a smaller form (probably *Hyalella knickerbockeri*) farther out in the lake among the aquatic plants. The Horsetail (*Ceratophyllum demersum*) was one of its favorite haunts. Some of our herbarium specimens of this plant were found full of these beach fleas. Many specimens were obtained from the plants raked up from various depths. The Amphipods could be obtained by washing the plants in a tub or bucket of water. A few were taken at night in the towing-net. Some were found in stomachs of fishes seined August 3, 1906, south of Arlington station.

The freshwater shrimp (*Palæmonetes exilipes*) was not common in or about the lake. Only a few were obtained, one on August 2, 1899, one on September 6, 1899, and one on October 23, 1900, all in the Outlet. Two were secured in Lost Lake, one on August 1, the other September 1, 1900. Another was taken November 27, 1900, upon a mass of aquatic plants dredged some distance from shore in the lake. This species therefore appears to be rather rare at this lake. In Little River near Aboite, Allen County, Indiana, immense numbers of this shrimp were found in masses of *Ceratophyllum*, from which the transparent creatures jumped with great alacrity when hauled up out of the water. They were found in great abundance also in Chester River near Chester, Md.

The Copepod Parasites.

By Charles B. Wilson, Professor of Biology, State Normal School, Westfield, Mass.

Three species of *Argulus*, two of *Ergasilus*, and one of *Achtheres* were found upon the fish of the lake. The species of *Argulus* have all been described elsewhere (Proc. U. S. Nat. Mus., XXV, pp. 709, 715, 718). The life history of one species, *A. maculosus*, was obtained in full, and a brief account was published in 1907 (Proc. U. S. Nat. Mus., XXXII, p. 416). Of the two species of *Ergasilus*, one (*E. centrarchidarum*) has been described by Wright.* This species is common everywhere on all fishes of the perch family. The other species was new to science; it was named *E. versicolor*, and a full description with figures was published in 1911 (Proc. U. S. Nat. Mus., XXXIX, p. 341: pl. 45).

The single species of *Achtheres*, *A. percarum*, has also been described by Wright, Nordmann, Kroyer and others, but several details were here supplied that had hitherto been lacking.

The complete life-history was also worked out for both genera; that of *Achtheres* had been partially described before by Claus and Kellicott, while not a single detail had ever been published for *Ergasilus*.

1. *Argulus catostomi* Dana & Herrick.

Found in the gill-cavity of the white sucker, *Catostomus commersoni*. The discovery of this species in Indiana, together with those recorded from Lake Champlain and the rivers of Massachusetts, Connecticut and New York, shows the distribution of this parasite to be identical with that of the host it infests. The specimens here obtained and those from Lake Champlain include males, the first of that sex to be recorded for this species.

2. *Argulus americanus* Wilson.

Found on the outside surface of the Dogfish or Bowfin (*Amia calva*). This species does not appear to be very common at Lake Maxinkuckee, but possibly an examination of a larger number of fish would show a different result. This is the first instance of the species having been obtained from fish in their native haunts.

3. *Argulus maculosus* Wilson.

Found on the outside surface of the Common Bullhead (*Ameiurus nebulosus*), the Yellow Catfish (*Ameiurus natalis*), and the Rock Bass or Redeye (*Ambloplites rupestris*). Only two females were found on the Redeye; both were full of ripe eggs; evidently they were hunting

* Proc. Canadian Institute (N. S.), 1, p. 243.

for a suitable place to deposit them, and were only using the Redeye as a temporary host.

The Yellow Cat is the true host of this *Argulus*, and nearly half the fish of that species that were examined yielded specimens of this parasite.

4. *Ergasilus centrarchidarum* Wright.

Found on the gill-filaments of the Calico Bass (*Pomoxis sparoides*), the Redeye (*Ambloplites rupestris*), the Warmouth (*Chænobryttus gulosus*), the Bluegill (*Lepomis pallidus*), the Small-mouthed Black Bass (*Micropterus dolomieu*), the Large-mouthed Black Bass (*M. salmoides*), the Yellow Perch (*Perca flavescens*), and the Walleyed Pike (*Stizostedion vitreum*), and would have been found almost certainly upon the different sunfishes had there been an opportunity to examine them.

As its name rightly implies, it is a family rather than a specific parasite, and is very widely distributed, as are the hosts upon which it lives.

5. *Ergasilus versicolor* Wilson.

Found only on the two species of Catfish (*Ameiurus nebulosus* and *A. natalis*), the latter of which was the more badly infested. This species was not found upon any other fish in the lake, although many hundreds of them were searched for it, nor was *Ergisilus centrarchidarum* so common on the other fish, ever found on these catfish.

E. versicolor has since been obtained from the Channel Cat (*Ictalurus punctatus*), and the Eel Cat (*Ictalurus anguilla*), in the Mississippi River.

The species is thus distinctively a Catfish parasite in sharp contrast to *E. centrarchidarum*, which is a Perch parasite.

The life history of *Ergasilus* worked out upon these two Maxinkuckee species was published in Vol. 39, Proc. U. S. Nat. Mus., pp. 313–326, and still stands as the only contribution to the ontogeny of the entire family.

6. *Achtheres ambloplitis* Kellicott.

Found on the gill arches of the Redeye (*Ambloplites rupestris*), the Bluegill (*Lepomis pallidus*), the Small-mouthed Black Bass (*Micropterus dolomieu*), the Large-mouthed Black Bass (*M. salmoides*), and the Walleyed Pike (*Stizostedion vitreum*). It was particularly common on the Redeye and the Small-mouthed Bass, two-thirds of the specimens examined being infested with this parasite. Like the first species of *Ergasilus* mentioned above, it is a family rather than a specific parasite, as its name implies. But it is even more widely distributed; for it is as common on the European as on the American Perch, and is probably as widely distributed as the Perch family itself.

The life history of this species appeared in Vol. 39, Proc. U. S. Nat. Mus., pp. 194–224: pls. 29–36.

The Crawfishes.

By William Perry Hay, Head of the Department of Biology and Chemistry, Washington, D. C., High Schools.

Crawfishes are quite common in Lake Maxinkuckee and in Lost Lake; on the land about the lakes they are less frequent. The truly aquatic species are found chiefly in the shallower depths, hiding under rocks, sticks, and among Chara and other aquatic vegetation. But even at their best, not as many will be taken in the seine as will be secured in similar collecting in sluggish streams. The greatest number taken in one haul of the seine in Lake Maxinkuckee was twenty-two.

In the collections turned over to me for identification and study, four species are represented, namely: *Cambarus blandingi acutus*, *C. diogenes*, *C. propinquus*, and *C. immunis spinirostris*; or, using English names instead of Latin combinations, we may designate these four species as the Pond Crawfish, the Solitary Crawfish, the Gray Rock Crawfish, and the Rock Crawfish. Of these, the first three have long been known to occur in northern Indiana, but *C. immunis spinirostris* has not heretofore been known north of Terre Haute. One or two other species probably occur in the Maxinkuckee region. *C. argillicola* Faxon has been reported from several localities north, east and south of Lake Maxinkuckee, and *C. rusticus* Hagen has been taken near Mount Etna, Huntington County, Indiana.

Beyond doubt, the crawfish fauna of this lake, or of any other, will repay careful study. The habits and economic importance of these animals are only poorly known; but it must be that, as a source of food supply for other animals, or as scavengers, they fill a field of usefulness.

As the species of crawfishes are rather difficult to distinguish, and as the present account is for the general public rather than for the zoologist, it will be impracticable to give more concerning the structural characters of these than is absolutely indispensable for their recognition. Before beginning this, however, it must be stated that the male crawfish may be distinguished from the female by the presence of two pairs of rigid appendages which are attached to the first two joints of the abdomen or tail, and which, projecting nearly straight forward, lie in a sort of groove between the bases of the walking legs. In the female the abdomen is broader than in the male, and the appendages of the first two joints are slender and flexible like those which follow. The rostrum is the beak-like projection of the shell (or carapace) above the eyes.

1. *Cambarus blandingi acutus* (Girard). Pond Crawfish.

This species may be at once distinguished by the fact that in the males the third and fourth pairs of walking legs bear a hook on the third joint from the base. The rostrum is long and approximately triangular, with a pair of small teeth quite close to the tip. The large pincers and the legs which bear them are long, slender, and roughly granular.

This crawfish is represented in the collection by two males and seven females from Aubeenaubee Creek, one male and one female from Culver Inlet, eight males and two females from Spangler Creek, and by two males and one young female from Bruce Lake.

This is the pond crawfish of the region, its home being in woodland ponds. Individuals were seen from time to time, but they usually escaped under the leaves. Several dead ones were found in ponds. Generally speaking, it is not a very abundant species anywhere. It is occasionally met with in the sloughs of the Mississippi.

2. *Cambarus diogenes* Girard. The Solitary Crawfish.

This crawfish is an inhabitant of the lake at certain times only. It visits the water early in the spring for the purpose of producing its young, but during the remainder of the year each individual lives alone in a burrow over which it constructs a chimney of mud pellets. This habit is so peculiar, being shared by only one other Indiana species, that it alone should be almost enough to distinguish the solitary crawfish; but as some of our readers may wish to know what the animal is like, the following description is given: The body is high and compressed; the rostrum is short, thick-edged, and without teeth near the tip; the two longitudinal, curved lines on the back run together throughout the whole part of their length, so that only small triangular spaces are left between them in front and behind. The color is usually quite brilliant for a crawfish, the claws, rostrum, and the elevations on the shell being more or less marked with crimson and yellow.

Represented in our collections by one large female and seven young from Aubeenaubee Creek. Other examples were noted in 1901 as follows:

March 31, a good-sized female caught in a pool at the birch swamp; April 1, one dead, in ditch east of railroad, in Green's marsh; April 2, remains of several seen in the Outlet; April 3, remains of one found in Green's marsh; April 4, two caught, copulating east of the railroad, in Green's marsh, and one caught in the marsh north of Lost Lake; April 9, three living ones seen, two caught, and remains of great numbers at the drained lake; April 11, one big one caught at mouth of Farrar's Creek, and one at mouth of Aubeenaubee Creek; April 15, several seen in creek at south end of the lake, two caught; April 17, a female with eggs caught on west side of lake; April 19, a large one dead at water's edge just east of the depot; May 3, chimneys abundant east of Lost Lake outlet; May 17, one caught at edge of Lake Maxinkuckee at Long Point, with small young attached to it. This is a large, "meaty" species with heavy pincers, and, except where its natural habitat gives it a muddy flavor, makes an excellent food.

3. *Cambarus propinquus* Girard. The Gray Rock Crawfish.

This species may be recognized at once by the fact that the upper surface of the rostrum has a low median longitudinal ridge. This is too low to be visible, but may be detected by passing the tip of one's finger across from side to side, when the elevated portion may easily be felt. The species is usually an inhabitant of running water and will probably be found to occur most abundantly about the inlets and outlets of the lake. It is represented in our collections by fifteen males and twenty-nine females from Aubeenaubee Creek, nine males and five females from Lake Maxinkuckee, seven males and ten females from Culver Inlet, one male and one female from outlet of lake, and four males and seven females from East Inlet.

This is the common crawfish of the lake. It is found in considerable abundance everywhere among rocks and in the Chara. The lake form is brownish gray in color. It is too small to be of much use as human food. This species is also found in Yellow River, near Plymouth, and appears to be the most common species of the region. They do not burrow, but hide under rocks or bits of boards or sticks, under which they may make small excavations. Of many notes taken the following may be given here:

April 27, 1901, several seen in the bottom, one bluish in color; two copulating. June 3, a large shed carapace in Outlet Bay. June 7, several caught; they hide under boards; one very small one with its mother. June 12, many caught, more seen; almost every blunt-nosed minnow's nest is watched by one or two. June 13, a good many at minnows' nests. June 16, some caught at minnows' nests. June 22, still at minnows' nests. In 1904, October 19, a common content of fish stomachs; fishermen report that they are the best bait now; one angler caught six black bass with crawfish and one with a minnow. October 3, many at the head of the Outlet, about eight seen in a small space; one was eating at a dead grass pike; it stayed there a good while. October 31, one still eating in the morning at the pike; very little of the pike eaten. November 2, still eating at the pike. November 14, one near shore east of Long Point eating a minnow. November 22, two caught while copulating. November 25, two caught copulating east of Long Point. January 1, 1905, three seen together, two smallish, copulating, and a big one nearby.

From numerous observations of the crawfishes of the lake the following conclusion may be drawn:

There appears to be no special time for mating, and no special breeding period was observed; nor again, any special time for moulting. It is probable that in the fairly uniform temperature of the lake the lives of the crawfishes are not so markedly divided into seasons as they are in the river crawfishes. Generally, in rivers heavily populated with crawfishes, one can find immense numbers of moulted shells at certain periods—usually about the beginning of July—but in Lake Maxinkuckee only occasional and scattered cast-off skins can be found.

The nature of the food was not easily discovered by examination of stomach contents, as the material was too finely comminuted. A few were seen eating dead fishes as mentioned above. They are usually found in the vicinity of minnow nests, and probably devour fish eggs to some extent. Various fishes, especially walleye and bass, eat them at times, and they are one of the principal foods of the soft-shelled turtle. The lake species are rarely used for bait, perhaps because of the difficulty of obtaining soft-shells or "peelers" in the lake; river crawfishes are sometimes used.

The crawfishes of the lake often have protozoa attached to the gills, but this probably does not seriously inconvenience them.

4. *Cambarus immunis spinirostris* Faxon. The Rock Crawfish.

In general form and appearance this species is somewhat like the last, but it lacks the longitudinal ridge on the rostrum. The teeth of the rostrum are apt to be very small and, in the males, the tips of the first abdominal appendages are slender, blade-like, and recurved.

Represented in the collections by nine males and eight females from Aubeenaubee Creek, one male from Culver Inlet, and twelve young females from Norris Inlet.

Notes on Certain Protozoa and Other Invertebrates of Lake Maxinkuckee.

By Barton Warren Evermann,
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and
Howard Walton Clark,
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The field work upon which these notes are based was carried on under the auspices of the United States Bureau of Fisheries, at irregular intervals between July, 1899, and October, 1913, in connection with a physical and biological survey of Lake Maxinkuckee, Indiana.

The Protozoans and Cœlenterates.

No special attention was paid to the Protozoa of the lake; only those forms were noted which thrust themselves upon the attention.

The protozoan life of the lake is not conspicuous except for a few forms which are found in such abundance as to attract attention.

The list of species identified is a short one, not because these organisms are rare at the lake, but because no one of the party engaged in the study of the lake was especially interested in or familiar with them. An attempt was made to collect and preserve all forms that attracted the attention, but these were naturally only a small proportion of the species present. Whenever time from our other multifarious and more pressing duties permitted, attempts were made to collect these organisms, and at one time, stimulated by the handsome figures of some of the more ornate forms figured by Leidy and Kent, an especial attempt was made to obtain some of the more striking forms, but the search was rather fruitless. It so happened that the plankton, which should have contained a number of these organisms, was submitted to two different experts, one interested in Algæ, the other in Crustacea, with the result that such Protozoa as there were went by default.

Forms of doubtful affinity, by some placed among Algæ and by others as animals, such as *Peridinium*, *Ceratium* and *Volvox*, are included, *Volvox* especially exhibiting characters which strongly suggest a position in the animal series.

Following are our notes upon the few species identified:

1. *Arcella vulgaris* Ehrenberg

Upon examining the stomachs of a number of tadpoles caught at the edge of Aubeenaubee Bay in August (1906), a goodly number of *Arcella vulgaris* were obtained. The tadpoles when caught were busy sucking the surface of weeds and sticks, as is their habit, and from these they probably obtained the Protozoa. It is probable that Protozoa form an important part of the food of young tadpoles. On other occasions we have seen them taking in large numbers of Paramœcium.

Arcella vulgaris was abundant September 3 (1906), with other material (*Paramœcium*) forming a scum over water in a tumbler where some duckweeds were kept. It was also present in hand-gathered material obtained at the dam in the Outlet, October 30, of the same year.

2. *Centropyxis aculeata* Stein

Taken occasionally in the summer and autumn of 1906 in gatherings in shallow water near shore.

3. *Euglypha alveolata* Dujardin

Obtained in collections near shore, summer and autumn of 1906.

4. *Dinobryon sp.*

Found occasionally near shore in Lost Lake, but not abundant. In the small lakes about St. Paul, Minn., where it is very abundant, it furnishes an important item in the food of the fresh-water mussels.

5. *Euglena viridis* Ehrenberg

Some found in a scum in pools in Green's marsh. The great amount of vegetation makes the water almost as rich as an infusion. Obtained August 22 (1906). Euglena formed a bright green scum over the small pools.

6. *Volvox aureus* Ehrenberg

Not found by us at all in the lake, but exceedingly abundant in Farrar's Pond and a pond east of the lake, in the spring of 1901, large swarms being seen there, a single dip of a common dipper always containing several examples. A large number of examples obtained from a small pond near the lake April 24 (1901). Its favorite habitat is in shallow pools, easily warmed throughout and containing in the bottom an abundance of dead leaves or similar fertilizing matter. This species was exceedingly abundant in the shallow, well-fertilized carp ponds at Washington, D. C., in the spring of 1906.

7. *Peridinium tabulatum* (Ehrenberg)

Taken rather less frequently in the vertical hauls than its relative, *Ceratium macroceras*, and apparently not very common. One might naturally expect it to be more common near shore. It was not noted often in surface hauls. It is a species of world-wide distribution, and probably is abundant where conditions are favorable.

There is very little difference between the genera *Ceratium* and

Peridinium, the horns or projections, which are the distinguishing characteristics, occurring in all degrees of development.

8. *Ceratium macroceras* Schrenk

Common in the vertical plankton hauls, occurring in the great majority of hauls, but not common in the surface towings. A similar form, *C. tripos*, was collected in towing near shore at Eagle Lake. The long horns or projections of this species are developed perhaps as much to give buoyance to the form as for protection. The Peridinales, represented by this and the two preceding species, are claimed by both botanists and zoologists.

9. *Stentor cæruleus* Ehrenberg

While raking up weeds through a hole in the ice at the Weedpatch, January 15 (1901), it was noted that the water dripping from the plants turned the snow a vivid green. The snow thus colored was taken home and examined, and the green color was found to be due to multitudes of green stentors. These were kept in a vessel for some time. On January 6 they began to gather on sticks, on snail shells, on the sides of the vessel, and on the under surface of the water, assuming a globular form. The species was probably *cæruleus*.

On February 7, on looking through the ice on Outlet Bay, it seemed full of a reddish fine material like stirred-up mud. Examination revealed the presence of small diatoms and many green stentors.

10. *Stentor* sp.

Among our notes mention is made of another Stentor, larger than the green one, brownish and with a large, flat peristomal disc, circular, with a side cleft, like a water-lily leaf.

On October 14 (1907) it was noted that brown stentors were attached to the under side of lily pads in Hawk's marsh.

11. *Vorticella chlorostigma* Ehrenberg?

On June 26 (1901) white, fluffy little globules, which shrank to minute size when touched, and which proved upon examination to be composed of colonies of *Vorticella*, were found very abundant on the submersed tips of *Ceratophyllum* leaves at the Inlet. Late in the autumn of 1904 (October 31, November 2 and 16), the same objects were noted, but in considerably longer and larger patches, on various weeds, such as *Myriophyllum*, etc., in the vicinity of Winfield's. Again, in the autumn of 1906, they were exceedingly abundant in various weeds, especially dying leaves of Vallisneria, in Outlet Bay. So far as we have observed, these organisms seem to increase greatly during the autumn. Both white and green colonies were found, alike in everything except color, and it is probable that they were the same species under different conditions. The green forms showed distinctly against the dead *Vallisneria* leaves, which had faded to a papery white. It may be it was common during the summer, but concealed by its green substratum. June 22 (1906) it was plentiful on the weeds in Lost Lake.

In a note of June 26, concerning this species, occurs the remark, "This is a larger sort; there are also other smaller isolated ones present." On July 25, and previously, it was common in both lakes in weedy, stagnant places, forming a white halo along stems, not in balls. In addition to these there are minute free Vorticella-like organisms attached to the parasitic copepods on the gills of fishes, and on August 28 (1908) a number of minute clear Vorticellas were found on the body of a Cyclops. A species of *Vorticella* was abundant July 31 (1906) on *Anabæna* in plankton scum. Small Vorticellas are found in myriads on objects in Hawk's marsh. They can be found there more abundantly than anywhere else about the lake.

12. *Epistylis* sp.

A species of *Epistylis*, probably *plicatilis* Ehrenberg, was observed forming a dense growth on the shells of a small *Planorbis*, March 25 (1901) near Chadwick's pier.

The copepods of the same region at that time presented a very fuzzy appearance, and upon examination were found to be thickly overgrown with the same or a similar protozoan.

13. *Opercularia irritabilis* Hempel

Abundant during the summer and autumn of 1906 upon the lower surface of the shell (plastron) and also on the skin of various turtles, especially the painted and snapping turtles, making a close, short, brown fuzzy growth. The turtles were botanic gardens above and zoological gardens below. The organisms seemed to do them no injury, and were gotten rid of when the turtles shed their scutes. It sometimes forms a halo about the heads of small turtles, in which case it was at first mistaken for Saprolegnia. It is usually the head of the Musk Turtle that is affected. In this case it appears to do no harm, as the turtles are quite lively.

Something very like this, probably the same thing, was observed abundantly (August 6, 1907), on the shoulders of a dragonfly larva.

14. *Vaginicola leptosoma* Stokes

A species of *Vaginicola*, perhaps *leptosoma*, was rather common along the shore of the lake by Overmyer's hill, attached to algæ, October 28 (1906). There were at least six examples on one small bunch of algæ. The sheath was brownish and transparent. When jarred, the animal retracted into the sheath, usually doubling up somewhat into a sigmoid curve.

15. *Tokophrya quadripartita* (Claparède & Lachmann) Butschli

Common, intermixed with *Opercularia irritabilis*, on the ventral scutes of a Musk Turtle, September 12 (1906). It was also found to some extent on the back.

16. *Ophrydium* sp.

By far the most abundant and conspicuous protozoan in the lake was a species of *Ophrydium* which formed large blue-green gelatinous colonies about the size of a hazelnut, or larger. These semitransparent blue-green balls remain in about the same condition the year round. They are found abundantly wherever the carpet Chara grows, and are usually attached to it or to pebbles; or, quite frequently, to mussel shells either alive or dead. Clear colonies, remarkable for their unusual transparency, were found on submerged pieces of tile, August and September (1907). At certain times, as August 1 (1906), and August 1 and October 12 (1907), great quantities are washed ashore. The colonies are sometimes hollow, as were many of those washed ashore August 1 (1907).

17. *Hydra fusca* L.

Not frequently encountered in the lake. On October 31 (1906), however, multitudes were found under leaves at the water's edge on the east side, and on November 13 more were found in a similar position. November 18 one was found attached to floating *Wolffiella* in Norris Inlet.

The Worms.

Our notes on this group are few and very unsatisfactory. We give here only such of them as seem to possess some value.

The attention we were able to give to these forms was so little that we are unable to say much regarding their relative or actual abundance, their distribution, or their relation to the biology of the lake.

Flat-worms or Planarians, small, soft, flat objects, gray above, white below, and oval in outline, were common on rocks and among weeds in the lake. In certain material (Vorticella, etc.), obtained near Norris Inlet, they were quite common. They were often abundant on Ceratophyllum also. They were so soft that they often pulled apart when attempts were made to remove them from the rocks.

Small pinkish parasites (probably a species of *Distomum*), resembling minute leeches, were found quite common in the stomachs of fishes, particularly the Straw Bass (*Micropterus salmoides*) and the Skipjack (*Labidesthes sicculus*). Usually during the winter the stomachs of these fishes contained little or no food, but in most cases from one to several of these parasites were found in each.

Round-worms, resembling *Ascaris*, are frequent intestinal parasites of the snakes of this region, and one small form was found in the intestine of a mussel.

Tapeworms were almost invariably present in the several shrews (*Blarina brevicauda*) examined. They were also common in the yellow perch and walleyed pike, and practically every dogfish (*Amia calva*) examined was heavily loaded with them. Many duck stomachs examined, especially those of the ruddy duck, contained from a few to many tapeworms.

Angleworms or Fishworms are not abundant in this region. The country about the lake is chiefly sandy, a soil not favorable to angleworms. At the edges of ditches, marshes and woodland ponds, where the soil is a black loam with some admixture of clay and decaying vegetation, a rather small species of *Lumbricus* is fairly abundant. Fishermen who know these places are usually able to secure all they need for bait. The farmers and farmers' boys and the boys of the village are the ones who make most use of fishworms in their angling.

On December 7 (1904), worms which resembled angleworms were observed in considerable numbers coiled up under a submerged water-soaked board at Long Point, where they evidently were passing the winter in that condition. These worms, however, possessed no annular ring. In alcohol they display a fine opalescent iridescence in reflected light. One seemed to be dividing by a constriction near the middle.

Some very small worms, resembling fishworms in general appearance when alive, were seen at the mouth of a ditch April 19 (1901).

Cotylaspis insignis Leidy is a common parasite of the mussels of Lake Maxinkuckee and Lost Lake. To the naked eye this parasite looks like a minute yellowish leech. Its position in the mussel is close up in the axils of the gills. It was found in *Lampsilis luteola* and also in *Anodonta grandis footiana*, from one to several being found in nearly every example of these species examined August 23 (1906). It was also found in mussels taken on September 28 following, in Little River near Fort Wayne.

The so-called Horsehair Snake or worm (*Gordius* sp.) is very abundant in and about Lake Maxinkuckee. According to anglers, many of the grasshoppers used by them for bait are infested with this parasite. On August 2 (1906) large numbers were seen writhing about in mud among snails along the Outlet where it had been suddenly lowered by a dam at the railroad bridge. We suspect that they may be parasitic in this snail also. They were frequently found in fishes, either free in the lower intestine or encysted and coiled up in some of the internal organs. The bluegill appears to be especially liable to infection by Gordius. It may be that the fish become infected through the grasshoppers they devour. On August 6 (1906) these worms were noted in considerable numbers in shallow water on the east side of the lake.

A long, slender, brownish worm, probably a species of *Tubifex*, was found in considerable numbers projecting up into the shallow water from the soft mud bottom of Lost Lake. These were first observed June 8

(1901), when the bottom near the shore was seen to be covered with small whitish mounds about the size of buckshot, which gave a peculiar mottled or dappled appearance. When some of this mud was dipped up and examined the small mounds were seen to be small sand tubes in which the worms were and from which they waved about in graceful undulations. They were observed again at the same place on June 15. On June 18 many were seen in the creek under the railroad bridge, and on June 25 some were noted at the south end of Lake Maxinkuckee. And finally, on November 4 (1904), numerous burrows were seen in shallow water near shore in Lost Lake.

Thorn-head worms (Acanthocephali) were found to be common intestinal parasites of various fishes and turtles. Among fishes the redeye appeared to be most affected. The carnivorous turtles, such as the soft-shelled and the snapper, were especially subject to them, while the herbivorous species, particularly the painted turtle, were comparatively free.

Record may here be made of a Bryozoan, *Plumatella polymorpha*, possibly related to the Gephyrean worms. *Plumatella polymorpha* is a compound animal, many individuals budding off from one another, as in plants. The moss-like colonies of this species were very common in the lake among the Chara and other plants. They were noted in the Chara near the depot pier, off Long Point, near Winfield's, and at the south end near the Farrar cottage. Indeed, it appears to be distributed generally through the lake wherever there are patches of vegetation. Among the Charas it forms a brown, upright, bushy growth. In the Weedpatch it was common on the leaves of *Potamogeton amplifolius*. On October 23 (1900) it was found to be abundant on Ceratophyllum in rather deep water. A week later (October 29) a good deal was gotten on Myriophyllum. Early in the spring (March 1, 1901), it was seen growing on *Potamogeton robbinsii*, and a little later it was found in abundance in front of Arlington station. It was often found on Chara and other aquatic plants dredged at various times. It was also found growing on tile piles September 1 (1906).

During the autumn of 1900 the stadioblasts were frequent in plankton scum along shore, often being present in great abundance. They somewhat resemble floating sand grains, but are lighter in weight, being minute circular brown discs, uniform in shape and size. Under magnification they show series of facets like the compound eye of insects.

On October 18 (1900), one of the buoys which had been for some time anchored out in the lake was found to be covered with a flat, creeping growth of this species.

As *Plumatella polymorpha* occurs in this lake it is highly worthy of its specific name, as it shows great variation in form and general appearance.

The leaves upon which it grows are often eaten by fishes, probably for the sake of the Plumatella. The yellow perch and bluegill are the species in whose stomachs we found it most abundantly. The stomach of a bluegill caught at the Weedpatch October 26 (1904) was full of stadioblasts. During the autumn of 1904 it was noted as exceedingly abundant.

So far as we know, *Plumatella polymorpha* is the only Bryozoan in this lake.

The Sponges.

Sponges are not especially abundant in the lake. In some of the not far distant lakes, as Winona Lake, they frequently form a thick coating around the submerged portions of bulrushes growing out in the water, but at Lake Maxinkuckee this was not observed. They are not common on the rocks. On September 9 (1906) some were found forming a coating on submerged rocks on the east side, and some of these were collected a few days later. On November 5 (1906) some flat ones found on rocks on the east side were apparently being eaten by insect larvæ. On September 22 (1907) Prof. U. O. Cox of the Indiana State Normal found some flat sponges covering a rock where the lake enters the Outlet at the wagon bridge, and there were more on a rock farther down between the wagon and railroad bridges. This completes the record for the flat sponges.

A long, green, string-like form found hanging among the weeds at the lake, especially at the Weedpatch, was much more common. This was observed quite frequently and often obtained when collecting aquatic plants. Occasionally these long strings were washed up near shore. On October 27 (1900) these sponges were observed forming stadioblasts on the weeds in Lost Lake.

Occasionally the sponges form small, blue-green, spherical masses, like bullets, around the stems of Chara. On January 22 (1901) some of these spherical sponges were observed on carpet chara about five feet out from the Arlington Hotel.

Sponges are quite common in creeks and ponds near the lake. The long form is common in Twin Lakes. There are long, finger-like forms in Yellow River, and they were abundant in the Outlet about the bridge below Walley's.

The sponges were submitted for identification to Mr. Edward Potts, of Media, Pa., who in a letter dated May 24 (1905) writes so interestingly regarding the material that we here quote his letter in full:

> Yours with package of material was received by first mail yesterday A. M.; and having nothing important on hand, I examined the vials at once, with the following results:

First, I must express my pleasure in finding that you had sent only *Sponges;* that is, remembering that frequently even workers in other lines of science are utterly unfamiliar with these forms, and hence send one gelatinous and otherwise incongruous articles. I was glad to learn that you know a sponge when you see it. The only possible exception is in your No. 5, which, as you supposed, is not a sponge but only a puzzle, which may perhaps be explained by considering the fibres to be a form of alga, or more probably, the stems or stipes (as the "Micrographic Dictionary" calls them) of some, possibly all, those Diatoms now found at the outer surface of the sub-spheres. I have frequently found Diatoms so growing.

No. 1 is *Carterius tubisperma* Mills, and is, I am sorry to say, the only sponge in satisfactory condition for safe determination. Nos. 2 and 4 are, I fully believe, of the same species as No. 1, and they have plenty of gemmules or statoblasts; but these are so far from maturity that, if the same species, the chitinous coat is extremely thin and it apparently has not yet developed the foraminal tubules, the granular crust, and protective birotulate spicules which should be the determining points. I do not understand why this should be so with the date given (November 15 and later); but I suppose it possible that cold spring water or its unusual depth may have retarded development to a date later than that with which I have been familiar. This is further suggested by No. 3, in which I have failed to find any gemmules, and which reminds me of the appearance and condition of forms that I have sometimes called perennial or evergreen sponges, which apparently continue their growth all through the winter, at least in deep water.[2]

No. 3 is clearly a different sponge from the others, as shown by its shorter and more robust spicules (skeletal), which, as you will see, are covered with very minute spines. I should have been much pleased to find the stadioblasts of this sponge. The skeleton spicules suggest *Meyenia leidyi* Carter, although in that species they are rarely microscopical. You may meet with it again under more favorable circumstances.[3]

Although I fear they are too soft for safe transportation, I propose to pack with the vials returned, two trial slides, No. 1, showing *Carterius tubisperma,* in which you may see the foraminal tubules before mentioned and the armature of radial birotulate spicules, beside the skeleton and dermals; and No. 2, showing separated spicules of the same.

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[2] See my Monograph, pp. 245 and 246.

[3] See fig. 1, plate X, of my Monograph.

Aphids and Ants on Fruit Trees.

S. D. Conner, Purdue University Agricultural Experiment Station.

As an amateur horticulturist I have had quite a lot of trouble with aphids on fruit trees, particularly those trees around the residence. Year after year I have seen the young, growing shoots of the apples, cherries and peaches literally covered with various kinds of aphids until the young leaves curled up and stopped growth. Without doubt the growth of the young trees has been very much set back and the vitality of the trees sapped. I have used nicotine sprays with more or less success, but it takes eternal vigilance and many expensive sprayings to keep them down.

In observing the habits of the aphids I have noticed the well-known fact that ants were very much in evidence wherever the aphids were present. I, of course, had been told that the ants did no damage to the trees, but nevertheless I hated to see them profiting from such a pest as the aphids, so in the early spring of 1917 I purchased a can of tree tanglefoot and applied a two-inch band of this sticky material about one-fourth inch thick around each tree, for the purpose of keeping the ants and any other crawling insect off the trees. Well, I stopped the ants and, much to my surprise, I had no aphids on the trees. The aphids have wings, but they did not seem to use them to good advantage, for wherever there were no ants there were no aphids. Some weeks later I noticed on an apple tree some aphids and, looking closer, I saw some ants. I examined the sticky band on the tree trunk and found that some tall grass had bridged it over, allowing the ants to get up the tree, where, I presume, they carried the aphids. I removed the grass, sprayed the tree with nicotine and had no more aphids on that tree. It appeared to me that my young trees made a much more vigorous and sustained growth than they ever did before.

Among other trees I banded was a sour cherry standing near a fence. The tanglefoot was applied high to this tree. A water sprout that came out below the tanglefoot was soon completely covered with black aphids, while not an aphid was to be seen above the band until some weeks later, when the limbs near the fence, becoming heavy with fruit and new growth, sagged and touched the fence. Then ants and aphids appeared on that side and gradually spread all over the whole tree. I watched my trees all summer, and so long as I kept the ants off the trees I saw only a few scattering aphids. I saw one good colony of aphids, on a peach tree, that must have obtained a foothold by flying. This colony was destroyed by means of nicotine spray, and I had no further trouble with that tree.

At intervals during the summer the sticky band had to be freshened. I used a band about two inches wide and from one-eighth to one-fourth inch thick. None of my trees seem to have been injured in the least at the end of a year and one-half. The experience of 1917 was repeated with practically the same results in 1918.

It may be wondered why, if the aphids can fly, they did not get on the trees above the sticky bands. In reading Farmers' Bulletin No. 362, U. S. Department of Agriculture, on "The Common Mealy Bug and Its Control in California," I ran across a good explanation. Ants were found to carry and protect the mealy bugs in the same way they do the aphids. Woglum and Nuels in this bulletin say: "Remarkable results have been secured by keeping the Argentine ant off of trees infested with mealy bugs by banding with a sticky mixture. In 1915 and 1916, trees that when first freed from ants were infested severely with the mealy bug became commercially clean without exception within a period of six weeks to three months." It seems that the ant not only carried but protected the mealy bug from its natural enemies, the brown lace-wings and a ladybird beetle.

It seems logical to suppose that the same relation would exist between the aphids, the ants and the enemies of the aphids, such as the ladybugs. Although the mealy bug does not fly, as does the aphid, the fact remains that the aphid, like the mealy bug, seems to depend upon the ant for protection and cannot long survive the attacks of its enemies when this protection is withdrawn.

One entomologist told me, "You keep the aphids off your trees and the ants will not bother you." But I say, "Keep the ants off and you will not be bothered with aphids." It is much easier to work from the ant end of the game than it is from the aphid end.

Memorial of Albert Homer Purdue.

By George H. Ashley, The United States Geological Survey.

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Albert Homer Purdue, late State Geologist of Tennessee, was born March 29, 1861, in Warrick County, Indiana, near Yankeetown—a small village in the loess-covered hills bordering the Ohio River—an hour's ride by trolley east from Evansville. While the people of the town came, as a rule, from Yankeeland, one of Mr. Purdue's grandfathers had been an early settler in western middle Tennessee. His early education was obtained at Yankeetown and later at the Indiana State Normal School at Terre Haute, from which he graduated in 1886. In 1886–1887 Mr. Purdue taught at Sullivan, Indiana. In 1887–1888 he was superintendent of public schools at West Plains, Missouri. In 1887, at Indianapolis, Indiana, he married Miss Bertha Lee Burdick, who died of consumption a year later. From 1889 to 1891 he was assistant superintendent of the United States Indian School at Albuquerque, New Mexico. Part of his duties were the selection of children from the reservation for the school and the rounding up of boys who had run away—a line of work that led to many interesting experiences. From 1891 to 1894 he was at Stanford University, from which he obtained the degree of A. B. in 1893. While there he made geologic studies on the San Francisco Peninsula, and during 1892–1893 was an assistant geologist for the Arkansas Geological Survey with the writer, studying the southern part of the Ouachita uplift. This association with Purdue in the field during the summer and fall of 1892 was one of the pleasantest epochs in the writer's life. We were living on the country, in a region little settled at that time, and Purdue's vivid description of his week's experience, when we got together at the end of each week, gave an air of romance and adventure to the whole undertaking. This work and that in the Coast Range Mountains of California, both under the eye of Branner and with his counsel, Purdue counted as among the most valuable training experiences he could have had, as he could not help getting somewhat of Branner's broad point of view and critical study of details. In 1894, after a year of graduate work at Stanford, he became a candidate for the elective position of State Geologist of Indiana; but his long absence

A. H. Purdue.

from the State had put him out of touch with the political personnel of the Republican party and he failed to get the nomination. Perhaps he would have succeeded if he had listened to the demands of those who wished the promise of places which they were not prepared to fill. The winter following he was principal of the high school at Rensselaer, Indiana. Then came a year of graduate work as a Fellow at the University of Chicago.

His professional career began in 1896, when he was elected Professor of Geology at the University of Arkansas, his position after 1902 being that of Professor of Geology and Mining. Here his executive ability and judgment were early recognized, and as time went on more and more of the administrative committee work of the university fell on his shoulders. He was chairman of the Committee on Student Affairs and of the Classification Committee, which had in charge the arrangement of courses, etc. In 1898 he married Miss Ida Pace, of Harrison, Arkansas, at that time Associate Professor of English at the university—a woman of unusual mental and social attainments, who comes of a family distinguished in the life of Arkansas. In 1895, again in 1901, and from then on Mr. Purdue was a field assistant on the United States Geological Survey, devoting his summers to field-work. With the Survey he had the reputation of being one of the very few teaching geologists whom that organization could count on to carry out a program not only in the field but in the office preparation of his reports. At the time of the St. Louis Exposition he was made Superintendent of Mines and Metallurgy for the State. In 1907 Mr. Purdue was made State Geologist *ex officio* of the Arkansas Survey. Though having at his disposal only very meager funds, Purdue was able to prepare or have prepared a number of highly creditable reports, including one on the slates of the State, by himself; one by Prof. W. N. Gladson on the water powers of the State, and one by Prof. A. A. Steel on mining methods in the coal fields of the State.

As a teacher, Purdue brought to his work the results of his normal-school preparation, and the training received under Branner and J. P. Smith at Stanford, and Salisbury, Chamberlain and others at Chicago, together with his own rather varied experience along that line. He was not a believer in the lecture method of instruction, but rather in the students working out their results under the stimulus of actual contact with the problems in the field and laboratory, and in this knowledge being reinforced by repeated review and by application to new and practical problems. He had little regard for the student who would not work and he would bar such students as much as possible from his classes. The great energy he put into his teaching in both the class-room and field wonderfully impressed his students and assistants, so that he constantly inspired them to obtain greater results and attain higher ideals. When he left the University of Arkansas the students presented him a silver loving cup as a token of the respect they held for him as a teacher. His students speak of his class-work being as good as any course in logic, as he led them to analyze their data and taught them how to draw proper conclusions therefrom; so that, aside from those who decided to take up geology as a profession, his old students, scattered all over the United States, look back to the work in his classes as one of the most profitable experiences of their university life. Among his students who were led into adopting geology as a life work may be named Miser and Mesler, of the United States Geological Survey; Carl Smith, Munn, McCreary, Hutchinson, and others, who, after more or less time spent with the national organization, have gone into consulting or professional work in the oil industry.

Purdue had great faith in the constructive ability of the boy brought up on the farm, in which class most of his students fell, and in a talk a few years ago he explained the reason for that ability as due to the constant association in labor of father and son on the farm, the son getting the advantage of the father's example and counsel as they worked together in the fields or gardens, and thus acquiring ideals of industry, efficiency and initiative commonly lacking in the city- or town-bred boy.

In 1912 Mr. Purdue was elected State Geologist of Tennessee, which position he filled with honor to himself and the State until his death, on December 12, 1917. Of his success as State Geologist of Tennessee the best testimony is the steady stream of high-grade publications that flowed from his office. Equally convincing from another direction is the fact that during the session of the last State legislature his work and its value to the State received unstinted praise, and the enlarged appropriation for the work of the Survey went through practically without question or opposition.

Purdue had for thirty years suffered at times from intestinal trouble that had proved more and more of a handicap as time went on. Last spring, after a winter of unusual demand, he suffered a sudden attack of this old trouble, which for a time undermined his health and threatened to require an immediate operation. A number of trips to the field and for rest led to his regaining somewhat his old vigor, though not entirely.

The last week of November he made an automobile trip into east Tennessee for the purpose of studying the manganese deposits of that region. He became so ill that he stored his car and returned to Nashville by railroad. He was taken immediately to a local hospital and, after a few days, underwent an operation, with the hope of having his health restored. The morning of the operation he dictated for publication in the Resources of Tennessee a paper giving the results of his recent investigation of manganese. Then he walked into the operating room as calmly as if he were going into his office for a day's work. At first everything indicated a speedy recovery, but complications arose and he died a week later from uremic poison.

Mr. Purdue was quiet and unassuming—a man who disliked display, who sought always to keep his own personality and achievements in the background, yet a man who made friends that stuck, because he could prove himself a true friend under all circumstances; a man whose judgment was sought by many; a man whose influence was always for sanity, for uplift, for scientific accuracy, even in the simple things of life. I still remember that when we were working together in the mountains of Arkansas, it was my method to fall into the ways of the people with whom we were living, especially in adopting the vernacular of the region—a habit to which Purdue always objected and for which he often chided me. He would insist that, as educated men, we had no right not to give the mountain people a glimpse of correct English. This same regard for the Queen's English is seen in the painstaking care with which he edited all of the manuscripts published by him as State Geologist.

As a field geologist, Purdue was tireless, painstaking and thorough, and the same energy and careful attention characterized all of the preparation of his reports. This desire for high quality and accuracy doubtless reduced somewhat the number and length of papers prepared by him, but his work made up in quality what it lacked in volume.

While he was at the University of Arkansas he spent the summer months in the field in that State—most of the time in camp with a party of from one to three of his students—and wrote his reports at odd moments during the school year. Although his field-work was varied, it consisted mainly of detailed areal mapping for the United States Geological Survey in a number of quadrangles in the northwestern and west-central parts of the State. Whenever funds were appropriated by the Arkansas legislature for the State Survey he made it count as much as possible by co-operating with the United States Geological Survey. Most of his geologic work in Tennessee was administrative, but he found time to make numerous short field trips into different parts of the State. Much of the work carried on under his administration as State Geologist in that State was done in co-operation with the United States Geological Survey and the United States Soil Survey.

Among his more important papers are the Winslow and Eureka Springs–Harrison folios and the De Queen–Caddo Gap and Hot Springs folios, awaiting publication; the slate deposits of Arkansas, besides a large number of shorter publications issued by the United States Geological Survey, State Surveys of Arkansas and Tennessee, and many others published in magazines or elsewhere. Considering the large amount of administrative work in the University of Arkansas that fell to his lot, this is a rather remarkable showing of scientific results for a teaching professor occupying practically the whole bench of geology.

Mr. Purdue was a member of the American Institute of Mining Engineers, the Indiana Academy of Sciences, the National Geographic Society, and the Seismological Society of America. He was a Fellow of the American Association for the Advancement of Science, the Geological Society of America, and the Geological Society of London. He often attended the meetings of State Geologists, of the Conservation Congress, and of the Southern Commercial Congress. While at the University of Arkansas he was made a teacher member of the Kappa Alpha fraternity. In 1907 he was elected to the Stanford chapter of Sigma Xi. The commencement following his resignation as Professor of Geology at the University of Arkansas that institution conferred on him the degree of LL.D. There was no recognition that he prized more highly than his election, in 1911, to the Council of the Geological Society of America. He was President of the Tennessee Academy of Sciences at the time of his death and was already considering possible subjects for the next annual address.

As a citizen, Mr. Purdue was always public-spirited, entering in large degree into the life and activities of the place of his home and of the State at large. In Nashville, besides his interest in the Commercial Club, he was active in other civic and social clubs, including the Rotary, Freolac, Tennessee Historical Society, Nashville Engineering Society, Reynolds Lodge, Knights of Pythias, Phœnix Lodge, Free and Accepted Masons, and was a generous subscriber to the work of various organizations. His home, with two boys now of college age, was always a place for real Southern hospitality, for Purdue had a large sense of humor and a live personal interest in the welfare of all his friends, and a wife whose intellectual attainments and personal charms not only added to the welcome of the home but were a constant inspiration to the man.

There is appended a list of titles of papers and addresses, including several prepared but not yet published.

Bibliography.

1895. Observations on the glacial drift of Jasper County, Indiana. Proceedings of the Indiana Academy of Sciences, 1894, pages 43–46.

The Charleston (Missouri) earthquake. Proceedings of the Indiana Academy of Sciences, number 5, pages 51–53.

1896. Review of sketch of the geology of the San Francisco Peninsula, by Andrew C. Lawson. Journal of Geology, volume 4, pages 640–644.

Some mounds of Vanderburg County, Indiana. Proceedings of the Indiana Academy of Sciences, pages 68–70.

1897. A strange village. "The Ozark."

Review of the former extension of the Appalachians across Mississippi, Louisiana and Texas, by J. C. Branner. Journal of Geology, volume 5, pages 759–760.

1898. The geography of Arkansas (text). American Book Company, Cincinnati.

The function of Greek-letter fraternities. "The Ozark."

1899. The geography of Arkansas. Arkansas School Journal.

Review of the department of geology and natural resources of Indiana, Twenty-third Annual Report. Journal of Geology, volume 7, pages 720–721.

1901. Valleys of solution in northern Arkansas. Journal of Geology, volume 9, pages 47–50, 2 figures.

Physiography of the Boston Mountains. Journal of Geology, volume 9, pages 694–701, 2 figures.

Responsibilities of university students. "The Ozark."

Illustrated note on a miniature overthrust fault and anticline. Journal of Geology, volume 9, pages 341–342, 1 figure.

Lead and zinc deposits of north Arkansas. Lead and Zinc News, St. Louis, volume 1, number 2.

1902. Review of evolution of the northern part of the lowlands of southeastern Missouri, by C. F. Marbut. Journal of Geology, volume 10, number 8, pages 919–921.

Demands upon university curricula. Proceedings of the Ninth Annual Meeting, Southern Educational Association, pages 188–199.

1903. Geographic processes. New York Teachers' Monograph, volume 5, number 2.

Is the normal school passing? Atlantic Educational Journal.

The saddle-back topography of the Boone chert region, Arkansas (abstract). Science, new series, volume 17, page 222.

On the origin of geographic forms. Arkansas School Journal.

1904. A topographic result of the alluvial cone. Proceedings of the Indiana Academy of Sciences, 1903, pages 109–111, 6 figures.

Notes on the wells, springs, and general water resources of Arkansas. United States Geological Survey Water-supply Paper 102, pages 374–388.

1905. Water resources of the Winslow quadrangle, Arkansas. United States Geological Survey Water-supply Paper 145, pages 84–87, 1 figure.

Underground waters of the eastern United States — northern Arkansas. United States Geological Survey Water-supply Paper 114, pages 188–197, 4 figures.

Concerning the natural mounds. Science, new series, volume 21, pages 823–824.

Water resources of the contact region between the Paleozoic and Mississippi embayment deposits in northern Arkansas. United States Geological Survey Water-supply Paper 145, pages 88–119.

Address representing the faculty at the inauguration of J. N. Tillman as President of the University of Arkansas, September 20.

1906. Is the multiplication of mining schools justifiable? Mines and Minerals, volume 26, pages 411–412.

A discussion of the structural relations of the Wisconsin zinc and lead deposits, by Professor Grant. Economic Geology, volume 1, number 4, pages 391–392.

1907. Developed phosphate deposits of northern Arkansas. United States Geological Survey, Bulletin 315, pages 463–473.

On the origin of limestone sink-holes. Science, new series, volume 26, pages 120–122.

Cave-sandstone deposits of the southern Ozarks. Bulletin of the Geological Society of America, volume 18, pages 251–256, 1 plate, 1 figure. Abstract, Science, new series, volume 25, page 764.

United States Geological Survey Geological Atlas, Winslow folio (number 154), 6 pages, 4 figures, 2 maps, and columnar-section sheet.

1908. A new discovery of peridotite in Arkansas. Economic Geology, volume 3, number 6, pages 525–528, 2 figures.

1909. The slates of Arkansas. Arkansas Geological Survey, pages 1–95, 7 plates.

Structure and stratigraphy of the Ouachita Ordovician area, Arkansas (abstract). Bulletin of the Geological Society of America, volume 19, pages 556–557.

1910. The collecting area of the waters of the hot springs, Hot Springs, Arkansas. Proceedings of the Indiana Academy of Sciences, 1909, pages 269–275; Journal of Geology, volume 18, pages 279–285.

The slates of Arkansas. United States Geological Survey, Bulletin 430, pages 317–334.

Mineral deposits of western and northern Arkansas. Fort Smith Times-Record, pages 123–127.

The stored fuels of Arkansas (booklet). Published by Fort Smith Commercial League, 1910; also Proceedings of Arkansas Bankers' Association.

Possibilities of the clay industry in Arkansas (booklet). Published by the Brick Makers' Association of Arkansas, Little Rock.

Some essentials of public speaking (abstract). University Weekly, Fayetteville, Arkansas.

1911. The operation of the mine-run law in Arkansas. Arkansas Gazette.

Recently discovered hot springs in Arkansas. Journal of Geology, volume 19, number 3, pages 272–275, 2 figures.

The operation of the mine-run law in Arkansas. The Tradesman, volume 66, number 19, pages 27–28.

1912. Some neglected principles of physiography. Proceedings of the Indiana Academy of Sciences, 1911, pages 83–87, 1 figure.

Reported discovery of radium in northern Arkansas. Science, new series, volume 35, number 904, page 658.

Compendium of the mineral resources of Arkansas. [Little Rock] Board of Trade Bulletin, 30 pages.

On the impounding of waters to prevent floods. Tennessee Geological Survey, The Resources of Tennessee, volume 2, number 6, pages 226–230.

The waste from Hillside wash. Tennessee Geological Survey, The Resources of Tennessee, volume 2, number 6, pages 250–254.

Administrative report of the State Geological Survey, 1912. Tennessee State Geological Survey, Bulletin 15, 17 pages.

The iron industry of Lawrence and Wayne counties. Tennessee Geological Survey, The Resources of Tennessee, volume 2, number 10, pages 370–388, 7 figures.

Failure of the Nashville reservoir. Engineering Record, volume 66, number 20, page 539.

The zinc deposits of northeastern Tennessee. Tennessee Geological Survey, Bulletin 14, 69 pages, 1 plate (map), 30 figures.

The zinc deposits of northern Tennessee. Mining Science, volume 66, pages 249–251, 2 figures.

1913. The importance of saving our soils. Tennessee Geological Survey, The Resources of Tennessee, volume 3, number 1, pages 50–53.

Water supply for cities and towns. Tennessee Geological Survey, The Resources of Tennessee, volume 3, number 2, pages 80–83, 1 figure.

Geology and Engineering. Tennessee Geological Survey, The Resources of Tennessee, volume 3, number 2, pages 105–109, 3 figures.

Failure of the reservoir at Johnson City, Tennessee. Engineering Record, volume 67, number 22, page 600.

The gullied lands of west Tennessee. Tennessee Geological Survey, The Resources of Tennessee, volume 3, number 3, pages 119–136, 8 figures.

The minerals of Tennessee, their nature, uses, occurrence, and literature (literature by Elizabeth Cockrill), Tennessee Geological Survey, The Resources of Tennessee, volume 3, number 4, pages 183–230.

Field and office methods in the preparation of geologic reports; note taking. Economic Geology, volume 8, number 7, page 712.

The education of and for the farm. Tennessee Agriculture, Proceedings of the Middle Tennessee Farmers' Institute, Twelfth Annual Convention, pages 425–428.

1914. The State Geologist and conservation. Tennessee Geological Survey, The Resources of Tennessee, volume 4, number 1, pages 24–28.

A double waste from hillside wash. Tennessee Geological Survey, The Resources of Tennessee, volume 4, number 1, pages 3–37.

The education of mine foremen (an address).

Bauxite in Tennessee. Tennessee Geological Survey, The Resources of Tennessee, volume 4, number 2, pages 87–92, 2 figures.

Road materials of Tennessee. Tennessee Geological Survey, The Resources of Tennessee, volume 4, number 3, pages 132–135.

Some neglected principles of physiography (abstract). Transactions of the Tennessee Academy of Sciences, volume 1, pages 92–94.

Zinc mining in Tennessee. Engineering and Mining Journal, volume 98, number 10, pages 419–421, 4 figures, map.

Administrative report of the State Geologist, 1914. Tennessee Geological Survey, Bulletin 18, 17 pages.

1915. Why not call things by their right names? Engineering and Mining Journal, volume 100, number 19, pages 765–766.

The call of the world (an address).

1916. Oil and gas conditions in the Central Basin of Tennessee. Tennessee Geological Survey, The Resources of Tennessee, volume 6, number 1, pages 1–16, 1 plate, 1 figure.

Oil and gas conditions in the Reelfoot Lake district of Tennessee. Tennessee Geological Survey, The Resources of Tennessee, volume 6, number 1, pages 17–36, 3 figures.

A plea for better English. Stanford Alumnus, volume 17, number 5, pages 182–184.

Notes on manganese in east Tennessee. Tennessee Geological Survey, The Resources of Tennessee, volume 6, number 2, pages 111–123.

Materials of Tennessee that invite the chemist. Manufacturers' Record, volume 70, number 11, page 110.

The nature of private reports. Engineering and Mining Journal, volume 102, number 13, page 546.

United States Geological Survey Geological Atlas, Eureka Springs-Harrison folio (number 202), 22 pages, 6 plates, 13 figures. (By A. H. Purdue and H. D. Miser.)

1917\. The State Geologist and conservation. Science, new series, volume 45, number 1159, pages 249–252.

Administrative report of the State Geologist. Tennessee Geological Survey, The Resources of Tennessee, volume 7, number 1, pages 5–25.

By-product coke and oven opportunities in Tennessee. Tennessee Geological Survey, The Resources of Tennessee, volume 7, number 1, pages 26–39, 2 figures.

The Glenmary oil field. Tennessee Geological Survey, The Resources of Tennessee, volume 7, number 2, pages 105–108.

General oil and gas conditions of the Highland Rim area in Tennessee. Tennessee Geological Survey, The Resources of Tennessee, volume 7, number 4, pages 220–228.

Things the farmer should know. Cumberland Valley National Bank letter, Nashville, Tennessee.

Bauxite in the United States, 1916. Mineral Industry during 1916, pages 42–47.

Unpublished Reports.

Manganese deposits of Bradley County. Tennessee Geological Survey, The Resources of Tennessee, volume 8, number 1, January, 1918, pages 46–47. (In press.)

Gravel deposits of the Caddo Gap and De Queen quadrangles. United States Geological Survey, Bulletin 690–B. (By A. H. Purdue and H. D. Miser; in press.)

Asphalt deposits and oil and gas conditions in southwestern Arkansas. United States Geological Survey Bulletin. (By A. H. Purdue and H. D. Miser; in preparation.)

United States Geological Survey Geological Atlas, Hot Springs folio. (By A. H. Purdue and H. D. Miser; in preparation.)

United States Geological Survey Geological Atlas, De Queen–Caddo Gap folio. (By A. H. Purdue and H. D. Miser; in preparation.)

Professor M. J. Golden, Noted Educator, Called by Death.

R. B. Trueblood, Purdue University.

In the death of Michael Joseph Golden, for years a member of the Purdue University faculty, which occurred December 18, 1918, at his home, 320 State Street, West Lafayette, Ind., this community and the professions of engineering and education lose a noted educator and highly esteemed citizen. Professor Golden retired as an active member of the faculty in 1916, after rendering extraordinary service since 1884. He was beloved by students, faculty and alumni, and, although he was a strict disciplinarian, he was ever eminently square in his dealings with the student body, to whom he was familiarly known as "Mike." That in the university community Professor Golden was not fully appreciated by the freshmen was a result of intent on the part of upperclass men to inspire awe and even fear in the hearts of the first-year men. This was possible in some measure because of Professor Golden's manner of speech to his freshmen classes, which was well designed to inspire respect for things good and true, and to discourage the habits of inattention, indolence and dishonesty. Even these students, however, soon learned that their interests were his interests, for he was in sympathy with all student activities and took prominent part in many of them.

He believed in practicing what he preached. He was always ready and willing to help those who helped themselves and needed help, and on the other hand he believed it was the right and privilege of every student to be allowed to get his own education.

He took advantage of every opportunity presented by critical situations in the activities of students to urge them to dealings of justice, honesty and courtesy among themselves and with their opponents. He was one of the staunchest advocates of athletics Purdue had, and his brilliant personality and keen sense of humor made him a figure much sought after in all gatherings of students and alumni. He was for years a member of the board of insignia of the athletic association. Probably no other individual in the university community wielded so widespread and so effective an influence for the better things in the university life of the student as did he.

None knew better than his colleagues his professional ability, his kindliness and his generosity. His was a character of strength. No adjectives are required in such a description. He was honest, frank and fearless. He was loyal to his family, to his friends, to his Alma Mater, and last of all to himself. His feeling of loyalty to Purdue weighed heavily against flattering offers which would take him away.

So he remained, striving with all his energy to make his department in the university do its work so well that there was no other anywhere doing it better. His constant aim was to co-ordinate the work of practical mechanics with the needs of the employers of engineering graduates. In this problem the interests in contact are many and varied, so that progress was necessarily slow; but every line of work in the department reflects his effort, which was tireless.

Professor Golden was a Canadian by birth, having been born in Stratford, Can., November 17, 1862. He received his early education at Lawrence, Mass., and was for some time a special student at the Massachusetts Institute of Technology. For one year he was instructor in mechanical drawing at the high school at Hyde Park, Mass. He came to Purdue in 1884 as instructor in shop work. In 1894 he received his degree from Purdue University as a mechanical engineer. From 1889 until June, 1916, he served as professor in practical mechanics at Purdue, and has been Director of the practical mechanics laboratory since 1907. In shop management and shop experiments he was intensely interested. On one trip east for a short period of time he began making experiments with ball bearings, and he is said to have been one of the first experimenters in that line. Upon his return these experiments were continued here, and valuable conclusions resulted from the data received from them. Keen appreciation of manufacturing conditions, fine perception and good judgment prompted Professor Golden in the development of his department, which increased in size and effectiveness under his guidance, becoming a model of its kind. His course of shop lectures was perhaps the best and most comprehensive in existence and proved of almost inestimable value to the young engineer; so much so that it is indeed seldom but that a returning alumnus speaks of his indebtedness for this work.

His last notable work was in connection with the instruction in mechanical drawing. This work was developed to such a state that the results were highly satisfactory to both students and instructors, and by it the efficiency of this part of his department was very considerably increased. His educational work was more far-reaching than was generally known. He was the author of texts used in correspondence-school instruction.

He spent a great deal of time in research, in collaboration with his sister, Mrs. Bitting, investigating microscopically the structure of wood. For this work he designed and built much special apparatus. His talents in photography lent themselves well to this work, the results of which are highly appreciated by investigators as well as commercially. Professor Golden's appreciation of the beautiful in nature and in art was greater than usually is the lot of the layman. Among those who have received most generously of his most willing aid, and who mourn him most sincerely, are the Sisters of St. Francis of St. Elizabeth Hospital, where he lectured and taught, planned and advised, taking of his own time unselfishly for this work.

In June, 1916, Professor Golden was granted a leave of absence because of ill health, and he retired from the faculty in 1917. Professor Golden was a member of the Theta Xi fraternity, Indiana Academy of Science, American Society of Mechanical Engineers, the American Society of Naval Engineers, and the Manual Training Teachers' Association of America. He was a devout member of St. Mary's Church and was for many years chancellor for the Knights of Columbus, relinquishing this post because of ill health.

Since his retirement in 1916, he had devoted his time to traveling, in the hopes of benefiting his failing health. Professor Golden is survived by three sisters: Miss Josephine Golden, 320 State Street, West Lafayette; Miss Helen Golden, professor in mechanical drawing at Purdue, and Mrs. Katherine Bitting of Washington, D. C.

Professor Golden was the author of "A Laboratory Course in Wood Turning" and "Pattern Making Notes," both used in the university as texts; "Shop Lecture Notes," which were so used for years; "Pattern Making," which he wrote for the International Correspondence School, and "Molding," which he prepared for the same school. Besides these he has written brochures and pamphlets descriptive of "Purdue University Shops," "Tests of Ball Bearings," and other engineering papers.

Some Trees of Indiana.

By F. M. Andrews.

Some trees that are exceptional for size, or for some other facts, have been mentioned from time to time. A few of these, together with some facts, will be briefly referred to here.

One of our largest and most beautiful trees, Liriodendron Tulipifera L., has attained, as is well known, great dimensions both in height and in diameter. Britton[1] in his Illustrated Flora gives this tree often a height of 190 feet and a diameter of 12 feet. A tree of Liriodendron Tulipifera L. having a diameter of 11 feet was cut down, a good many years ago, about one mile north of Bloomington, Indiana. It divided into two large branches some considerable distance above the ground and probably attained a height of 175 feet. Sargent[2] states that this species of tree may sometimes attain a height of 200 feet.

In describing Liriodendron Tulipifera, Wood[3] says: "Near Bloomington, Indiana, we measured a tree of this species which had been recently felled. Its circumference four feet from the ground was 23 feet; 80 feet from the ground its dimension was five feet; the whole height was 125 feet. The trunk was perfect, straight and cylindric."

When in the lumber business a good many years ago, I cut into lumber many fine specimens of this species. I recall one specimen which was seven feet in diameter three and one-half feet from the ground. The trunk was straight and was free of all branches for a height of 90 feet, where it was three feet in diameter. Where this tree was cut off three and one-half feet from the ground, a cavity some inches in size was found about 10 inches from the circumference, which had been chopped out many years before. Evidently the party who had chopped out the block of wood concluded that it would not split easily enough for the making of fence rails, which was a necessary occupation in that day. The wound thus made had grown completely over in the usual manner and left no trace of its existence on the surface of the trunk. The Fifteenth Annual Report of the Indiana Board of Forestry shows on page 107 a partial view of a yellow poplar seven feet in diameter. No sawmills exist in this part of the country that would saw

[1] N. L. Britton and A. Brown, An Illustrated Flora of the U. S. and Canada, 1913. Second Edition, Vol. II, p. 63.

[2] C. S. Sargent, Manual of the Trees of North America, 1905, p. 325.

[3] Alphonso Wood, Class Book of Botany, 1868, p. 215.

into lumber without waste such logs as those of Liriodendron Tulipifera having a diameter of 12 feet as given by Britton,[1] or even a diameter of 10 feet as given for this tree by Sargent.[2] Therefore, in order to handle these large logs, they were often split or quartered by bursting with gunpowder, so that they could be handled in the mill on the saw-carriage. The large double saw rigs having both a large upper and lower circular saw would lack a good deal of being able to handle such sticks of timber without previous reduction. The waste even then and in logs of moderate size is great when it is remembered that the ordinary gauge of sawmill circular saws cut away one-fourth of an inch of timber for each "line" or board that is sawed. Therefore, in logs 12 feet in diameter and 12 feet long a large amount of good timber, if the log is sound, will be cut away in the form of sawdust and wasted. In proportion smaller logs, of course, lose in sawing. Band sawmills are more economical, since the kerf of most such saws is usually one-eighth of an inch. Trees of the yellow poplar seven feet in diameter are now, however, rarely found in Indiana, and no specimen 11 feet in diameter now exists. The scores of sawmills in Indiana have been one large agency in the removal of the timber. Most of these mills are equipped with circular saws and can cut from a few hundreds or thousands of feet of lumber daily up to many thousands of feet. Since, however, the strain on a circular saw is considerable, and this increases greatly with the increase in velocity of the "feed," a large circular sawmill cannot be safely operated when cutting more than 80,000 feet of lumber per day. Much timber is now being cut into lumber that thirty or forty years ago would have been rejected, or only used for fuel, if even that. A band sawmill, besides being more economical as to narrowness of kerf, will cut more lumber per day, and for the same capacity requires less power to operate than the circular sawmill. The large "stationary sawmill" in various parts of the country use "band" or "gangsaws" and often cut hundreds of thousands of feet. For example, the plant of the Great Southern Lumber Company, Bogalusa, Louisiana, has the largest sawmill in the world. It has cut 1,018,000 feet of lumber in a single day.[3] With such factors as the sawmill, consumption for railroad ties, etc., and the "proverbial forest fires," the forests are rapidly disappearing.

Near Worthington, Indiana, stands what is probably the largest tree in this State. It is Plantanus occidentalis, is 42 feet 3 inches in circumference and 100 feet high. Wood[4] also says of this species that,

[1] N. L. Britton and A. Brown, l.c.

[2] C. S. Sargent, l.c.

[3] American Forestry, 1918, June, Vol. 24, p. 338.

[4] Wood, Alphonso, i.c., p. 610.

"Along the Western rivers trees are found whose trunks measure from 40 to 50 feet in circumference." Britton[3] gives it a diameter of 14 feet, and Gray[4] gives it a diameter of 2 to 4.2 m. and calls it "our largest tree." A partial view of this tree is given in the Fifteenth Annual Report of the Indiana State Board of Forestry for 1915, page 109.

In my yard is a hickory, Cary ovata, which was formerly very tall. It is about three feet in diameter and at present only about 100 feet high. Formerly it was 170 feet high, but 70 feet of the top has been cut off.

There are still a number of areas of native forests containing good-sized trees in Indiana. Among these may be mentioned Turkey Run.[1] The farm of Mr. W. L. Jennings near Lexington, Scott County, Indiana.[1] This farm is reported to have 100 acres of fine forest.[1] The farm now belonging to Indiana University near Mitchell, Indiana, has about 80 acres of fine, large oak and poplar and some other kinds of trees. But these and other areas still exist only because the pony sawmill, the proverbial forest fire and other timber-devouring agencies have been thus far kept out.

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[3] Britton, l.c., Vol. 2, p. 242.

[4] Gray, New Manual of Botany, 7th Edition, p. 454.

[1] Fifteenth Annual Report of the State Board of Forestry, 1915.

Ascomycetes New to the Flora of Indiana.[1]

Bruce Fink and Sylvia C. Fuson, Miami University, Oxford, Ohio.

This work is presented as a contribution to a knowledge of the ascomycetes of Indiana. The collecting was begun by the authors in Union County, July 21, 1917, and most of the collections were made during August and September of the same summer in the following counties: Franklin, Hendricks, Montgomery, Parke, Tippecanoe, and Union. Thus far, about six hundred and twenty-five specimens have been brought together, representing thirty-eight counties. Of this number, fifty-five were obtained from the herbarium of Purdue University and about the same number from the herbarium of Wabash College.

It is the intention to record in this first paper a list of the ascomycetes found which have not been published previously for the State. Of these there are about one hundred and forty, including two new species. A second paper, which is to follow, will consist of an arrangement of all the ascomycetes now known to Indiana.

The classification used in this paper follows that initiated by Bruce Fink in "The Ascomycetes of Ohio,"[1] published in Bulletin 5 of the Ohio Biological Survey, June, 1915.

Full sets of the species are preserved in the herbaria of Bruce Fink and Sylvia C. Fuson, and a partial set was sent to the herbarium of Purdue University.

Unless otherwise stated, all collections were made by the authors. Other collectors mentioned are H. W. Anderson, J. C. Arthur, F. E. Bryant, G. W. Clark, Miss Katherine Longhead, C. P. Orton, J. R. Schram, Miss Simonds, and M. B. Thomas.

The authors are under obligations to the following persons for help in collecting, or for the furnishing of facilities for collecting: H. W. Anderson, J. C. Arthur, J. W. Clokey, A. N. Fuson, Mrs. A. N. Fuson, H. S. Jackson, C. A. Ludwig, D. P. Miller, John Miller, L. O. Overholtz, George A. Ross, J. M. Van Hook, and Miss Bernice Wren. We are also indebted to Dr. E. J. Durand and to Dr. C. L. Shear for determining some difficult species.

The list of species not previously reported from Indiana follows.

[1] Contributions from the Botanical Laboratories of Miami University—XV.

PEZIZALES.

Pezizaceae.

Geopyxis nebulosa (Cooke) Sacc.
On rotten logs in woods. Parke, Montgomery.
Humaria fusispora Berk.
On moist ground in grassy wood. Jasper (Arthur 1903).
Lachnea setosa (Nees) Phill.
On old stumps in wood. Montgomery.
Peziza bronca Peck.
On soil in open wood. Tippecanoe.

Ascobolaceae.

Ascobolus atrofuscus Phill. and Plow.
On burnt soil in open wood. Montgomery.
Ascophanus carneus (Pers.) Boud.
On sheep dung under belljar. Tippecanoe (Arthur 1896).
Ascophanus testaceus (Moug.) Phill.
On old sacking. Tippecanoe (Arthur 1903).
Saccobolus neglectus Boud.
On cow dung in open pasture. Montgomery.

Helotiaceae.

Chlorosplenium chlora (L. and S.) Mass.
On rotten logs in woods. Montgomery, Parke, Tippecanoe.
Helotium fraternum Peck.
On petioles in low wood. Parke.
Helotium lutescens Fries.
On old log in Sayre's wood. Union.
Lachnum leucophaeum (Pers.) Karst.
On dead pokeberry stems on low, open, flood plain. Montgomery.
Lanzia helotioides Rehm.
On old log in low wood. Montgomery.
Phialea scutula (Pers.) Gill.
On dead balsam and other decaying stems on flood plain of Sugar Creek. Montgomery.
Sclerotinia tuberosa (Hedw.) Fuck.
On soil in wood. Tippecanoe (Reed).

Mollisiaceae.

Belonidium minutissium Fries.
On dead tree trunks in Sayre's wood. Union.
Beloniella dehnii (Rabenh.) Rehm.
On rough cinquefoil. Tippecanoe (Orton 1911).

Mollisia cinerea (Batsch) Karst.
On decaying logs in wood at Turkey Run. Parke.
Orbilia leucostigma Fries.
On dry sticks in woods. Montgomery, Parke, Tippecanoe, Union.
Orbilia vinosa (Alb. and Schw.) Karst.
On osage orange in open woods. Montgomery, Union.
Tapesia cinerella Rehm.
On rotten logs in woods. Parke, Tippecanoe, Union.

Cenangiaceae.

Dermatea carpinea (Pers.) Rehm.
On dead tree trunk in Sayre's wood. Union.
Sarcosoma rufa (L. and S.) Rehm.
On soil in Sayre's wood. Union.

Patellariaceae.

Karschia fusispora (Cooke and Peck) Sacc.
On logs in wood. Montgomery.
Patellaria atrata (Hedw.) Fries.
On logs in wet, open woods. Montgomery, Tippecanoe.

LECANORALES.

Lecideaceae.

Bacidia inundata (Fries) Koerb.
On moist bricks, limestone, and other rocks, usually in woods. Monroe, Montgomery, Putnam, Tippecanoe, Union.
Bacidia rubella (Hoffm.) Mass.
On bark of willow in open wood. Tippecanoe.
Bacidia schweinitzii (Tuck.) Fink.
On bark of beech in Sayre's wood. Union.
Buellia myriocarpa (Lam. and DC.) Mudd.
On board fences and telephone poles along roadsides. Franklin, Montgomery, Union.
Lecidea coarctata (J. E. Smith) Nyl.
On bricks, limestone, and other moist rocks in Crawford's wood. Montgomery.
Lecidea enteroleuca Ach.
On flat, exposed rocks in open pasture. Union.
Lecidea myriocarpoides Nyl.
On rotten stump on Indiana University Campus wood. Monroe.
Lecidea uliginosa (Schrad.) Ach.
On rotten stumps in woods. Hendricks, Montgomery, Union.

CLADONIACEAE.

Cladonia bacillaris (Del.) Nyl.
On stumps in open pasture. Hendricks.

Cladonia cariosa (Ach.) Spreng.
On soil in Crawford's wood. Montgomery.

Cladonia coniocraea (Floerke) Spreng.
On rail fences and old logs in woods. Hendricks, Montgomery, Tippecanoe, Union.

Cladonia macilenta Hoffm.
On rail fences and old logs in woods. Montgomery, Tippecanoe, Union.

COLLEMACEAE.

Leptogium tremelloides (L.) S. F. Gray.
On shaded, mossy rocks along creek. Montgomery.

PYRENOPSIDACEAE.

Pyrenopsis fuscoatra Fink sp. nov.
Thallus of brown-black, minute, flat or convex, usually scattered, sometimes disappearing granules, these often forming a more or less broken crust; apothecia minute, 0.1 to 0.3 mm. in diameter, concolorous, scattered or clustered, hemispherical or flattened, pyrenocarpic or finally more or less open, with a flesh pink to concolorous disk; hypothecium pale or tinged brown; hymenium pale below and brown above; asci clavate or ventricose; paraphyses slender, hyaline, distinct to coherent semi-distinct, brown tipped; spores simple, hyaline, oblong-ellipsoid, 13 to 22 mic. long and 7 to 10 mic. wide, 8 in each ascus.
On limestone in low, moist, open fields. Montgomery.

PELTIGERACEAE.

Peltigera horizontalis (L.) Hoffm.
On rocks at The Shades. Montgomery.

Peltigera praetextata (Sommerf.) Fink comb. nov.
On limestone rocks in wood. Tippecanoe.

ACAROSPORACEAE.

Acarospora cervina (Wahl.) Koerb.
On granite boulders in open pasture. Montgomery.

Lecanoraceae.

Lecanora dispersa (Pers.) Floerke.

On chistose and granite boulders in open fields. Franklin, Montgomery, Union.

Lecanora hageni Ach.

On fences, old stumps, and limestone rocks. Monroe, Montgomery, Union.

Lecanora varia (Hoffm.) Ach.

On bark of hickory, old stumps, and picket fences. Hendricks, Montgomery, Union.

Pertusariaceae.

Pertusaria pustulata (Ach.) Nyl.

On apple bark in Sayre's wood. Union.

Parmeliaceae.

Parmelia ciliata (Lam. and D. C.) Fink comb. nov.

On bark of sycamore in Sayre's wood. Union.

Parmelia conspersa (Ehrh.) Ach.

On granite boulders in Crawford's wood. Montgomery.

Parmelia rudecta Ach.

On bark in woods. Franklin, Hendricks, Montgomery, Parke, Tippecanoe, Union.

Usneaceae.

Ramalina fraxinea (L.) Ach.

On fence posts in open country. Union.

Teloschistaceae.

Placodium aurellum (Hoffm.) Fink comb. nov.

On limestone and on sandstone conglomerate. Montgomery, Union.

Placodium microphyllinum Tuck.

On board and rail fences. Montgomery, Union.

Placodium pyraceum (Ach.) Fink.

On dead roots in open pasture. Montgomery.

Placodium sideritis (Tuck.) Fink comb. nov.

On limestone boulders in open woods. Franklin, Montgomery, Putnam.

Placodium ulmorum Fink comb. nov.

On bark in wood. Tippecanoe.

Placodium variabile (Pers.) Nyl.

On exposed limestone boulder on open hillside. Franklin.

Teloschistes lychneus (Ach.) Tuck.

On maple bark in open field along road. Montgomery.

Physciaceae.

Physcia aquila (Ach.) Nyl.
On bark in woods. Montgomery.

Physcia astroidea (Fries) Nyl.
On walnut bark in woods. Franklin, Montgomery.

Physcia endochrysea (Hampe) Nyl.
On bark and rocks in woods. Hendricks, Montgomery, Tippecanoe.

Physcia leucoleiptes (Tuck.) Fink comb. nov.
On bark in woods and along roadsides. Franklin, Monroe, Montgomery.

Physcia obscura (Schaer.) Nyl.
On bark in woods and along open roadsides. Franklin, Montgomery, Union.

Physcia pulverulenta (Schreb.) Nyl.
On stumps, tree trunks, and paling fences. Franklin, Montgomery, Union.

Physcia tribacia (Ach.) Nyl.
On old posts and on bark, usually toward base of trees, in woods. Hendricks, Montgomery, Parke, Union.

Pyxine sorediata (Ach.) Fries.
On old logs in wood along creek. Montgomery.

Rinodina lecanorina Mass.
On hornblend granite in Crawford's wood. Montgomery.

HELVELLALES.

Geoglossaceae.

Leotia stipitata (Bosc.) Schröt.
On grassy place in open wood. Montgomery.

Helvellaceae.

Helvella crispa (Scop.) Fries.
On ground in grassy wood. Montgomery.

Helvella sulcata (Schäff.) Afz.
On open hillside along road. Montgomery.

PHACIDIALES.

Stictidiaceae.

Stictis radiata (L.) Pers.
On dead stems of pokeberry on low, open, flood plain of Sugar Creek. Montgomery.

HYSTERIALES.

Hysteriaceae.

Gloniopsis gerardiana Sacc.
On old limbs in Crawford's wood. Montgomery.

Gloniopsis lineolata (Cooke) Sacc.
On rail fence along roadside. Hendricks.

Glonium lineare (Fries) Sacc.
On sycamore bark in open pasture. Union.

Glonium nitidum Ell.
On exposed logs in open wood. Montgomery (Miller).

Glonium stellatum Muhl.
On old logs in wood. Montgomery (Anderson).

Hysterium insidens Schw.
On rail fence in woods. Hendricks, Montgomery.

Hysterographium cinerascens Schw.
On fallen tree. Montgomery.

Hysterographium lesquereauxii (Duby) Ell. and Ev.
On old logs in wood. Union.

Hysterographium rousselii De Not.
On exposed paling in open wood along road. Montgomery.

Hysterographium variabile Cooke and Peck.
On decorticate wood, rails, and fence posts, in woods. Montgomery, Parke, Tippecanoe.

Graphidaceae.

Opegrapha varia Pers.
On bark in woods. Parke, Tippecanoe.

Arthoniaceae.

Arthonia dispersa (Lam. and DC.) Duf.
On maple bark in woods. Montgomery, Union.

Arthonia lecideella Nyl.
On bark, usually in woods. Hendricks, Montgomery, Parke, Tippecanoe, Union.

Arthonia radiata (Pers.) Ach.
On basswood bark in low wood. Tippecanoe.

HYPOCREALES.

Hypocreaceae.

Chromocrea gelatinosa (Tode) Seaver.
On old log in wood at Turkey Run. Parke.

Hypocrea lenta (Tode) Berk. and Br.
On exposed logs along border of wood. Montgomery.

Hypocrea sulphurea (Schw.) Sacc.
On Exidia over decorticate wood in Sayre's wood. Union.
Nectria episphaeria (Tode) Fries.
On osage orange bark in open field along Sugar Creek. Montgomery.
Nectria sanguinea Fries.
On dead stems of common ragweed on low ground near Sugar Creek. Montgomery.

DOTHIDIALES.

Dothidiaceae.

Dothidea glumarum Berk. and Curt.
On couch-grass in wood. Montgomery (Thomas 1893).
Phyllachora potentillae Peck.
On cinquefoil in wood. Montgomery (Thomas 1893, 1913).

SPHAERIALES.

Chaetomiaceae.

Chaetomium bostrychodes Zopf.
On sheep dung in pasture. Tippecanoe (Arthur 1896).

Sordariaceae.

Sporormia minima Auersw.
On cow dung in open pasture. Montgomery.

Sphaeriaceae.

Lasiosphaeria hirsuta (Fries) Ces. and De Not.
On decaying logs in wood at Turkey Run. Parke.
Lasiosphaeria hispida (Tode) Fuck.
On old wood along dry branch. Montgomery.
Lasiosphaeria ovina (Pers.) Ces. and De Not.
On old logs in Sayre's wood. Union.
Leptosphaeria borealis Ell. and Ev.
On ash in wood along creek. Montgomery.
Leptosphaeria doliolum (Pers.) Ces. and De Not.
On old aster stems in low, open field. Montgomery.
Leptosphaeria dumentorum Niessl.
On stems of giant ragweed and mint in open field near Sugar Creek. Montgomery.
Leptosphaeria subacuta (Cooke and Peck) Sacc.
On stems of giant ragweed in low, open field. Montgomery.

Leptosphaeria subconica (Cooke and Peck) Sacc.
On dead stems of actinomeris in low, open field near creek. Montgomery.

Teichospora obducens (Fries) Fuck.
On ash bark in open wood. Union.

Trichosphaeria pilosa (Pers.) Fuck.
On old sticks in wood. Montgomery.

Ceratostomaceae.

Ceratostomella barbarostra (Duf.) Sacc.
On maple bark on Indiana University Campus. Monroe.

Amphisphaeriaceae.

Amphisphaera incrustans Ell. and Ev.
On old wood in open pasture. Montgomery.

Pleosporaceae.

Ophiobolus acuminatus (Sow.) Duby.
On dead grape stems in low, open field. Montgomery.

Ophiobolus anguillides (Cooke) Sacc.
On dead stems of giant ragweed in low field. Montgomery.

Ophiobolus solidaginis (Fries) Sacc.
On dead stems of giant rágweed in low ground near Sugar Creek. Montgomery.

Valsaceae.

Diaporthe albocarnis Ell. and Ev.
On dead twigs in wood. Montgomery. (Anderson.)

Diaporthe orthoceras (Fries) Nits.
On dead stems of actinomeris in open ground. Montgomery.

Eutypa ludibrunda Sacc.
Old wood along roadside. Montgomery.

Eutypella cerviculata (Fries) Ell. and Ev.
On log in wood. Tippecanoe.

Diatrypaceae.

Diatrype asterostoma Bock. and Curt.
On beech twigs in open pasture. Union.

Melogrammataceae.

Botryosphaeria sumachi (Schw.) Cooke.
On sumach bark in open, flood plain. Montgomery.

Xylariaceae.

Hypoxylon insidens Schw.
On exposed board in wood. Montgomery.
Hypoxylon stigmateum Cooke.
On hickory log in woods. Montgomery, Union.
Xylaria digitata (L.) Grev.
On old log in wood. Montgomery.

PYRENULALES.

Verrucariaceae.

Verrucaria epigea (Pers.) Ach.
On exposed soil in Sayre's wood. Union.
Verrucaria muralis Ach.
On exposed bricks, sandstone, and limestone boulders. Franklin, Monroe, Montgomery, Putnam.
Verrucaria nigrescens Pers.
On exposed limestone boulders in open field. Montgomery, Putnam, Tippecanoe.
Verrucaria rupestris Schrad.
On exposed sandstone in open wood along road. Montgomery.
Verrucaria sordida Fink sp. nov.
Thallus partly hypolithic, the epilithic portion thin, sordid, roughened, clinky-areolate, the poorly defined areoles minute, 0.2 to 0.5 mm. across; apothecia numerous, concolorous or darker, minute, 0.15 to 0.25 mm. across, semi-immersed, dimidiate, the superficial portion subconical and surmounted by a minute and obscure ostiole; hypothecium and hymenium pale; paraphyses gelatinizing and disappearing early; asci clavate, becoming distended and variously shaped; spores simple, hyaline, oblong-ellipsoid, 16 to 22 mic. long and 9 to 12 mic. wide, 8 in each ascus.
On limestone boulders along dry run. Montgomery.
Verrucaria viridula Ach.
On rock on north side of barn. Montgomery.

Pyrenulaceae.

Pyrenula cinerella (Flot.) Fink.
On cultivated cherry bark in Sayre's wood. Union.
Pyrenula leucoplaca (Wallr.) Karst.
On beech bark in wood at Turkey Run. Parke.
Pyrenula nitida (Weig.) Ach.
On bark in wood at Turkey Run. Parke.

Dermatocarpaceae.

Endocarpon pusillium Hedw.
On limestone and granite boulders in woods. Franklin, Montgomery, Union.

Thelocarpon prasinellum Nyl.
On board along Sayre's wood. Union.

Trypetheliaceae.

Trypethelium virens Tuck.
On beech bark in wood. Tippecanoe.

PERISPORIALES.

Erysibaceae.

Microsphaera euonymi (DC.) Sacc.
On cultivated spindle tree. Tippecanoe (Orton).

Sphaerotheca humuli fuliginea (Schlecht.) Salm.
On tamarix and heal-all on low ground. Montgomery.

ASPERGILLALES.

Aspergillaceae.

Penicillium crustaceum L.
On canned fruit. Tippecanoe (Simonds 1906).

EXOASCALES.

Exoascaceae.

Exoascus mirabilis Atkins.
On wild plums. Jefferson (Clark 1898), Orange (1909).

Taphrina caerulescens (Mont.) Tul.
On scarlet oak in wood. Montgomery (Thomas 1893).

Taphrina potentillae (Farl.) John.
On cinquefoil (*Potentilla canadensis*). Vigo (Arthur).

Bibliography.

Haines, Mary P. List of ferns, mosses, hepaticae, and lichens collected in Wayne County. Ind. Geol. Surv. 1879: 235–239. 1879.

Ludwig, C. A. Fungous enemies of the sweet potato in Indiana. Proc. Ind. Acad. Sci. 1912: 103, 104. 1912.

O'Neal, Claude E. Some species of *Nummularia* common in Indiana. Proc. Ind. Acad. Sci. 1914: 235–241. 1914.

Osner, Geo. A. List of plant diseases. Proc. Ind. Acad. Sci. **1916**: 327–332. 1916.

Osner, Geo. A. List of plant diseases. Proc. Ind. Acad. Sci. **1917**: 145–147. 1917.

Owens, Charles E. A monograph of the common Indiana species of *Hypoxylon*. Proc. Ind. Acad. Sci. **1911**: 291–308. 1911.

Pipal, F. J. List of plant diseases. Proc. Ind. Acad. Sci. **1915**: 379–397. 1915.

Ramsey, Glen B. The genus *Rosellinia* in Indiana. Proc. Ind. Acad. Sci. **1914**: 251–259. 1914.

Rose, J. N. The mildews of Indiana. Bot. Gaz. **11**: 60–63. 1886.

Underwood, L. M. List of cryptogams at present known to inhabit the State of Indiana. Proc. Ind. Acad. Sci. **1893**: 30–67. 1893.

Underwood, L. M. Report of the botanical division of the Indiana state geological survey for 1894. Proc. Ind. Acad. Sci. **1894**: 144–156. 1894.

Van Hook, J. M. Indiana fungi. Proc. Ind. Acad. Sci. **1910**: 205–212. 1910.

Van Hook, J. M. Indiana fungi II. Proc. Ind. Acad. Sci. **1911**: 347–354. 1911.

Van Hook, J. M. Indiana fungi III. Proc. Ind. Acad. Sci. **1912**: 99–101. 1912.

Van Hook, J. M. Indiana fungi III. Proc. Ind. Acad. Sci. **1915**: 141–146. 1915.

Wilson, Guy. Flora of Hamilton and Marion counties, Indiana. Proc. Ind. Acad. Sci. **1894**: 156–176. 1894.

NOTE: The following papers are said to have been read before the Indiana Academy of Science, but we have been unable to obtain either of them:

Brannon, M. A. Some Indiana mildews. Read in 1887. Never published.

Evans, W. H. Lichens of Indiana, 1887. Said to have been published.

THE DORMANT PERIOD OF TIMOTHY SEED ATER HARVESTING.

M. L. FISHER, Purdue University.

The suggestion for this study came in August, 1916, through a request from the Illinois Seed Company, Chicago, Illinois, asking for data as to the length of time after harvesting until timothy seed reached its maximum germinating power. No such data were at hand and a very careful search of all the available literature revealed but one mention of any previous work on the subject. In Fuhling's Landwirthschaftliche Zeitung for March 15, 1894, there was reported such a study of several different kinds of seeds, and from that study a conclusion had been drawn that timothy seed reaches its maximum germinating percent in four weeks after harvest.

At the time of receiving the above inquiry it was too late to make an investigation for the season of 1916. In the season of 1917 an investigation was begun. Heads of timothy were harvested from a lot back of the Agricultural Building at Purdue University. It was decided to make the study in two parts.

1. A study of the germinating qualities of individual heads was made to see if there was such a thing as individuality in heads.

2. A number of heads were shelled together for a mass selection and this was used in duplicate. The shelled seed was allowed to stand in an open pan in the laboratory. The timothy heads were not ripe enough to shatter from the spikes, but were easily shelled. The culms below the spikes were still green. The heads were harvested August 11th, and the first tests set at once. The second test was set August 20th, and the third test September 5th. For the individual head testing, five heads were selected. A small amount of seed was shelled from the base of the spikes and one hundred seeds (more or less accurately) counted out for testing. For the mass tests duplicate lots of one hundred seeds (more or less accurately counted) were taken. The seeds were tested on blotters in moist chambers formed by turning one plate over another. The following tables show the results of these tests:

TABLE 1.

Dormancy of Timothy Seed—Details of Results.

Series	Date Set	Period Germ. Days	Head 1			Head 2			Head 3			Head 4			Head 5			Mass 1			Mass 2		
			No. Germ.	Hard Seed	%	No. Germ.	Hard Seed	%	No. Germ.	Hard Seed	%	No. Germ.	Hard Seed	%	No. Germ.	Hard Seed	%	No. Germ.	Hard Seed	%	No. Germ.	Hard Seed	%
Series 1......	8-11	29	25	65	27 7	27	76	26.2	25	64	28	38	50	39.7	17	75	18.4	5	84	5.6	3	89	3.2
Series II......	8-20	26	57	40	58 7	47	3* 51	46.5	39	2* 54	41	91	12	88.3	51	45	53.1	60	33	64.5	76	19	80
Series III.....	9-6	16	96	4	96	99	1*	99	98	2*	98	100	0	100	98	2	98	88	2* 10	88	88	1* 11	88
Hard seed from Mass Series 1....	9-10	20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	46	2* 28	60.5	....	....	....
Hard seed from Series II.	9-29	20	31	8	79.4	2	47	4.0	41	13	75.9	3	7	30	31	11	73.8	4	29	12.1	12	6	66.6

*Rotten.

TABLE II—Summary of Table I.

	Series I From harvest, days—none.		Series II From harvest, days—10		Series III From harvest, days—25		Hard seed from Series I From harvest, days—31, plus first test	Hard seed from Series II From harvest, days—50, plus first test
	%	%	%	%	%	%	%	%
Head 1...	27.7	....	58.7	....	96.0	....	....	90.7
Head 2...	26.2	....	46.5	....	99.0	....	....	48.5
Head 3...	28.0	....	41.0	....	98.0	....	....	84.4
Head 4...	39.7	....	88.3	....	100.0	....	....	91.2
Head 5...	18.4	....	53.1	....	98.	....	....	85.4
Mass 1....	....	5.6	....	64.5	....	88	78.8	....
Mass 2....	....	3.2	....	80.0	....	88	....	....
Ave......	28.0	4.4	57.5	72.2	98.2	88	78.8	80.3

In Table 1 are given the detailed results obtained from the individual heads and from the duplicates in the mass tests. In Series I it is to be observed that in every case there was a large percentage of hard seed. After the first five days, or first count, very few seed germinated. The majority of the seed that germinated did so during the first five days. After twenty-four days had passed and no germination had taken place for several days this series was broken up. However, upon a second thought it was decided to see what effect letting these seed dry out and then retesting would have. The hard seed from one of the mass tests was used for this purpose, and the table shows that 60.5% of the hard seed germinated. However, after a period of seventeen days no more seed would germinate in this lot. In Series II it was decided to try out the hard seed from all of the tests by first letting them dry out on the pads. The data in the table show the results of these tests. In Series III there was so small a percentage of hard seed that it was not deemed necessary to retest. In Table 2 is shown the summarized results of the tests. From the data presented above we may make the following observations:

1. Immediately after harvesting only a very small percentage of germination may be expected from timothy seed. In the case of the individual heads tested, an average of 28 percent was obtained, while in the mass selections only an average of 4.4 percent was obtained. In ten days after harvesting the individual heads had practically doubled their germinating power, averaging 57.5 percent. The mass selections had very greatly improved, averaging 72.2 percent. In twenty-five days

after harvesting the individual heads had practically reached their maximum percent, averaging 98.2%, while the mass selections had reached a satisfactory germinating percentage—88% (U. S. Gov. standard being 85–90 percent). (Yr. Bk. U. S. D. A. 1896, p. 623.)

2. Alternate drying and wetting increases the germinating percentage. However, where seed was kept wet throughout the period no further germination took place in the hard seeds.

3. The testing of the five individual heads showed that there is some variation in the germinating quality of the single heads, as illustrated by head No. 4 in the test.

4. The individual heads reached a higher percentage of germination than the mass selections. Possibly this was due to the fact that in individual heads the seed remained attached to the spikes until shelled off for testing, while in the case of mass selections the seed was shelled off of the spikes as soon as harvested. The first condition is the one which would prevail under farm practice.

5. Seed alternately wetted and dried will eventually reach a high percentage of germination.

6. It seems reasonable to conclude from the data obtained that between three and four weeks from the time of harvesting is necessary for timothy seed to reach its maximum germinating power.

7. If timothy seed which has been harvested and threshed before it has reached its maximum germinating power is kept from heating and sown at once it would eventually give a fair stand of plants.

Bibliography.

Fühling's Landwirthschaftliche Zeitung, March 15, 1894.

The Birds of the Sand Dunes of Northwestern Indiana.

C. W. G. Eifrig, Oak Park, Illinois.

The region covered by this list is not the entire area of sand dunes in Lake and Porter counties, but is the "Dunes" in the narrower sense, i. e., the strip of dune country immediately adjoining the south end of Lake Michigan to a width of from one to two miles, extending from Gary to Michigan City, a distance of about twenty-five miles. This is an immensely interesting region to nature lovers and students of various branches of natural history or science. It is interesting to the physiographer, geologist and geographer, as here may be seen the destructive as well as the constructive forces of nature actually at work. It is a perfect Eldorado to the zoologist, especially those devoted to the study of ornithology and entomology, as well as the botanist. And in few other regions can studies in ecology be carried on as well as here. All of this needs no further elucidation in this connection. Most phases of it have been written upon, as, e. g., by Prof. W. S. Blatchley and Mr. A. W. Butler in the twenty-second annual report of the Indiana Department of Geology and Natural Resources for 1897; by Dr. H. C. Cowles, in his "Plant Societies of Chicago and Vicinity"; by R. D. Salisbury, in "The Geography of Chicago and Its Environs"; by V. E. Shelford, in his "Animal Communities"; and others. There is also a well-written account of the Dunes by Mr. A. F. Knotts of Gary in the Indiana geological report for 1916. Lately, artistically gotten-up books on the Dunes are beginning to appear, as "The Sand Dunes of Indiana," by E. S. Bailey; "The Dune Country," by E. H. Reed, and others.

Since the publication of Mr. Butler's "Birds of Indiana" in the 1897 report, which is one of the best if not *the* best state list of birds known to the writer, little has been published on the avifauna of the Dunes. Some short notes have been published on certain rare species here by Mr. H. L. Stoddard, of the Harris Public School Extension of Field Museum, who has spent much time in the Dunes in connection with his work. The notes are to be found in the "Auk," Vols. 33 and 34.

The writer's idea in compiling this list is not so much to quote old records, but to give the *present* status of the avifauna of this section. He has spent many days in the Dunes, in every month of the year, and has also accumulated material from the observations of members of the Chicago Ornithological Society, many of whom also go to the Dunes as often as they can. As an example of what may be seen here, at a time when very little of interest can usually be seen in most places in this latitude, I quote the species I saw during my last three visits to the Dunes, on November 30th, December 21st and 27th, 1918, namely, Evening Grossbeaks, Pine Grossbeaks, Tufted Titmouse, Red-breasted Mergansers, Hooded Mergansers, Herring Gulls, Red-headed Woodpeckers, Chickadees, Blue Jays, Tree Sparrows, Juncos, Cardinals, White-breasted Nuthatches, Redpolls, Downy Woodpeckers, and Crows. Anyone familiar with bird conditions will see how difficult it would be to duplicate this list in most places. The writer deplores his lack of time to enter into the subject more fully, and hopes to be able to do so at some future time. In the meantime, everyone able to do so ought to lend his aid to the proposal to make a part of this alluring region a national park. Let it remain a monument of nature and a high school of and in nature forever!

Order Pygopodes: Diving Birds.

1. *Colymbus auritus*, Horned Grebe. A none too common migrant, especially in spring, and one may now and then breed in Long Lake, near Millers, or some others of the larger and not too accessible lakes that are between the dunes or along the southern end of them. They are seen on Lake Michigan in April, and several have been seen or taken on Long Lake, April 3rd, 15th and 21st, 1916, and April 25th and May 5th, 1917.

2. *Podilymbus podiceps*, Pied-billed Grebe. A common migrant and breeding species, nearly every pond or lake harboring one or several pairs. Late records are: April 1, 1916; June 2 and 6, 1916, nests with four to seven eggs found in Long Lake; July 18, 1911, family of old with young.

No doubt, if a competent observer would stay here throughout at least one whole year and patrol the beach daily, he would also see Holboell's Grebe and the Eared Grebe, but the writer knows of no late records.

3. *Gavia immer*, Loon. Formerly, no doubt, a common breeder here, but is so no longer. This shy bird does not stay where the genus homo becomes abundant, as is now the case in the Dunes, but it still tarries here in migration. April 1, 1915, one swam about, a short distance from shore, at Tremont.

What has been said in the case of the Grebes undoubtedly holds good for the Loons, too. The Red-throated Loon would probably also be seen by continuous observation. And this is still more true of the species of the next order, the *Longipennes*. Nearly all the far northern Jaegers, Gulls and Terns probably put in an appearance here, especially in long, severe winters and after strong northerly gales, but it takes more than ordinary fortitude to be out on the lake shore then.

ORDER LONGIPENNES: Long-winged Swimmers.

4. *Stercorarius longicaudus*, Long-tailed Jaeger. This is an instance of what painstaking search may reveal. Mr. H. L. Stoddard shot a fine male of this species at Dune Park, September 21, 1915. Mr. F. M. Woodruff, of the Chicago Academy of Science, mentioned several other occurrences of this boreal species to me.

5. *Larus hyperboreas*, Glaucous Gull. One was shot at Millers, August 8, 1897, which is in Mr. Woodruff's collection.

6. *Larus argentatus*, Herring Gull. An abundant winter resident, and a few, probably unmated individuals may be seen even in summer. April 24, 1915, there were many over the lake at Tremont; August 30, 1916, about ten at Millers. At the latter place, where there is a fishermen's colony on the beach, it is one of the common sights to see one perched on the top of every post in the lake and numerous others flying about.

7. *Larus delawarensis*, Ring-billed Gull. Almost as abundant as the preceding species, some days even predominating in numbers. A female was taken as early as August 3, 1915. Often flies up close to the walker along the beach, as if to inspect him.

8. *Larus philadelphia*, Bonaparte's Gull. Although this is next to the Herring and Ring-billed Gulls the commonest of the migrating gulls on Chicago River and off the lake shore at the parks, we do not see it nearly so often as the two other gulls at the south end of the lake. Probably we have just missed the days of their abundance. May 10, 1917, I saw about ten flying about in the harbor of Michigan City.

9. *Sterna caspia*, Caspian Tern. This now turns out to be a rather regular and not uncommon migrant here. In late August and early September as high as twenty have been seen at one time over the lake at Mineral Springs. Stoddard took specimens August 30, 1914, and September 4, 1915. I saw one at Millers August 30, 1916.

10. *Sterna forsteri*, Foster's Tern. An abundant migrant, at about the same time as the preceding species. August 30, 1916, a flock of about two hundred were fishing parallel to the water line near Millers, two or three rods from shore, where they were continually diving from about twenty feet above the water into the schools of minnows in the shallow water below, making as much noise as possible, reminding one of a lot of small boys on a rampage. Most still had the black crown of their nuptial dress.

11. *Sterna hirundo*, Common Tern. May almost be called a summer resident, as it is common after the first of August, and I have seen twenty as late as May 20 (1915), at Mineral Springs. Some days this species makes up the bulk of the tern flocks over the lake, on others the preceding leads in numbers.

12. *Sterna dougalli*, Roseate Tern. A specimen of this rare accidental visitor to inland waterbodies was secured by Mr. Stoddard on the beach between Millers and Dune Park, August 14, 1916. This seems to be the first clear record for this bird in Indiana, for the records cited by Mr. A. W. Butler in his "Birds of Indiana" either are for adjoining states only or do not state whether the specimen was taken or not.

13. *Hydrochelidon nigra surinamensis*, Black Tern. This species is extremely common in August and September at the southern end of Lake Michigan, where we have taken specimens as late as August 30 (1916), still in the entirely black breeding plumage. If they do not nest in the region under discussion, they certainly do in the immediate vicinity, as on Wolf and Hyde Lake, almost on the state line, also in larger sloughs a little south of the dune region.

Order Steganopodes: Totipalmate Swimmers.

14. *Phalacrocorax auritus auritus*, Double-crested Cormarant. Although we have no recent records for the occurrence of this species, there are numerous ones for the immediate neighborhood of the dune region in a wider sense than as used above, such as Liverpool, Lake County, three miles south of Millers, where one was taken October 16, 1896; it is frequently seen in Chicago, at the lake in the south end of the metropolis, and in the adjoining parts of Michigan. Mr. K. W. Kahmann, the Chicago taxidermist, frequently has specimens sent to him from Kouts, Porter County. Hence there can be no doubt as to the occurrence in the dune region in the restricted sense indicated above.

15. *Pelecanus erythrorhynchos*, White Pelican. Mr. F. M. Woodruff reports two at Millers, seen in the fall of 1896, and I have seen a specimen at Mr. K. W. Kahmann's shop, taken at Kouts, Porter County. There can be no doubt as to the casual occurrence of this species in the dune area.

Order Anseres: Lamellirostral Swimmers.

16. *Mergus americanus*, Merganser. This is a common migrant and winter resident. They were common at Millers December 17, 1895, and on January 14, 1897; four were seen there.

17. *Mergus serrator*, Red-breasted Merganser. Of the same status as the preceding species. Saw two at Millers, November 30, 1918.

18. *Lophodytes cucullatus*, Hooded Merganser. Another common migrant and winter resident all over the southern end of Lake Michigan, with the added difference that it also breeds in the vicinity, along the Kankakee River. It no doubt formerly bred along the Grand and Little Calumet, and near the larger dune ponds, and may do so still.

19. *Anas platyrhynchos*, Mallard. A common sojourner during migration, and probably would breed if there were not so many hunters at Long Lake. I saw about ten fly over the dunes from this lake on March 18, 1916.

20. *Anas rubripes*, Black Duck. Of similar status as the preceding, only not so abundant. Stoddard took a male, May 5, 1917, at Millers, Lake County, out of eight he saw there.

21. *Chaulelasmus streperus*, Gadwall. A rare migrant, or probably accidental visitor. A specimen was taken October 18, 1896, at Liverpool, Lake County, practically in the dune region.

22. *Mareca americana*, Baldpate. A common migrant and not infrequently breeds in the neighborhood of the Dunes. May 12, 1917, I saw a pair and approached it quite closely, at Long Lake, which acted as though very much at home. They have been found breeding along the Kankakee and in the adjoining parts of Illinois and Michigan.

23. *Nettion carolinense*, Green-winged Teal. A migrant of somewhat uncertain status. Mr. Stoddard saw a pair at Dune Park, April 1, 1917.

24. *Querquedula discors*, Blue-winged Teal. A common migrant and rather common breeder over the whole region. May 30, 1916, I saw two in Long Lake, which indicates their breeding there. May 31, 1912, I saw three or four on Hyde Lake in Illinois, right over the Indiana line. When once the Dunes are made a state or national park, or when at least the present federal law regarding spring shooting is enforced strictly, also against the "original squatters" in this region, who now consider themselves above such laws, this species, as well as the Mallard, the Hooded Merganser, the Wood Duck, the Baldpate and others will no doubt breed here again as in former years.

25. *Spatula clypeata*, Shoveller. Of similar status as the preceding, perhaps not quite as common. I saw two pair in Long Lake, April 24, 1916, and May 31, 1912, three in Hyde Lake, near the Indiana line.

26. *Dafila acuta*, Pintail. A common migrant. E. W. Nelson in his "Birds of Northeastern Illinois" states that he, in 1875, found several pair nesting in the sloughs near the Calumet River, which may have been within this region.

27. *Aix sponsa*, Wood Duck. The quiet and often rather large ponds on the south margin of and between the Dunes are ideal breeding places for this beautiful duck, and it is no doubt only owing to the relentless persecution of past years that it now is seldom or never seen in summer. Let us hope for better times for them in the near future. It is almost criminal in my eyes to shoot and pluck such beauty.

28. *Marila americana*, Redhead.

29. *Marila valisneria*, Canvas-back. These two species were formerly abundant on Wolf and George Lakes, at the edge of the dune country, also at Liverpool, Lake County, where a large flock of the latter were seen February 28, 1896, by Mr. J. G. Parker, but now they are far less common.

30. *Marila marila*, Scaup Duck. March 18 and April 24, 1916, I saw flocks of fifteen and seven on Long Lake which I took to be this species. There is absolutely no reason why they should not be here, as well as *Marila affinis*, since they breed from Minnesota northward and winter from there south and southeastward, thus being almost compelled to cross over.

31. *Marila affinis*, Lesser Scaup Duck. An abundant migrant over the whole region of which the Dune region is the centre.

32. *Marila collaris*, Ring-necked Duck. Also this species can hardly avoid being found here during migration, although I have no positive dates at my command. It is simply a matter of having enough time to be there continually during migration to find this and other species of similar habits and range.

33. *Clangula clangula americana*, Golden-eye. A common winter resident throughout the southern end of Lake Michigan. This is a hardy species and is in some places called Winter Duck. March 18, 1916, I saw about twenty-five on Long Lake.

34. *Charitonetta albeola*, Buffle-head. Not as common as the preceding one, since it spends the winter farther south as a rule. Mr. Stoddard took a female out of a small flock on Long Lake, April 25, 1917.

35. *Harelda hyemalis*, Old-squaw. An abundant winter resident. Mr. J. G. Parker, Jr., and Mr. F. W. Woodruff saw large flocks of them at Millers in January and February, 1897.

The Eiders and Scoters would probably in time nearly all be seen by one who would have the time and hardihood to patrol the beach daily during the winter, as there are records for them from as near the south end of the lake as Chicago.

36. *Erismatura jamaicensis*, Ruddy Duck. Early records show that this species not only visited here but bred in this region. Mr. H. K. Coale found two males and a female together at Tolleston, now a part of Gary, May 9, 1877. It no doubt still returns to the ponds and sluggish streams so well loved by it, as the Grand and Little Calumet.

What has above been said concerning the Eiders and Scoters probably holds good for the various Geese, of which we have no definite record for the narrow region under discussion. They would probably nearly all be seen in time. Mr. Stoddard saw six Snow Geese off Gary October 21, 1916, which I would put down as *Chen hyperboreus hyperboreus*, since that is the form whose breeding range is west of Hudson

Bay, and would probably come south on the west side of Lake Michigan, while those coming southwest in fall along the coast from Michigan should be the eastern form, *Chen hyperboreus nivalis.*

37. *Chen caerulescens,* Blue Goose. Mr. Stoddard saw a flock of about forty off Gary, October 21, 1916, one of which, a fine male, he collected. He concludes that this species is probably common for a few days in fall along the southern end of the lake.

38. *Branta canadensis canadensis,* Canada Goose. This species not so long ago bred in the Calumet marshes, adjacent to our area, and is now a common migrant and winter resident. March 18, 1916, a flock of about forty were holding a sort of convention, apparently, at the edge of the ice, off Millers, where they were very noisy, as though debating hard. April 1, a flock of twelve flew northward, later a flock of thirty came in wedge formation, then formed a broad line front, and then suddenly, as if by command, broke and plunged down on the lake.

39. *Olor columbianus,* Whistling Swan. Mr. Woodruff reports seeing several specimens that had been taken at Liverpool, Lake County, and he himself shot one near Hyde Lake in Indiana. It no doubt still flies over our region in its migration.

ORDER HERODIONES: Storks, Herons, Ibises.

40. *Botaurus lentiginosus,* Bittern. A common summer resident. April 24, 1916, I heard two "pumping" at Mineral Springs.

41. *Ixobrychus exilis,* Least Bittern. A common summer resident in the fringe of cat-tail around most ponds, especially at Long Lake, where I scared up one September 25, 1915. Stoddard found a nest under construction there June 2, 1916.

42. *Ardea herodias,* Great Blue Heron. A migrant of diminishing numbers, and a few pairs may still breed along the Calumet, as they formerly did in considerable numbers. I saw one August 13, 1915, at Millers.

43. *Butorides virescens virescens,* Green Heron. A rather common summer resident. They like to place their nests in button bush (*Cephalanthus occidentalis*) and other growth forming dense masses, and this is found along the edge of sloughs in abundance. April 24, 1916, we saw one at Dune Park, also June 24.

44. *Nycticorax nycticorax naevius,* Black-crowned Night Heron. While we have not seen or taken this species lately in the Dunes, it is rather common in the whole neighborhood, e. g., Hyde Lake, Kouts, etc., so it cannot fail to at least visit the region occasionally.

45. *Grus mexicana,* Sandhill Crane. Mr. Stoddard saw three near Dune Park, April 7, 1917. He is familiar with the species from a residence of years in Florida. They have lately been reported from a num-

ber of neighboring locations also, such as Crete, Illinois, near the Indiana line.

46. *Rallus elegans*, King Rail. A common summer resident in the large and small cat-tail areas of the region. Dates range from April 13 to October 21.

47. *Rallus virginianus*, Virginia Rail. Also a summer resident, perhaps not quite as common as the preceding species. May 30, 1916, I saw three at Mineral Springs.

48. *Porzana carolina*, Sora. Abundant migrant, but probably less common breeder than the two preceding species. April 24 and May 20, 1916, I saw one and two respectively at Mineral Springs.

There can be no doubt that the Yellow and Black Rails are also found here, but owing to their small size, secretive habits, the difficulty of flushing them, and aversion on the part of the dune hiker to thoroughly explore the areas of cat-tail, they have so far escaped detection, but have been seen at Hyde and Wolf Lakes, immediately adjoining.

49. *Gallinula galeata*, Florida Gallinule. Nests rather commonly on Long Lake. April 22, 1917, the first ones of the year were seen there, and June 6, 1916, a nest of seven partly incubated eggs was found.

50. *Fulica americana*, Coot. An abundant migrant and sparing nester. They would no doubt nest commonly if left undisturbed. A few nest on Long Lake. January 6, 1917, we found a dead one that appeared to have died recently.

Order Limicolae: Shore Birds.

If one could for a whole year, or at least throughout the spring and fall migration, patrol the beach of the dune country systematically, many more species of *Limicolae* would undoubtedly be seen than are here recorded, for it is the logical place for them to be met with. Whether they come in fall along the east or west shore of Lake Michigan, they must come here, the south end of the lake.

51. *Philohela minor*, Woodcock. A summer resident which is not very common. The many campers and dune prowlers probably make this region increasingly distasteful to it. July 18, 1911, I flushed two from a willow thicket at the border of a small pool at Millers, and I have seen them at Mineral Springs.

52. *Gallinago delicata*, Wilson's Snipe. A common migrant.

53. *Macrorhamphus griseus griseus*, Dowitcher. A rare migrant. Mr. F. W. Woodruff saw one or more of them at Liverpool, September 2, 1892.

The Stilt Sandpiper, *Micropalama himantopus*, has also been taken near our region, and no doubt is also one of the rare sojourners among the shore birds.

54. *Tringa canutus*, Knot. A migrant, probably not as rare as usually thought. Mr. Stoddard took two specimens, both in spring plumage, June 2, 1917, and September 2, 1916, at Millers, and I took one at the same place from among a flock of Sanderlings, September 25, 1916.

55. *Pisobia maculata*, Pectoral Sandpiper. An abundant migrant.

56. *Pisobia bairdi*, Baird's Sandpiper. A rare migrant. A few may be seen during August and September on the beach near Millers, which, by the way, seems to be the best place for Sandpipers, especially the rare ones. Mr. Stoddard secured two fine specimens at Dune Park, August 23, 1916, and two at Millers, September 2, 1916.

57. *Pisobia minutilla*, Least Sandpiper. A common migrant. The small troops of scurrying sandpipers on the beach are largely made up of this species. August 13, 1915, I saw about ten at Millers.

58. *Pelidna alpina sakhalina*, Red-backed Sandpiper. A common spring migrant over the whole neighborhood, so it must at times be found here also. Mr. G. F. Clingman took a specimen here, on the beach, June 1, 1879.

59. *Ereunetes pusillus*, Semipalmated Sandpiper. A common migrant along the beach, where it may be seen in the company of the Least Sandpiper, Sanderling and others. August 14th, 23rd and 30th, 1916, they were plentiful on the beach at Millers.

60. *Calidris leucophaea*, Sanderling. An abundant migrant. The earliest record for the fall migration is July 18 (1911), when I took two from a flock of fifteen at Millers. From then on they are common up to about October 1. One taken by Stoddard, August 23, 1916, at Millers, was still in breeding plumage, but after that date all were in the fall dress. June 2, 1917, Stoddard saw several in full nuptial plumage near Dune Park.

61. *Limosa haemastica*, Hudsonian Godwit. Probably a rare migrant. Mr. Charles Brandle took one on Wolf Lake, Indiana, September 15, 1898, which is close to our region.

62. *Totanus Melanoleucus*, Greater Yellow-legs. Migrant. Mr. J. G. Parker has seen them as early as March 30 (1895) at Liverpool.

63. *Totanus flavipes*, Yellow-legs. Of similar status as the last.

64. *Helodromas solitarius solitarius*, Solitary Sandpiper. A not uncommon migrant. May 20, 1916, I saw one at Mineral Springs.

65. *Catoptrophorus semipalmatus inornatus*, Western Willet. Mr. F. W. Woodruff refers the Willets seen along the beach near Millers to the western form. He has taken many there. It is seen occasionally from August 1 to the 15th of September, also late in April or early in May. (Woodruff.)

The chances are that both the eastern and western forms occur here.

66. *Bartramia longicauda*, Upland Plover. Apparently a rare breeder in our restricted region, but common along the southern edge of it. Mr. A. W. Butler gives several breeding records for Lake County and the Calumet marshes in Indiana.

67. *Tryngites subruficollis*, Buff-breasted Sandpiper. Apparently a rare migrant. Mr. Stoddard took a fine specimen at Millers on August 30, 1916. Up to the publishing of Mr. Butler's "Birds of Indiana," there was only one record of its having been taken in the state. This, then, would be the second.

68. *Actitis macularius*, Spotted Sandpiper. A common summer resident. April 24, 1916, I saw two at Mineral Springs, and, on May 20, six.

The Curlews seem to be a thing of the past.

69. *Squatarola squatarola*, Black-billed Plover. Rather rare along the beach. Stoddard saw three on August 30, 1916, at Dune Park; September 2, 1916, he collected four fine specimens between Millers and Gary, ranging from full breeding dress, through the eclipse plumage of a few black feathers only on belly, to entire fall dress. The last one noted by him was October 15, 1916, near Gary.

70. *Charadrius dominicus dominicus*, Golden Plover. Probably now rarer here than the preceding species. Both are migrants, of course. I saw two, April 24, 1915, at Tremont.

71. *Oxyechus vociferus*, Killdeer. A common migrant and breeder.

72. *Aegialitis semipalmata*, Semipalmated Plover. A migrant, associating with Semipalmated and Least Sandpipers on the beach.

73. *Aegialitis meloda*, Piping Plover. Formerly a common, now a rather rare breeder. Despite the overrunning of its peculiar breeding grounds on the part of campers, bathers, dune prowlers, ecology classes and others, this dapper, attractive little beach sprite has survived here as breeder to probably a half dozen pairs between Millers and Mineral Springs. Its peculiar habitat is the depression between the first two low, incipient dunes, a few rods back from the lake. Sets of eggs are found nearly every year. Stoddard has taken specimens August 23, 1916, in full summer dress; August 23, 1916, in the eclipse plumage, and September 2, 1916, in full winter dress.

74. *Arenaria interpres interpres*, Turnstone. A migrant. Mr. Stoddard took one June 2, 1917, at Millers in full breeding plumage. They are here again by August 5 (1916), when he took another specimen yet in full spring dress. One taken August 23, 1916, was partly changed, and the last of September 2, 1916, was entirely in winter plumage.

Order Gallinae: Gallinaceous Birds.

75. *Colinus virginianus virginianus*, Bob-white. This attractive species is not as common here as one would wish. Their musical call is

heard but rarely. March 11, 1916, we saw a covey of about twelve at Mineral Springs; August 24 we heard one; August 13, 1915, I saw two on the dune immediately behind the electric railway station at Millers.

76. *Bonasa umbellus umbellus*, Ruffed Grouse. This fine species still holds its own in the dense covers of scrubby oak, juniper, sumac, etc., between the middle dunes and in the woods on the southern fringe of them. No more than three or four at the highest are seen in a day's walk. March 11, 1916, I flushed three at Mineral Springs; on the 18th, one at Millers; July 16, 1915, also one at the last-named place; one January 6, 1917, and one February 17, 1917.

77. *Tympanuchus americanus americanus*, Prairie Chicken. Very rare here. Mr. Stoddard saw two near Mineral Springs in the fall of 1913. They had probably sought refuge there from the persecution of hunters a little farther south.

ORDER COLUMBAE: Pigeons and Doves.

77. *Zenaidura macroura carolinensis*, Mourning Dove. A rather common summer resident, but present in spring and fall as well. April 1, 1916, two were seen at Millers; on the 24th, four at Mineral Springs; May 20th, six at Millers, one nest on ground, with two eggs.

The last records of the memorable Passenger Pigeon, which is a thing of the past for this region, are probably those given by Mr. Woodruff in his "Birds of the Chicago Area," where he quotes from the "Auk," Vol. 12, page 389, as follows: "April 8, 1894, Mr. Edward J. Geckler saw a flock of about fifteen Wild Pigeons flying while in a woods near Liverpool, Indiana.

"Mr. Kaempfer, a taxidermist of this city, had a fine male Passenger Pigeon mounted on one of his shelves which was brought in on March 14, 1894. The gentleman who brought it said he shot it near Liverpool, Indiana, and saw quite a number of them at that time."

ORDER RAPTORES: Birds of Prey.

79. *Cathartes aura septentrionalis*, Turkey Vulture. A rare accidental visitor, though one would expect it to be more common. Stoddard saw three at Tremont, July 4, 1917. For hawks this is a great region, as is to be expected, considering the great number of small rodents and large and small swamp birds found here.

80. *Circus hudsonius*, Marsh Hawk. This is the commonest hawk, where it finds the many large and small swales to its liking for feeding and nesting. They come early and stay late. March 11, 1916, five or six were seen at Mineral Springs; on the 18th, two; April 1, 1916, four, or rather two pair, were observed mating at Millers. May 20, 1916, we saw seven at Mineral Springs and found a nest in a large swale with

five half-incubated eggs. May 30th another nest with four eggs was found there. Stoddard located six nests within a radius of one mile of Mineral Springs.

81. *Accipiter velox*, Sharp-shinned Hawk. A much rarer breeder. March 11, 1916, we saw one at Mineral Springs; April 1st, two; August 13, 1915, I saw one at Millers; May 12, 1917, one in immature plumage at Mineral Springs.

82. *Accipiter cooperi*, Cooper's Hawk. This species is a little commoner than the preceding. It has picked on the stand of large timber in the Mineral Springs–Tremont sector as being to its liking. April 1, 1916, we saw four at the former place; May 2, one; May 25, 1914, Stoddard found a nest with four partly incubated eggs 45 feet up in a tamarack. July 13, 1915, he took four young, nearly ready to fly, from a nest at the latter place. The next year he located a nest in the same place, also with four eggs, on May 21st. We saw two there February 17, 1917.

83. *Astur atricapillus atricapillus*, Goshawk. Probably a rare winter visitant. I saw one February 17, 1917, at Mineral Springs, carrying a cottontail in his talons.

84. *Buteo borealis borealis*, Red-tailed Hawk. A rather uncommon summer resident, commoner in migration. April 24, 1916, we saw two at Mineral Springs; May 12, 1917, one.

85. *Buteo lineatus lineatus*, Red-shouldered Hawk. This is after the Marsh Hawk the commonest hawk. One or more can be seen at every visit to the Dunes. Dates are: April 24, 1915, one seen at Tremont; May 29, 1916, one at Mineral Springs; March 11, 1916, four at Mineral Springs; April 1, one at Millers; August 20, 1916, one at Mineral Springs; September 25, 1915, one at Millers. Mr. Stoddard found a nest at Mineral Springs.

86. *Buteo platypterus*, Broad-winged Hawk. Seems to be rare here, probably common enough on some days during migration. Mr. Butler quotes Mr. C. E. Aiken, who says that it breeds in Lake County. I saw two at Whiting, Lake County, April 18, 1914.

87. *Archibuteo lagopus sancti-johannis*, Rough-legged Hawk. Mr. Butler quotes Mr. J. G. Parker as saying that this is the commonest of the large hawks in Lake County in winter. I saw one November 30, 1918, near Millers.

88. *Haliaetus leucocephalus leucocephalus*, Bald Eagle. Up to within twenty years or less ago this great bird was almost a common sight in the Dunes, nesting regularly. When the number of foolish gunners increased, it had to go; but it still comes back from time to time as if to survey its former realms again. Mr. Stoddard saw a bird in the immature plumage at close range at Millers, October 15, 1916, and Mr. W. D.

Richardson, who spends more time in the Dunes than anybody I know of, saw three at Mineral Springs, June 17, 1917.

89. *Falco columbarius columbarius*, Pigeon Hawk. Probably not as rare as supposed. We saw one at Mineral Springs, March 11, 1916.

90. *Falco sparverius sparverius*, Sparrow Hawk. Rather rare here. I saw one at Millers, September 29, 1915.

The Osprey can hardly fail to at least pass over our region at times, but I have no recent dates. Mr. Stoddard and I saw one near Kouts, Porter County, just a few miles south of the Dunes, May 6, 1916.

91. *Asio wilsonianus*, Long-eared Owl. Apparently a rare migrant and breeder, but is perhaps only more secretive than rare. Stoddard has seen several at Mineral Springs, and found a nest of them with three partly feathered young, May 25, 1914.

92. *Asio flammeus*, Short-eared Owl. Should be common here, as the swales that attract the Marsh Hawk are equally attractive to it, but it is not. It must nest, as adults were frequently seen during May and June, 1914, at Mineral Springs.

93. *Cryptoglaux acadica acadica*, Saw-whet Owl. Probably a rare permanent resident, as witness these dates: Mr. Stoddard took one February 15, 1914, at Millers, and one April 4, 1915, at Mineral Springs.

94. *Otus asio asio*, Screech Owl. Like the Sparrow Hawk, this is not as common as one would expect. It is, of course, a permanent resident. We saw one near Millers on March 18th and on August 30th, 1916.

95. *Bubo virginianus virginianus*, Great Horned Owl. Contrary to expectations, this species is commoner here than the Screech Owl or Short-eared Owl seem to be. In a walk between the dunes from Millers to Mineral Springs, three or four may be scared up, and there is a pair staying in the dark tamarack and pine swamp at the latter place, and another one nearby. We saw three, e. g., March 11th and 18th, 1916; August 30, we saw one near Millers being pestered by crows. Stoddard has found three nests in one season alone, to which were added three or four more near to Dune Park or Mineral Springs the following seasons. Here are nesting data: March 15, 1914, a nest was found with three slightly incubated eggs in a scrub pine, forty feet up; March 17th, two eggs were found in the cavity at the top of a large dead pine stub. The third, containing three downy young, in a similar location, was found April 4th. February 25, 1917, a nest with two eggs was found near Dune Park, thirty feet up in a pine, in an old crow's nest. March 4th there were three eggs, which are now in my collection. February 24, 1918, one was found in the same neighborhood, probably built by the same pair, containing two eggs, in a Banksian Pine, of which fine photographs were secured by Mr. W. D. Richardson, who succeeded in taking

pictures of the female on the nest, as well as of the young later on. The nest was discovered by Dr. Alfred Lewy. On one of the nests the remains of a Ruffed Grouse were found, on another those of a Bittern.

ORDER COCCYGES: Cuckoos and Kingfishers.

96. *Coccyzus americanus americanus*, Yellow-billed Cuckoo. A summer resident which is not exactly common. I have seen one at Millers on each of the following dates: May 20, July 18, and August 30, 1916.

97. *Coccyzus erythraphthalmus*, Black-billed Cuckoo. Much rarer as migrant and breeder than the preceding species.

98. *Ceryle alcyon*, Belted Kingfisher. A moderately common breeder in the region. April 1, 1916, we saw three on the way from Gary to Millers along the Grand Calumet. Here and along the creek at Tremont they are seen all summer and fall.

ORDER PICI: Woodpeckers.

99. *Dryobates villosus villosus*, Hairy Woodpecker. Rare here, as indeed it seems to be over most of its range. I saw one April 24th and May 20th, 1916, at Mineral Springs, the latter date showing that it breeds.

100. *Dryobates pubescens medianus*, Downy Woodpecker. A common migrant, not as numerous as breeder. March 11 and 18, 1916, several were seen attacking old cattail stalks at Mineral Springs.

101. *Picoides arcticus*, Arctis Three-toed Woodpecker. A rare winter visitant. Mr. Stoddard secured a male of this species March 11, 1917. Mr. Butler does not give this species at all, so this seems to be the first record for Indiana.

102. *Sphyrapicus varius*, Yellow-bellied Sapsucker. A very common migrant. Some dates are: March 30, April 1 and 24, 1916, Tremont.

103. *Melanerpes erythrocephalus*, Red-headed Woodpecker. A not very common summer resident; when there is a good acorn crop, a few sometimes winter in the Dunes. April 24, 1915, several were seen at Tremont; May 20, 1916, I saw six at Mineral Springs; November 30, 1918, about fifteen near Millers.

104. *Colaptes auratus luteus*, Northern Flicker. A common migrant and breeder. Now and then an odd one stays over winter. Thus we saw one at Mineral Springs, February 14, 1917.

ORDER MACROCHIRES: Goatsuckers, Swifts, etc.

105. *Antrostomus vociferus vociferus*, Whip-poor-will. Must be called a rare migrant here and should breed, although I have no dates for it, unless one seen May 20, 1915, at Mineral Springs, indicates breeding. The Whip-poor-will seems to me to be decidedly decreasing in numbers.

106. *Chordeils virginianus virginianus*, Nighthawk. There must be days or evenings when this species passes over in numbers, but we have never been here then, nor have we dates that indicate nesting, but a few pair probably do. May 20, 1916, I found a dead one along the railway track between Gary and Millers, which seemed to have flown against a wire, an unusual thing for such an accomplished flier.

107. *Chaetura pelagica*, Chimney Swift. Cannot be called common here in the usual meaning of that word as applied to Chimney Swifts. A pair or two are seen around the farm buildings of the region and a few more in the village of Millers. They arrive during the last week in April and are gone by the end of August, with a few stragglers flying over in September.

These last two species seem to me to be extending their fall migration farther into autumn every year.

108. *Archilochus colubris*, Ruby-throated Hummingbird. This is the only member of the order that can be called common, even if only locally so. What comes near to being a nesting colony of them was discovered by Mr. Stoddard and Mr. Richardson along the creek at Tremont, where they found nine nests within a rather small radius. We also found an old nest in Mineral Springs, 25 feet up in a black birch, 10 feet out on a limb.

ORDER PASSERES: Perching Birds.

109. *Tyrannus tyrannus*, Kingbird. A moderately common breeder, but abundant on certain days in migration. Thus on August 13, 1915, on a walk from Gary to Millers, it seemed to be the most prominent bird. On the other hand, May 20, 1916, we saw only two at Mineral Springs.

110. *Myiarchus crinitus*, Crested Flycatcher. For this species the Dunes and adjacent swampy woods are a metropolis. Stoddard found several pairs nesting where the B. & O. Railroad passes through such woods near Millers, June 21, 1914. May 20, 1916, we saw about twelve at Mineral Springs, and August 3, 1915, about four at Millers; May 30, 1916, five at Mineral Springs.

111. *Sayornis phoebe*, Phoebe. A few pair only breed in the Dunes. March 30, 1916, Stoddard must have struck a migrating flight of them, for he saw twelve near Millers; April 1, along the Calumet from Gary to Millers, we saw only two, one singing or twittering ecstatically in flight, which I never saw a Phoebe do before.

112. *Nuttallornis borealis*, Olive-sided Flycatcher. Rather common in migration from the middle of August to the first week in September, between and on the dunes just back from the lake. August 23, 1916, Stoddard took four at Mineral Springs, and saw a number of them August 30 near Millers.

113. *Myiochanes virens*, Wood Pewee. The melancholy note of this small flycatcher is not nearly as often heard as one would suppose from the wooded condition of the Dunes. On the other hand it cannot be called rare.

114. *Empidonax flaviventris*, Yellow-bellied Flycatcher. A probably not uncommon migrant. We saw one or two at Mineral Springs, May 20 and 30, 1916.

115. *Empidonax virescens*, Acadian Flycatcher. Uncommon over most of the Dunes, but nests rather commonly in the damp woods along the creek at Tremont. Stoddard found nests on the following dates: July 30, 1915, one with two partly feathered young; June 28, 1916, one with one young and one addled egg, and one on the same day with two freshly laid eggs, at Mineral Springs.

116. *Empidonax trailli trailli*, Traill's Flycatcher. A few nest in bushes in the open swamps.

117. *Empidonax minimus*, Least Flycatcher. A common enough migrant, but scarce breeder. May 20, 1916, there were about six in a migratory wave.

The Shore Lark or Horned Lark (*Otocoris alpestris alpestris*) probably occurs here in company with the Snow Buntings and Longspurs, which frequent the beach at times in fall and winter, but I have no records.

118. *Otocoris alpestris praticola*, Prairie Horned Lark. A rare breeder in our circumscribed area, common enough just a little south of the Dunes.

119. *Cyanocitta cristata cristata*, Blue Jay. A common permanent resident; especially common in the tamarack swamp at Mineral Springs, which is protected from the cold north wind by several dunes.

120. *Corvus brachyrhynchos brachyrhynchos*, Crow. A rather common breeder and quite a few stay over winter. The flocks of migrating crows show what seems to be a crossing of migration routes here. Flocks coming from southwest in spring cross over to the eastern shore of Lake Michigan, while others coming from southeast seem to make for the western shore of the lake, heading toward Wisconsin, thus crossing their paths. In fall it is, of course, reversed. We believe to have noticed the same thing with other migrants, too, e. g., Bluebirds.

121. *Dolichonyx oryzivorus*, Bobolink. A common summer resident, breeding in the swales and moist meadows adjoining the dunes on the south.

122. *Molothrus ater ater*, Cowbird. This is a decided nuisance in our region. April 24, 1915, I saw several hundred on a walk of two miles from Tremont to Mineral Springs, and most were apparently looking for nests. To this I ascribe the fact that there are relatively so few small birds found here in summer, such as warblers, finches, etc.

Cowbird eggs or young are found in many if not most of the nests of small species found here. They should be thinned out.

123. *Agelaius phoeniceus phoeniceus*, Red-winged Blackbird. A common summer resident. They arrive the first and second week in March and some stay late into November.

124. *Sturnella magna magna*, Meadowlark. A common summer resident in the same places as the Bobolink. We saw one at Mineral Springs March 11, 1916. Mr. H. K. Coale asserts that the form breeding in Indiana and Illinois is *Sturnella magna argutula*, Southern Meadowlark, which is probably correct.

125. *Icterus galbula*, Baltimore Oriole. A moderately common summer resident.

126. *Euphagus carolinus*, Rusty Blackbird. A migrant of somewhat uncertain behavior in regard to time and appearance.

127. *Quiscalus quiscalus aeneus*, Bronzed Grackle. An abundant migrant, but not very common as breeder. Arrives at the same time as the Redwing and is found late into fall.

128. *Hesperiphona vespertina vespertina*, Evening Grosbeak. This rare, erratic northern visitant now turns out to be a very common winter resident in the Dunes. They were first discovered by Mr. Stoddard, February 6, 1916, along the Calumet between Gary and Millers, making their quarters in a densely grown ravine on the north side of the river. At first a flock of about forty-five was seen, then we saw small flocks at Mineral Springs on March 11 and 18; March 30, flocks of seventy-five and fifty were seen. Then more and more disappeared, until May 4 the last one was seen. They reappeared in the same places, but not so many, in November of the same year, 1916, and were seen now and then also in Chicago till the last week in May, when Mr. H. K. Coale saw one in Highland Park. We saw small flocks of six to eight March 24, 1917, at Mineral Springs, and Stoddard took one there May 15.

The reason for this preference for the Dunes became apparent when I examined the stomach contents of several taken; this consisted mostly of the berries of *Rhus trilobata*, *Rhus aromatica*, and even *Toxicodendron vernix*. The first two are extremely abundant near Millers, the last at Mineral Springs. November 30, 1918, I saw about eighteen at Millers, and again December 21st and 28th.

129. *Pinicola enucleator leucura*, Pine Grosbeak. A rare, irregular winter visitant. I took one out of two seen November 30, 1918.

130. *Carpodacus purpureus purpureus*, Purple Finch. Another most erratic visitant, only with this difference that it may also be seen in summer. We have not found it often in the Dunes. April 1, 1916, we saw two near Gary, and January 6, 1917, there was a solitary one in the big timber at Mineral Springs.

131. *Loxia curvirostra minor*, Crossbill.

132. *Loxia leucoptera*, White-winged Crossbill. These two erratic northern visitants were reported as numerous for Lake County during the summer of 1869 and during the following winter, as quoted by Mr. Butler. They still turn up every winter, mostly the former, at Beach, near Waukegan, north of Chicago, and it is unthinkable that they would not also visit the extensive stands of conifers at the south end of the lake.

133. *Acanthis hornemanni exilipes*, Hoary Redpoll. On December 23, 1916, Mr. Stoddard noticed among the numerous redpolls, then in the tamarack swamp at Mineral Springs, a small flock of larger and whiter ones than linaria. He secured one, which proved to be this form; the rest took flight and never showed themselves again.

134. *Acanthis linaria linaria*, Redpoll. March 11, 1916, there were hundreds in the swamp at Mineral Springs. By November 25th of the same year they were back again and were seen December 23, January 6, 1917, on which days about five hundred were here. By March 24th they had dwindled down to about fifteen, at least that is all we saw. They fed on the seeds of black birch and alder. They were abundant in many places around Chicago that winter.

There is every likelihood that the other forms of Acanthis linaria turn up here at times, as they have done at Chicago, but there is no one here to register it.

135. *Astragalinus tristis tristis*, Goldfinch. A common summer resident, and some flocks stay over winter. April 24, 1915, they were common at Tremont; May 30th, about fifty at Mineral Springs; also July 18th; August 13th, families of old and young could be seen; August 30, 1916, on the other hand, I saw only one at Millers.

136. *Passer domesticus*, English Sparrow. This pest is here, too.

137. *Spinus pinus*, Pine Siskin. An irregularly abundant migrant. October 12, 1919, a flock of about 500 were at Mineral Springs.

138. *Plectrophenax nivalis*, Snow Bunting. An irregular migrant and winter visitant. Sometimes arrives about the middle of October, in other years later. Stoddard took three October 28, 1916, near Tremont; October 24, 1915, January 6 and February 17, 1917, a little flock was on the beach near Mineral Springs. They are always on the beach, not among the Dunes.

139. *Calcarius lapponicus lapponicus*, Lapland Longspur. Not common. March 18, 1916, we saw a flock of about twenty at Dune Park, where the dunes have been removed and a large, level, weed-grown area is now found instead.

140. *Pooecetes gramineus gramineus*, Vesper Sparrow. A few breed here; they are found from March 30th (1916) to October 28th (1916).

141. *Passerculus sandwichensis savanna*, Savannah Sparrow. Also is not common here. April 24, 1916, there were quite a number on the large swale at Mineral Springs.

142. *Passerherbulus henslowi henslowi*, Henslow's Sparrow. What might almost be called a breeding colony is found in the same large swale mentioned under the preceding species. They were first noticed April 24, 1915, and 1916. In May their harsh "*tsray*" call is very noticeable.

143. *Passerherbulus lecontei*, Leconte's Sparrow. A rare migrant. Stoddard collected one at Mineral Springs, October 19, 1916.

144. *Passerherbulus nelsoni nelsoni*, Nelson's Sparrow. Mr. Butler quotes H. K. Coale and others, who say they have found this elusive species repeatedly in Lake County, next to the Dunes.

145. *Zonotrichia leucophrys leucophrys*, White-crowned Sparrow. A not too common migrant.

146. *Zonotrichia albicollis*, White-throated Sparrow. An abundant migrant.

147. *Spizella monticola monticola*, Tree Sparrow. An abundant migrant and winter resident.

148. *Spizella passerina passerina*, Chipping Sparrow. A rather uncommon summer resident. This sparrow is strangely rare in northeastern Illinois and northwestern Indiana, although common or abundant in most places of its range. Stoddard found one of the few nests of a season at Tremont on July 15, 1917, containing one young and one Cowbird. During migration they are common enough on some days; thus, April 14, 1915, there were many at Tremont; May 29, 1916, I saw about fifteen at Mineral Springs, but on the 30th only three.

149. *Spizella pusilla pusilla*, Field Sparrow. A more common breeder than the foregoing species. They arrive about the beginning of April. On the first of that month, 1916, we saw one near Millers.

150. *Junco hyemalis hyemalis*, Slate-colored Junco. An abundant migrant and winter resident. September 25, 1915, we saw about twenty near Millers, and April 24, 1916, there were still many at Tremont.

151. *Melospiza melodia melodia*, Song Sparrow. A very common summer resident, because the many bush-fringed pools and small watercourses are just to its liking. They come early in March, and Mr. Stoddard saw one as late as December 23 (1916).

152. *Melospiza lincolni lincolni*, Lincoln's Sparrow. A rare migrant; perhaps only rarely seen because so secretive. Stoddard took one May 20, 1916, at Mineral Springs.

153. *Melospiza georgiana*, Swamp Sparrow. An abundant migrant and less common summer resident. April 1, 1916, we saw one; May 20 about ten at Mineral Springs.

154. *Passerella iliaca iliaca*, Fox Sparrow. A common migrant; not seen, however, in such numbers as *Z. albicollis*. April 1, 1916, we saw six on the way from Gary to Millers.

155. *Pipilo erythrophthalmus erythrophthalmus*, Towhee. This is one of the commonest summer residents in this region, from April 1 (1916) to late in October.

156. *Cardinalis cardinalis cardinalis*, Cardinal. A permanent resident, but seen only in a few chosen places. At Mineral Springs and Tremont, and especially along the roads leading from there to the beach, from one up to a dozen may be seen any day, summer or winter. November 30, 1918, I saw about fifteen near Millers.

157. *Zamelodia ludoviciana*, Rose-breasted Grosbeak. A rare summer resident.

158. *Passerina cyanea*, Indigo Bunting. A summer resident which is somewhat more numerous than the preceding, but cannot be called common.

159. *Piranga erythromelas*, Scarlet Tanager. A rather rare summer resident, something like the Rosebreast in numbers. A little more numerous in migration.

160. *Progne subis subis*, Purple Martin. A summer resident which cannot be called plentiful. May 30, 1916, I saw only about six on the way from Millers to Mineral Springs, a distance of about twelve miles.

161. *Hirundo erythrogastra*, Barn Swallow. A little more numerous than the preceding. Both form small colonies about the farm buildings on the southern edge of the Dunes. Thus on the walk above referred to from Millers to Mineral Springs, I saw about fifteen of this species.

162. *Iridoprocne bicolor*, Tree Swallow. During migration many can be seen gracefully skimming over Long Lake, but only a few stay to nest. On June 19, 1915, I saw a pair at a nesting hole in a dead cottonwood on top of a dune at Millers, and Mr. Stoddard found a nest with four fresh eggs in a hole in a telegraph pole near Long Lake, June 8, 1914.

The Cliff Swallow will, no doubt, occasionally be found here, too.

163. *Riparia riparia*, Bank Swallow. This is the only swallow that can be called common, and this only locally. There are several fair-sized colonies in precipitous places on the first dune from the beach, on the side facing the lake, near Millers. July 9, 1915, about three hundred, mostly young, were perching on the sand of the beach there or flying about aimlessly.

164. *Stelgidopteryx serripennis*, Rough-winged Swallow. A rare breeder. June 10, 1915, a pair was at the nesting hole in the same cottonwood in which the tree swallows were.

165. *Bombycilla cedrorum*, Cedar Waxwing. A locally common summer resident, and some will probably be found in winter, too.

The Bohemian Waxwing (*Bombycilla gzrrula*) has been reported once or twice from Whiting, Lake County.

166. *Lanius Borealis*, Northern Shrike. Mr. Stoddard shot one of this species at Mineral Springs, December 23, 1916.

167. *Lanius ludovicianus migrans*, Migrant Shrike. A rather rare summer resident. There is a pair yearly building its nest at Mineral Springs, near the electric railway station; but that is the only pair I know of.

168–171. The Vireos are represented by the Red-eyed (*Viroesylva olivacea*) and the Warbling Vireos (*Vireosylva gilva gilva*) as summer residents, the former moderately common, the latter rare; and the Philadelphia (*Vireosylva philadelphica*) and the Blue-headed Vireos (*Lanivireo solitarius solitarius*) as uncommon migrants. The Yellow-throated (*Lanivirce flavifrons*) should be here, but we have not yet seen it.

In respect to Wood Warblers the Dunes are a disappointment, both as regards nesting and migrating ones. There must be something in the biological or physiographic conditions that is repellant to most species. In the woodland tract just south of the Dunes proper, they are abundant enough during migration, but in the Dunes only certain species as the Myrtle, Magnolia and Palm Warblers are, or they may be normally numerous at certain points where a large tract of woodland partakes of the character of the non-dune forest, as at Tremont.

The following species breed here: The Black and White Creeping (*Mniotilta varia*), the Yellow Warbler (*Dendrocia aestiva aestiva*), the Ovenbird (*Seiurus aurocapillus*), the Maryland Yellow-throat (*Geothlypis trichas trichas*), the Redstart (*Setophaga ruticilla*), the Chat (*Icteria virens virens*). Of these the Yellow-throat is the commonest, the shrubbery along the many pools proving congenial to it; next comes the Yellow Warbler, which is common in a few bushy pools near Millers and Dune Park, then the Ovenbird, but only at Tremont. The Black and White Creeper is not common, the Redstart still rarer, and the Chat has been found only one summer and in one place. The Pine Warbler (*Dendroica vigorsi*) and the Prairie Warbler (*Dendroica discolor*) probably breed here, since they each have been found once in breeding time or nearly so, as the latter, July 16, 1916, at Tremont by Dr. A. Lewy.

The following may breed here occasionally, as they have been found in all the adjoining area around the Dune region: The Worm-eating Warbler (*Helmitheros vermivorus*), the Prothonotary Warbler (*Protonotaria citrea*), which nests abundantly at Kouts, Porter County; the

Blue-winged Warbler (*Vermivora pinus*), the Golden-winged Warbler (*Vermivora chrysoptera*), the Cerulean Warbler (*D. cerulea*), the Louisiana Water-Thrush (*Seiurus motacilla*), the Kentucky Warbler (*Oporornis formosus*), and possibly the Sycamore Warbler (*D. dominica albilora*). The Louisiana Water-Thrush has been seen by Mr. Stoddard at Mineral Springs, May 5th, 1917, and it breeds abundantly just south of our region. The Cerulean I have found at South Bend and at Addison, Illinois, east and west of the Dunes, and is reported just to the south, too. The same holds good for the rest.

The following are the migrant warblers: The Nashville Warbler (*V. r. rubricapilla*), taken May 20th, 1916, at Mineral Springs; the Orange-crowned Warbler (*V. c. celata*), taken by me May 27, 1919, near Millers; the Tennessee Warbler (*V. peregrina*), which we took at Mineral Springs, May 20th and August 30th, 1916; the Cape May Warbler (*D. tigrina*), taken August 30th, 1916; the Black-throated Blue Warbler (*D. caerulescens*), seen April 24th, 1915; the Myrtle Warbler (*D. coronata*), the Magnolia Warbler (*D. magnolia*), the Chestnut-sided Warbler (*D. pensylvanica*), the Bay-breasted Warbler (*D. castanea*), the Black-poll Warbler (*D. striata*), the Blackburnian Warbler (*D. fusca*), the Black-throated Green Warbler (*D. virens*), the Palm Warbler (*D. palmarum*), the Northern and Grinnell's Water-Thrushes (*S. n. noveboracensis* and *S. noveboracensis notabilis*), the Connecticut Warbler (*Oporornis agilis*), taken May 21st, 1916, at Mineral Springs; the Mourning Warbler (*O. philadelphia*), seen in numbers by me May 27, 1919, along Long Lake; Wilson's Warbler (*Wilsonia pusilla pusilla*), and the Canada Warbler (*W. canadensis*), taken by Mr. Stoddard even so late as July 1st, 1917, at Tremont. Of these only the Myrtle, Magnolia, and Palm Warblers seem to be common during migration, while of species as the Black-throated Blue and Green, the Chestnut-sided, the Blackburnian, and others, usually so common in migration elsewhere, only one or two individuals are seen in a hunt of several hours in the most favorable places, such as was May 20th, 1916, at Mineral Springs. As Kirtland's Warbler (*D. kirtlandi*) has been reported from a number of points in surrounding country, it must almost of necessity also pass through here occasionally.

(Nos. 172–210.)

211. *Anthus rubescens*, Pipet. This has been reported from Liverpool, October 18, 1895, as quoted by Mr. Butler.

212. *Dumetella carolinensis*, Catbird. A common migrant and breeder. May 20, 1916, I saw about twenty at Mineral Springs.

213. *Toxostoma rufum*, Brown Thrasher. A less common breeder than the foregoing species.

214. *Thryothorus l. ludovicianus*, Carolina Wren. Since the Cardinal is here in some numbers, and the Yellow-breasted Chat has been seen a whole summer, this species should not be too uncommon, especially at Tremont, where conditions are ideal for it, but it is almost absent. Mr. Stoddard has taken one at Mineral Springs, November 25, 1916. I expect it to move into here, however, sooner or later.

215. *Troglodytes aedon parkmani*, Western House Wren. This is, over certain parts of our area, a rather common summer resident, notably on the first dune from the lake, between Millers and Dune Park, where it likes to make its nest in old, vine-covered stumps on the top of the dune.

216. *Nannus hiemalis hiemalis*, Winter Wren. A not uncommon migrant. They are commonest from April 1st to 24th (1916).

217. *Cistothorus stellaris*, Short-billed Marsh Wren. I have never seen a place where this species was so numerous, at least locally, as in this region. At Mineral Springs, in the large swale, there is a regular colony of them. May 29th, 1916, I counted about fifty here. Their song is a sharp "psit tsit tsit," ending in a trill that sounds like the knocking together of pebbles. Henslow's Sparrow is its neighbor here, as also the Marsh Hawk.

218. *Telmatodytes palustris iliacus*, Prairie Marsh Wren. This western form of the Long-billed Marsh Wren is extremely common in all larger cat-tail sloughs in the Dunes. They arrive about the middle of April. May 30th, 1916, I saw about 75 along Long Lake alone. Of the numerous nests seen, some contained two to three eggs. By July 18th their fully grown young still further increase their numbers. At Cary, Illinois, I found some in the marsh as late as October 17th.

219. *Certhia familiaris americana*, Brown Creeper. A common migrant. April 24th, 1916, I saw about 30 at Mineral Springs. I would not be surprised to find a pair breeding some summer at Tremont or nearby, as they have been found at Kouts, 25 miles south.

220. *Sitta carolinensis carolinensis*, White-breasted Nuthatch. A not common migrant and scarcer breeder. Even on great migration days not more than three or four are seen. This species seems to me to be decreasing in number over a large part of its range.

221. *Sitta canadensis*, Red-breasted Nuthatch. An even rarer migrant than the last species.

222. *Baeolophus bicolor*, Tufted Titmouse. A rare resident. Has so far been found at Tremont only, June 28th and December 23rd, 1916 (Stoddard).

223. *Penthestes a. atricapillus*, Chickadee. An abundant winter resident and moderately common breeder, mostly again at Mineral Springs and Tremont. March 11, 1916, a large flock was attacking cat-tail stalks

of the previous season along the edge of the tamarack swamp at Mineral Springs.

224. *Regulus satrapa satrapa*, Golden-crowned Kinglet.

225. *Regulus c. calendula*, Ruby-crowned Kinglet. Both are abundant migrants. In the cold spring of 1916, I saw about thirty of the latter as late as May 20th at Mineral Springs.

226. *Polioptila caerulea*, Blue-gray Gnatcatcher. A rare migrant and breeder. April 18th (1914) is the earliest date I have for them.

227. *Hylocichla ustelina*, Wood Thrush. A rare summer resident, although it should be plentiful in such a fine place as Tremont.

228. *Hylocichla fuscescens fuscescens*, Veery. A not very common migrant. What percentage of them is the western form, *salicicola*, is hard to say without taking a great many, which one does not like to do. But the chances are that both occur.

229. *Hylocichla a. aliciae*, Grey-cheeked Thrush. On a few days during migration a more abundant species than the preceding, e. g., May 20th, 1916, when about ten were seen at Mineral Springs.

230. *Hylocichla ustulata swainsoni*, Olive-backed Thrush. Of about the same status as the foregoing.

231. *Hylocichla guttata pallasi*, Hermit Thrush. A somewhat more abundant migrant than the two preceding species. The earliest date we have is April 1st (1916).

232. *Planesticus m. migratorius*, Robin. In the Dunes proper a not very abundant summer resident. Some days in summer one sees only about two all day; more common about the farms along the southern edge of the Dunes.

233. *Sialia sialis sialis*, Bluebird. Also not so common here as in farming regions, but more so than the preceding. The earliest date I have is March 11 (1916), but they probably appear before this in mild seasons.

Bibliography.

F. M. Woodruff, "Birds of the Chicago Area," 1907.

A. W. Butler, "The Birds of Indiana," 1897.

Some manuscript notes by Mr. H. L. Stoddard.

My own notes.

A Synopsis of the Races of the Guiana Flycatcher, Myiarchus ferox (Gmelin).

Harry C. Oberholser, The U. S. National Museum.

The present status of the forms of *Myiarchus ferox* (Gmelin) seems not to be wholly satisfactory. The following notes are offered as an attempt to aid in their elucidation, and also to call attention to the need of more definite information regarding the various subspecies, particularly their geographic distribution.

For the use of material the writer is indebted to the authorities of the United States National Museum, the American Museum of Natural History, and the Carnegie Museum at Pittsburgh, Pennsylvania.

The geographic distribution of *Myiarchus ferox* as a species extends from Costa Rica and the Island of Tobago south through the continent of South America to northern Argentina. At present four subspecies are current: *Myiarchus ferox ferox*, *Myiarchus ferox venezuelensis*, *Myiarchus ferox panamensis*, and *Myiarchus ferox actiosus*. An additional race, *Myiarchus ferox insulicola*, has been recently described by Messrs. Hellmayr and von Seilern; and two others, *Myiarchus ferox cantans* and *Myiarchus ferox phaeocephalus*, have been recognized. In addition to these we find it necessary to add another, *Myiarchus ferox ferocior* Cabanis, making now a total of eight subspecies. The bird known as *Myiarchus cephalotes* Taczanowski, which some authors suppose to be a subspecies of *Myiarchus ferox*, is without much doubt a distinct species.

Myiarchus ferox ferox (Gmelin).

[*Muscicapa*] *ferox* Gmelin, Syst. Nat., vol. I, part 2, 1789, p. 934 (Cayenne; based primarily on *Tyrannus cayanensis* Brisson, Ornith., vol. II, 1760, p. 398).

Subspecific characters.—Size moderate; upper parts dark and olivaceous; gray of throat and yellow of posterior lower parts also of a rather deep shade.

Measurements.—Male: wing, 85.5–88 mm.; tail, 86–89; exposed culmen, 19.

Female: wing, 82.5–86 mm.; tail, 83–88; exposed culmen, 18–19.

Type locality.—Cayenne.

Geographic distribution.—French Guiana, British Guiana, Trinidad, eastern Venezuela, and northern Brazil south to the Amazon valley and west at least to the Madeira River.

REMARKS.—This, the typical form of the species, was originally described by Gmelin as *Muscicapa ferox*,[1] based chiefly on the *Tyrannus cayanensis* of Brisson.[2] This is without doubt the species now known as *Myiarchus ferox*, so that the proper application of the name *ferox* to this species is clear and the currently accepted designation correct. This, with the exception of *Myiarchus ferox insulicola*, is the darkest race of the species. The exact limits of its geographic distribution remain, however, yet to be determined.

MYIARCHUS FEROX INSULICOLA Hellmayr and von Seilern.

Myiarchus ferox insulicola HELLMAYR and VON SEILERN, Verh. Ornith. Gesell. Bayern, vol. XII, Heft 3, July 25, 1915, p. 202 (Man-o'-War Bay, Tobago Island).

Subspecific characters.—Similar to *Myiarchus ferox ferox*, but wing and tail much longer; bill stouter; upper parts darker and more grayish (less greenish); throat and jugulum darker; and rusty margins of the rectrices more conspicuous.

Measurements.—Male: wing, 94 mm.; tail, 94; exposed culmen, 21.

Type locality.—Man-o'-War Bay, Island of Tobago, West Indies.

Geographic distribution.—Island of Tobago.

REMARKS.—This recently described subspecies is very distinct from *Myiarchus ferox ferox*, and is the darkest race of the species. It seems to be confined to the Island of Tobago.

MYIARCHUS FEROX VENEZUELENSIS Lawrence.

Myiarchus venezuelensis LAWRENCE, Proc. Acad. Nat. Sci. Phila., vol. XVII, February, 1865, p. 38 (Venezuela).

Subspecific characters.—Similar to *Myiarchus ferox ferox*, but upper parts lighter and more grayish or brownish.

Measurements.—Male: wing, 84–87 mm.; tail, 86–89; exposed culmen, 17.

Female: wing, 80–84 mm.; tail, 81–86; exposed culmen, 16.5–17.5.

Type locality.—Venezuela.

Geographic distribution.—Middle and western Venezuela, west to central Colombia.

REMARKS.—This bird, originally described as a distinct species, is without doubt a subspecies of *Myiarchus ferox*, and its representative in western Venezuela and eastern Colombia.

[1] Syst. Nat., vol. I, part 2, 1789, p. 934.

[2] Ornith., vol. II, 1760, p. 398.

Myiarchus ferox panamensis Lawrence.

Myiarchus Panamensis Lawrence, Ann. Lyc. Nat. Hist. N. Y., vol. VII, 1862 (May, 1860), p. 284 (Isthmus of Panama).

Subspecific characters.—Similar to *Myiarchus ferox venezuelensis*, but larger; upper parts lighter and more grayish (less brownish), particularly on head and neck; yellow of lower parts paler.

Measurements.[1]—Male: wing, 87–96.5 mm.; tail, 80.5–93.5; exposed culmen, 17.5–21.

Female: wing, 88.5–100.5 mm.; tail, 84–96; exposed culmen, 19–22.

Type locality.—Canal Zone, Panama.

Geographic distribution.—Panama and western Colombia.

Remarks.—This flycatcher is clearly but a subspecies of *Myiarchus ferox ferox*, being connected with that form through *Myiarchus ferox venezuelensis*.

Myiarchus ferox actiosus Ridgway.

Myiarchus ferox actiosus Ridgway, Proc. Biol. Soc. Wash., vol. XIX, September 6, 1906, p. 116 (Pigres, mouth of the Gulf of Nicoya, Costa Rica).

Subspecific characters.—Similar to *Myiarchus ferox panamensis*, but with upper parts anteriorly more grayish, posteriorly darker and paler, and yellow of lower surface paler.

Measurements.[1]—Male: wing, 92–97 mm.; tail, 85.5–91; exposed culmen, 18.5–21.5.

Female: wing, 89.5–95.5 mm.; tail, 85.5–91; exposed culmen, 18.5–21.5.

Type locality.—Pigres, mouth of the Gulf of Nicoya, Costa Rica.

Geographic distribution.—Pacific coast of Costa Rica.

Remarks.—This seems to be a well-differentiated race, distinguished from *Myiarchus ferox panamensis* as above noted, but it seems to be confined to Costa Rica.

Myiarchus ferox phaeocephalus Sclater.

Myiarchus phæocephalus Sclater, Proc. Zool. Soc. Lond., 1860, p. 281 (Babahoyo, western Ecuador).

Subspecific characters.—Similar to *Myiarchus ferox actiosus*, but gray of head and neck not so much tinged with olive brown; yellow of lower parts darker.

Type locality.—Babahoyo, western Ecuador.

Geographic distribution.—Ecuador and Peru.

[1] Ridgway, Bull. U. S. Nat. Mus., No. 50, pt. IV, 1907, p. 641.

Remarks.—This rather well differentiated subspecies is apparently the representative of the *Myiarchus ferox* group in Ecuador and Peru, but its limits of distribution are at present undefined. It is of interest to note, however, that in color it much more closely resembles the Costa Rican *Myiarchus ferox actiosus* than it does the intervening *Myiarchus ferox panamensis.*

Myiarchus ferox ferocior Cabanis.

Myiarchus ferocior Cabanis, Journ. f. Ornith., vol. XXXI, No. 162, April, 1883, p. 214 (Tucuman, Argentina).

Subspecific characters.—Similar in size to *Myiarchus ferox ferox*, but upper parts lighter and more brownish (less greenish) olive; gray of throat lighter.

Measurements.—Male: wing, 90 mm.; tail, 89; exposed culmen, 19.

Female: wing, 85 mm.; tail, 86; exposed culmen, 16.5.

Type locality.—Tucuman, northern Argentina.

Geographic distribution.—Northern Argentina and Paraguay, with probably also Bolivia and southwestern Brazil.

Remarks.—This seems to be a recognizable race, differing from both *Myiarchus ferox ferox* of Guiana and *Myiarchus ferox swainsoni* of southeastern Brazil. No specimens have been examined from southwestern Brazil or from Bolivia, but in all probability this is the form of the species that occupies those areas. Further investigation, however, must settle this point.

Myiarchus ferox swainsoni Cabanis and Heine.

M[yiarchus]. Swainsoni Cabanis and Heine, Mus. Hein., part 2, September 30, 1859, p. 72 (Brazil).

Myiarchus cantans Pelzeln, Ornith. Bras., 1869, pp. 117, 182. (Rio Janeiro, Sapitiba, Ypanema, and Curytiba, Brazil) (type locality, Curytiba, State of Sao Paolo, Brazil).

Subspecific characters.—Similar to *Myiarchus ferox ferocior*, but bill shorter, upper parts paler, somewhat more grayish, and more uniform, the pileum and auriculars not noticeably darker than the surrounding parts, as is the case in *Myiarchus ferox ferocior.*

Description.—Adult male, No. 177677, U. S. N. M.; San Carlos do Pinhal, September, 1895. Upper parts dark citrine drab, the darker centers of the crown feathers dull olive brown, and the upper tail-coverts slightly rufescent; tail warm fuscous, the outer webs of the outer pair of tail-feathers and the very narrow tips of all, pale brown; all but the exterior pair of rectrices basally edged with rufescent brown; wings fuscous, the tertials edged on the outer webs with buffy white, the primaries and all the superior wing-coverts, excepting the primary coverts, margined with pale dull brown, these edgings darker and more rufescent on the lesser coverts; sides of head and neck like the upper parts, but somewhat more grayish; lores paler and somewhat buffy grayish; throat and jugulum pale smoke gray; lining of the wing barium yellow, somewhat clouded by brownish gray; remainder of lower parts pale primrose yellow.

Measurements.—Male: wing, 94.5 mm.; tail, 88; exposed culmen, 16.5. Female: wing, 83.5 mm.; tail, 83.5; exposed culmen, 17.

Type locality.—Southeastern Brazil.

Geographic distribution.—Southeastern Brazil, north at least to Bahia, probably also to Pernambuco.

REMARKS.—This race has already been revived by Mr. Hellmayr,[1] under the name *Myiarchus ferox cantans*, and it apparently can be distinguished from both *Myiarchus ferox ferox* and *Myiarchus ferox ferocior*. From *Myiarchus ferox ferox* it differs in its smaller, paler bill, its much paler, more grayish or brownish (less greenish), and more uniform upper parts, and in its paler ventral surface. How far to the northwestward in Brazil it ranges remains yet to be determined.

Whenever recognized, this race has been known as *Myiarchus ferox cantans* Pelzeln, but it should apparently be called *Myiarchus ferox swainsoni*. Cabanis and Heine, in describing their *Myiarchus swainsoni*,[2] gave as its locality only Brazil, and they included in their literature citations also localities that belong under *Myiarchus ferox ferocior*; but the diagnosis is clearly applicable to the bird from southeastern Brazil, called later *Myiarchus cantans* by von Pelzeln.[3] Since *Myiarchus swainsoni* Cabanis and Heine has several years' priority over *Myiarchus cantans* Pelzeln, it is the name that should be used for the present subspecies.

[1] Novit. Zool., vol. XVII, No. 3, December 15, 1910, p. 302.

[2] Mus. Hein., part 2, September 30, 1859, p. 72.

[3] Ornith. Bras., 1869, pp. 117, 182.

Erosional Freaks of the Saluda Limestone.

Elmer G. Sulzer, Madison.

In the Madison region, the Saluda Limestone presents many peculiar freaks of erosion. The best exposures of these peculiarities are on the Hitz Hill, immediately northwest of Madison.

There is exposed in part of the quarry (extreme east part) about ten feet of typical limestone. Its top is distinctly formed and above it are several feet of white, chalky clay, doubtless formed by the decomposition of this same formation. The section as above described extends for about thirty feet. Beyond there is a sharp, clean-cut projection of the rock. Where this projection is supposed to join the

Figure showing the irregularity of erosion of the saluda limestone.

main body, however, a crack from one to three inches wide intervenes. This gives rise at first to the supposition that there may be a fault, but this possibility is speedily ruled out when, by minutely tracing the rock courses, similar occurrences of them on a smaller scale are found.

Probably the most wonderful thing about this section and many similar ones in this locality is the presence of this chalky stratum at different levels. This stratum is at times both overlaid and underlaid by limestones and does not blend into them but is separated from them by distinct lines of contact. In the section discussed above chalky strata also occur in the projection but at a very different level. At the same level in the main quarry is the solid limestone.

Remnant Monument Near Madison.

Elmer G. Sulzer, Madison.

In 1898 Dr. Chas. R. Dryer* described Jug Rock, a peculiar example of erosion in Martin County, Indiana. The existence of monuments of a similar character near Madison is well known to only the few scien-

Fig. 1. Complete pinnacle.

Fig. 2. Wide monument with cave formation.

* Proc. Ind. Acad. Sci., 1898, p. 268.

tists who have had occasion to do work there. These curiosities have been formed from the Laurel Limestone of the Niagara series. The most eastern exposures of this formation on the Ohio River occur only about two miles east of Madison. By the time the formation reaches Madison practically its entire thickness is exposed. The monuments are first found, going west, in Wilburs Woods, one-half mile north of Madison. The accompanying illustrations serve to give some idea of their

Fig. 3. Isolated monument.

character. They are a very noticeable feature along the river some distance below Hanover Landing, but their full development is found in the above mentioned locality. I have noticed these monuments in Jefferson County at times standing individually as Jug Rock, at times maintaining a partial connection with the mother rock, and again being only a pinnacle. They can be seen in all stages of development in this locality.

A Kinetic Model of the Electron Atom.

R. R. Ramsey, Indiana University.

Modern theories of the structure of an atom assumes one or more electrons in motion in or about a central body or positive nucleus. Probably the experiment which has been the most helpful in giving an idea as to the structure of an atom is the Mayer experiment of the floating needles. (Experiments with Floating and Suspended Magnets, Illustrating the Action of Atomic Forces, the Molecular Structure of Matter, Allotropy, Isomerism, and the Kinetic Theory of Gases. Alfred M. Mayer, Scientific American Supplement, Vol. 5, p. 2045, June 22, 1872.) This, together with the work of J. J. Thomson, has become almost classic. (Phil. Mag., Vol. 7, p. 237, 1904.) The experiment gives an idea of the possible structure of atoms and may account for the periodic variations of the properties of the atoms. Thus one by assuming that an atom of large atomic weight has more electrons than one of small atomic weight, may account for the periodic table. The

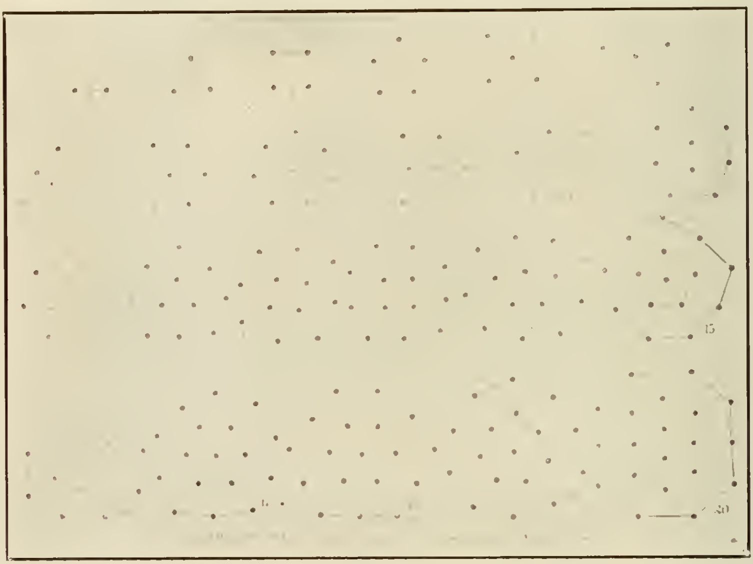


Fig. 1.

periodic variations of the properties of the atoms may be illustrated by the periodic variation of the number of needles in any of the rings, the inside ring, say. This has been done by Lyon. (Phys. Rev., Vol. 3, p. 232, 1914.) Figure 1 is a reproduction of the groupings of the needles taken from Mayer's original article. The following table taken from Thomson's work gives the theoretical groupings of the magnets from one to one hundred. The lower row of figures gives the number of magnets in the inside ring, and the upper row of figures gives the number in the outside ring. The intervening rows give the number in the intervening rings.

TABLE.

Number of Corpuscles in Order.

1	2	3	4	5

5	6	7	8	8	8	9	10	10	10	11
1	1	1	1	2	3	3	3	4	5	5

11	11	11	12	12	12	13	13	13	13	13	14	14	15	15
5	6	7	7	8	8	8	8	9	10	10	10	10	10	11
1	1	1	1	1	2	3	3	3	3	4	4	5	5	5

15	15	15	16	16	16	16	16	16	16	17	17	17	17	17	17	17
11	11	11	11	12	12	12	13	13	13	13	13	13	14	14	15	15
5	6	7	7	7	8	8	8	8	9	9	10	10	10	10	10	11
1	1	1	1	1	1	2	2	3	3	3	3	4	4	5	5	5

17	18	18	18	18	18	19	19	19	19	20	20	20	20	20	20	20	20	20	21	21
15	15	15	15	16	16	16	16	16	16	16	16	16	17	17	17	17	17	17	17	17
11	11	11	11	11	12	12	12	12	13	13	13	13	13	13	13	14	14	15	15	15
5	5	6	7	7	7	7	8	8	8	8	8	9	9	10	10	10	10	10	10	11
1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	4	4	5	5	5	5

21	21	21	21	21	21	21	21	22	22	22	22	22	22	22	22	23	23	23	23	23	23	23	24
17	18	18	18	18	18	19	19	19	19	19	20	20	20	20	20	20	20	20	20	20	21	21	21
15	15	15	15	16	16	16	16	16	16	16	16	16	16	17	17	17	17	17	17	17	17	17	17
11	11	11	11	11	12	12	12	12	12	13	13	13	13	13	13	13	13	14	14	15	15	15	15
5	5	6	7	7	7	7	8	8	8	8	8	8	9	9	10	10	10	10	10	10	10	11	11
1	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	4	4	5	5	5	5	5

24	24	24	24	24	24	24
21	21	21	21	21	21	21
17	18	18	18	18	18	19
15	15	15	15	16	16	16
11	11	11	11	11	12	12
5	5	6	7	7	7	7
1	1	1	1	1	1	1

The object of the present paper is to describe an extension of the Mayer experiment in which the magnets or needles are rotated. In order to understand how the experiment illustrates the structure of an atom it will be well to point out some of the properties of atoms. All atoms have mass and all the atoms of the same element have the same mass. We find that the elements have different atomic weights. Hydrogen has the atomic weight, one; and uranium, the heaviest, has the atomic weight, 238. Thus the mass of the uranium atom is 238 times that of the hydrogen atom.

The atoms of certain elements have the ability to unite with certain other elements to form compounds. Certain elements form the bases and certain others the acid radicals of the compounds. Or certain are said to be electropositive and others are said to be electronegative. If we examine the elements, starting with the lightest, hydrogen, and taking them one by one in order of their atomic weight or mass, we find that this property of combining varies periodically. In this manner we can form the periodic table.

All elements have a definite spectrum. That is, they give off light of a certain wave length. Light is a vibratory motion of the ether. The wave length or frequency depends upon the source. Thus the atoms or something in the atoms must vibrate with certain frequencies. The same as in music, when one hears the note middle C one knows that there is a string, reed, or something vibrating so as to make 261 vibrations per second. In the same manner when one sees the D line of sodium one knows that there must be something in the sodium atom which makes $5. X 10^{11}$ vibrations per second.

The X-rays are known to be due to a wave disturbance whose wave length is one thousandth that of sodium light. Thus when a swiftly moving electron or cathode ray strikes an atom of platinum there must be a disturbance set up in the atom whose frequency of vibration is one thousand times that which produces the disturbance which we call light.

Besides the radiations or wave disturbances of the ether which are set up by the atom, there are the corpuscular radiations which are given off by the atom, such as in the photo-electric effect, ionization by hot objects and flames, and the cathode rays, in all of which electrons are shot off from the atom.

A theory of atomic structure must account for all of these phenomena. Several theories and modifications have been suggested, all of which involve electrons rotating about or in a central body or region of force which has been called the positive nucleus.

The Mayer experiment with the extension which I propose can be used as an analogy or as an illustration of what happens in an atom. The various phenomena of wave motion and corpuscular radiations can be explained by assuming them to be due to certain motions and disturbances which are seen in the experiment. The experiment lends itself to any or all of the theories as the fundamental assumptions may be changed to fit the particular theory in question.

The classical method of performing the experiment is by floating magnetized needles by means of corks in water. I have found that small bicycle balls floated on mercury are much more convenient. (Professor Merritt used this method at Cornell University in 1900.) The mercury surface lends itself admirably for projection with reflected light. In projection it is well to focus not on the balls but on a plane a short distance above the balls or on the focal point of the concave mirror made by the depression caused by the balls. The position of the ball is then shown on the screen as a point of light. Fig. 5a is a photograph of three balls; the time of exposure is one-fifth of a second. Fig. 5b is a photograph of some thirty balls; the time of exposure is one-hundredth of a second. In this the balls are shown as points so fine that one can scarcely see them in the photograph.

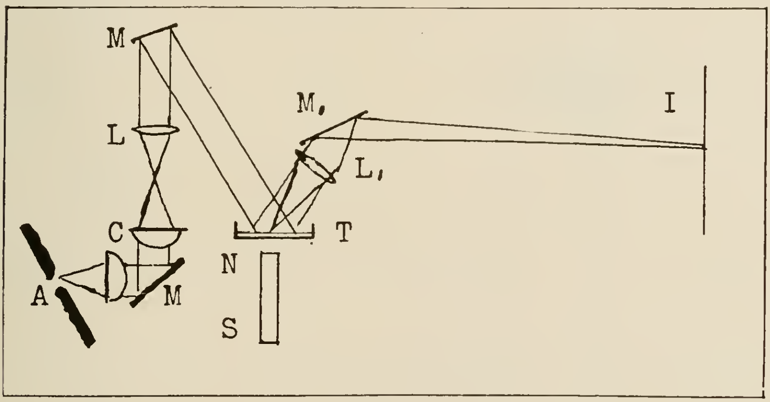


Fig. 2.

Fig. 2 shows diagrammatically the arrangement of the apparatus for projection. A, C, and L are the arc, the condensing lenses, and the objective lense of a vertical projection lantern. M is a mirror with which the light is thrown down on the mercury in the tray, T. L' is a lense with which an image of the balls floating on T is focused on the screen, I. M' is a mirror. N & S is an electro magnet which serves as the positive nucleus.

In the classical Mayer experiment the balls are fixed. There is no motion. There is nothing to suggest how the atom may radiate. The atom is dead. The motion of the atom must be imagined. It is usual to imagine the needles to rotate about the center with a constant angular velocity. This is contrary to the laws of planetary motion as illustrated in the Solar system.

While working with this experiment the thought came to me to rotate the mercury and thus rotate the balls. A wooden tray was made with an electrode at the center and four electrodes, one at each corner which are connected in multiple. By sending a current in at the center electrode and out at the corners one has an approximately radial current flowing at right angles to the magnetic field of the magnet which plays the part of the positive nucleus in the experiment. This causes the mercury to rotate and carry the balls with it. The apparatus consists of a wooden tray as shown in Fig. 3. The dimensions are 15 x 15 cm.

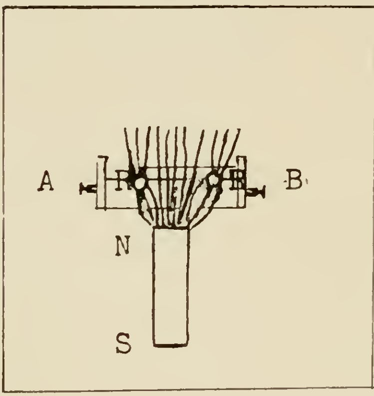


Fig. 4.

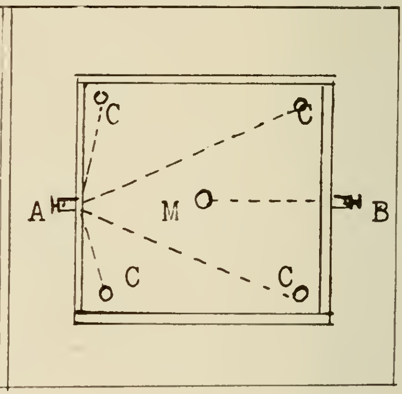


Fig. 3.

and 2 cm. in depth. The electrodes C and M are made of platinum. It has been found later that the electrodes C can be made of iron without appreciably distorting the magnetic field. A and B are binding posts which are connected to the electrodes by wires, shown by dotted lines, which are in grooves on the under side of the box. The apparatus can be centered up by placing one ball on the mercury surface after the current has been turned on through both the magnet and the tray and then shifting the tray until the ball remains practically still at the center of the rotating mercury.

When two balls are placed on the rotating surface they do not rotate about the center on the same circle as one would expect from the Mayer experiment. No. 1 first rotates about No. 2, and then No. 2 rotates about No. 1, their paths resembling rotating elipses. Figs. 5d, 5e, and 5f are photographs showing various phases of the motion. The time of exposure is about one-half a second.

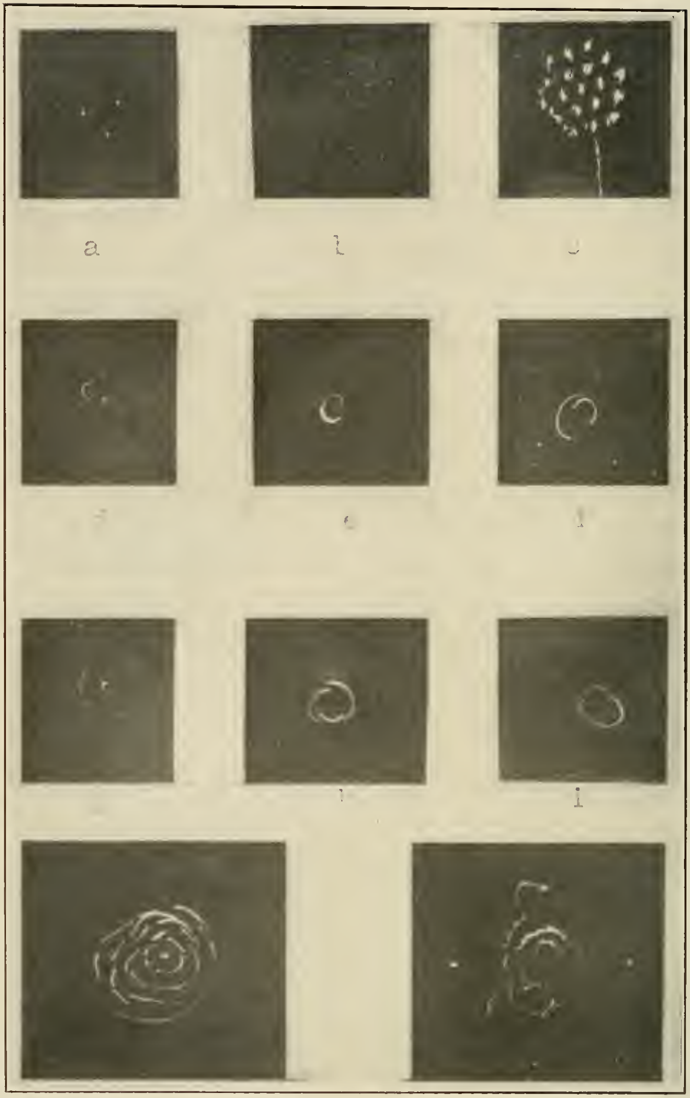
With three balls the motion is more complicated, the three balls taking turns in the center. Figs. 5g, 5h, and 5i give photographs of the motion of three balls. The motion reminds one of a complicated game of leap frog.

With a number of balls the motion becomes very complicated. The mercury at the edges of the tray is stationary while the central portion is rotating. The angular velocity increases as we go from the edge to the center; the balls floating on the surface tend to take up the same angular velocity as the mercury on which they float. Thus there is a tendency for the balls to take up a motion which may approximate to planetary motion. Thus we may assume that they obey Kepler's law. This is shown in Fig. 5j. This photograph also shows two balls exchanging rings.

In the Mayer experiment, balls stationary, when there are a number of rings any one ball is held in its place by the central force and the mutual repulsion of the neighboring balls. The balls of one ring fit into the crotches of the neighboring rings. When the balls are rotating and the angular velocity of the outer ring is less than that of the inner ring there is a slipping of one ring with respect to the one next to it. This slipping produces a perturbation or a vibratory motion which is superimposed on the regular circular motion. This perturbation may be said to be the source of some sort of radiation, light perhaps.

When a ball is allowed to come in from the outside there is a great disturbance of the whole system. This is shown in Fig. 5c, where a ball has been caught coming from the bottom of the photograph into the system. In this case the balls were not rotating. If the balls represent electrons this disturbance may be said to be the source of X-rays as when a cathode ray hits an atom of platinum, say. With a large number of balls the motion is very much more complicated than one would expect. At times a ball will start out from the outer ring and apparently seem to try to escape from the system. Due to the friction of the mercury and the nature of the field the ball always returns. If a ball were to escape it would cause a rearrangement of the others or a disturbance similar to that caused by an added ball. This tendency of the balls to fly off is especially great if the current through the mercury is increased, or if the system is absorbing energy. This may be an illustration of what takes place in the photo-electric effect or in the case of ionization produced by hot bodies.

In the case when a ball flies out when rotating at normal or constant velocity we have an explanation of gamma rays caused by beta rays. Or we may let the balls represent alpha rays, helium atoms, or that



j k

Fig. 5.

which in the atom makes alpha rays or helium atoms after they have escaped, and we have an illustration of a radioactive substance. To illustrate the disintegration of an atom of radium through its several disintegration products I made a tray in which I imbedded a ring of iron so as to make a magnetic field which is strong at the center and diminishes as we go along a radius passing through a minimum and then through a maximum over the ring of iron. Fig. 4 is a cross-section of the tray and central magnet. N, S, is the central magnet. R, R, is a cross-section of the iron ring. A and B are binding posts by which the current is led in and out. The variations of the field is represented by lines of force.

To use this the current is turned on the magnet and a number of balls are placed in the center of the tray, forming the characteristic figure due to the particular number as in the Mayer experiment. The current is then turned through the tray, causing the balls to rotate. When a ball at irregular intervals starts out on a tangent it will be caught and held by the intense field over the iron ring at R. Thus if the ball represents an alpha particle, the escape of beta rays and the gamma radiation may be explained as being due to the disturbance in the atom due to the rearrangement of the electrons in the atom. As many as eight or ten balls may escape from the system, each rearrangement of the system representing one of the products in the radioactive series. Fig. 5k is a photograph of this. The four white spots, one at the top and one at the bottom and one on either side, are balls which have been thrown out and caught and held stationary over the staples which hold the iron ring in place. At the top of the photograph is shown the path of a ball which is being thrown out and caught by the ring.

Getting the conditions right is a matter of trial. Some three or four trays were made before one was satisfactory. The dimensions of this tray are as follows: Length, 10 cm.; breadth, 10 cm.; depth, 2 cm. The iron ring is made of a 2½-millimeter rod bent into a ring of 6 cm. diameter.

No doubt many analogies will occur to the operator which have not been mentioned in this paper. The worst difficulty with the experiment is with the mercury. The mercury must be clean. Any film of dirt or dross on the surface of the mercury prevents the free motion of the balls.

The magnet and tray may be connected in series, but it is more convenient to have two circuits which may be manipulated independently.

Department of Physics, Indiana University.

Some Contributions of Physical Science to Military Efficiency.

C. M. Smith, Purdue University.

The technical and popular press has of late been offering much valuable material which shows the contributions of the physicist and the research laboratory to war problems. Moreover before these Proceedings are printed and circulated it is certain that much more information along the same line will be released. It is not the purpose of this paper to give a complete catalog of the achievements of physical science in the war, nor to set forth in detail the devices which have been developed and applied. It is, however, my purpose to sketch briefly some of the general lines along which the physicist gave aid to the military forces, and to point out some of the valuable results which have followed from the large activities and generous appropriations which were called out by the pressure of war conditions.

It will undoubtedly appear that instances are rare where war-inspired research has resulted in the discovery of any distinctly new principle or law. The lay public, keenly alert for some wonderful invention or discovery, which should overwhelm the opponent as by a great cataclysm, frequently voiced the question why our active scientists were not bringing forward this all-important achievement. But the hoped-for result did not come about. Rather the achievements of physical science in the war consisted in the application of already well-known principles, but with a *refinement* and a *precision* heretofore not realized. The careful consideration from the standpoint of theory of the lines and balance of a shell, of the form of its ends, and of the proper width and thickness of its copper band resulted in the addition of miles to its range and increased the accuracy of gunfire manyfold. Such precision studies, often highly theoretical in nature, growing in numbers to scores or hundreds, all contributed to an increased efficiency of the military forces, and their full value cannot at this time be realized.

Studies similar to the above resulted in our becoming free from European markets in the matter of high-grade optical glass. Precision methods of glassworking, amounting almost to quantity production, were developed, and lenses and prisms large and small, and plane parallel plates were turned out in large numbers with an exactness heretofore hardly thought possible. In photography, in the great development of photographic map making, ray filters were devised for eliminating the effects of haze. By means of these, landscape details were clearly delineated, while without them the plates revealed little more than a bank of clouds.

In the development of suitable instruments for giving the aviator information as to his position, altitude and speed, and for enabling the accurate dropping of bombs upon assigned target areas, the combined skill of many specialists brought results of surprising value. With a dynamo-generator attached to the frame of the airplane, driven by the air stream and with a control so perfect that in spite of the inevitable large variations in speed practically a constant voltage could be maintained for the radio equipment, the aviator was enabled to signal or talk with ground stations, with other aircraft or with his companions in the same machine.

In the science of acoustics many old and well-known principles have been revived, extended and applied in a variety of ways. Of especial value were those applications to sound-ranging, for locating positions, and even determining caliber of enemy guns. Moreover the observer is enabled to distinguish between sounds due to discharge, flight and bursting of the shell. Highly developed listening devices gave invaluable information in locating enemy aircraft, in detecting mining operations, and in submarine detection. The widely used methods of ground telegraphy, invaluable in communication, recall the early experiments long antedating modern radio.

Meteorology has taken its place as essentially a new department of physical science, and a careful study of the earth's atmosphere has led to results of the highest importance in determining wind conditions before and after gas attacks, in correcting data for artillery fire, in revealing favorable conditions for the aviator, in foreseeing conditions which will aid or hinder transport service and in predicting fog and rain.

In the field of electricity the vacuum tube or electron relay has demonstrated its indispensability for countless uses; telephonic and other communication devices have been perfected to an astonishing degree; the dangers of electrostatic charges on balloon fabrics have been studied and methods of control devised; and the quality of small portable batteries has been much improved and their life increased. In radio communication, already highly developed before the war period, startling results have been realized. Closed coil reception has proved successful in the absence of large antenna installations, and has made possible satisfactory work in uni-directional sending and receiving, in triangulation and in receiving on submerged submarines even at transatlantic distances. Without the vacuum tube much of this important work would have been impossible.

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Finally, however, the student of the scientific achievement of the war period, whether in applications of known laws and perfection and refinement of existing devices, or in pure research, cannot but be impressed by the large body of knowledge and experience which has come as a by-product of the study of war problems. During the war both government and private laboratories left no promising clue untraced, and no suggestion was ignored if it seemed to contain any germ of expectation. Although a large part of this activity did not result in devices or processes directly useful or applicable to war problems, nevertheless out of it all is sure to come a wealth of results of value to our scientific and industrial life. Now that the immediate need for high pressure research is at an end, there should be no decline in the research spirit. Now, more than before, the effort should be made to maintain and advance the effectiveness of all existing organizations and agencies which encourage and promote diligent research in physics.

One outgrowth of the intense activity in physical research has been a growing interest in physical science and its applications. Our students have been keener and more alert and the instructor has before him a wealth of illustrations with which to enrich his classroom and laboratory work. Also in the popular press, setting aside the purely sensational, there has been given to the reading public much stimulating material, and the people at large have been brought to a wider appreciation of scientific laws and facts.

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Proceedings of the

Indiana Academy of Science

1919

PROCEEDINGS

OF THE

Indiana Academy of Science

1919

F. PAYNE, Editor.
Bloomington, Ind.

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CONSTITUTION.

ARTICLE I.

SECTION 1. This association shall be called the Indiana Academy of Science.

SEC. 2. The object of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; 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 investigation and discussion as may further the aims and objects of the Academy as set forth in these articles.

WHEREAS, The State has undertaken the publication of such proceedings the Academy will, upon request of the Governor, or one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

SECTION 1. Members of this Academy shall be honorary fellows, fellows, non-resident members, and active members.

SEC. 2. Any person engaged in any department of scientific work, or in any original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Application for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

Sec. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men, and who have been members of the Academy at least one year, may be recommended for nomination for election as follows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

Section 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a President, Vice-President, Secretary, Assistant Secretary, Press Secretary, Editor, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-Presidents of the Academy, shall constitute an Executive Committee. The President shall, at each annual meeting, appoint two members to be a committee which shall prepare the programs and have charge of the arrangements for all meetings for one year.

Sec. 2. The annual meeting of the Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the Executive Committee. Other meetings may be called at the discretion of the Executive Committee, shall constitute the council of the Academy, and represent it in the transaction of any necessary business not especially provided for in this constitution, in the interim between general meetings.

Sec. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing. No question of amendment shal be decided on the day of its presentation.

BY-LAWS.

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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 mem-

bers 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 President shall deliver a public address on the morning of one of the days of the meeting at the expiration of his term of office.

3. The Press Secretary shall attend to the securing of proper newspaper reports of the meetings and assist the Secretary.

4. No special 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 arrearage by the Treasurer, shall have their names stricken from the roll.

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

8. An Editor shall be elected from year to year. His duties shall be to edit the annual Proceedings. No allowance shall be made to the Editor for clerical assistance on account of any one edition of the Proceedings in excess of fifty ($50) dollars, except by special action of the Executive Committee. (Amendment passed December 8, 1917.)

AN ACT TO PROVIDE FOR THE PUBLICATION OF THE REPORTS AND PAPERS OF THE INDIANA ACADEMY OF SCIENCE.*

(Approved March 11, 1895.)

Whereas, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory board, assist in the direction and execution of any investigation within its province without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State; and,

Whereas, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form; and,

Whereas, The Constitution of the State makes it the duty of the

*Failure of Legislature at its 1919 session to appropriate anything for publication of the Proceedings for 1919 and 1920.

General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement; therefore,

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

SEC. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such service, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less than 1,500 nor more than 3,000 copies of each of said reports shall be published, the size of the edition within said limits to be determined by the concurrent action of the editors and the Commissioners of Public Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage.

PUBLIC OFFENSES—HUNTING WILD BIRDS—PENALTY.

(Approved March 15, 1913.)

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That section six (6) of the above entitled act be amended to read as follows: Section 6. That section six hundred two (602) of the above entitled act be amended to read as follows: Section 602. It shall be unlawful for any person to kill, trap or possess any wild bird, or to purchase or offer the same for sale, or to destroy the nest or eggs of any wild bird, except as otherwise provided in this section. But this section shall not apply to the following named game birds: The Anatidae, commonly called swans, geese, brant, river and sea duck; the Rallidae, commonly known as rails, coots, mud-hens and gallinules; the Limicolae, commonly known as shore birds, plovers, surf birds, snipe, woodcock, sandpipers, tattlers and curlews; the Gallinae, commonly called wild turkeys, grouse, prairie chickens, quails, and pheasants; nor to English or European house sparrows, blackbirds, crows, hawks or other birds of prey. Nor shall this section apply to any person taking birds or their nests or eggs for scientific purposes under permit as provided in the next section. Any person violating the provisions of this section shall, on conviction, be fined not less than ten dollars ($10.00) nor more than fifty dollars ($50.00).

INDIANA ACADEMY OF SCIENCE.

OFFICERS, 1920

President,
H. L. BRUNER.

Vice-President,
W. A. MCBETH.

Secretary,
HOWARD E. ENDERS.

Assistant Secretary,
R. M. HOLMAN.

Press Secretary,
FRANK B. WADE.

Treasurer,
WILLIAM M. BLANCHARD.

Editor,
F. PAYNE.

Executive Committee:

BIGNEY, A. J.,
BLANCHARD, W. M., ..
BLATCHLEY, W. S.,
BRANNER, J. C.,
BRUNER, H. L.,
BURRAGE, SEVERANCE,
BUTLER, AMOS W.,
COGSHALL, W. A.,
COULTER, JOHN M.,
COULTER, STANLEY,
CULBERTSON, GLENN,
DRYER, CHAS. R.,
EIGENMANN, C. H.,
ENDERS, HOWARD E.,
EVANS, P. N.,
FOLEY, A. L.,
HAY, O. P.,
HESSLER, ROBERT,
HOLMAN R. M.,
JORDAN, D. S.,
MCBETH, W. A.,
MEES, CARL L.,
MOENKHAUS, W. J.,
MOTTIER, DAVID M.,
MENDENHALL, T. C.,
NAYLOR, JOSEPH P.,
NOYES, W. A.
PAYNE, F.,
WADE, F. B.,
WALDO, C. A.,
WILEY, H. W.,
WILLIAMSON, E. B.,
WRIGHT, JOHN S.,

Curators:

Botany ....J. C. Arthur.
Entomology ....W. S. Blatchley.
Herpetology }
Mammalogy } ....A. W. Butler.
Ornithology }
Ichthyology ....C. H. Eigenmann.

COMMITTEES ACADEMY OF SCIENCE, 1920.

Program.

R. C. Friesner, Butler College, Indianapolis.

Stanley Coulter, Lafayette.

E. R. Cummings, Bloomington.

F. B. Wynn, Indianapolis.

Nominations.

E. B. Williamson, Bluffton.

W. J. Moenkhaus, Bloomington.

J. P. Naylor, Greencastle.

State Library.

Amos Butler, State House, Indianapolis.

W. S. Blatchley, Indianapolis.

A. L. Foley, Bloomington.

Biological Survey.

H. S. Jackson, Agr. Exp. Sta., West Lafayette.

Richard Lieber, Dept. of Conserv., Indianapolis.

R. M. Holman, Crawfordsville.

Will Scott, Bloomington.

Distribution of Proceedings.

Howard E. Enders, West Lafayette.

W. M. Blanchard, Greencastle.

E. R. Cummings, *Bloomington.*

A. Richards, Crawfordsville.

Membership.

F. M. Andrews, Bloomington.

C. A. Behrens, West Lafayette.

A. D. Thorburn, Indianapolis. Care Pittman-Moore Co.

Auditing.

E. B. Williamson, Bluffton.

Rollo R. Ramsey, Bloomington.

Relation of the Academy to the State.

R. W. McBride, 1239 State Life Bldg., Indianapolis.

Glenn Culberson, Hanover.

John S. Wright, Indianapolis, Care Eli Lilly Co.

Amos W. Butler, State House, Indianapolis.

W. W. Woolen, Indianapolis.

D. A. Rothrock, Bloomington.

Publication of Proceedings.

F. Payne, Bloomington.

Geo. N. Hoffer, West Lafayette.

J. A. Badertscher, Bloomington.

D. M. Mottier, Bloomington.

Advisory Council.

John S. Wright.

R. W. McBride.

Glenn Culbertson.

Stanley Coulter.

Wilbur Cogshall.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

Years	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885–1886	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886–1887	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887–1888	J. P. D. John*	Amos W. Butler			O. P. Jenkins.
1888–1889	John C. Branner	Amos W. Butler			O. P. Jenkins,
1889–1890	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890–1891	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891–1892	J. L. Campbell*	Amos W. Butler			C. A. Waldo.
1892–1893	J. C. Arthur	Amos W. Butler	Stanley Coulter W. W. Norman		C. A. Waldo.
1893–1894	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894–1895	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895–1896	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896–1897	Thomas Gray*	John S. Wright	A. J. Bigney		W. P. Shannon.
1897–1898	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.*
1898–1899	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899–1900	D. W. Dennis*	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900–1901	M. B. Thomas*	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901–1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine*	Geo. W. Benton	J. T. Scovell.
1902–1903	W. S. Batchley	John S. Wright	Donaldson Bodine*	G. A. Abbott	W. A. McBeth.
1903–1904	C. L. Mees	John S. Wright	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1904–1905	John S. Wright	Lynn B. McMullen	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1905–1906	Robert Hessler	Lynn B. McMullen	J. H. Ransom	Charles R. Clark.	W. A. McBeth.
1906–1907	D. M. Mottier	Lynn B. McMullen	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1907–1908	Glenn Culbertson	J. H. Ransom	A. J. Bigney	G. A. Abbott	W. A. McBeth.
1908–1909	A. L. Foley	J. H. Ransom	A. J. Bigney	G. A. Abbott	W. A. McBeth.
1909–1910	P. N. Evans	Geo. W. Benton	A. J. Bigney	John W. Woodhams	W. J. Moenkjhaus.
1910–1911	C. R. Dryer	A. J. Bigney	E. B. Williamson	Milo H. Stuart	W. J. Moenkhaus.
1911–1912	J. P. Naylor	A. J. Bigney	E. B. Williamson	Milo H. Stuart	W. J. Moenkhaus.
1912–1913	Donaldson Bondine*	A. J. Bigney	C. M. Smith	F. B. Wade	W. J. Moenkhaus.
1913–1914	Severance Burrage	A. J. Bigney	Howard E. Enders	F. B. Wade	W. A. Cogshall.
1914–1915	Wilbur A. Cogshall	A. J. Bigney	Howard E. Enders	F. B. Wade	Wm. M. Blanchard.
1915–1916	A. J. Bigney	Howard E. Enders	E. B. Williamson	F. B. Wade	Wm. M. Blanchard.
1916–1917	W. J. Moenkhaus	Howard E. Enders	P. A. Tetrault	F. B. Wade	Wm. M. Blanchard.
1917–1918	E. B. Williamson	Howard E. Enders	P. A. Tetrault	F. B. Wade	Wm. M. Blanchard.
†1918–1919	E. B. Williamson	Howard E. Enders	P. A. Tetrault	F. B. Wade	Wm. M. Blanchard.
1919–1920	H. L. Bruner	Howard E. Enders	R. M. Holman	F. B. Wade	Wm. M. Blanchard.

* Deceased †Officers continued—Annual meeting not held because of influenza epidemic.

MEMBERS.*

FELLOWS.

Andrews, F. M., 901 E. 10th St., Bloomington....................†1911
Associate Professor of Botany, Indiana University.
Plant Physiology, Botany.

Arthur, Joseph C., 915 Columbia St., Lafayette..................1893
Professor Emeritus of Botany, Purdue University.
Botany.

Badertscher, J. A., 312 S. Fess Ave., Bloomington...................1917
Associate Professor of Anatomy, Indiana University.
Anatomy.

Beede, Joshua W., 404 W. 38th St., Austin, Texas...................1906
Bureau of Economic Geology and Technology, University of Texas.
Geology.

Behrens, Charles A., 217 Lutz Ave., West Lafayette.................1917
Professor of Bacteriology, Purdue University.
Bacteriology.

Bennett, Lee F., 309 S. 9th Street, Janesville, Wis...................1916
With the H. W. Gossard Company.
Geology, Zoology.

Bigney, Andrew J., Evansville....................................1897
Professor of Physiology, Evansville College.

Blanchard, William M., 1008 S. College Ave., Greencastle, Ind.......1914
Professor of Chemistry, DePauw University, Greencastle, Ind.
Organic Chemistry.

Blatchley, W. S., 1558 Park Ave., Indianapolis.......................1893
Naturalist.
Botany, Entomology, and Geology.

Breeze, Fred J., Muncie...1910
Branch State Normal School.
Geography.

Bruner, Henry Lane, 324 S. Ritter Ave., Indianapolis................1899
Professor of Biology, Butler College.
Comparative Anatomy, Zoology.

*Every effort has been made to obtain the correct address and occupation of each member, and to learn in what line of science he is interested. The first line contains the name and address; the second line the occupation; the third line the branch of science in which he is interested. The omission of an address indicates that mail addressed to the last printed address was returned as uncalled for. Information as to the present address of members so indicated is requested by the secretary. The custom of dividing the list of members has been followed.

†Date of election.

Bryan, William Lowe, Bloomington....................................1914
President Indiana University.
Psychology.

Butler, Amos W., 52 Downey Ave., Irvington, Indianapolis............1893
Secretary, Indiana Board of State Charities.
Vertebrate Zoology, Anthropology, Sociology.

Cogshall, Wilbur A., 423 S. Fess Ave., Bloomington..................1906
Associate Professor of Astronomy, Indiana University.
Astronomy.

Coulter, Stanley, 213 S. Ninth St., Lafayette.......................1893
Dean School of Science, Purdue University.
Botany, Forestry.

Cox, Ulysses O., P. O. Box 81, Terre Haute..........................1908
Head Department Zoology and Botany, Indiana State Normal.
Botany, Zoology.

Culbertson, Glenn, Hanover..1899
Chair Geology, Physics and Astronomy, Hanover College.
Geology.

Cumings, Edgar Roscoe, 327 E. Second St., Bloomington...............1906
Professor of Geology, Indiana University.
Geology, Paleontology.

Deam, Charles C., Bluffton..1910
Druggist, Botanist, State Forester.
Botany.

Dryer, Charles R., Oak Knoll, Fort Wayne............................1897
Geography.

Dutcher, J. B., 1212 Atwater St., Bloomington.......................1914
Associate Professor of Physics, Indiana University.
Physics.

Eigenmann, Carl H., 630 Atwater St., Bloomington....................1893
Professor of Zoology, Dean of Graduate School, Indiana University.
Embryology, Degeneration, Heredity, Evolution and Distribution of American Fish.

Enders, Howard Edwin, 249 Littleton St., West Lafayette.............1912
Professor of Zoology, Purdue University.
Zoology.

Evans, Percy Norton, 302 Waldron St., West Lafayette................1901
Director of Chemical Laboratory, Purdue University.
Chemistry.

Fisher, Martin L., 325 Vine St., West Lafayette.....................1919
Prof. Crop Production, Purdue University.
Agriculture, Ornithology.

Foley, Arthur L., Bloomington....................................1897
Head of Department of Physics, Indiana University.
Physics.

Hessler, Robert, Logansport......................................1899
Physician.
Biology.

Hufford, Mason E., Bloomington....................................1916
Assistant Professor of Physics, Indiana University.
Physics.

Hurty, J. N., 31 E. 11th Street, Indianapolis....................1910
Secretary, Indiana State Board of Health.
Hygiene and Chemistry.

Hyde, Roscoe Raymond, 4101 Penhurst Ave., Baltimore, Md..........1909
Assistant Professor Physiology and Zoology, Indiana State Normal.
Zoology, Physiology, Bacteriology.

Jackson, Herbert S., West Lafayette..............................1919
Chief of Botany, Agr. Expr. Station, Purdue.
Plant Pathology.

Kenyon, Alfred Monroe, 515 University St., West Lafayette.........1914
Professor of Mathematics, Purdue University.
Mathematics.

Koch, Edward W., Buffalo, N. Y...................................1917
Care of University of Buffalo Medical School.
Pharmacology.

Logan, Wm., N., 924 Atwater St., Bloomington.....................1917
Professor of Economic Geology, Indiana University.
State Geologist.

McBeth, Wm. A., 1905 N. 8th St., Terre Haute.....................1904
Professor of Geography, State Normal School.

McBride, Robert W., 1239 State Life Building, Indianapolis........1916
Lawyer.

Markle, M. S., Richmond..1919
Professor of Botany, Earlham College.

Middleton, A. R., 705 Russell St., West Lafayette.................1918
Professor of Chemistry, Purdue University.
Chemistry.

Morrison, Edwin, East Lansing, Michigan...........................1915
Assoc. Professor of Physics, Mich. Agr. College.
Physics and Chemistry.

Mottier, David M., 215 Forest Place, Bloomington..................1893
Professor of Botany, Indiana University.
Morphology, Cytology.

Naylor, J. P., Greencastle....................................1903
Professor of Physics, DePauw University.
Physics, Mathematics.

Nieuwland, J. A..1914
Notre Dame University.
Botany and Organic Chemistry.

Payne, F., 620 S. Fess St., Bloomington...............................1916
Professor of Zoology, Indiana University.
Cytology and Genetics.

Ramsey, Rolla R., 615 E. Third St., Bloomington....................1906
Professor of Physics, Indiana University.
Physics.

Rettger, Louis J., 31 Gilbert Ave., Terre Haute.....................1896
Professor of Physiology, Indiana State Normal.
Animal Physiology.

Rothrock, David A., 1000 Atwater St., Bloomington.................1906
Professor of Mathematics, Indiana University.
Mathematics.

Schockel, Barnard, Terre Haute....................................
Professor of Physical Geography.
State Normal School.

Scott, Will, Bloomington..1914
Associate Professor of Zoology, Indiana University.
Zoology, Lake Problems.

Shannon, Charles W., 518 Lahoma Ave., Norman, Okla................1912
With Oklahoma State Geological Survey.
Geology.

Smith, Albert, 500 University St., West Lafayette (Army Service).....1908
Professor of Structural Engineering.
Physics, Mechanics.

Smith, Charles Marquis, 152 Sheetz St., West Lafayette.............1912
Professor of Physics, Purdue University.
Physics.

Stoltz, Charles, 530 N. Lafayette St., South Bend....................1919
Physician.
Medicine.

Stone, Winthrop E., Lafayette....................................1893
President of Purdue University.
Chemistry, Administration.

Van Hook, James M., 639 N. College Ave., Bloomington..............1911
Assistant Professor of Botany, Indiana University.
Botany.

Wade, Frank Bertram, 1039 W. Twenty-seventh St., Indianapolis......1914
Head of Chemistry Department, Shortridge High School.
Chemistry, Physics, Geology, and Mineralogy.

Williamson, E. B., Bluffton......................................1914
President, The Wells County Bank.
Dragonflies.

Woollen, William Watson, Indianapolis............................1908
Lawyer.
Birds and Nature Study.

Wright, John S., 3718 N. Pennsylvania St., Indianapolis...............1894
Manager of Advertising Department, Eli Lilly Co.
Economic Botany.

NON-RESIDENT MEMBERS AND FELLOWS.

Abbott, G. A., Grand Forks, N. Dak., Fellow..........................1908
Professor of Chemistry, University of North Dakota.
Chemistry.

Aldrich, John Merton, Washington, D. C., Fellow....................1918
Custodian of Diptera, U. S. National Museum.
Dipterologist.

Aley, Robert J., Orono, Me., Fellow.................................1898
President of University of Maine.
Mathematics and General Science.

Branner, John Casper, Stanford, California.
President Emeritus of Stanford University.
Geology.

Brannon, Melvin A., President Beloit College, Beloit, Wis.
Plant Breeding, Botany.

Burrage, Severance, Denver, Colo., Fellow..........................1898
Professor of Bacteriology, University of Denver.
Public Health Work.

Campbell, D. H., Stanford University, California.
Professor of Botany, Stanford University.
Botany.

Clark, Howard Walton, U. S. Biological Station, Fairport, Iowa.......
Scientific Assistant U. S. Bureau of Fisheries.
Botany, Zoology.

Cook, Mel T., New Brunswick, N. J., Fellow..........................1902
Plant Pathologist, New Jersey Experiment Station.
Botany, Plant Pathology, Entomology.

Coulter, John M., University of Chicago, Chicago, Ill., Fellow........1893
Head Department of Botany, Chicago University.
Botany.

Davis, B. M., Oxford, Ohio.
Professor of Agricultural Education.
Miami University.

Evermann, Barton Warren, Director Museum,
California Academy of Science, Golden Gate Park, San Francisco. Cal.
Zoology.

Goss, William Freeman M., 61 Broadway, New York, Fellow............1893
President The Railway Car Manufacturers' Association.

Greene, Charles Wilson, 814 Virginia Ave., Columbia, Mo.
Professor of Physiology and Pharmacology, University of Missouri.
Physiology, Zoology.

Hargitt, Chas. W., 909 Walnut Ave., Syracuse, N. Y.
Professor of Zoology and Director of the Laboratories, Syracuse University.
Hygiene, Embryology, Eugenics, Animal Behavior.

Hay, Oliver Perry, U. S. National Museum, Washington, D. C.
Research Associate, Carnegie Institute of Washington.
Vertebrate Paleontology, especially that of the Pleistocene Epoch.

Huston, H. A., 42 Broadway, New York City, Fellow..................1893
Manager soil and crops service syndicate.

Jordan, David Starr, Stanford University, California.
Chancellor Emeritus of Stanford University.
Fish, Eugenics, Botany, Evolution.

Kingsley, J. S., University of Illinois, Urbana, Ill.
Professor of Zoology.
Zoology.

Knipp, Charles T., 915 W. Nevada St., Urbana, Ill.
Professor of Experimental Physics, University of Illinois.
Physics, Discharge of Electricity Through Gases.

McDougal, Daniel Trembly, Tuscon, Ariz.
Director, Department of Botanical Research, Carnegie Institute, Washington, D. C.

Marsters, V. F., Kansas City, Mo., care of C. N. Gould, Fellow........1893
Geologist.
Botany.

McMullen, Lynn Banks, State Normal School, Valley City, N. D.,
Head Science Department and Vice-President State Normal School.
Physics, Chemistry.

Miller, John Anthony, Swarthmore, Pa., Fellow.......................1904
Professor of Mathematics and Astronomy, Swarthmore College.
Astronomy, Mathematics.

Moore, George T., St. Louis, Mo.
Director Missouri Botanical Garden.
Botany.

Noyes, William Albert, Urbana, Ill., Fellow........................1893
Director of Chemical Laboratory, University of Illinois.
Chemistry.

Ransom, James H., Detroit, Mich., Fellow........................1902
Chemistry.

Reagan, A. B.
Superintendent Indian School, Kayenta, Arizona.
Geology, Paleontology, Ethnology.

Smith, Alexander, care Columbia University, New York, Fellow........1893
Head of Department of Chemistry, Columbia University.
Chemistry.

Springer, Alfred, 312 E. Second St., Cincinnati, O.
Chemist.
Chemistry.

Swain, Joseph, Swarthmore, Pa., Fellow............................1898
President of Swarthmore College.
Science of Administration.

Waldo, Clarence A., 401 W. 18th St., New York City..................1893
Mathematics, Mechanics, Geology and Mineralogy.

Wiley, Harvey W., Cosmos Club, Washington, D. C., Fellow............1895
Professor of Agricultural Chemistry, George Washington University.
Biological and Agricultural Chemistry.

Zeleny, Chas., 1003 W. Illinois St., Urbana, Ill.
Professor of Experimental Zoology.
Zoology.

ACTIVE MEMBERS.

Acre, Harlan Q., Gorden, Nebr.
Botany.

Adams, Wm. B., 431 S. College Ave., Bloomington.
Assistant in Botany, Indiana University.

Allen, William Ray, 709 Atwater Ave., Bloomington.
Zoology, Indiana University.

Allison, Luna E., 435 Wood St., Lafayette.
Care Agricultural Experiment Station.
Botany.

Anderegg, Frederick O., 322 Waldron St., West Lafayette.
Assistant Professor of Chemistry, Purdue University.

Anderson, Flora Charlotte, Route 5, Crawfordsville.
Botany.

Atkinson, F. C., 2534 Broadway, Indianapolis.
Chemistry. American Hominy Company.

Baldwin, Ira L., 601 University St., West Lafayette.
Instructor in Bacteriology, Purdue University.

Baker, William Franklin, Indianapolis, care St. Vincent's Hospital.
Medicine, Roentgenology, Pathology.

Barnhill, Dr. T. F., Indianapolis.
Professor of Surgery, Indiana University School of Medicine.

Barr, Harry L., Stockland, Ill.
Botany and Physics.

Bates, W. H., 403 Russell St., West Lafayette.
Associate Professor of Mathematics, Purdue University.
Mathematics.

Beals, Colonzo C., 103 Russell St., Hammond.
Botany.

Begeman, Hilda, Sanborn.
Physics.

Begeman, Lulu, Sanborn.
Mathematics Teacher, Sanborn High School.

Berteling, John B., 228 W. Colfax Ave., South Bend.
Medicine.

Bishop, Harry Eldridge, 3344 Michigan Ave., Chicago.
Glass Container Association of Chicago.

Bliss, G. S., Fort Wayne.
State School for Feeble Minded.

Bond, Charles S., 112 N. Tenth St., Richmond.
Physician.
Biology, Bacteriology, Physical Diagnosis and Photomicrography.

Bond, Dr. George S., Indianapolis.
Professor of Medicine, Indiana University School of Medicine.

Bonns, Walter W., Indianapolis, care of Eli Lilly & Co.
Plant Physiology.
Director of Botanical Department.

Bourke, A. Adolphus, 2304 Liberty Ave., Terre Haute.
Instructor, Physics, Zoology, and Geography.
Botany, Physics.

Brossman, Charles, 1503 Merchants Bank Bldg., Indianapolis.
Consulting Engineer.
Water Supply, Sewage Disposal, Sanitary Engineering.

Bruce, Edwin M., 2108 N. Tenth St., Terre Haute.
Professor of Chemistry, Indiana State Normal.
Chemistry.

Bybee, Halbert P., University Station, Austin, Texas.
Adjunct Professor of Geology, University of Texas.

Byers, Cecil W., 408 Russell St., West Lafayette.
Assistant in Physics, Purdue University.

Campbell, Elmer G., 220 Sylvia St., West Lafayette.
Assistant Prof. Agricultural Botany, Purdue University.

Canis, Edward N., Route A-2, Box 372-A, Indianapolis.
Nature Study.

Caparo, Jose Angel, Notre Dame.
Professor of Physics and Mathematics, Notre Dame University.
Mathematics, Physics and Electrical Engineering.

Carr, Ralph Howard, 27 N. Salisbury St., West Lafayette.
Professor of Agricultural Chemistry, Purdue.

Carter, Edgar B., 2615 Ashland St., Indianapolis.
Director of Scientific Work, Swan-Myers Company.
Chemistry and Bacteriology.

Chansler, Elias J., Bicknell.
Farmer.
Ornithology and Mammals.

Chapman, Edgar K., 506 S. Grant St., Crawfordsville.
Professor of Physics, Wabash College.

Christy, O. B., State Normal School, Muncie.
Botany and Agriculture.

Clark, Jediah H., 126 E. Fourth St., Connersville.
Physician.
Medicine.

Collins, Anna Mary, 2734 58th St., Seattle, Wash.
Zoology.

Conner, S. D., 204 S. Ninth St., Lafayette.
Chemistry, Experiment Station.

Coryell, Noble H., N. Y. City.
Department of Geology, Columbia University.

Crockett, W. P., Shortridge High School, Indianapolis.
Physics Teacher.

Dean, John C., University Club, Indianapolis.
Astronomy.

Denny, Martha L., Manhattan, Kan.
Kansas Agricultural College.
Zoology.

Deppe, C. A., Franklin.
Franklin College.

Dietz, Harry F., State House, Indianapolis.
State Entomologist's Office.
Entomology.

Dolan, Jos. P., Syracuse.
Lake Study.

Douglas, Benjamin W., Trevlac.
Fruit Culture.

Douglas, Mary, Attica.
Zoology.

Downhour, D. Elizabeth, 1655 N. Alabama Street, Indianapolis.
Zoology and Botany, Teachers College.

DuBois, Henry M., 1408 Washington Ave., LaGrande, Ore.
Paleontology and Ecology.

Dukes, Richard G., Corner Seventh and Russell Sts., West Lafayette.
Purdue University.
Engineering.

Earp, Samuel E., 634 Occidental Bldg., Indianapolis.
Physician.
Medicine.

Edmonson, Clarence E., 822 Atwater St., Bloomington.
Dean of men, Indiana University.
Physiology.

Eldred, Frank R., 3325 Kenwood Ave., Indianapolis.
Director, Scientific Dept., Eli Lilly & Co.
Chemistry.

Emerson, Charles P., 602 Hume-Mansur Bldg., Indianapolis.
Dean Indiana University Medical College.
Medicine.

Epple, Wm. F., 311 Sylvia St., West Lafayette.
Assistant in Dairy Chemistry, Experiment Station, Purdue University.

Estabrook, Arthur H., Indianapolis, care Board of State Charities.
Heredity and Eugenics with Board of State Charities.

Evans, Samuel G., 1452 Upper Second St., Evansville.
Merchant.
Botany, Ornithology.

Felver, William P., Bay St., P. O. Box 486, Louis, Miss.
Geology, Chemistry.

Fisher, L. W., Detroit, Michigan, care Parke, Davis & Co.
Zoology.

Foresman, George Kedzie, 110 S. Ninth St., Lafayette.
Instructor in Chemistry, Purdue University.

Friesner, Ray C., 71 Rutter Avenue, Indianapolis.
Charge of Botany, Butler College.

Fuller, Frederic D., 4520 W. 28th St., Bryan, Texas.
Experiment Station.
Chemistry, Nutrition.

Funk, Austin, 404 Spring Street, Jeffersonville.
Physician.
Diseases of Eye, Ear, Nose and Throat.

Galloway, Jesse James, Geology Department, Columbia University, New York City.
Geology, Paleontology.

Gardner, Max W., West Lafayette, Purdue Experiment Station.
Plant Pathology.

Gatch, Willis D., 605 Hume-Mansur Bldg., Indianapolis.
Professory of Surgery, Indiana University Medical School.

Gates, Florence A., 3435 Detroit Ave., Toledo, O.
Teacher of Botany.
Botany and Zoology.

Gidley, William, 236 Littleton St., West Lafayette.
Pharmacy, Purdue University.

Gillum, Robert G., Terre Haute.
Professor of Chemistry, State Normal School.
Chemistry.

Gingery, Walter G., Shortridge High School, Indianapolis.
Mathematics.

Glenn, Earl R., 646 Park Avenue, New York City.
The Lincoln School of Teachers College, Columbia University.
Physics.

Goldsmith, William Morton, Winfield, Kansas.
Professor of Zoology, Southwestern College.
Zoology.

Gray, Harold, 511 Elwood Avenue, Cuyahoga Falls, Ohio.
Chemistry.

Greene, Frank C., 30 N. Yorktown St., Tulsa, Okla.
Geology.

Hadley, Joel W., 1127 Fairfield Avenue, Indianapolis.
Geology.
Teacher Chemistry and Biology.

Hadley, Murray N., 608 Hume-Mansur Bldg., Indianapolis.
Physician.
Surgery.

Hanna, U. S., Atwater Street, Bloomington.
Associate Professor of Mathematics, Indiana University.

Hansford, Hazel Irene, S. Eastern Hospital for Insane, N. Madison.
Psychology.

Happ, William, South Bend.
Botany.

Harding, C. Francis, 503 University St., West Lafayette.
Head of Electrical Engineering, Purdue University.

Harman, Paul M., 311 E. South Ave., Bloomington.
Physiology.

Heimburger, Harry V., St. Paul, Minn.
Instructor in Biology in Hamline University.

Heimlich, Louis Frederick, 495 Littleton St., West Lafayette.
Instructor in Botany, Purdue University.

Hemmer, Edwin John, Somerville.
Botany.

Hendricks, Victor K., 5642 Kingsley Boulevard, St. Louis, Mo.
Assistant Chief Engineer, St. L. & S. F., Mo., Kan. & Texas; Mo., Okla. & Gulf Railroads.
Civil Engineering and Wood Preservation.

Hess, Walter E., S. College Avenue, Greencastle.
Professor of Biology, DePauw University.

Hetherington, John P., 417 Fourth St., Logansport.
Physician.
Medicine, Surgery, X-Ray, Electro-Therapeutics.

Hinman, Jack J., Jr., State University, P. O. Box 313, Iowa City, Iowa.
Assistant Professor of Epidemiology, State University of Iowa,
Water Chemist and Bacteriologist, State Board of Health.

Hitchens, A. Parker, care Eli Lilly & Co., Indianapolis.
Physician and Biologist.

Hoffman, George L., care of Western Pennsylvania Hospital, Pittsburgh, Pa.
Bacteriology, Serology.

Hole, Allen D., 615 National Road West, Richmond.
Professor of Geology, Earlham College.
Geology.

Holman, Richard M., Crawfordsville.
Professor of Botany, Wabash College.

Houseman, H. V., 300 S. Bradford St., Plattsville, Wis.
Chemistry and Physics.

Howlett, Berton A., 503 Elm St., Valparaiso.
Associate Professor of Physics, Valparaiso University.

Huber, Leonard L., Hanover.
Hanover College.
Chemistry and Biology.

Hull, Julia, St. Anne, Ill.
Zoology.

Hutchinson, Emory, Norman Station, Ind.
Zoology.

Hutton, Joseph Gladden, Brookings, S. Dak.
Associate Professor of Agronomy, State College.
Agronomy and Earth Science.

Hyslop, George, 200 Chatterton Parkway, White Plains, N. Y.
Cornell Medical School.

Irving, Thos. P., Notre Dame.
Physics.

Jackson, James W., Central High School, Chattanooga, Tenn.
Chemistry Teacher.

Jackson, Thomas F., 8 N. Yorktown, Tulsa, Okla.
Geology.

Jacobson, Moses A., 800 Fourth St., Portsmouth, Virginia.
Bacteriology.

James, Evalyn G., 144 Butler Avenue, Indianapolis.
Botany.

Jopling, John C., 119 W. Lake Avenue, Barberton, Ohio.
Chemist.

Jordan, Charles Bernard, West Lafayette.
Director School of Pharmacy, Purdue University.

Kaczmarcek, Regidius M., Box 54, Notre Dame.
Professor of Biology and Bacteriology.
Natural Science.

Knotts, Armenis F., 800 Jackson St., Gary.
Nature Study.

Kohl, Edwin J., University St., West Lafayette.
Instructor in Biology, Purdue University.

Lieber, Colonel Richard, State House, Indianapolis.
Director, State Conservation Commission.
Conservation.

Liston, Jesse G., R. F. D. No. 2, Lewis.
High School Teacher.
Geology.

Ludwig, C. A., R. R. 1, Clemson College, S. C.
Agriculture, Botany.

Ludy, L. V., 600 Russell St., West Lafayette.
Professor Experimental Engineering, Purdue University.
Experimental Engineering in Steam and Gas.

Luten, Daniel B., 1056 Lemcke Annex, Indianapolis.
Bridge Engineer.
Applied Civil Engineering.

Mahin, Edward G., 27 Russell St., West Lafayette.
Professor of Analytical Chemistry, Purdue University.

Mains, E. B., 212 S. Grant St., West Lafayette.
U. S. Agricultural Experiment Station.
Plant Pathology and Mycology.

Mallon, Marguerite, 221 Waldron Street, West Lafayette.
Instructor in Food Chemistry, Purdue University.

Malott, Burton J., Indianapolis, Care Tech. High School.
Teacher in Physiography and Geology.

Malott, Clyde A., 521 E. Second St., Bloomington.
Assistant Professor of Geology, Indiana University.
Geology.

Mason, Thomas E., 130 Andrew Place, West Lafayette.
Assistant Professor of Mathematics, Purdue University.

McCarty, Morris E.

Miller, J. Ford, 946 N. Meridian St., Indianapolis.
Student in Zoology and Embryology.

Miller, John W., 444 Littleton St., West Lafayette.
Instructor in Plant Physiology and Botany, Purdue University.

Montgomery, Dr. H. T., 244 Jefferson Bldg., South Bend.
Geology.

Morrison, Harold, Bureau of Entomology, Washington, D. C.
Entomology.

Morrison, Louis, 80 S. West St., Richmond.

Munro, G. W., 202 Waldron St., West Lafayette.
Mechanical Engineering.

Myers, B. D., 321 N. Washington St., Bloomington.
Professor of Anatomy, Indiana University.

Nelson, Ralph Emory, 232 Littleton St., West Lafayette.
Chemistry, Purdue University.

Newman, G. B., Frysburg, Maine.
Entomology.

Nicholson, Thomas E., 519 N. Fess Avenue, Bloomington.
Instructor in Psychology, Indiana University.

Noyes, Harry A., 27 Cottage Street, Westfield, N. Y.
Research Chemist and Bacteriologist.

Oberholzer, H. C., National Museum, Washington, D. C.
Biology.

O'Neal, Claude E., Delaware, Ohio.
Botany.

Orahood, Harold, Kingman.
Geology.

Orton, Clayton R., State College, Pa.
Professor of Botany, Penna. State College.

Owen, D. A., 200 S. State St., Franklin.
Professor of Biology. (Retired.)
Biology.

Papish, Jacob, Ithaca, N. Y.
Department of Chemistry, Cornell University.
Chemistry.

Peffer, Harvey Creighton, 1022 7th St., West Lafayette.
Head School of Chemical Engineering, Purdue University.

Petry, Edward J., 722 East 8th St., Brookings, South Dakota.
Professor of Botany, South Dakota State College.

Pickett, Fermen L., Pullman College Station No. 36, Washington.
Botany.

Pinkerton, Earl, Box 411, Walters, Okla.
Manager Walters Natural Gas Co.

Prentice, Burr N., 400 Russell St., West Lafayette, Ind.
Assistant Professor of Forestry, Purdue University.

Pressey, S. L., 801 Atwater Ave., Bloomington.
Instructor in Psychology, Indiana University.

Pressey, Mrs. S. L., 801 Atwater Ave., Bloomington.
Student in Psychology, Indiana University.

Price, Walter A., 123 Sheetz St., West Lafayette.
Associate Professor Entomology, Purdue University.

Proulx, Edward G., 111 Waldron St., West Lafayette.
State Chemist, Agricultural Experiment Station.

Richards, Aute, Norman, Oklahoma.
Professor of Zoology, Oklahoma University.

Richards, Mrs Mildred Hoge, Norman, Oklahoma.
Zoology.

Rifenburgh, S. A., Valparaiso, Ind.
Instructor Zoology, Valparaiso University.

Rightsell, Raymond M., Shortridge High School, Indianapolis.
Teacher in Physics.

Riley, Katherine Robert, 50 Whittier Place, Indianapolis.

Roark, Louis, Box 1162, Tulsa, Okla.
Roxana Petroleum Company.
Petroleum Geologist.

Roberts, R. Chester, Hougham Street, Franklin.
Chemistry Teacher.

Sheak, William H., 162 N. 20th St., Philadelphia, Pa.
Mammalogy.

Sherman, George W., 4 Murdock Flats, West Lafayette.
Assistant Professor of Physics, Purdue University.

Shonle, Horace A., Care Eli Lilly & Company, Indianapolis.
Chemist.

Showalter, Ralph W., Indianapolis.
Director Biological Department, Eli Lilly & Co.
Biology.

Silvey, Oscar W., College Station, Texas.
Physics, University of Texas.

Smith, Chas., Piper, 354 S. 10th St., San Jose, California.
Systematic Botany.

Smith, John E., 63 S. Edwards Street, Franklin.
Professor of Physics.

Snodgrass, R. E., 2063 Park Road, Washington, D. C.
U. S. Bureau of Entomology.
Entomology.

Southgate, Helen A., 218 W. 6th St., Michigan City.
Biology.

Spitzer, George, 1000 Seventh St., West Lafayette.
Dairy Chemist, Purdue University.
Chemistry.

Spong, Philip, 3873 E. Washington St., Indianapolis.
Biology Student in Butler College.

Stockdale, Paris, 521 E. 2nd Street, Bloomington.
Assistant in Geology, Indiana University.

Stone, Ralph Bushnell, 307 Russell St., West Lafayette.
Registrar and Assistant Professor of Mathematics, Purdue University.

Sulzer, Elmer G., Madison.
Geology.

Tatlock, Myron W., Shortridge High School, Indianapolis.
Teacher in Physics.

Taylor, Joseph C., 117 Ninth St., Logansport.
Student in University of Wisconsin.

Terry, Oliver P., 215 Sheetz St., West Lafayette.
Professor of Physiology, Purdue University.

Tetrault, Philip Armand, 607 University St., West Lafayette.
Assistant Professor of Biology, Purdue University.

Test, Louis A., 629 Russell Street, West Lafayette.
Professor of General Chemistry, Purdue University.

Tevis, Emma Louise, 122 W. 18th St., Indianapolis.
Department Experimental Medicine, Eli Lilly & Co.

Thompson, Clem O., Hanover.
Professor of Education, Hanover College.

Thompson, David H., Champaign, Illinois.
Department of Experimental Zoology, University of Illinois.
Graduate Student in Zoology.

Thornburn, A. D., 105 High Street, Indianapolis.
Chemist Pitman-Moore Company.

Toole, E. H., Care Botany Dept., University of Wisconsin, Madison, Wis.
Botany, Plant Physiology and Pathology.

Troop, James, West Lafayette.
Professor of Entomology, Purdue University.

Turner, B. B., 1017 Park Ave., Indianapolis.
Associate Professor of Pharmacology, Indiana University School of Medicine.

Turner, William P., 222 Lutz Ave., Lafayette.
Professor of Practical Mechanics, Purdue University.

Van Nuys, W. C., Box No. 34, Newcastle.
Superintendent Indiana Epileptic Village, Fort Wayne.

Visher, Stephen S., 817 E. 2nd Street, Bloomington.
Assistant Professor of Geology, Indiana University.

Voorhees, Herbert S., 804 W. Wildwood Ave., Fort Wayne.
Instructor in Chemistry and Botany, Fort Wayne High School.
Chemistry.

Weatherwax, Paul, LeConte Hall, Athens, Ga.
Associate Professor of Botany, University of Georgia.
Botany.

Weems, M. L., 102 Garfield Ave., Valparaiso.
Professor of Botany.
Botany and Human Physiology.

Wiancko, Alfred T., 230 S. Ninth St., Lafayette.
Chief in Soils and Crops, Purdue University.
Agronomy.

Wildman, E. A., Earlham College, Richmond.
Chemistry.

Wiley, Ralph Benjamin, 777 Russell St., West Lafayette.
Associate Professor of Hydraulic Engineering, Purdue University.

Williams, A. A., Valparaiso.
Professor of Mathematics, Valparaiso University.
Mathematics, Astronomy.

Wilson, Charles E., Agr. Exper. Sta., St. Croix, Virgin Islands, U. S. A.
Zoology and Economic Entomology.

Wilson, Mrs. Mildred N., St. Croix, Virgin Islands, U. S. A.
Plant Physiology.

Wilson, Mrs. Etta L., 2 Clarendon Ave., Detroit, Mich.
Botany and Zoology.

Wilson, Ira T., 521 E. Kirkwood Avenue, Bloomington.
Assistant in Zoology, Indiana University.

Wood, Harry W., Bloomington.
Geography and Geology, Extension Division, Indiana University.

Wynn, Frank B., 421 Hume-Mansur Bldg., Indianapolis.
Professor of Pathology, Indiana University School of Medicine.

Young, Gilbert A., 739 Owen St., Lafayette.
Head of Department of Mechanical Engineering, Purdue University.

Yuncker, Truman G., Wood Street, Greencastle.
Professor of Botany, DePauw University.

Zehring, William Arthur, 303 Russell St., West Lafayette.
Assistant Professor of Mathematics, Purdue University.
Mathematics.

Fellows	58
Members, Active	198
Members and Fellows, Non-resident	34
Total	290

SPRING MEETING.

State Forestry Reserve, Henryville, Indiana,
Thursday, May 22, 1919.

Business Meeting.

At 8:30 P. M. the meeting was called to order by the Vice President, Charles Stoltz, at the Forester's Residence of the State Forestry Reserve. The following named persons were present: Charles Stoltz, John S. Wright, D. M. Mottier, M. S. Markle, Frank B. Wade, H. F. Montgomery, Armanis Knotts, Mason L. Weems, Paul Weatherwax, J. M. Van Hook, Mabel Hansford, F. J. Pipal, Mr. Christie, B. A. Howlett, Walter Gingery, J. Ford Miller, and Howard E. Enders.

On motion, duly passed, the Academy is to make up the deficit incurred by the Ladies' Aid Society of Henryville in the preparation of supper for a larger number of visiting members than appeared.

The following named persons were nominated and duly elected to membership:

Frederick O. Anderegg, Assistant Professor Chemistry, Purdue University.
Hilda Begeman, Assistant in Physics, Indiana.
Lulu Begeman, Mathematics teacher, Sanborn H. S.
Mary Douglass, Student, Purdue, Attica.
Berton A. Howlett, Associate Professor Physics, Valparaiso University.
Julia O. Hull, Student, Purdue, St. Anne, Illinois.
Col. Richard Lieber, Director State Conservation Commission, Indianapolis.
J. Ford Miller, Student, Purdue, West Lafayette.
Edward G. Proulx, State Chemist, Purdue University.
George W. Sherman, Asst. Professor Physics, Purdue University.
Louis Agassiz Test, Prof. General Chemistry, Purdue University.

Armanis Knotts of Gary, introduced the matter of the next Spring Meeting. He invited the Academy to Gary and the Dunes, and guarantees free automobiles and provision to visit the points of interest on the dunes, the manufactories of Gary, and the Field Museum in Chicago. He also spoke of the work of the Dunes Park Association and its efforts to enlist interest in the project of making it a national park. Its preliminary step has been to secure an option on five hundred and twenty acres of land. Men of wealth are interested in its development but additional membership is solicited. Favorable expression was made by the members present.

John S. Wright explained the failure of the legislative appropriation for the publication of the Proceedings, through an oversight on the part of the enrolling clerk to include this item, together with two others, after they had been authorized. After a discussion of the subject it was moved and passed that the publication of the 1918 Proceedings proceed, and that the number of copies, and of free reprints to authors be reduced as much as necessary.

Announcement of plans for the next day was made.

Adjourned, 9:30 P. M.

CHARLES STOLTZ, Vice President,
HOWARD E. ENDERS, Secretary.

FRIDAY MAY 23, 1919.

During the forenoon the members and guests joined Assistant Forester Deam in a tramp through the State Forestry Reserve, in a study of the various plantings and of the topography of the Reserve to the "Look-Out" and back to the Forester's Residence. At noon the party went by electric cars to New Albany and Silver Springs, thence by train to Marengo, where President E. B. Williamson and J. H. Williamson, together with F. M. Gauge and A. C. Ruthven of the University of Michigan, joined in supper at the Murphy House. Twenty-one members and guests sat down to the supper, after which President Williamson called for informal remarks from a number of persons.

Informal business related to a reduction in the number of free reprints from the Proceedings so as to come within the unexpended balance of the publication fund.

Plans for the trip into Marengo Cave were announced, and immediately after supper the party made a tour of the cave under the leadership of a competent guide. The geological formations were studied and several cave animals were collected by Dr. Ruthven and others.

Heavy rains during the night led to a dispersal of the party early Saturday morning.

HOWARD E. ENDERS, Secretary.

WINTER MEETING.

Minutes of the Executive Committee.

Claypool Hotel, Indianapolis, Ind.,
December 4, 1919.

The Executive Committee was called to order at eight o'clock by President E. B. Williamson, in parlor "B". The following members were present: Wm. Blanchard, W. S. Blatchley, Amos W. Butler, W. A. Cogshall, Glenn Culbertson, C. H. Eigenmann, Howard E. Enders, A. L. Foley, Robert Hessler, W. A. McBeth, D. M. Mottier, Charles Stoltz, F. B. Wade, E. B. Williamson, John S. Wright, F. M. Andrews, C. C. Deam, H. S. Jackson and R. W. McBride.

The minutes of the last meeting of the Executive Committee were read and approved after which the reports of the standing committees were received.

Committee on Relation of Academy to State.

R. W. McBride reported on the failure of the legislative appropriation for 1919-1920. Through failure of the enrolling clerk, for some reason or other, to enter the twelve hundred dollar, ($1,200) appropriation after it had passed the House and Senate. The history of the appropriation to the Academy was related and suggestions were made as to the mode of proceedure.

The committee has prepared a resolution which it hopes may be communicated to every member of the legislature at its special session. It would also devise that each member of the Academy seek through his representative, to have the original appropriation restored.

It was pointed out that there had been no change in the wording of the original appropriation since it was made in 1909, and that it had thus passed the House and Senate but that it had been omitted by the enrolling clerk.

The report was received and on motion was duly passed. The Secretary is authorized to have five hundred (500) copies of this appropriation bill printed for distribution to members of the legislature, and a committee of three is to be appointed to formulate a letter to be sent by the Academy members to each member of the legislature.

A discussion followed on the advisability of asking for an increased appropriation but the consensus of opinion favored a request for twelve hundred dollars ($1,200), the sum which the legislature intended to appropriate rather than to make an uncertain trial for a large amount, though the demands are urgent. The committee:

Howard E. Enders,

Stanley Coulter,

A. M. Kenyon.

Program Committee.

C. C. Deam and F. B. Wade reported that a program of fifty-seven (57) titles is printed, together with eleven delayed titles. Provision has been made with the Claypool Management for rooms to provide for a satisfactory rendering of the program and the banquet.

Committee on Biological Survey.

H. S. Jackson, chairman, reported that the work of the committee during the year had been chiefly to stimulate activity on the part of persons engaged in the work of the State, and it has thus secured the promise of two papers for the present meeting.

The report was then read which indicated, in part, the work accomplished in previous years and outlined the possibilities for early attention. It is advised that a committee be appointed to confer with the State Conservation commission, with a view to cooperate with it in extending the survey.

On motion: first, the report was received; second, a committee is to be named to prepare a resolution for presentation at the close of the Symposium on Friday evening. It is understood that the committee is to confer with the members of the Conservation Commission on this matter. Committee:

C. H. Eigenmann,

Glenn Culbertson,

H. S. Jackson.

Committee on State Library.

Amos W. Butler reported the very satisfactory condition of the Library of the Academy under careful direction of the State Librarian. Foreign publications are now beginning to arrive and are being bound as rapidly as volumns are completed. Extensive foreign and domestic exchanges are received. The report was accepted.

Committee on Distribution of Proceedings.

Howard E. Enders reported that the 1918 proceedings are on press and are promised for delivery in January or February.

The Membership Committee.

The Membership Committee nominates the following named persons for membership:

Wm. B. Adams, Asst. Botany, Indiana University.
Price W. Allen, Asst. Prof. Entomology, Purdue University.
Ira L. Baldwin, Instr. Bacteriology, Purdue University.
Cecil W. Byers, Asst. Physics, Purdue University.
Elmer G. Campbell, Asst. Prof. Agr. Botany, Purdue University.
O. B. Christy, Prof. Botany and Agr., Muncie Normal School.
G. H. A. Clowes, Physiological Chemist, Indianapolis.
W. P. Crockett, Physics Teacher, Shortridge H. S., Indianapolis.
Ray C. Friesner, Prof. Botany, Butler College.
Max Wm. Gardner, Assoc. Botanist, Purdue Exper. Station.
Joel W. Hadley, Teacher Chem. and Biol., Indianapolis.
A. Parker Hitchens, Physician, Indianapolis.
Evalyn G. James, Student in Botany, Indiana University.
Marguerite G. Mallon, Instr. in Food Chem., Purdue University.
John W. Miller, Instr. Plant Pathology, Purdue University.
G. B. Newman, Instr. Entomology, Purdue University.
Raymond M. Rightsell, Physics Teacher, Shortridge High School.
R. Chester Roberts, Chemistry teacher, Franklin, Ind.
Horace A. Shonle, Chemist, Indianapolis.
John E. Smith, Professor of Physics, Franklin.
Stephen S. Visher, Asst. Prof. Geology, Indiana University.
Ira T. Wilson, Asst. in Zoology, Indiana University.
Truman G. Yuncker, Professor of Biology, DePauw University.

Committee on Publication of Proceedings.

Editor L. F. Bennett's report was read in which he outlined the undue delay on the part of the printer, thus causing the unexpended funds of the Academy to revert to the General Fund of the State.

Treasurer's Report.

The balance in the Treasury, December 2, 1918		$462.07
Dues collected		241.00
Total		$703.07
Expended	$216.81	
Balance, December 2, 1919	486.07	
	$703.07	

On motion the report of Treasurer Blanchard is referred to the Auditing Committee for subsequent report.

Unfinished Business.

Chairman H. L. Bruner read the Revised Report of the Committee on the Establishment of a Research Endowment Fund.

On motion the report is accepted to be spread upon the minutes and is referred to the general business session.

The following named persons are nominated as fellows upon the recommendations of W. A. Cogshall, Amos Butler and F. B. Wade:

M. L. Fisher, Purdue University.
H. S. Jackson, Purdue University.
M. S. Markle, Earlham College.
Chas. Stoltz, South Bend.

Adjourned 10:30 P. M.

E. B. WILLIAMSON, President,
HOWARD E. ENDERS, Secretary.

Business Session.

Meeting called at 9 o'clock in Assembly Room of Claypool Hotel on December 5, 1919. The Executive Committee minutes were read and approved as read. Demarchus Brown, State Librarian, was called upon to present minutes on the relation of the State Library to our Proceedings and exchanges. The library serves as custodian, cataloguer, and binder.

President Williamson discussed causes that led to abandoning of the general winter meeting a year ago, prevalence of Influenza. The Conservation Bill went into effect April 1, 1919. It required the nomination of three members of Academy of Science from which the Governor of the State was to select one to serve on the committee. President Williamson appointed a canvassing committee to determine by correspondence who should be nominated. Stanley Coulter was so named by the Governor from the list of three submitted by the Secretary.

On motion, duly passed, the twenty-three persons nominated were elected to membership in the Academy.

On motion, the names of the four persons nominated for fellowship were elected fellows.

The Auditor's report was received.

The committee on The Establishment of the Research Endowment Foundation read its Revised Report.

On motion, duly passed, the plan as outlined is attempted as read with one correction as indicated on the printed copy.

Business having been concluded, the academy proceeded with the general program and papers, numbered one to seven, were taken up.

Adjourned, 12 o'clock noon.

Called Meeting of Executive Committee.

Meeting was called to order at 1:30 in Assembly Room. The report of the nominating committee was received as follows:

For Trustees of the Academy Foundation—

Amos Butler.

Robt. Hessler.

For Directors Research—

H. L. Bruner,

R. W. McBride,

John S. Wright,

Glenn Culbertson,

A. L. Foley.

On motion, the nomination was accepted.

Adjourned, 1.35 P. M.

Business Session.

The meeting was called to order at 1:35 by President Williamson in Assembly Room. On motion, the two Trustees and five Directors proposed by the Executive Committee are elected to serve on the Research Endowment Foundation.

The Spring meeting was discussed. Invitations have been received from Gary, and Madison was suggested as a possibility.

Resolution on Metric System.

The general adoption of the Metric System was discussed and the following resolution was introduced.

Whereas, the Majority of the Nations are now using the Metric system.

Whereas, Science in all of its Departments, in all parts of the world, has adopted the Metric System.

Therefore, *Be it Resolved:* That the Indiana Academy of Science place itself on record as favoring and urging the compulsory use of the Metric system in the United States at once and that the Secretary of the Academy be instructed to send a copy of these resolutions to the President of the United States.

The suggestion of State Flower was discussed. The following resolutions were then presented.

The Resolution on State Flower.

Whereas the Indiana Legislature in 1913 (Acts of 1913 on page 967) passed a law making the Carnation the State Flower.

Whereas the Carnation is a native of Southern Europe and no specie or color is specified, and the Carnation does not lend itself to art.

Therefore, *Be it Resolved:* That the Legislature be asked to change the name of the State Flower to one that is a native of Indiana and is well adapted to art.

That the Flower should be native of every county of the State, and known to all, and by one name only, such as the Tulip Tree, Flowering Dogwood, May Apple, Blood Root, etc. On motion, the Academy expresses its approval of the resolution favoring a wild flower rather than a hothouse plant for the State Flower.

On motion, the Academy goes on record as favoring the blossom of the Tulip Tree as the State Flower.

Ajourned, 12 o'clock.

Sectional Meetings.

Physical Science including Geology, Geography, Physiology and Chemistry: The Biological sciences including Botany, Bacteriology, and Zoology. The Physical Science section was held in Parlor "B", W. A. Cogshall, chairman. The Biological section met in Assembly room, E. B. Williamson, chairman.

Academy Banquet.

The Academy Banquet in which sixty-three members participated, was held in the Claypool Hotel from 6:30 to 8:00 o'clock. A short business meeting was held at the close of the banquet at which Stanley Coulter, as chairman, read the report of the Nominating Committee. For President, H. L. Bruner; for Vice President, W. A. McBeth; Secretary, Howard E. Enders; Assistant Secretary, R. E. Holman; Press Secretary, F. B. Wade; Treasurer, Wm. M. Blanchard; Editor, F. Payne.

On motion, the above named officers were elected.

On motion, Stanley Coulter is to serve as committee, with the power to act, in an effort to bring about a closer affiliation between the State Academy and the American Association for Advancement of Science.

Suggestions were made favoring the latter part of May as most favorable time for the Spring meeting.

Adjournment.

General Evening Session.

An evening session at which papers of popular interest were presented was held in the Assembly Room of the Claypool Hotel beginning at 8:15. In a short business session the trustees and directors which had been nominated to serve on the Academy Research Foundation were elected.

Adjournment.

E. B. WILLIAMSON, President.
HOWARD E. ENDERS, Secretary.
INDIANAPOLIS, DECEMBER 5, 1919.

Revised Report of the Committee

Appointed To Consider the Establishment of a Research Endowment Fund.

To the Members of the Indiana Academy of Science:

At the Bloomington meeting of the Academy, December, 1917, the report of the committee appointed to consider the advisability of establishing a research fund, was referred back to the committee for further revision, final action being postponed in order to give both the committee and the membership of the Academy ample time to consider the important project. Copies of the original report were sent to all members early in 1918. As a result of suggestions which have been received from many sources, the committee respectfully submits the following revised report.

R. W. McBride,
J. S. Wright,
H. L. Bruner, Chairman,
Committee.

A PLAN FOR THE ESTABLISHMENT AND ADMINISTRATION OF A FUND FOR THE PROMOTION OF RESEARCH

Financial Management of the Fund.

Trustees—Election—Appointment—

The Academy shall organize a board of three trustees for the custody and financial management of a research endowment fund.

The treasurer of the Academy shall be *ex officio* a member of this board, and the other two members shall be nominated by the executive committee and elected by vote of the Academy membership.

The first board shall be constituted as follows: The treasurer of the Academy and one member elected for a term of three (3) years, and one member elected for a term of four (4) years.

Thereafter the trustees, other than the treasurer of the Academy, shall be elected for terms of four years. Vacancies in office caused by death or resignation shall be filled by appointment by the president of the Academy, but the appointment shall be merely to fill the unexpired term.

Bonds—

The trustees shall be required to furnish bonds in accordance with the amount of the funds intrusted to their keeping, the amount of bonds required to be subject to revision annually or with every accession to the fund of an amount of one thousand dollars ($1,000.00) or more.

The fees for bonding the trustees shall be paid out of the current funds of the Academy, likewise all other expenses of administering the research endowment fund, until it shall reach an amount yielding twenty-five hundred dollars ($2,500.00) or more annually, whereon, at the option of the Academy, the cost of administration may, as far as compatible with the terms of the bequests to this fund, be paid out of the interest accruing from the fund.

The executive committee of the Academy shall appoint a standing committee which shall have charge of the bonding of trustees and be the custodian of the bonds.

Remuneration—

Trustees shall serve without pay, but shall be reimbursed for necessary expenses incurred in the actual performance of their duties.

Investments—

The trustees shall keep all research endowment funds invested in standard securities, such as are prescribed by law in Indiana for the investment of the legal reserve of life insurance companies. In the event real estate or property other than money is conveyed to the Academy for research purposes and is sold, the funds accruing from such sale shall be promptly reinvested in securities of the class named above.

The trustees shall select some well-established bank or trust company, having safety deposit boxes, as a custodian of all securities, moneys, and negotiable papers, etc.

Reports—

It shall be the duty of the trustees to make written sworn reports on the fund at each annual winter meeting of the Academy, and at such other times as the executive committee or the president of the Academy may designate.

Duties of Trustees—Financial—

The duties of the trustees of the fund shall be restricted chiefly to the financial management of the principal and the interest under the rules provided. They shall not as trustees have a voice in the appropriation of such proceeds as are available for research work, but shall turn them over to such committees or individuals as are properly designated by the Academy, to be employed in research work.

Establishment of the Research Endowment Fund.

This fund shall be established by the following methods:

(a) By annual appropriations from the current revenues of the Academy. It shall be the duty of the treasurer to report to the Academy at each annual meeting such an amount as in his judgment can be spared for this purpose. Funds so appropriated shall be irrevocable by the Academy.

(b) By conveying to this fund all fees from life members.

(c) By establishing the relationship of patron, with a fee of $100.00, and conveying all such fees to this fund.

(d) By gifts, etc.

(e) Except when the conditions of individual bequests or gifts specify to the contrary, the annual proceeds of the fund shall be reinvested and become a part of the principal fund until the principal is sufficient to yield an annuity of two hundred dollars ($200.00).

(f) In soliciting or accepting gifts an effort should be made to have the proceeds available for use at the discretion of the research committee, excepting those cases in which the donor wishes to favor special scientific interests and will contribute funds adequate to support researches in this line.

(g) It is recommended that donors of small bequests for special purposes should be persuaded, if possible, to give the Academy wide latitude in the use of the annuities, permitting them to accumulate, where necessary, until the total income shall be sufficient to accomplish substantial results.

(h) The establishment of prize funds is to be discouraged as incompatible with the main object of this fund, which is to aid men of proper training to do research work, by giving it support while in progress, especially where adequate resources would be unobtainable otherwise.

Scientific Administration.

The Academy, through its executive committee, shall organize a Research Committee composed of five *Fellows*, representing different departments of science, to administer the proceeds of this fund.

The first committee is to be nominated by the Executive Committee and elected by the members of the Academy—one for one (1) year, one for two (2) years, one for three (3) years, one for four (4) years, and one for five (5) years. Their successors are to be elected by the Academy members for terms of four years each, and two *Fellows* shall be nominated by the executive committee as candidates for each vacancy caused by the expiration of terms of office. Vacancies by resignation or death shall be filled by appointment by the president for the unexpired term, and if possible the one appointed shall represent the same department of science as the retiring member or a department not already represented on the committee.

Duties—

This committee shall receive and investigate applications for assistance in reasearch work and present its recommendation in writing to the executive committee for confirmation.

Investigations in pure science shall have preference in making awards. Preference is likewise recommended for members of the Academy engaged upon valuable work for which other adequate resources are not available.

No awards shall be construed as binding on the Academy beyond the fiscal year for which they are made, nor for funds unearned by the endowment at the time at which the award is made. Nothing in this provision, however, is to be construed to prevent the Academy from continuing appropriations from year to year to aid in the completion of valuable work, but such continuance shall be by separate yearly allowances.

The research committee shall be the custodian of all apparatus of permanent value which shall be purchased through appropriations of the Academy.

Minor rules and regulations pertaining to other details of administration shall be made by the research committee and the executive committee of the Academy.

Remuneration—

Members of the research committee shall receive no remuneration for their services, but their necessary expenses, incurred in the actual performance of their duties, shall be paid by the Academy.

Beneficiaries' Requirements—

The research committee shall require from each beneficiary of the fund annually, or as frequently as it may deem expedient, a report regarding the progress of his research.

Researches supported by appropriations from the Academy may be published anywhere, provided in all cases, that due acknowledgment shall be made of such assistance. A copy of each publication not included in the Proceedings of the Academy shall be presented to the library of the Academy.

Apparatus purchased by beneficiaries from funds furnished by the Academy shall be the property of the Academy, and shall be subject to the order of the research committee, when the investigation for which it was provided is completed.

Notices—

Awards of financial assistance shall be made in writing, addressed to the trustees of the fund and signed by the chairman of the research committee, the president, and the secretary of the Academy.

Promotion Work—

It shall be the duty of the research committee to co-operate with the trustees of the fund and the executive committee, in giving suitable publicity to the plans of the Academy to establish this fund, and to invite contributions.

PROGRAM

OF THE

THIRTY-FIFTH ANNUAL MEETING

OF THE

Indiana Academy of Science

Claypool Hotel, Indianapolis

THURSDAY AND FRIDAY

December 4 and 5, 1919

OFFICERS

E. B. WILLIAMSON, Bluffton.....................President
DR. CHAS. STOLTZ, South Bend.............Vice-President
HOWARD E. ENDERS, West Lafayette............Secretary
P. A. TETRAULT, West Lafayette...........Asst. Secretary
FRANK B. WADE, Indianapolis..............Press Secretary
W. M. BLANCHARD, Greencastle.................Treasurer
LEE F. BENNETT, Janesville, Wis...................Editor

General sessions of the Academy will be held in the Assembly Room of the Claypool Hotel. Section meetings in the Assembly Room and in the Palm Room.

Thursday, December 4, at 8:00 P. M., Executive Committee meets at Claypool Hotel.

GENERAL PROGRAM

Friday, December 4, at 9:00 A. M., Assembly Room, Claypool Hotel.

Business meeting........................ 9:00 to 9:30 A. M.
General session.......................... 9:30 to 12:00 A. M.
Lunch ....12:00 to 1:30 P. M.
Business meeting........................ 1:30 to 2:00 P. M.
Section meetings........................ 2:00 to 6:00 P. M.

Physical Sciences in Assembly Room. All lantern papers to be given in this room.

Biological Sciences in Palm Room.

Annual Academy Dinner. 6:30 P. M., Dining Room to be announced at meeting. Members who expect to be present at the dinner will please not fail to mail at once the enclosed card to Mr. F. B. Wade, 1039 West Twenty-seventh Street, Indianapolis, in order that plates may be reserved.

General session, 8:00 P. M., in Assembly Room.

No Saturday program is planned.

TITLES OF PAPERS TO BE READ.

The papers listed below will be read in the order in which they appear on the program except that certain portions of the program will be presented pari passu in sectional meetings. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another, whose time is aproximately the same. Where no statement of time was sent with the papers, they have been uniformly assigned ten minutes.

Opportunity will be given after reading of each paper for a brief discussion.

Whenever possible, authors should bring their papers typewritten and in shape for the editor of the proceedings to turn over to the printer. Drawings and other illustrations should also be ready for the engraver and delivered with the manuscript to the Secretary.

1. Whales and Whale Fisheries of the North Pacific Ocean—15 minutes—William Watson Woollen.

2. Hydrangia Arborescens, var. sterilis Torr. and Gray, as an Ornamental Plant—10 minutes—D. M. Mottier.

3. The Forest Problem in Indiana—20 minutes—lantern—B. W. Douglass.

4. The Irwin Expedition to Peru, Bolivia and Chile, lantern—35 minutes—Prof. C. H. Eigemann.

5. Lorenzo E. Daniels (Biographical Sketch)—5 minutes—W. S. Blatchley.

6. James E. Weyant (In Memoriam)—5 minutes—Frank B. Wade.

7. Trees as a Nature Lover Sees Them—20 minutes—lantern—Dr. Frank Wynn.

8. Correction of the Acoustics of the Auditorium of the Student Building of Indiana University—8 minutes—lantern—Arthur L. Foley.

9. A. New Method of Aerating Water—10 minutes—lantern—Arthur L. Foley and Will Scott.

10. Synchronous Leaping of Fish—5 minutes—Arthur L. Foley.

GENERAL PROGRAM.

8:00 P. M. Friday.

11. The Burden We Bear, a Study of the Problem of the Mental Defectives of Indiana—40 minutes—lantern—Amos W. Butler.

12. The Pelicans of Pyramid Lake—25 minutes—illustrated with moving pictures—Barton Warren Evermann, California Academy of Sciences, San Francisco, Cal.

13. The Department of Conservation, State of Indiana, Present and Future—The Division of Geology represented by W. N. Logan—5 minutes; The Division of Entomology, represented by Frank N. Wallace—10 minutes; The Division of Forestry, represented by Chas. C. Deam—5 minutes; The

Division of Lands and Waters, represented by Chas. G. Sauers—5 minutes; The Division of Fish and Game, represented by Geo. N. Mannfeld—15 minutes; Concluding Remarks by the Director, Richard Lieber—10 minutes.

SECTION PROGRAM.

2:00 P. M. Friday.

Physical Sciences and all lantern papers in Parlor "B".
Biological Sciences in Assembly Room.

PHYSICAL SCIENCES—GEOLOGY AND GEOGRAPHY.

14. Origin of Indianaite—15 minutes—lantern—W. N. Logan.

15. The Calumet Region—15 minutes—Chas. R. Dryer.

16. The Stratigraphy of the Chester Series of Indiana—10 minutes—charts—Clyde A. Malott and J. D. Thompson, Jr.

17. A Notable Case of Successive Stream Piracy—10 minutes—charts—Clyde A. Malott.

18. Nomenclature of Indiana Geological Formations—20 minutes—charts and maps—E. R. Cummings.

19. Beach Cusps—20 minutes—E. R. Cummings.

PHYSICS AND CHEMISTRY.

20. Ground Resistance—10 minutes—blackboard—R. R. Ramsey.

21. Defects in Mouthpieces of Telephones and Other Sound Recording Apparatus Shown by Sound Wave Photographs—10 minutes—lantern—Arthur L. Foley.

22. Retardation of a Sound Wave Moving Tangentially Along a Solid Wall—5 minutes—lantern—Arthur L. Foley.

23. A New Method of Investigating the Electric Spark—5 minutes—lantern—Arthur L. Foley.

24. An Electric Device for indicating at a Power House, the Depth of Water in a Distant Reservoir—5 minutes—lantern—Arthur L. Foley.

25. The Spectrum of Phosphorescent Mercury—10 minutes—E. K. Chapman.

26. The Chemist and the Community—5 minutes—W. M. Blanchard.

27. Some Chemical Reactions with High Frequency Corona—20 minutes—lantern—F. O. Anderegg.

28. Segregation and Growth of Crystals in Bearing Metals—10 minutes—lantern—E. G. Mahin.

29. A Study of the Soils of Hancock County, Indiana—10 minutes—R. H. Carr, H. S. Copeland and E. Gentzler.

MATHEMATICS.

30. Checks on the Accuracy of Computations in the Solution of Triangles (by title only) A. M. Kenyon.

BIOLOGICAL SCIENCES.

Palm Room, 2:00 O'clock Friday.

BOTANY AND BACTERIOLOGY.

31. A Strange Phlox—4 minutes—charts—Elmer G. Campbell.

32. Additions to the Fungus Flora of Indiana—5 minutes—H. S. Jackson.

33. An Arrangement of the Ascomycetes of Indiana—10 minutes—Bruce Fink and Sylvia C. Fuson.

34. Indiana Plant Diseases, 1919—15 minutes—Max W. Gardner.

35. The Uredinales of Indiana, III—5 minutes—H. S. Jackson.

36. Prevalence of the Loose Smut of Wheat in Indiana—10 minutes—F. J. Pipal.

37. The Dodders of Indiana—10 minutes—T. G. Yuncker.

38. Plants New or Rare to Indiana, IX—5 minutes—Chas. C. Deam.

39. Apparatus for Aerating Plants—5 minutes—F. M. Andrews.

40. A Study of Pollen, II—10 minutes—F. M. Andrews.

41. A Warming Needle for Arranging Specimens in Paraffin—5 minutes—F. M. Andrews.

42. The Relation of Hydrogen Ion Concentration and Titratable Acidity in Bacteriological Media—10 minutes—Ira L. Baldwin.

43. A List of the Parasitic Fungi of Montgomery County, Indiana—10 minutes—H. W. and P. J. Anderson, Massachusetts Agricultural College.

44. A Pipette for Holding and Measuring Sterile Fluids—5 minutes—Chas. A. Behrens.

45. The Cultivation of Spirochaeta Novyii Without the Use of Tissue—20 minutes—Chas. A. Behrens.

ZOOLOGY.

46. Influenza from a Biologic Viewpoint—10 minutes—Robert Hessler.

47. Notes on the Birds of Carroll, Monroe and Vigo Counties, Indiana—25 minutes—Barton Warren Evermann.

48. Selection for High and Low Bristle Number in the Mutant Strain "reduced"—15 minutes—F. Payne.

49. The Appearance of Fresh Water Medusae in Indiana—5 minutes—F. Payne.

50. The Inheritance of Orange Eye Color in Drosophlia—10 minutes—F. Payne and Martha Denny.

51. An Ecological Note on the Andean Lapwing Ptilosocelys resplendens—5 minutes—William Ray Allen.

52. Ecological Note on the Andean Frog, Cyclorhamphus culeus, Garman—5 minutes—William Ray Allen.

53. The Ingesting Mechanism of the Unioniade—10 minutes—charts—William Ray Allen.

54. Notes on the Biology of some common fireflies—10 minutes—specimens—Walter N. Hess.

55. The Orthoptera of Eastern North America—10 minutes—W. S. Blatchley.

56. Birds Singing at Night—5 minutes—M. L. Fisher.

57. The Life History of Myobia Musculi, a Parasite Upon Rats—10 minutes—chart—Howard E. Enders.

Come prepared to let the new program committee know where you want to go on the next annual spring trip.

Should the Academy do anything toward getting the metric system of weights and measures into more general use in this country?

Remember that we do not now plan to hold the meetings over to Saturday.

Our Treasurer will be on hand at the meeting to receive your annual dues. Perhaps you are in arrears on account of the loss of last year's meeting. Prescription, "Double the dose."

What did you do with that reply card in regard to the banquet? The Commissary Department must count noses. Mail it now.

ADDITIONAL TITLES.

58. A Case of Asphyxiation by Hydrogen Sulphide. Wm. M. Blanchard.

59. Stellite Mirrors for Astronomical Instruments. W. A. Cogshall.

60. Wild, or Indian Rice, (Title) Albert B. Reagan.

61. The Influenza and the Navajo, (Title) Albert B. Reagan.

62. A Trip in the Little Fork and Nett Lake Country, Minnesota, (Title) Albert B. Reagan.

63. A Trip Among the Rainy Lakes, (Title) Albert B. Reagan.

64. Bryozoa of the Stones River Group of Central Tennessee, (Title) H. N. Coryell.

65. A Synopsis of the Forms of Electron Platyrhynchum, (Title) Harry C. Oberholser, U. S. National Museum.

66. Huffmans Lake: A Map, Its Original Conditions and Some Additional Observations on Oscillatoria Prolifica, Will Scott.

67. The Depletion of the Fishes of Lake Maxinkuckee by Saprolegnia sp., Will Scott and Howard E. Enders.

68. The Food of the Daphnids, Homer G. Fisher, with an introduction by Will Scott.

69. The Flood Myth of the Chippewas, A. B. Reagan.

70. Glacial Deposits in Pine River Valley, Colorado, A. B. Reagan.

71. Probable Eocene Deposits in the Fort Apache Region, Arizona, A. B. Reagan.

72. Some Notes on the Estimation of Chromium as Chromic Oxide, Wm. M. Blanchard and Pauline Norris.

73. The Mineral Resources of Indiana; How They Are Utilized, W. N. Logan.

WHALES AND WHALE FISHERIES OF THE NORTH PACIFIC.

BY

William Watson Woollen.

Captain George Vancouver, under a Commission from the Government of Great Britain, in 1792, 1793 and 1794, explored the Northwest Coast of America from north latitude 30° to north latitude 60°, in a search for the Strait of Anian, afterwards known as the North West Passage. For a number of years I have been making a study of his explorations, and in doing so have made five voyages to Alaska, the fourth of which extended to the head of Cook Inlet in north latitude 61°. The following paper is based on observations made while making those voyages, supplemented by a study of various authorities upon the subject of whales.

On the 7th of April, 1792, Vancouver reached latitude 35°25′, longitude 217°24′, where he found himself in the midst of immense numbers of the sea blubber of the species Medusa Villilia. The surface of the ocean, so far as the eye could reach, was covered with these creatures in such abundance that even a pea could hardly be dropped clear of them. In the afternoon his ship passed within a few yards of about twenty whales of the anvil headed or spermaceti species playing in the water. His conclusion was, that these whales were induced to resort hither to feed upon the immense number of the Medusa, with which the region abounded.

On Monday, the 25th of June, he had reached a point in the Strait of Georgia beyond the present site of the City of Vancouver. In his record of that day, he says: "In the course of the forenoon a great number of whales were playing about in every direction; and though we had been frequently visited by these animals in this inland navigation, there seemed more about us now than the whole of those we had before seen, if collected together." He also says, "That in sailing from Desolation Sound to Menzies Bay, numberless whales, enjoying the season, were playing about the ship in every direction." These quotations from Vancouver's Journal, and many others that might be made, show the great abundance of whales that were to be found in the North Pacific Ocean a century and a half ago and how tame they were at that time.

The first of these animals that I have had the privilege of seeing was that of a dead one which was brought from the East to Indianapolis, many years ago on two open flat cars, for exhibition. The next one was seen July 11, 1911, sporting in the Strait of Georgia, between Vancouver and Active Pass. After that I saw many of them, singly and in pairs, but I have never seen a "school" of them. I saw a Beluga, or white whale, near to Kodiak, October 1, 1914. On my return trip of that voyage I formed the acquaintance of Alfred Hanger, an intelligent man, who had long been engaged in whale fishing, and from him gained much information about whales and whale fishing. The following are the whales which he said are found on the Northwest Pacific Coast: Right Whale, Bowhead Whale, Sulphur Bottom Whale, Fin Whale, California Gray Whale, Sperm Whale, Bottle-nose Whale, White Whale and Killer Whale. His story of whales and whale fishing, in the main, corresponds very much with what I have found in the authorities that I have consulted.

The mammalia is constituted of the highest order of the animal kingdom. Strange as it may seem, a whale belongs to this order, and not to that of the fishes which in form and habitat, it so much resembles. It is a hot, red blooded creature, breathing by means of lungs, which lie in the interior of the body in a definite chest cavity, shut off from the rest of the cavity of the body by a large muscular partition or diaphragm. Frequently it has vestiges of the hairs which cover the bodies of other mammals and the presence of a few scattered hairs in the neighborhood of the mouth. It brings forth its young alive and suckles them with milk. At Kyuquot Whaling Station I saw the foetus of one that was six feet long that had been taken from a slaughtered mother whale. The bones of the skull are precisely like those of other mammals, and only differ slightly in their relative arrangement.

Whales are the giants of creation; they are not only the largest of the living animals, but of all animals that have existed, except perhaps the one hundred and thirty foot Dinosaur, recently described, and in many respects are the most interesting and wonderful of all creatures. They are all fish-like in form with tapering bodies, one pair of paddles, no apparent vestige of hind limbs, no external ears, tiny eyes, and black piebald or white coloration. They are divided into two families, namely, Mystacoceti, or toothless whalebone whales, and Odontoceti, or toothed whales. All of the members of the first family are called whales, but of the second only certain of the larger ones are so termed, the smaller species being popularly spoken of as "Bottlenoses", "Dolphins" and "Porpoises".

The family Mystacoceti, or whalebone whales, is subdivided into three genera, (1) Balaena, (2) Megaptera, and (3) Balenoptera. The Balaena consist of the Greenland, or more properly Arctic right whale, and several other species described according to their geographical distribution. In the Greenland or Arctic right whale all the peculiarities which distinguish the head and mouth of the whales from those of other mammals have attained their greatest development. The head is of enormous size, exceeding one-third of the whole length of the creature. The cavity of the mouth is actually longer than that of the body, thorax, and abdomen altogether. The upper jaw is very narrow, but greatly arched from before backwards, to increase the height of the cavity and allow for the great length of the baleen, or whalebone; the enormous rami of the mandibles are widely separated posteriorly, and have a still further outward sweep before they meet at the symphysis in front, giving the floor of the mouth the shape of an immense spoon. In front of the door to "Ye Old Canosity Shop" on the wharf at Seattle, I saw a pair of jaw bones of a whale which were marked as being twenty feet and one inch long and weighing one thousand pounds each.

The Baleen blades of these whales, or whalebone, as known in common parlance, attain the number of three hundred and eighty or more on each side, and those in the middle of each series have a length of ten to twelve feet. It is by means of this apparatus that the whale is enabled to avail himself of the minute, but highly nutritious, crustaceans and Medusa Villilia which swarm in immense shoals in the seas it frequents. These plates of baleen or whalebone act as strainers. The food thus filtered off by the action of the whale bone and the raising of the tongue and shutting of the jaws is left stranded upon the gigantic tongue and then swallowed down the narrow throat. This whale attains a length of fifty to sixty-five and occasionally seventy feet. It produces a single foal or "sucker" at a birth, which at birth is ten to fourteen feet long. The bowhead whale, whose range is circumpolar, probably belongs to this species. According to Scammon, it is seldom seen south of the fifty-fifth parallel north latitude, which is about the farthest southern extent of winter ice. In other words, it is an "ice whale". This whale and the southern right whale resemble each other in the absence of a dorsal fin and longitudinal furrows in the skin of the throat and chest, but they differ in that the southern right whale possesses a smaller head in proportion to its body, shorter baleen, a different shaped contour of the upper margin of the lower lip, and a greater number of vertebrae.

The Megaptera, commonly called the "humpback" whale, is characterized from all others of the group, especially by its immense length of the pectoral fins or flippers, which are indented or scalloped along their margins, and are, except at the base, of a white color, nearly all the rest of the body being black. It differs from the right whale and resembles the rorqual in having the skin on the throat and chest marked with deep longitudinal furrows. The Baleen or whalebone plates are short and broad and of a deep black color. The usual length of the adult ranges from forty to fifty feet. The production of its oil varies more than in all other whales. Scammon reports having seen individuals which yielded but eight or ten barrels of oil and others as much as seventy-five. Whalemen distinguish this mammal at a considerable distance by its undulating movement. They are found in both the North and South Pacific. During the breeding season this species is remarkable for its amorous antics. At such times their caresses are of the most amusing and novel character. When lying side by side of each other they frequently administer alternate blows with their long fins, which love pats may, on a still day, be heard at a distance of miles.

The Balaenoptera composed of the rorquals or fin whales have the plicated skin of the throat like that of the megaptera, the furrows being more numerous and close-set; but the pectoral fin is comparatively small and the dorsal fin distinct and falcate. This whale is comparatively small, flat and pointed in front, the baleen or whalebone short and coarse, the body long and slender, and the tail very much compressed before it expands into the flukes. The rorquals are perhaps the most abundant and widely distributed of all the whales, being found in some of their modifications in all seas, except the extreme Arctic, and probably Antarctic regions. They yield a small quantity of inferior whalebone, and a limited amount of blubber or subcutaneous fat. There are four and probably five species of the rorqual. (1) Sibbaldi, named in honor of Sir Robert Sibbaldi; Borealis; (3) Rostrata; (4) Musculus, and (5) Sulphureus. The sibbaldi is the greatest of all the whales. Whalers know it by its large size and by the height to which it spouts. Its speed too, when going rapidly, is great—something like twelve miles an hour. It feeds upon Crustacea, lives mainly in pairs, and reproduction is said to take place every three years. The species borealis, known as Rudolph's Rorqual has a length of forty to fifty feet; color bluish black above and white below; upper surface with oblong light spots. Baleen black with white bristles; number of plates three hundred and thirty. It is inoffensive in character. It is estimated that it can remain under water eight to twelve hours. The species rostrata has a length of twenty-five to thirty-three feet, color greyish-black above, and white below; dorsal fin high at commencement of last third of the body; pectoral fin one-eighth of the total length of the body; plates of baleen about three hundred and twenty-five. This is the smallest of the rorquals, and is readily distinguished from them by the white band which crosses the pectoral limb, and by the sharp snout—hence the specific name of "rostrata". The species musculus, grows to a length of sixty to seventy feet. The color is gray-slate above, white below. The dorsal fin low with straight margins, is placed slightly in front of the last fourth of the body; the pectoral fin has a length of one-ninth of the body. The plates of baleen and bristle are of a dark bluish black color, and the number of them ranges up to three hundred and seventy. This is perhaps the commonest species of the rorquals. The species Sulphureus, commonly known as the "Sulphur Bottom" whale, is one of the longest of the whales; an example of it having been measured and found to be ninety-five feet in length with a girth of thirty-nine feet. It weighed one hundred and forty-seven tons, and yielded one hundred and ten barrels of oil. Ordinarily one of them yields about eight hundred pounds of baleen or whalebone. The name is derived from the yellowish color of the under parts of its body; the back is lighter in color than is usual, and is sometimes a very light brown, approaching to white. During the months from May to September, inclusive, these whales are found in large numbers close in with the shore.

The family Odontoceti is composed of the toothed whales. Correlated with the presence of the teeth is the absence of baleen or whalebone. Beddard says, "So sharply defined are the Odontoceti from the Mystacoceti that intermediate types are sadly to seek; and both additions, in fact, have each specialized on their account in the same kind of direction in parallel lines. We have great-headed Cetaceans in both groups. The Cachalot corresponds to the Right whale. There are giants and pigmies amongst the families of each. The small Kogia is a near ally of the bulky Cachalot. The somewhat dwarfish Neobalaena is not far off from the leviathan of the Greenland seas. There are Odontocetes without a dorsal fin, and Odontocetes with that fin. The Rorquals correspond to the latter, the Greenland whale to the former. The head of the Sperm whale or cachalot is about one-third of the length of the body, very massive, high and truncated in front, owing to its huge size and remarkable form mainly to the great accumulation of a peculiarly modified form of fatty tissue, filling the large hollow on the upper surface of the skull. The oil contained in the cells in this great cavity, when refined, yields Spermaceti, and the thick covering of blubber, which everywhere envelopes the body, produces the valuable sperm-oil of commerce. The single blowhole is a longitudinal slit, placed at the upper and interior extremity of the head to the left side of the middle line. The opening of the mouth is on the underside of the head, considerably behind the end of the snout. The lower jaw is extremely narrow, and has on each side from twenty to twenty-five stout conical teeth, which furnish ivory of good quality. The upper teeth are quite rudimentary and buried in the gum. The pectoral fin or flipper is short, broad, and truncated, and the dorsal fin a mere low protuberance. The general color of the surface is black above and grey below, the colors gradually shading into each other. The food of the sperm whale consists mainly of various species of cephalapods, but they also eat fish of considerable size. The substance called "ambergris", formerly used in medicine and now in perfumery, is a concretion formed in the intestine of this whale, and is found floating on the surface of the seas it inhabits. Its genuineness is proved by the presence of the horny beaks of the cephalopods on which the whale feeds. The remaining Odontoceti are all animals of much smaller size than the sperm whale, but to several of them the name "whale" is commonly applied.

The Beluga or White whale is entirely northern in its range. Its name "Beluga" is derived from the Russian and signifies white. The young is blackish, the older whale a mottled, and finally a yellowish hue is arrived at, which is gradually blanched to pure white. It reaches a length of sixteen to twenty feet. It is a singular fact that these whales, unlike many Cetacea, have a distinct noise which has earned for them the name of "Sea Canary". They live in companies and feed upon fish, cephalopods and crustacea. Though this is a marine whale, it sometimes ascends rivers, it is said, in pursuit of salmon. It has been known to ascend the Yukon River for a distance of seven hundred miles.

The Orca or Killer whales grow to a length of twenty to thirty feet. They are powerful, rapacious animals, and are the only whales that feed upon their own kind and upon large prey. They are a species of rapacious, carnivorous whale, whose upper and lower jaws are armed with sharp, saw-like teeth. They are known as the tiger-hearted gladiators of the sea. The Killer whale never hunts alone. It pursues its titanic quarry in couples and trios, and sometimes in veritable wolf-like packs of a half dozen. I witnessed one of these attacks in Queen Charlotte Sound. They have been known to assault the largest whales of the sea. Burns tells of an attack of this nature upon a large bowhead whale and Scammon of one upon a Californian Grey whale which he witnessed. He says, "They made alternate assaults upon the old whale and her offspring, finally killing the latter, which sunk to the bottom, where the water was five fathoms deep. During the struggle the mother became nearly exhausted, having received several deep wounds about the throat and limbs. As soon as their prize had settled to the bottom the three Orcas descended, bringing up large pieces of flesh in their mouths, which they devoured after coming to the surface."

The common porpoise is a gregarious whale found in both the Atlantic and Pacific. It reaches a length of five to six feet and is generally blackish, but white on the belly. Like the stormy petrel they have the reputation of presaging foul weather, when they sport and chase one another about vessels, an instance of which I witnessed in Lynn Canal.

It seems to be hardly a matter of doubt that whales were first utilized only when stranded on shore. The discovery thus made of the economic value of many parts of these huge monsters led naturally to their pursuit, either from the shore or open sea. As to the actual date of the first active hunting of them there is dispute, the real date of the origin of this pursuit being difficult to ascertain. Hakluyt thinks it was practiced on the Norway coast as early as A. D. 890. In the first place it probably was practiced from the shore. Beddard says, "No doubt as soon as the value of stranded whales was ascertained they would be hunted in this fashion, and then as the shore-coming whales got scarcer they would be pursued by the whalers further and further into the ocean". The American whale fishing began as early as the year 1614. At first the animals were pursued from the shore; and Nantucket Island was the headquarters of the industry. The whales were watched for from a "tall spar", and when an animal was seen to spout the boats immediately set out in pursuit. The whale when captured was towed into shore, and the flensing done on the beach. Verrill says that, at that time no ships had set forth in quest of whales and the whalemen depended upon those which could be captured from small boats and it was not until 1688 that the first whaleship set forth on a true whaling cruise. Within a dozen years the sails of the sloops, brigs and schooners from Nantucket and other Massachusetts towns were spread to the winds of the Atlantic from the Equator to the Arctic Circle.

Never very abundant, the right whales, that is the Arctic right, or Greenland whale, and the North Atlantic whale, of which the oil served to light the way of our ancestors and the whalebone to give shapely form to the women, have become very rare. In our time the Greenland whale is not regularly hunted except in Davis and Lancaster Straits, Hudson Bay, on the Northwest Coast of North America about Point Barrow. Even in those places it is no longer abundant. The second species of right whale, the North Atlantic right whale is at present scarcely more abundant than the Greenland whale. In contrast with the foregoing, finbacks and Humpbacks abound in all seas, such as the blue whale, the rorquals, the pollack whale, the common humpback, and many other less well-known species. The cetaceans are at present relentlessly pursued for commercial purposes.

The finback whale fishery began in 1867, when the celebrated Norwegian sailor, Svend Foyn with his destructive machine captured his first whale, and in the first year took thirty of them. In less than fifteen years this fortunate inventor found himself possessed of more than $2,000,000. Encouraged by this example, companies were organized to exploit this source of profit, to such an extent that in 1887 there were no less than thirty-five whaling vessels on the coast of Finmark. In good years they captured from twelve hundred to thirteen hundred finbacks. According to the Norwegian Fisheries Journal four companies alone in 1911 captured fourteen hundred and seventy-two finback whales, and in the Antarctic seas around South America, not less than ten thousand finbacks and humpbacks were killed. In 1913 nine companies with thirty-two steamers were established in the South Shetlands, and they caught more than three thousand whales.

The early days of whaling, as we have seen, was "shore whaling" by means of small boats, and all the whales attacked and captured were those which approached close to the shores and could be seen from the land. This whaling was carried on by means of harpoons and lances. The first Nantucket whaling vessels were small, thirty-ton sloops fitted for cruises of a few week's duration and after capturing one whale they returned to port. From the small sloops of those early days the vessels were increased in size until large barks, ships and brigs were in almost universal use. The tools, weapons and implements of those early days were not well adapted to the capture and cutting up of whales, and the later whalers found it difficult to improve upon them. The most improvement made was the harpoon-gun invented by Svend Foyn in 1867. This gun is heavily constructed throughout and has a bore of three inches and placed in the extreme bow of the whaling vessel. The harpoon is a very heavy missle, weighing several hundred pounds. A bomb containing roughly a pound of powder is screwed on to the harpoon, and the latter then rammed home and in the same manner shot. Coiled upon the iron plate under the gun muzzle is the "doregoer", made of the best Italian steam tarred hemp, four and half inches in circumference, one end of which is attached to the harpoon about eighteen inches from the point. Attached to the other end of the "foregoer" is one of the main whale lines from the winch, this line being of Russian steam-tarred hemp, about four hundred fathoms in length, and of five and a half inches circumference. Thus equipped a vessel is ready for action.

Near the top of the mast head is located the lookout barrel, from which point of vantage the lookout can cover a much larger area than a man on deck would be able to do. As soon as a whale is sighted the vessel is run as close to it as possible, and when within range the gun is fired. A time fuse is attached to the bomb on the harpoon, this being ignited by the discharge of the gun, and five seconds after the discharge the bomb explodes. On the shaft of the harpoon are barbs, which expand on entering the body of the whale, making it next to impossible for the hafpoon to be drawn out. As soon as struck the whale sounds and goes to the bottom. These animals have enormous strength and will at times tow the vessel several miles before beginning to weaken. As soon as the line slackens it is snubbed around a heavy steam winch on the deck just ahead of the bridge, after which the wounded whale is played in much the same manner that a fish is played by an expert angler, a continual strain being kept on him, slackening sometimes to avoid a wild rush, but always reeling in slack at every opportunity. The strain soon begins to tell on the whale, his rushes growing shorter and less vicious, and finally he rises to the surface, lashing the water white in his struggles. Should he blow blood when he reaches the surface, the whalers know he is mortally wounded, and wait until he dies, but if he blows clear and quiet, the "pram", a peculiar spoon shaped boat adapted from a Norwegian model, is lowered and rowed along side and a long lance is driven into him until he blows blood, which shows an internal hemorrhage, from the effects of which he soon expires, rolling over on his back in his last struggle, and then sinking to the bottom. The line is now rapidly hove in until a heavy strain shows the slack is in and the weight of the whale is showing, when the line is run through a heavy iron block at the foremost head, this being heavily rigged in order to stand the tremendous strain. Fathom by fathom the line comes in until at last the dead body is alongside. A chain is attached around the tail and the winch then heaves the tail out of water, causing the animal to hang vertically head down from the bow. The vessel is then forced ahead at full speed to bring the body to the surface. The lobes of the tail are then severed and brought on board. In order to make the carcass more buoyant, air is blown into the abdominal cavity by means of a Westinghouse air pump.

If the whaler is not ready to return to the station immediately, a buoy with the ship's flag attached, is secured to the whale, and both allowed to go adrift while the vessel continues its hunt, sometimes as many as three or more whales being brought in at one time, all with their tails out of the water, and hoisted to the bow. Upon arrival at the station the whales are attached to a buoy in front of the ship, from which a line is taken and the animal hauled into the mouth of the ship between two cribs filled with rocks, which act as guides to keep it centered, at the same time to ballast the nose of the slip under water at all stages of the tide. A large one and a half inch diameter iron chain is then attached to the tail of the whale and it is hauled out of the water under the "flensing" shed by a powerful steam winch. As soon as the whale is in place, men with long handled knives commence "flensing", that is, removing the blubber. This is a layer of fat directly under the skin, covering the whole body like a huge blanket, and varying in thickness from four to seven inches. The men walk from the head toward the tail, cutting long gashes in the blubber as they go, then a steel hook attached to a wire cable is hooked in at the end of a strip, the steam winch heaves in on the wire, and the long strips are peeled off one after another.

As fast as removed the strips of blubber are put into the slicer, or blubber cutter, and chopped into half-inch slices, which are dropped into an endless bucket elevator to be hoisted to the blubber pots, where the oil is fried out by means of steam pipes running through pots. After the blubber is exhausted in these pots, it is conveyed in a chute to a drainage tank, where the bulk of the water is separated by gravity, and then to the dryer, where, mixed with the residue of the meat, it is turned into guano. After the blubber is removed from the carcass and the inside fat is taken out by chopping through the ribs, the carcass is hauled up to the carcass platform which is at right angles to and a few feet higher than the main slip. Here another gang of men remove the meat from the skeleton. This meat, which very much resembles beef both in appearance and flavor and is frequently eaten at the station, is put into pots arranged on both sides of the platform, where it is boiled and the oil extracted from it by an acid process. After the oil has been dipped from these meat pots, a sluice is opened and the residue is allowed to drop into the chute, where it is run into the drainage tank before mentioned, from thence going into the hot-air dryer with the blubber residue. Here it is made into guano by a drying process which dries the material thoroughly and then shreds it fine, after which it is ready for the market, its value as a fertilizer being very high. The blubber oil is ready for barreling as soon as it is cold, but the meat oil has to be clarified first, to remove the little particles of meat remaining in the liquid. The latter is the darker of the two oils, both before and after clarifying.

Heretofore, the parts of the whale utilized and the products prepared at a whaling station were as follows: Tails and tongues, sliced into thin strips and shipped to Japan, where they are eaten; oil, guano, bone meal, and the baleen or whalebone of commerce. A glue was also made from the residue of the blubber after boiling which was used for coating the insides of the barrels to hold the oil. In addition, experiments were made with the preparation of a meat extract from the flesh, and with the preparation of leather from the skin and stomach wall. An important addition to these uses, is the preparation and utilization of the flesh of whales as a food for the human family.

Seven whaling stations have been established along the Pacific Coast, and fully equipped for the preparation and handling of whale products. Each of these has its whaling fleet, that scours the ocean for a supply for the plant. These plants disposed of about one thousand whales during the season of 1918. It was my privilege to visit the Kyuquot Station in that year. My visit was at a fortunate time. The flenced carcass of a monster female whale was on the floor of the plant, and six others were anchored in the bay. These consisted of two Sperm whales, one Finback, one Bowhead, one Sulphur Bottom and one Humpback. They had just been brought in from a distance of sixty miles, thus showing how scarce whales are getting to be on the Pacific coast. When our vessel came into the bay and stirred the water, it was red with the blood of the slaughtered whales. I was able to examine the various processes of handling and converting whales into their various products. I was especially interested in the process of preparing and canning the flesh for human food and could see no reason why it would not be perfectly edible. In every detail it was done in a most cleanly manner. Certainly the flesh of a whale is grown or made from the cleanest of food and free from diseased conditions. Other nations use and relish the flesh of the whale as food. Why should not Americans do so? By doing so the question of meat supply will be much simplified.

HYDRANGEA ARBORESCENS VAR. STERILIS TORR. AND GRAY AS AN ORNAMENTAL PLANT.

David M. Mottier.

From time to time during the past twenty years, members of the botanical staff of Indiana University have pointed out to students the very showy and conspicuous specimens of the sterile form of *Hydrangea arborescens* L., to be found occasionally among the fertile plants of the species which grow abundantly on rocky banks, in shaded ravines and along streams in Monroe County, Indiana. These sterile specimens are very conspicuous because of the large, showy, snow-white flower clusters, in which not a single fruit is developed. Upon plants in their native habitat in the woods, the clusters of cymes often attain, in thrifty individuals, a diameter of from six to eight inches. Owing to their promising character as ornamental plants, and because of hardiness, specimens of sterile individuals were transplanted to the grounds of a local gardener near the university, where they have been under cultivation for a number of years. The plant is easily propagated from stem cuttings, and, in the second year, if pruned to a single cane or two, the clusters of flowers may attain a diameter of from fourteen to sixteen inches. For this reason, and because of the fact that sterile forms of *Hydrangea arborescens* are listed and offered for sale by florists under other names than *Hydrangea arborescens var. sterilis* Torr and Gray, the writer

Fig. 1.—Hydrangea arborescens var. sterilis. A clump transplanted when small from the woods to a blue grass lawn. It is three feet in diameter at the ground and bears about sixty-five large heads of flowers. (Courtesy of Mr. Hugh Hinkle.)

became interested in the probable origin of the sterile form as it occurs in this vicinity, and to know whether the plant advertised under other names may not have been obtained from the variety *sterilis* Torr. and Gray, taken into cultivation from some other part of its range, which, according to the manuals, extends from southern New York to Florida and west to Iowa and Missouri.

Fig. 1 is a photograph of a large clump of *H. arborescence var. sterilis* Torr. and Gray, which was transplanted from the woods to a blue grass lawn in the open sunshine. When transplanted from the woods, fourteen years ago, it consisted of a small plant with two or three canes. It has had no cultivation save an occasional watering in dry weather. At the present time the clump is three feet in diameter at the ground, and this summer bore sixty-five large heads of snowy-white flowers.

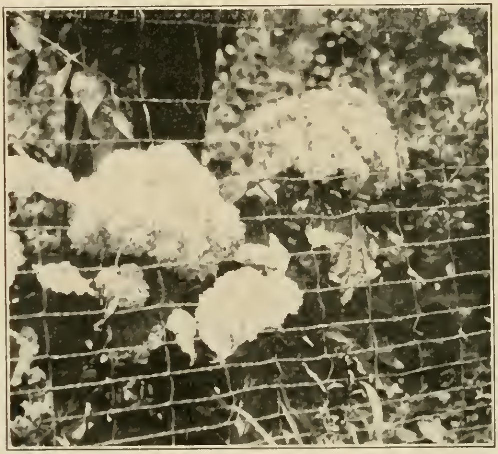


Fig. 2.—Hydrangea arborescens var. sterilis. Two flower clusters fourteen inches in diameter, borne by a plant two years old from a cutting.

Fig. 2 represents two flower clusters fourteen inches in diameter borne upon a plant two years old from a cutting.

Torrey and Gray[1] (Flora of North America, vol. 1, page 591) recognized four varieties of *Hydrangea arborescens* L. described as follows:

"a. *Vulgaris:* leaves ovate, obtuse at the base; flowers commonly all fertile.—H. *arborescens*, L.! (pl. gronov!) H. *vulgaris*, Michx.! etc.

"b. *Cordata:* leaves broadly ovate, more or less cordate, large; a few of the marginal flowers radiate, sterile.—H. cordata, Pursh.! l.c.; DC. l.c..

"c. *Oblonga:* leaves ovate—oblong, mostly acute at the base; a few of the marginal flowers radiate, sterile.

"d. *Sterilis:* flowers all sterile and radiate. The specimens upon which the description of this variety was based was collected at Wysox, Penna., by Mr. John Carey."

> In the later manuals (Gray and Britton and Brown) no varieties of *Hydrangea arborescens* L. are recognized. In both the sixth and seventh editions of Gray's Manual reference is made in the description of *H. arborescens* L. to the rare occurrance of radiant flowers thus: "flowers often all fertile, rarely all radiant, like the *Garden Hydrangea*." In the seventh edition the expression, "like the *Garden Hydrangea*", is omitted.

In Britton and Brown's Illustrated Flora (2nd edition) we find: "marginal sterile flowers usually few or none, but sometimes numerous, or forming the entire inflorescence."

In Bailey's Encyclopedia of Horticulture (Vol. 3, p. 1622, 1915.) three varieties of *H. arborescens* are listed as follows: "Var. *cordata*, Torr. and Gray, has the leaves broadly ovate and cordate. Var. *sterilis*, Torr. and Gray. A form with all the flowers sterile, sepals broadly oval, rounded or mucronate at the apex; leaves oval to oblong ovate, rounded or abruptly contracted at the base. It is doubtful whether this form is still in cultivation. Var. *grandiflora*, Rehd. A form of variety *cordata* with all the flowers sterile: heads 5-7 inches across; flowers ¾-inch across with ovate acute sepals; leaves ovate to ovate-elliptic; cordate or rounded at the base."

From the foregoing it is clear that Bailey regards var. *grandiflora* Rehder as a form of var. *cordata* Torr. and Gray, and expresses doubt as to whether var. *sterilis* Torr. and Gray is still in cultivation. He does not state when and where this variety had been in cultivation, nor are we told how var. *grandiflora* originated from var. *cordata*. Torrey and Gray (l. c. p. 591.) make no reference to the flowers being even occasionally all sterile in var. *cordata*.

The following remarks pertain to the wild specimens in the woods and to those transplanted to the lawn as stated in the foregoing, and not to plants propagated from those and subjected to cultivation. The native plants of *H. arborescens* L. growing in this vicinity agree with the descriptions in the manuals with the exceptions of the leaves. In Gray's manual the leaves are described as ovate, rarely heartshaped, while Britton and Brown refer to them as rounded, cordate, or rarely broadly cuneate at the base. In Torrey and Gray, the leaves are ovate or cordate, mostly acuminate, serrately toothed, puberulent or nearly glabrous.

In the plants observed by myself the leaves were generally heartshaped, although there may be a wide variation in different plants and upon different stems of the same clump. These gradations range from a broad, deeply cordate, truncate, to rounded and narrowly tapering bases. The smaller leaves near the inflorescence are frequently narrow with narrow tapering bases.

Variety *sterilis* possesses the same stem and leaf characters as the fertile species. The flowers, however, are all radiant, snowy-white, from 1½-3 cm. in diameter, very much larger in cultivated specimens; sepals broadly oval, rounded or obovate, somewhat pointed or rounded at the apex, but not mucronate; in most of the flowers stamens and pistil present, the latter becoming abortive, forming no seeds; in the rest of the flowers stamens and pistils rudimentary or none, or so rudimentary as to appear absent. It should be remembered that the radiant flowers of the fertile plants frequently bear stamens and pistils, the latter aborting.

Plants under consideration originated in nature from the fertile species, probably as a seed mutant or bud sport. They did not originate in cultivation.

If certain forms or varieties of *Hydrangea arborescens* merit the name "Hills of Snow," var. *sterilis* should be known in the garden as "Mountains of Snow."

In the near future a closer study will be made of the species in its natural habitat, along with the sterile variety. Owing to the conspicuous appearance of var. *sterilis* among the fertile species, the occasional specimens are readily found by plant lovers and removed to cultivation. As a result this variety is very rare in this vicinity at present. In the opinion of the writer the form or forms advertised by florists as *Hydrangea grandiflora* may probably be cultivated specimens of var. *sterilis*.

THE INDIANA FOREST PROBLEM.

Benjamin Wallace Douglass.

Emerson Hough has recently pointed out that we are living in a fool's paradise and that the time had arrived when we would have to take some measures to protect and if possible perpetuate our vanishing supplies of timber, coal and other natural resources.

The forest problem and the idea of making some provision for a future timber supply has for many years been before the public in a sort of half hearted way and it has been a source of inspiration for many half baked reformers who had turned to reform as a tired business man turns to golf. It has become a plaything for politicians and as a result there is no real progress in timber conservation to be seen.

It has recently been advocated that the solution of the problem in Indiana consisted in the purchase of some vast but vague number of acres of waste land and then reclaiming this land by the planting of trees. Such a project would be most admirable from the stand point of the political "reformer" for it would place in his hands a considerable amount of public money—and if there is anything that the average politician likes to do better than anything else it is to handle public funds.

Michigan forest land in which all young growth has been killed. Trees have been replaced by asters, fire weed and bracken ferns.

We are fortunately not in the dark as to the possible success of such a program for there have already been planted in Indiana quite a number of "forest plantations". It has been the writer's good fortune to visit many of these plantings and to secure data on the rate of growth, the value of the land, the possible return, etc. Without exception not a single plantation of this kind has produced enough to pay the taxes on the land it occupies. Without exception, every plantation visited could be characterized as an absolute failure. The best of them were planted on land that was good enough to be rated as good corn ground. In such situations young trees thrive fairly well but when planted in poor, "washed", abandoned soil the trees struggle along for years before they are large enough to cut first class bean poles. Certainly it is not proposed to buy high priced Indiana farm land, take it out of production and plant trees on it. And yet if we deliberately plant trees on the opposite type of land no one will ever be benefitted by the work—and the tax payers will have to foot the bill.

In southern Indiana we have still many thousands of acres of timber land. Some of this, most of it in fact, has been cut over more or less. It is difficult to find a tract from which no timber has ever been removed. There are other thousands of acres that have been cut over and practically all of the merchantable timber sold. This cut-over land has not been cleared for agricultural purposes, however, and still contains the stumps and roots of the former trees.

It is a well known fact that when a tree is cut down that the root will as quickly as possible send up one or more vigorous sprouts in an effort to replace the top. It is also well known that when the mature trees are

The forest fire is the worst enemy of our future timber supply.

removed in a forest the younger trees make a tremendous growth in a very short time. What then is to prevent these cut-over lands from replacing the trees removed much more quickly than similar trees could be grown on abandoned farm lands? There is but one answer to that question and that is "fire". Every year in Indiana we permit forest fires to rage over our timber lands and no one ever takes the trouble to do anything about it. In my own neighborhood we had a fire a few years ago that killed more young trees than have been planted in the state since the Board of Forestry was first organized. This particular fire was prevented from doing still greater damage only by the prompt action of a private individual. It was known at the time by whom the fire was started and a prosecution could have been made under the existing fire law but altho the authorities were notified they did not indicate any disposition even to investigate the matter.

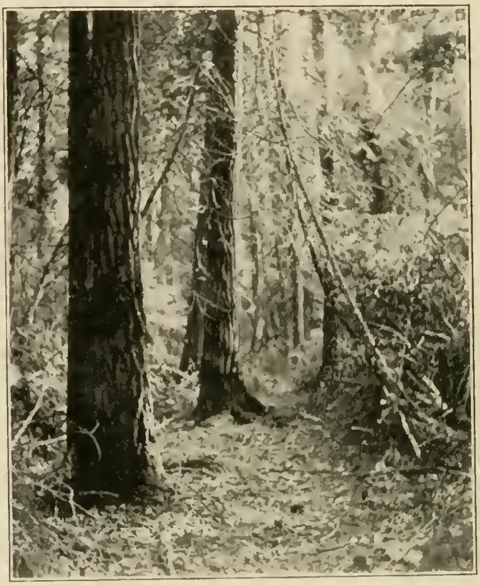
In our neighboring state of Michigan a similar condition prevails as it does in most of the states in the Union. Our public indifference to forest fires is preventing the growth of timber to supply our future wants and a stringent fire law would do more to perpetuate our forests than would any amount of forest planting on low grade state owned land. In Wisconsin I have seen large areas of white pine land that had been burned over year after year until even the humus had been burned out of the soil and only the pure sand sub-soil was left. In the same district I have seen small patches of land which have been protected from fire for thirty years or more and now have a perfect stand of pines nearly a foot in diameter. In Michigan I know of one tract of cut over land that has not had a fire in it for sixty years. To one who does not know the history of the place it is thought to be virgin forest and to all intents and purposes it is, for it bears a crop of trees that are ready for market.

A typical Catalpa planting. Plantings of this worthless tree have at various times been urged by the state.

In my own neighborhood in Indiana I know of one little tract of white oak land that has been protected from fire for over thirty years and supports a growth of very perfect trees nearly all of which are large enough to cut cross ties and many of them will make saw logs. On the same farm is another tract that has been burned over at intervals of a few years and the growth on it consists of sassafras, sumach, blackberry and tangled vines. If this tract should be protected for a few years the sassafras even would quickly reach a size that it would be valuable. Repeated burnings have killed successive crops of young trees until now only a stand of bean poles is left.

The question may be raised as to whether or not it is possible to enforce an anti-forest fire law. This might well be answered by referring to the results obtained by our northern neighbor. Canada has a forest fire law and enforces it. When a hunter or camper goes into a Canadian forest he knows beforehand just what will happen to him if he allows a fire to escape in the woods. The farmers have the same information and as a result such fires simply do not happen. The few forest fires that have been reported from Canada have either been set through agencies over which no control can be practiced (such as lightning) or they were "nipped in the bud" through the work of the law enforcing bodies.

The same laws and the same methods which have reduced Canadian fires to a minimum might well be applied to our own country and our own state. We would then have a chance to provide a timber supply for the future without tapping the public till to obtain funds for a gigantic experiment which is at best but doubtful in its outcome—but very certain in its outgo.



A part of a Michigan forest that has grown in the last sixty years. An evidence of what may be expected on cut-over lands when fire is kept out.

L. E. DANIELS—A BIOGRAPHICAL SKETCH.

BY

W. S. Blatchley.

Lorenzo E. Daniels was born March 4, 1852, near Mazon, Grundy Co., Illinois. He was reared on the farm, which he afterward inherited, and received his education in the country and village schools. He taught for two years, and later served one or two terms as sheriff of Grundy County. In time a portion of his farm became a town-site, so that he had in his later years a competence which enabled him to devote all his time to natural science.

In his boyhood days Daniels became interested in fossils and shells, and later in reptiles, conchology finally becoming his especial hobby. His home was located near Mazon Creek, which in that region flows through the Coal Measures, exposing numerous outcrops of the Upper Carboniferous Rocks. These he found rich in animal remains, especially in those of insects. In time he gathered personally one of the largest and most valuable private collections of Mazon Creek fossil insects extant. These were later worked up by a Dr. Handlirsch of Vienna and the results published as a Memoir by the U. S. National Museum.

In his study of recent Mollusca Daniels first collected all the species of land and fresh water shells near his home. After retiring from the sheriff's office he began to make annual collecting trips to other states, going the first few years to North Carolina, Tennessee or Florida, and later extending these trips to the far western States.

One of his sisters, Mrs. J. M. Foster, lived at Laporte, Ind., and for a number of years he made his home with her. While there he joined the Indiana Academy of Science, his name first appearing as a member in the Proceedings for the year 1900. It was at one of the Academy meetings about that time that I first met him. As I was then in need of an assistant to help me in locating the marl deposits in and about the lakes in northern Indiana, I secured his services and we worked together at that task during the summer of 1900. Finding him a willing and conscientious worker and an enthusiastic shell collector, I gave him a place as an assistant and field collector for the State Museum, and he served as such for four years. During the months from April to October inclusive of each year he collected shells, fishes, reptiles, batrachians and insects in different parts of the State. These he worked up and installed in the museum during the winter months. All the mounted turtles and snakes, the alcoholic fishes and reptiles, the butterflies in Denton tablets and 75% of the land and fresh water shells which were in the museum at the time I turned it over to my successor were collected and arranged by Daniels.

In the year 1899 I had published in my annual report as State Geologist an extended paper by R. E. Call, entitled "A Descriptive Illustrated Catalogue of the Mollusca of Indiana," which started out with the words: "This

Catalogue is intended to be complete and to fully exhibit our knowledge concerning the group of which it treats as presented in the fauna of Indiana." In it Call described, and for the most part figured, 185 species of land and fresh water shells from different parts of the State. In two years Daniels, by his close field collecting, found no fewer than 91 species not included in Call's catalogue. As up to that time he had had little experience in writing scientific papers, and as I was somewhat familiar with the subject of conchology, we prepared a joint paper entitled "On some Mollusca Known to Occur in Indiana: A Supplementary Paper to Call's Catalogue," in which these 91 species were described and many of them figured. This was published in the Twenty-seventh (1903) Annual Report of the Department of Geology. In the same volume was a paper by Daniels entitled "A Check List of Indiana Mollusca with Localities," in which the 276 species known from the State were listed and their local distribution given.

In 1905 Daniels returned to Laporte and later moved with his sister to a farm near Rolling Prairie in the same county, where he was living at the time of his death, which occurred in a Chicago hospital on October 23, 1918.

During his later years I saw Daniels only a few times, and these usually on occasions of the winter or spring meetings of the Academy, or when he visited this city in connection with his Masonic duties, a fraternity in which he took much interest and in which he received the thirty-third or highest degree. I last saw him at the annual meeting of the Indiana Audubon Society at Michigan City in May, 1917. He then told me that, in company with H. A. Pillsbry of Philadelphia, Junius Henderson of Boulder, Colorado, and Jas. H. Ferriss of Joliet, Illinois, all noted conchologists, he was making annual collecting trips to Idaho, Utah, New Mexico or Arizona in search of mollusks, reptiles, etc. The results of two of these trips were afterward published in joint papers by himself and Henderson in the Proceedings of the Philadelphia Academy of Natural Science.

Nearly a dozen species of fossil insects and shells were named in honor of Daniels by his co-workers and contemporaries. His private collection of land and fresh water shells was one of the largest and most complete in this country, and after his death was purchased by Bryant Walker of Detroit for the Museum of Zoology at Michigan University. His collection of fossil insects went to the museum of the University of Illinois. No disposal has as yet been made of his reptile collection.

During our four years of association on the State Survey I found L. E. Daniels to be a conscientious worker, an honorable gentleman, a genial companion. He was one of the kind of men who do much and say little. Of such men there are too few on this earth today. In his death this Academy lost a member of greater worth than is perhaps appreciated by most of us who are left.

I append herewith a list of the published writings of Daniels as far as I have knowledge of them. In addition to the two already mentioned there are three others which deal with Indiana Mollusca and may therefore be of more than passing interest to some of the members of the Academy. These are numbers 1, 3 and 4 of those cited.

1—Daniels, L. E.—1902—A new species of Lampsilis from the Wabash River. The Nautilus, Vol. XVI, pp. 13-14, pl. II.

2—1903—A Check List of Indiana Mollusca with Localities. Twenty-seventh Rep. Ind. Dept. Geol. & Nat. Resources, pp. 629-652.

3—1904—Geographic Range of Polygyra tridentata discoidea in Indiana. The Nautilus, Vol. XVIII, p. 92.

4—1905—Notes on the Semi-fossil Shells of Posey County, Indiana. The Nautilus, Vol. XIX, pp. 62-63.

5—1909—Records of Minnesota Mollusks. The Nautilus, Vol. XXII, pp. 119-121.

6—1911—Notes on Oreohelix, (Grand Canyon of the Colorado). The Nautilus, Vol. XXV, pp. 18-19.

7—1912—Abnormal Shells. The Nautilus, Vol. XXVI, pp. 38-42, pl. V.

8—Blatchley, W. S. & Daniels, L. E.—1903—On some Mollusca Known to occur in Indiana.—A Supplementary Paper to Call's Catalogue. Twenty-seventh Rep. Ind. Dept. Geol. & Nat. Resources, pp. 577-628, pls. I-III.

9—Henderson, Junius, & Daniels, L. E.—1916—Hunting Mollusca in Utah and Idaho. Proc. Acad. Nat. Sci. Philadelphia, pp. 315-339, pls. XV-XVIII.

10—1917—Hunting Mollusca in Utah and Idaho in 1916. Proc. Acad. Nat. Sci. Philadelphia, pp. 48-81, pls. XIX-XXII.

A METHOD OF DIRECT AERATION OF STORED WATERS.

BY

WILL SCOTT AND A. L. FOLEY.

The purpose of this paper is to describe a simple apparatus for the economic aeration of stored waters. The apparatus has been installed at the impounding reservoir and pumping station of the Indiana University water system.

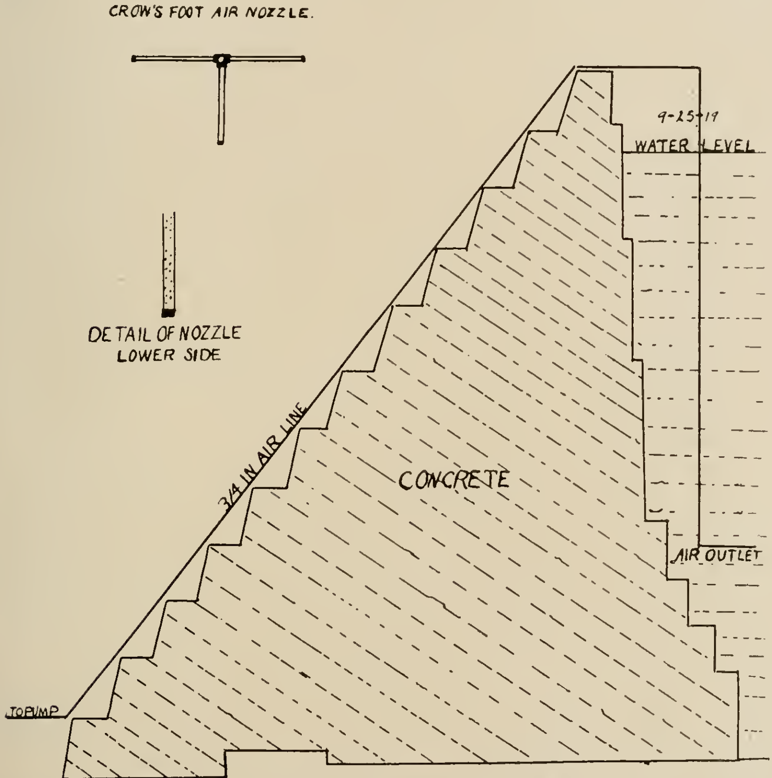


Figure 1. Shows the arangement of the air duct and nozzle in relation to the dam and the water level.

The impounding basin of this system is a dammed V-shaped valley, having the characteristic steep slopes of this valley type. These slopes are underlaid with the shales of the knobstone except at the upper levels where the shale is replaced with limestone. The knobstone is covered with a thin layer of soil on which it is difficult if not impossible to grow grass, partly because of the chemical composition of the soil, and partly because it is so thin. The only method for the prevention of erosion of the sides of the valley is forestration.

The form of the valley gives a deep narrow impounding basin, which is well protected from wind. This results in the complete thermal stratification of the water early in the summer. The leaves from the wooded slopes of the valley are blown into the water producing a very considerable amount of oxydizable material. The result is that during the latter part of the summer the oxygen is exhausted from the lower levels of the water. This oxygenless region increases in thickness until the autumn "turnover" and reaches the level of the intake early in August. As a result of this the water is very unpalatable during most of August and a part of September. Of course a better flavor could be obtained by placing the intake above the thermocline, but the water is carried directly to the taps without icing and hence it is a marked advantage to take it from the cooler water below the thermocline.

The apparatus consists of an ordinary compression pump such as is sold by the trade for use in garages. To this is coupled a ¾ inch air line which is carried over the dam and down to a point near the bottom of the reservoir, and just below the intake. This point is 9.75 M. below the top of the dam. At this end was attached a crow-foot formed of three ¾ inch pipes 7 feet long, and jointed at right angles to the line and to each other. The ends of these pipes are capped and small holes (⅛ inch) are drilled on the under side. These holes are 1 inch apart, placed alternately in two rows (Fig. 1). The pump is operated by a belt connecting it to the flywheel of one of the oil engines which operates the water pump. The pump usually runs eight hours in each twenty-four.

The pressure at the air outlet is slightly more than one additional atmosphere. The temperature was about 17 C., while at the surface it varied from 22 C. to 26 C. It was 22 C. on September 25, 1919. The increased pressure and the lower temperature would of course make the rate of gas absorbtion more rapid per unit of surface than it would be at the surface of the reservoir. By discharging the air through the small openings, small bubbles were produced which increased the surface per unit of air volume.

It was hoped that this operation would introduce enough oxygen to maintain a potable quality of water below the thermocline. The quality of the water was improved markedly, but the improvement was due, in part at least, to another set of factors which had not been considered when the apparatus was put into operation. These were the convection currents caused by the rising bubbles. The friction of these bubbles set up a vertical current that was approximately 100 sq. ft. in cross section. The rate of flow of this upward current was not measured but it was sufficient to raise the level of the surface some 2 or 3 cm.

The amount of dissolved oxygen was determined at various levels at the intake and at the deepest point in a cross section 150 feet above the dam. In the upper 8 M. at the upper station (the water was 1.75 M. below the top of the dam) there was more oxygen at every level than at the intake.

This indicates that the ascending currents carried some of the oxygenless water from the bottom toward the surface, while beyond the influence of this vertical current the water descended carrying with it oxygen which it had received at the surface from the air. Both of these currents were more or less mixed with the water that normally lay at the different levels.

The accompanying curves indicate the conditions in 1919 and also the conditions on the same date in 1912.

The usual method of aerating stored waters is to spray the water into the air or allow it to flow over rubble or an interrupted spillway. The advantage in the method just described is that it takes very much less energy to carry the air into the water than it does to force the water into the air.

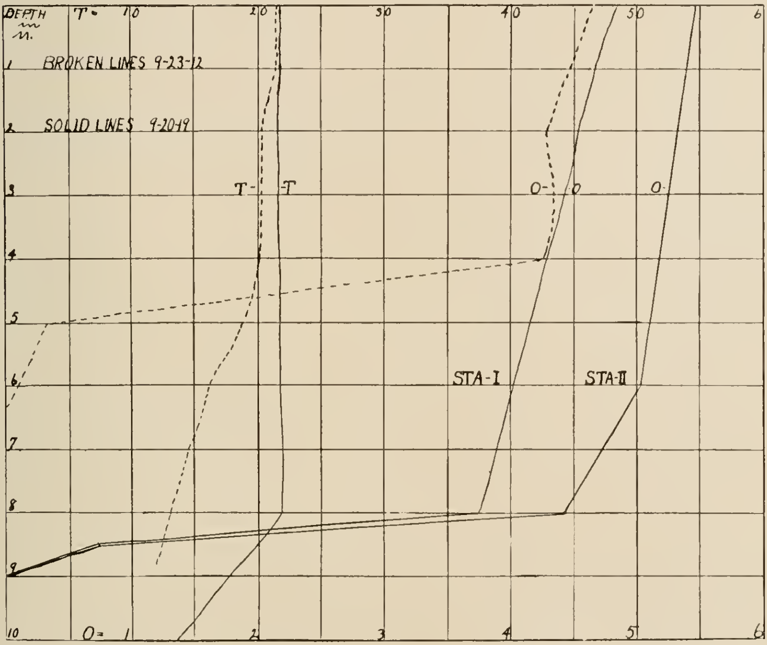


Figure 2. Broken lines are the curves for oxygen and temperature for September 23, 1912; the solid lines for September 20, 1919. T=temperature Centigrade. O=cc. of oxygen per liter. Station I is at the air outlet. Station II is 150 ft. up the pond from Station I.

THE DEPARTMENT OF CONSERVATION, STATE OF INDIANA, PRESENT AND FUTURE.

DIVISION OF GEOLOGY AND NATURAL RESOURCES.

W. N. Logan.

The personnel of the geological force as at present organized is as follows:

W. N. Logan, Ph.D., Economic Geology.

E. R. Cummings, Ph.D., Stratigraphy and Paleontology.

C. A. Malott, Ph.D., Topography and Glaciology.

S. S. Visher, Ph.D., Geography and Hydrology.

J. R. Reeves, Laboratory Assistant and Draftsman.

H. W. Legge, Preparator.

Office Force.

B. J. Malott, A.B., Assistant Geologist and Supervisor of Natural Gas.

A. J. Coleman, Curator of Museum.

Miss Alice O'Connor, Stenographer.

Field Corps for 1919.

W. N. Logan

C. A. Malott

P. B. Stockdale

Willis Richardson

Ted Jean

S. S. Visher

J. R. Reeves

G. A. Lee

O. H. Hughes

Fred Call

Topographic Corps, U. S. G. S.

Oscar Jones, Topographic Engineer.

J. I. Enders, Assistant Topographic Engineer.

Clarence Long, Chainman.

G. M. Rariden, Chainman.

L. C. Pitts, Rodman.

LINES OF INVESTIGATION.

The various lines of investigation carried on by the Division in the field and laboratory include: The investigation of the origin, mode of occurrence, distribution and utilization of Indiana kaolin. The results of these investigations are embodied in a report of some thirty thousand words accompanied by more than 100 maps, charts and photographs. A topographic map of thirty-six square miles in the heart of the kaolin district was completed for the use of those desiring to develop the kaolin mining industry.

A study of the stratigraphy of the Chester division of the Mississippian was continued by Dr. C. A. Malott who assisted in the field work on the kaolin report and later on, assisted by Mr. P. B. Stockdale made structural maps of portions of Jennings, Orange, and Pike counties and investigated oil conditions in Pike County.

One of the tasks assigned the Division by the passage at the last General Assembly of the Conservation laws was that of determining the amount of minable coal under navigable stream beds. The investigation of the amount of minable coal under the Wabash River in Vigo County was undertaken by Dr. S. S. Visher, who completed a report for publication. Dr. Visher also collected samples of limestones, collected information from industrial plants that use Indiana raw materials, located in Vigo, Clay and Putnam counties and carried on investigations in the oil field of Sullivan County.

In cooperation with the United States Geological Survey, the mapping of the Bedford and the Heltonville quadrangles lying adjacent to the Bloomington quadrangles was begun in September and continued until the first of November. Work will be resumed with favorable weather in the Spring.

PUBLISHED PAPERS.

Shorter articles were prepared and published as follows:

"The Natural Resources of Indiana and Their Utilization", published in the Guide book issued by the American Chemical, Metallurgical and Mining Institute.

"The Raw Materials of Indiana", published in the Chemical and Metallurgical Journal.

"The Occurrence of Coal in Monroe County", by the Indiana Academy of Science.

"On the Occurrence of Indianaite". Indiana Academy of Science.

"High Grade Clays and Kaolins of Indiana". United States Geological Survey.

PROPOSED LINES OF INVESTIGATIONS.

The division has in progress the investigation of the oil bearing shales of Indiana; the investigation of the shales of the Chester group and the fire clays of the state to determine their value to the ceramic industry; the investigation of the limestones of the state to determine which are best suited for agricultural purposes; the preparation of a hand-book on the Geology of Indiana. In the preparation of this volume, Dr. E. R. Cummings will have charge of the portion on stratigraphy and paleontology, Dr. C. A. Malott the portion on topography and glaciology, Dr. S. S. Visher the portion on geography and hydrology, and the writer the portion dealing with economic geology. Two advance chapters of this volume which have been prepared will be given wider distribution than the handbook. The study of the stratigraphy of the Chester group will be continued by Dr. Malott. It is hoped that we will be able to continue the topographic mapping until every quadrangle in the State of Indiana has been mapped.

THE DIVISION OF ENTOMOLOGY.

FRANK N. WALLACE.

The Division of Entomology of the Department of Conservation carries with it all the powers and duties of the old office of State Entomologist and in addition has new duties and broader powers than the State Entomologist had under the old laws. These powers and duties of the Division of Entomology cover such a wide field of activity that an appropriation of four or five times the amount now available would not be sufficient to see the work carried out as I would like to have it.

There are many duties of this office which are specifically required by our laws and it is only after these are accomplished, that we can turn to the other phases of the work. The field of insect study and control is so broad and the need so great, it is deplorable that more money is not available for this work.

Primarily, the State Entomologist's Office was established for the inspection and regulation of nurseries in the state and this is still one of its principal duties. The nursery agents and dealers are also licensed by our department and we now have a fairly good control over the nursery business. We have been able to eliminate most of the crooked methods which were practiced in the old days by some of the nurserymen and their agents.

The apiary inspection is an important part of our duties and this work has increased rapidly the past few years and most of the beekeepers of the state are now appreciating what the inspectors really mean to the beekeeping industry of Indiana. There is now a spirit of cooperation among the beekeepers, in the districts where the inspectors have worked during the past two years, that is extremely gratifying. Last summer I had four inspectors in the field and even then we could not cover as much territory as we had calls from. Yet, we visited 1772 apiaries and inspected 19,245 colonies. We were able to do this because we had a definite plan of work outlined last spring and followed it throughout the season. A comparison of this years work with former years will give you some idea of the benefit of our system of work. During the four years of Mr. Baldwin's regime, 844 apiaries were visited and 12,258 colonies of bees inspected. This record was taken from Mr. Baldwin's published reports and I am only quoting his figures. It shows that this season we did 57% more work than was formerly done in four years.

When disease is found we require each beekeeper to report to the office when his treatment of the disease has been completed and in most instances where we could get no report an inspector was sent out to see if our instructions were followed. We had to burn some hives on these reinspections as a few of the beekeepers still contend that they can keep bees in any manner they see fit. Out of 1772 inspections this season we have only 40 reports which have not yet been checked up on the work finished as we directed.

Beekeepers tours were held in many counties and 147 demonstration meetings were given where the treatment of foulbrood was shown and many other phases of beekeeping actually demonstrated.

Another service we have been able to render the beekeepers was securing sugar to feed colonies which were short of stores. All during the sugar shortage we have been able to secure sugar for all beekeepers in actual need of sugar and this fall we have again supplied many tons of sugar when it could be secured in no other way.

Under the Conservation Act we have very broad powers and the Division of Entomology should be able to handle any emergency that may arise in insect or plant disease control. It was this very fact that we did have the power to handle such situations that helped us this summer at Washington when the Federal Horticultural Board was considering placing a quarantine against the shipment of all small grains out of this state, because they believed the "Take-All" disease of wheat was established here. The Chairman of that board, Dr. Marlatt, said he hoped some day each state would see the wisdom of giving broad enough powers to a commission or board so that emergencies such as ours, could be handled by the states themselves, without the federal government having to establish quarantines against them.

You would naturally suppose that any excitement caused by an insect outbreak would be to our liking, yet we often bend our efforts to allay the excitement rather than add fuel to the flames. The army worm scare this summer will illustrate this. While in the southern part of the state, I had an urgent call to go to Henry County and when I arrived there a day late I found about two or three thousand farmers and other volunteers out digging trenches around wheat and rye fields. Not one trench in a hundred was effective and in only one case was trenching really necessary. I asked the newspapers to publish the real facts in regard to the army worm situation in their county and to get the farmers back to work on their corn which needed cultivation. The army worm panic cost $30,000 a day in that county as a farmer's time was worth at least $10.00 per day in his corn fields and the trenches that were dug were worse than useless. The army worm scare did an immense amount of damage because the first people on the ground did not understand conditions. I saved many counties from having a similar panic by getting there in time to allay their fears by showing the real conditions.

The florists have many perplexing insect problems and have had very little systematic help in any of the states. Their problems are different from the farmers or gardeners in that they do not have seasonal controls such as the winter brings to the farmers. With the thermometer held at a growing temperature the insect pests can multiply all year unless artificial means are used to control or exterminate them. A wide range of plants is often grown under one roof and an insecticide, which will give results on one plant, will ruin the foliage on others. I am hoping to be able to give the florists and greenhouse men more assistance along these lines and have plans under way to assign a man to this work this winter. We have rendered much valuable assistance to the florists but I would like to standardize some of the methods so that the growers would be able to apply remedies before pests became numerous enough to do serious damage.

I am often asked if insect damage is greater now than thirty or forty years ago. It is a difficult question to answer, but I believe that with our present knowledge and methods of control the insect pests do relatively less damage. The farmers and growers now recognize that much of the insect damage is preventable and are accepting any practical control which is presented to them. I hope the Division of Entomology will be able to render greater assistance now than it has under the old office.

THE DIVISION OF FORESTRY.

CHAS. C. DEAM.

The popular definition of forestry is the work of growing forest trees; their sale and conversion into lumber. This conception of forestry is the one, for the greater part, that is practiced in the United States. Foresters, however, see a wide difference between the growing of a tree and its utilization, and suggest a more restricted definition of the term. They prefer something like this: "Forestry is the work of growing the *greatest amount* of the most *valuable* timber in the *shortest* time at the *least expense*." The forester grows the forest; the axman and millman destroy it, diverging operations.

In the five minutes allotted to me to discuss this subject, I must assume that you are already acquainted with the present work of the Division of Forestry, and I will call your attention to the possibilities of the forestry of the future.

The achievements of the *future* must not be measured by those of the past. The present high price of lumber is arousing the people from their apathetic state of mind, induced by being surrounded on all sides by forests for centuries. The lumberman years ago appreciated the shortage of timber when he was compelled to go to other States for a supply. The consumer who is just behind the lumberman is now beginning to feel the pinch, and is asking, "will the present high price of lumber continue, diminish or increase?". I answer, "they will increase unless active measures are adopted to provide a future timber supply." How is this to be done? First, set aside enough timber land to insure a future supply of timber. In doing this it is best to err on the side of having too much rather than too little.

A study of the social and economic conditions of the land owners of the State, which considers the geographical location of the State, the fertility of our soil, the small size of our farms, the improvement and high price of our land, our railroad facilities, etc., shows that little can be expected from private forestry, and that our future timber supply must come from State owned forests.

The latest statistics credit Indiana with about two million acres of good timberland. The annual cut in the State far exceeds the growth. Yet, with this excessive cutting, our present forests furnish only 30% of the timber we consume. It is extremely conservative to place the number of acres of timberland we should have at a million acres. How many acres of timberland does the State now own? Only 2,000 acres. When the State buys 998,000 acres more, we can feel reasonably secure as to our future supply of timber.

Our forests must be placed under scientific management. Our empirical knowledge of forest management must give way to such work as is being done on the Clark County State Forest. Here a study is being made on about 175 acres which is divided into about 75 plots on which have been planted and are growing 24 species of native trees. This study consists of making and recording observations on the species in the several plots to throw light upon some of the following problems: Why do not forest trees bear seed every year? Why are the seed more viable some years than others? The best time of year to gather the seed? How to handle and store them? When to plant the seed? How deep to plant them? What protection the seed and seedlings should have in the nursery? The size of the seedling to be planted? The best time of year to plant? The spacing required by each species? What cultivation, if any, the young trees should receive? The control of insects and diseases. Now these problems with others, must be worked out for each species separately, and on different sites, before the forester's definition of forestry can be fulfilled.

The facts of plant physiology, those of physical and colloidal chemistry and other sciences, must be used to penetrate the unknown of plant behavior and response. The recent discovery and application of the laws of heredity offer a great opportunity to the forester. By breeding we have seen how quality and quantity have been greatly increased in both plants and animals, and it is reasonable to presume that in time, the forester will be able to double the growth rate of trees and greatly improve the quality of the wood. The nuts of the hickory and walnut will be improved as much as those of the pecan.

It is believed that the cry of the people for relief from a timber famine will be heard. The response will come from a Legislature that will know no politics; heed no preferences or prejudices; and will generously provide for State forests and their scientific management.

THE DIVISION OF LANDS AND WATERS.

Chas. G. Sauers.

Recreation is necessary to the stability and physical welfare of the community. The Lands and Waters Division is seeking to furnish recreation to a large share of the Hoosier public through the establishment of State Parks. Two are now maintained—Turkey Run in Parke County and McCormick's Creek Canyon in Owen County. There were 33,500 visitors to Turkey Run during the past season. Accessibility has been a great problem.

The auto now permits use of sites which a decade ago would have been inaccessible backwoods retreats. Our ideal is a chain of state parks, depicting the great natural beauty and physical features of the state, connected by a state parkway. A trip over this road would show virgin tracts of timber, broad open prairies, the Ohio valley, the magnificent beech woods of Southern Indiana, the lakes of the north and the great mining and quarrying districts—a gallery wherein are displayed the natural resources and beauties of Hoosierdom.

The Division of Lands and Waters is charged with investigation of cases of stream pollution. Our rapid industrial development has greatly increased the pollution by industrial waste, until the situation has become acute in many localities. The question is entirely economic and requires earnest co-operation between public, state and commercial interests. A campaign of relentless prosecution cannot succeed. It is the policy of the department to seek out cases of pollution and work with the offender to remedy the situation. Of course where reciprocity is lacking, the offender is prosecuted. The whole problem is very complex and requires the combined work of biologists, chemists, and engineers. The Department of Conservation is the logical clearing house for pollution matters, for developing co-operation among industries concerned, so the findings of the scientists may be made available. Much waste material may be reclaimed in profitable by-products; in some cases the disposal means increased cost in production of the original article, in any case the value of any waste product is its commercial value, when properly recovered, plus the amount of loss it occasions when unrecovered.

An almost untouched field is the regulation of the removal of sand, gravel, coal and marl from lake and stream beds. The drainage situation in the north must have exhaustive study.

The Division is an infant with enormous possibilities for growth. The duties bestowed upon it by the conservation law are numerous and far reaching. Our ideal is the establishment of a system of state parks—"public estates", where money spent in development will be profitably invested but where the chief return is in pleasure, happiness, and vitality, the value of which it is impossible to estimate; streams, which are clean and wholesome and abound in fish for the angler, furnish beauty to the tourist and healthful water to the cities; streams and lakes which have not given up their beauty and utility needlessly to the dredge; in brief the control of the lands and waters of the state to the end that they may serve their most desirable, useful and economical purpose with the greatest possible profit and pleasure to Hoosiers.

DIVISION OF FISH AND GAME.

George N. Mannfeld.

History and observation compel us to believe that conservation is more professed than practiced; that much that assumes the name and passes as such, is utterly spurious. Yet it is true that the doctrine of conservation, which seeks public good, is in obedience to the laws of nature, and a real and active virtue.

There can be no doubt that certain men are endowed with a sort of inherent instinct which leads them to hunting and fishing. There is nothing so satisfying and alluring to them as a day in the open. I think it may be safely said that the true hunter and fisherman is born, not made. I believe, too, that those who by instinct and birthright belong to the sporting fraternity are actuated by a genuine spirit of conservation. They are neither cruel, nor greedy and wasteful of the game and fish they pursue, and I am convinced that there can be no better conservators and protectors of game and fish, than those who are most enthusiastic in their pursuit. For it is they who restrain and regulate themselves, showing thereby fairness and generosity which is felt and recognized only by a true sportsman.

To the Indians and especially to the pioneers the word conservation had but little meaning. Our resources were used by them only to satisfy their needs. There was such an abundance that little thought was given to hunting and fishing for pleasure, or to cutting away the forests for profit. It was largely a matter of necessity with them.

All this has changed, and we now consider these natural resources from an entirely different angle. This means that a radical change has taken place since the days of the pioneers. Fishing and hunting as an occupation is a thing of the past. The trapping of fur-bearing animals, once a very profitable business, now will require strict regulation.

The disappearance of wild life in Indiana can be attributed to many things. However, they can all be traced back to the main cause, which is man himself. Nature in lavish fashion originally provided things so orderly that each particle of vegetable, mineral and animal life was put in its proper place. Man was only a minute thing in the grand whole, but, by his superior powers he has put himself in a dominating position. He has, in fact, made himself the possessor of all other things. This has come about through a slow process of evolution. There was a time when man was in the minority. All around him was an army plotting and waiting for a chance to attack and annihilate him. His enemies were all about him. They were the powers that ruled, but in time they were checked and man, assisted by his allies, the birds, became the conqueror. Today, he regards with disdain the army which is an enemy, and is prone to forget his true friends, the useful insectivorous birds. Being endowed with superior intelligence, he has been able to secure control over all the lower forms of animal life. This does not mean that his position is secure, but rather how strong his enemies may become, and how wisely he is holding his alliance with his feathered friends.

It is but natural that we should partake freely of the supplies of nature. That is what they are here for, but beyond satisfying our real needs, we have no right to destroy them to gratify our passions. For, should that be so, it would lead to the conclusion that one generation has the right to exterminate living creatures and deprive all future generations of their share of them. The remnant of wild life that is handed down to us, is a heritage. It should be used economically to supply our needs only, and then be passed on to our descendants. We have inherited a treasure, and it is a responsibility we have to see that others are left that heritage.

If the natural law was strictly observed, the balance in nature would remain fairly even. Upsetting the balance has resulted in a great need for conservation. Thus it can be seen that the enactment of protective laws was necessary, and their enforcement absolutely imperative now.

Wild life depends on forests for shelter and food, but mankind has taken them over for profit. Whole forests have been destroyed merely to gratify a desire for wealth. Little thought has been given to the consequences. Thus has wild life been destroyed and driven away.

In like fashion what has been done with our streams? Water is one of our primary natural resources and absolutely necessary for our existence. Instead of safe-guarding it for our own use and that of generations to come, we are daily polluting it and making of our streams dumping grounds for filth. Thus have the waters of our state year by year been made less fit for fish to live in and their number greatly lessened.

One of the first requisites then is to see that birds, game animals and fish have a home and proper environment to live in; then to see that they have food and are properly protected when they are reproducing themselves. This must be done by strict laws rigidly enforced. In proceeding with the work of game and fish conservation, the co-operation of every good citizen is needed. Public opinion must be molded in favor of game and fish laws. The public press here becomes of great importance.

Laws are but the crystallized expression of public opinion. If public opinion is opposed to a law, merely putting it on the statute books will not produce any results. It is necessary to create and foster an enlightened public opinion. When that is accomplished game and fish laws become more easy and effective of enforcement.

What is needed therefore, is a campaign of education. The public as a general rule is not informed as to game laws and the reason for their enforcement. As a wise man said, "He who knoweth the law, and knoweth not the reason of the law, knoweth not the law, for the reason of the law is the life of the law." If this be true, it follows that to teach the public the reason of a law is the first requisite. Game and fish propagation serve as an aid toward increasing wild life in the state, but the greatest good it accomplishes is in educating the public.

Fish hatcheries and game farms bring to public notice the life history and habits of fish and game in their wild state, which could not be imparted in any other way. A visit to a fish hatchery while the fish are spawning, convinces one that they should be protected when spawning in the lakes and streams. Such a visit has converted many a violator who formerly killed fish while on their nests.

The foregoing leads to the conclusion that:

1. Birds are of value to the people as insect, rodent and weed seed

destroyers; that they aid our vegetable and other crop producers, and assist in preserving our fast diminishing forests.

2. That game and fish are valuable as a food asset.

3. That hunting and fishing are an incentive and inducement to outdoor life, whereby man may recuperate his powers and renew his health.

4. That game and fish are valuable in an economic and financial way, because of the tourists' and sportsmen's travel attracted thereby.

These in themselves are well worth any effort that we put forth to conserve the supply of fish, game and birds of the State.

CONCLUDING REMARKS.

RICHARD LIEBER.

The Department of Conservation has for its object the business-like management of the people's interest and share in Nature's gifts. Reduced to its primitive principles, the basis of the wealth of a people consists in the relative fertility and productiveness of the land it inhabits. Water, air, soil, its richness in mineral and its fruitfulness determine the possibilities of national wealth, while cultivation, propagation and conservation are the forces at work which will guarantee the greatest possible return from Nature's bounty. To obtain this desirable end, sundry state offices were created in the past, which led a disconnected existence. As political offices they may have worked satisfactorily. As public offices, with the best of intentions on the part of able and industrious office holders, they have been failures or near failures.

Besides that, these offices were created at different times and in no way coordinated with the business of the State at large. That much overworked word "reconstruction" nevertheless found a correct use when applied to the realignment of all of those offices which have to do with the conservation of natural resources of our State, for the most backward in national economics is being driven to admit that public offices must serve as agencies to advance the interests of the human society, and their activities, therefore, must not only be efficient in their particular line, but must also be kept up to the modern standard of keen business administration.

Order is the first requisite of successful business: Order and co-ordination. In a private business the various branches are all co-ordinated. There is a system whereby the most infinitesimal detail is within immediate reach of the head of the institution. A private business would never dream of establishing a branch and then leave it to its own devices until inventory time, as the State does. In State affairs we have noticed that whenever a new demand was made on the state's administrative force, a new office or a new commission had to be added which, while in semi-touch with the administration, was entirely incapable of aligning itself with the balance of the state's work performed in the many other Departments, because it was thinking and operating disconnectedly.

Laboring under these conditions the State House has resembled more an office building where people hardly know their neighbors than a department store or an industrial plant where everybody is fitted into a coordinate place and function.

The Department of Conservation is an attempt on a large scale and I believe a successful one. at coordination. Every one of its branches is depending on and co-operating with the other.

Charles Richard Van Hise tersely says. "The principle of Conservation is not a simple subject which can be treated with reference to a single resource, independently of others: it is an interlocking one. The conservation of one resource is related to that of another. * * * * * * * * * A complete treatment of any part of the subject in all of its ramifications of necessity repeats a portion of the treatment of another part of the subject."

It has been the experience of those states that are in the lead of conservation work—New York, Louisiana and Wisconsin—that no single natural resource can be dealt with separately and independently from the other, and that only consolidation of the work makes real results possible.

The correctness of this theory was proven out in the first six months of our work. Not only did this natural support of one Division by another greatly facilitate work, but it also saved a great deal of time and avoided duplication. It made larger results possible, or, to put it in another way, it got more direct returns out of the moneys appropriated.

Starting with a well defined policy of self-limitation, it nevertheless took the Department some time to get under way because of the difficulty of limiting the scope of work in a well nigh unlimited field. Requests, if not demands for assistance, were naturally made, which, even if the office force had been adequate, would have exhausted our funds in short order. Many of these demands were entirely reasonable and in many instances the people should have had relief where we found it impossible to help owing to lack of personnel and funds.

If ever proof was wanted that the State needed a Department to conserve its natural resources, the large and variegated correspondence in our office containing requests for assistance and advice would furnish it. From topographic survey to petroleum lands; from analyses of clays, soils and minerals to identification of relics; from a lonely elm tree to Sand Dunes; from drainage projects to the use of cat-tail swamps as food producers; from farmers' woodlots to flood control; from kaolin to coal; from the protection of game and fish to that of lake levels; from stream pollution to fish culture; from wheat diseases to sugar supply for beekeepers, and so on without end.

As the Department advances, these demands will increase. The organization is such that it may be indefinitely enlarged and it is left to the wisdom of our lawmakers to make more extended work possible by legislative action. But before a legislature would be willing to appropriate more funds, it must needs have proof of results. Let me cite a few.

The working agreement between the Department of Conservation and Indiana Univrsity whereby a part of the Division of Geology's allotment of funds is paid out for field work during the summer months, gives the State practically eight months laboratory and research work in addition. free of cost. A part of that work is recognized in the report on Indiana Kaolin, Oil-bearing Shales, Limestones, the report on coal under state lands and the Handbook of Geology now in preparation.

By order of the Conservation Commission a log has to be kept and returned to the Office on all new wells drilled for oil and gas. Aside from safeguarding the field in a thorough manner these logs are of very great value in determining the substrata.

The work of the Division has demonstrated the need of a thoroughgoing soil survey in conjunction with the United States Government. The building stone industry has received valuable assistance through the result of a topographic survey conducted in Lawrence County together with the United States Geological Survey.

The Entomologist's efforts in warding off a Federal quarantine against Indiana wheat and thereby saving the Indiana farmers very considerable sums of money was made possible only by the fact that the Department has been clothed with police powers. Of similar value was the assistance rendered in the fights against the Army Worm and the Chinch bug.

The Tri-State Forestry Conference held in conjunction with the Federal Government and the wood-using industries is a land mark in the development of an effective forest policy.

A new hotel which was much needed has been completed at Turkey Run. Turkey Run, the first State Park to be developed, stands the State approximately $80,000 which includes individual contributions to the amonut of $40,000. In the past season (May to October inclusive) it has returned in round figures, an income of $4,500, thus showing that state parks, if needs be, can be made self-supporting.

Reference is made that the Division of Fish and Game distributed withln the State approximately 1,500,000 fry and fingerlings.

The results in the Game Warden Service were largely made possible through the readjustment of the work and speak for themselves. As a matter of comparison it is stated that whereas, in the first six months of the fiscal year 171 convictions for violations of the game and fish laws were made which brought to the school fund $985.00, the second six months returned 542 convictions and $3,310 to the school fund. Comparing with the preceding fiscal year a saving in salaries and expenses of $9,515.10 was made and an increase of revenue was had in the amount of $9,110.98; a total of $18,626.08. It should be mentioned that this is merely a beginning as the Department lost nearly three months in the necessary reconstruction of the force.

The publication of Dr. Evermann's remarkable Monograph on Lake Maxinkuckee is a work which is expected by the scientific world with keen interest and will widely advertise the natural advantages of Indiana lakes.

A full list of publications is as follows:

"Laws of Indiana Relating to the Natural Resources", 123 pages—compiled by Charles Kettleborough.

"A Digest of the Laws for the Protection of Fish, Game, Birds and Fur-Bearing Animals."—1919-1920, 44 pages.

"Your Part in a United Effort to Protect the Fish, Game and Birds of Indiana."—6 pages, Chas. Biedenwolf.

"The Way and Wherefore of Conservation in Indiana."—1919, 8 pages.

"Train Schedules and Hotel Rates of State Parks." Leaflet.

"Trees of Indiana", 299 pages—Chas. C. Deam.

"Turkey Run State Park, History and Description", 48 pages.

"The Natural Resources of Indiana and Their Utilization", W. N. Logan—Published in guide book of American Chemical, Metallurgical and Mining Institute.

"The Raw Materials of Indiana"—In Chemical and Metallurgical Journal.

"The Occurrence of Coal in Monroe County"—Indiana Academy of Science.

"On the Occurrence of Indianite"—Indiana Academy of Science.

"The High Grade Clays and Kaolins of Indiana."—U. S. Biological Survey.

On Press.

"Indiana Kaolin"—W. N. Logan—50 pages (estimates) Maps, colorprints and halftones.

"Lake Maxinkuckee" a monograph—Barton W. Evermann—1,500 pages (estimated), Maps, colorprints and halftones.

"Proceedings of Tri-State Forestry Conference, 100 pages (estimated).

That, in part, is the work done in the first six months of our official existence.

The importance of conservation, at this time, is only dimly seen. But, as Van Hise remarks: "In a hundred years from now the great political issues will be forgotten, but our times will be noted for the beginning of that movement which is destined to protect our natural wealth and build up a true appreciation of national values and responsibilities."

Up to the beginning of the present century we were all living in a fool's paradise, thinking that we were richer in every way than everybody else in the world, believing that our natural resources in minerals, coal, forests, waters, game and fish were inexhaustible. Our very laws expressed and breathed this spirit. We know now that in visible time we will have reached an end of many of Nature's gifts. The past war, for the first time in modern times, has confronted us with the ugly realization of a universal shortness of food. How then, could laws that were made before we knew what ailed us, before we realized our true condition, before we went through the actual experience, be made applicable and of working efficiency in our present day status?

The natural wealth of the State is the foundation and main-stay of our prosperity. The proper use, propagation and conservation of these riches are of the utmost importance to all of the people within the State and should be treated comprehensively in an entirely non-partisan, non-political and business-like manner. It is purely and simply a business matter, whether our people will get much or get little out of their own State. That they should get all that is to be had and that the natural wealth of our State may be kept in sustained use is the work of the Department of Conservation.

THE CHEMIST AND THE COMMUNITY.

Wm. M. Blanchard.

Some twenty-five years ago there was to be found in a certain college town a spring to whose waters had been ascribed for many years very pronounced medicinal qualities. People came from quite a distance to experience the efficacy of the healing fountain. The water possessed an odor suggestive of hydrogen sulphide and it became known as a sulphur water. It was taken on faith, no analysis of the water ever having been made. During long, dry summers the spring had a habit of withholding its healing fluid.

In course of time the benevolent old gentleman who taught chemistry at the college passed away and was succeeded by a much younger man whose interest in practical chemistry had kept pace with his studies of atoms and molecules. The famous spring attracted his attention. An analysis of the water showed evidence of marked sewage contamination and further investigation revealed the fact that the main sewer of the town, whose location had apparently been forgotten, passed within twenty feet of the spot from which the curative waters flowed.

The writer had a similar experience several years ago with several springs of Greencastle. Waters that were believed to be not merely potable but even particularly beneficial on account of the supposed presence of special salts were found to be merely well charged with bicarbonate of lime and the products of sewage decomposition.

But it is not merely in the examination of public waters that the teacher of chemistry may be of service to his community. To illustrate further, the town of Greencastle has not felt able to supply itself with paved streets but, like many other towns of the state, must still be content with Indiana lime stone. To keep down the dust during the summer liberal applications of road oil have been used for several years. The effectiveness of the oil has been by no means uniform and in some cases it has served its purpose for only a few weeks. Last spring various samples were submitted to the city council, each guaranteed to contain fifty per cent asphalt, prices practically the same. It was suggested that the chemist at the University in the town test them out and to such a request he readily responded. The oils were found to contain anywhere from thirty-two to fifty-six per cent of asphalt. The one with maximum content was chosen and as a result, although the summer was an unusually dry one, the residents were not troubled with dust during the entire summer.

One other instance may be cited. Last year the quality of coal gas supplied Greencastle varied considerably in quality and at times was practically of no use at all. Complaints had been made for some time but all break-downs and poor service generally, like every other evil, were attributed to the war. Near the close of the year the gas company asked the State Commission for an increase in rates and was granted it provided the company would maintain a gas output of standard quality. The plant being a small one, the company did not feel able to install a standard gas calorimeter and the town was not willing to bear the cost alone. At this point the instructor of chemistry at the college proposed that if the city and the company would together pay the cost of an inexpensive calorimeter, he would install it in his laboratory and make regular tests without charge. This proposition was accepted. An inexpensive instrument was secured and tested and standardized by an official calorimeter from the Bureau of Standards of Washington. Gas tests have been made quite regularly for many months and the quality of the gas has been maintained of a quality satisfactory to all parties concerned.

These illustrations indicate some of the various ways in which a chemist, even a teacher of chemistry, may be of practical service to his community. This brings us to the main point of this brief paper. Chemistry has come to be recognized as a distinct profession. The American Chemical Society is the largest organization of men of a single science in the world, its membership now running beyond the fourteen thousand mark. The large majority of these men is employed as research men or for routine work in chemical industries all over the country. Many others are professional consulting chemists who maintain professional laboratories where all kinds of chemical analyses are made and where various industrial problems are taken in for investigation and solution. Still others are teachers of chemistry and directors of research in our colleges and universities.

The value of chemistry to the nation, the state, and to every community is recognized. A professional chemist in any community would be of great service to the people at large in that community but the actual amount of work to be done in the town of average size would not warrant his employment for this purpose alone. Why not combine two functions? Why may we not have in every high school that is in a position to maintain a chemical laboratory a man of sufficient training and provided with an equipment of sufficient size and variety, not only to meet the requirements of a high school teacher but also to meet the more urgent chemical needs of the community? A little work of the latter kind would not only be valuable service to the public but would also stimulate interest in the subject of chemistry on the part of the students and very likely would lead to the discovery of many an embryonic scientist.

Where the city is of sufficient size to support a professional chemist, this work can be left to him. There is no thought of any competition on the part of the teacher of chemistry, whose chief business is to teach, with the professional chemist who has chosen this occupation as a source of livelihood. It is felt, however, that herein lies the possibility of a cooperation between our state laboratory and the chemical laboratories of our high schools and colleges to which some consideration might be given with resulting benefit to both schools and state. The competent high school teacher of chemistry might function as a kind of outpost of the state laboratory, the community providing the necessary material and equipment and the state laboratory such assistance as might be needed. Such cooperation would undoubtedly prove stimulating to the high school teacher, an assistance to the state laboratory, and of real benefit to the local community.

SEGREGATION AND GROWTH OF CRYSTALS IN BEARING METALS.

BY

E. G. Mahin and J. F. Broeker, Jr.

Purdue University

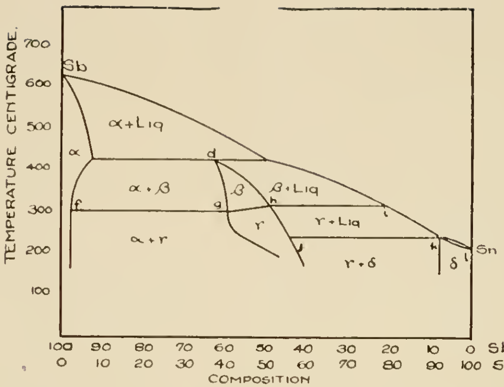
Bearing metals that have been used successfully in industrial practice are alloys that crystallize as conglomerates upon cooling from the liquid condition. A commonly accepted theory accounts for the anti-frictional qualities of such alloys upon this basis. It is understood that there must be certain hard particles embedded in a softer and more yielding matrix. The hard components serve to resist abrasion and to endure the wear and they are enabled to assume a form to accommodate microscopic irregularities of the moving journal surface through the limited plasticity of the supporting metal.

This being true, the conclusion seems obvious that it is highly important that a good bearing metal should be so constituted that the hard crystals are relatively small and well distributed but this is a most difficult condition to obtain in practical bearing casting. The formation of various metallographic constituents occurs at different temperatures and continued heating of the alloy results in rapid growth of any crystals that may have formed at that temperature or at a higher temperature. Also it is generally true that either flotation or settling occurs in the semi-liquid mass during cooling, since there are often considerable differences between the specific gravities of the solid and liquid portions. Growth and segregation may thus result in the formation of a bearing of very poor anti-frictional properties, even though the composition of the alloy as a whole is correct.

The work described in this paper has to do with one phase of an investigation of the relations existing between melting and pouring conditions on the one hand, and crystal segregation and growth on the other, of the alloy of tin, copper and antimony known as Babbitt metal or Navy Babbitt metal. The alloy used in the experimental work had the composition: tin 85.70%, antimony 9.86%, copper 3.34%, zinc 0.70% and lead 0.40%. The last two metals are to be regarded as impurities rather than as essential constituents.

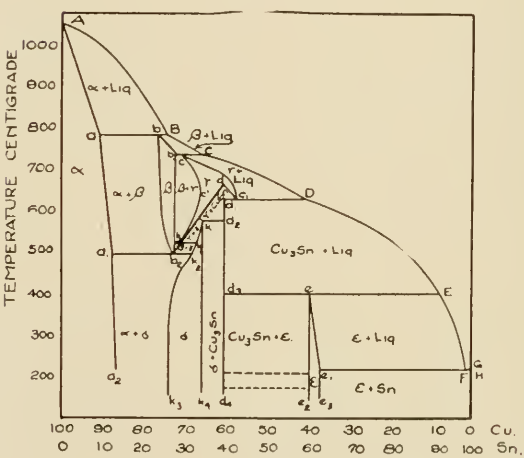
The constitutional diagrams for the binary tin-antimony and tin-copper systems, respectively, are shown in Figs. 1 and 2. These represent the conclusions of a number of experimenters and the diagrams are reproduced from Gulliver's "Metallic Alloys". The constitutional diagram for the ternary system tin-antimony-copper is not so well worked out but a part of the diagram, more or less idealized, is shown in Fig. 3. Referring to the composition of Babbitt metal, given above, it will be seen that the only metallographic constituents that will have any considerable importance in this connection are ϵ-tin-copper and γ-tin-antimony crystals. In the the photomicrographs the latter are shown as cubes, the former as peculiarly shaped crystals arranged in straight chains, stars and triangles.

γ-tin-antimony is the hardest constituent of this alloy and it also has the lowest specific gravity. It forms on the branch i-k of the liquidus of



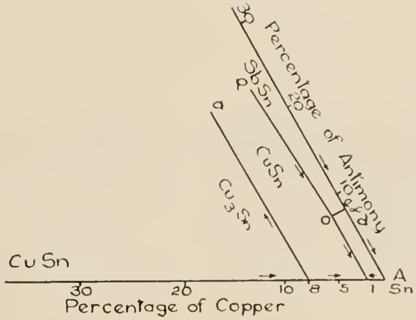
Equilibrium Diagram for Antimony Tin Alloy

Fig. 1



Equilibrium Diagram for Copper-Tin Alloys.

Fig. 2



Part of Provisional Copper-Antimony-Tin Diagram.

Fig. 3

Fig. 1. ε-tin-copper also is hard, has a lower specific gravity than that of tin and forms first of all crystals of the alloy of this composition, on a falling temperature, along the branch E-F of the liquidus of Fig. 2.

These crystals grow rapidly at temperatures within their formation ranges. On account of their relatively low specific gravities flotation in the still liquid portions readily occurs. It may easily happen that a given bearing may have its hard, wear-resisting components so large that they become broken in use and so distributed as to possess quite different properties at different points. Figs. 4, 5, 6, 7 and 8 illustrate the rapidity of flotation.* Metal was melted and immediately poured on a warm iron plate. A sheet about one-fourth inch in thickness solidified in less than thirty seconds. Figs. 4, 5, 6 and 7 show the cast, unpolished upper surface, Fig. 8 the lower surface, polished and etched with nitric acid. Even in the short time that elapsed between pouring and solidification, segregation of -crystals has occurred to so great an extent that none at all are present in the lower surface layer. Figs. 9 and 10 illustrate the extent of growth under unusual conditions, although it may be noted that such conditions might easily be brought about by inadequate control of furnace conditions.

Rapid growth and segregation at higher temperatures are well recognized phenomena. In the experiments described in this paper an attempt was made to determine the relative rates of growth and segregation of the two systems of crystals here mentioned, in temperature ranges near the respective solidi.

Working specimens were first prepared by melting a quantity of the alloy at 650° C., stirring thoroughly with a stick of wood and immediately casting in chill molds of cast iron. This resulted in the formation of fine crystals, as shown in Figs. 11 and 12, taken after polishing and etching sections of two of the pieces. These specimens were then heated to stated temperatures and either chilled or slowly cooled after certain periods of time. Treatments at temperatures above 250° C. were carried out by heating in covered crucibles in an electric muffle furnace. For lower temperatures the specimens were immersed in a bath of heated glycerine.

Sections of the treated specimens were examined and photographed as before. A measurement of crystals was made on the ground glass of the camera and actual sizes calculated. In the chill cast specimens γ-tin-antimony crystals varied from 0.015 to 0.05 mm and ϵ-tin-copper from 0.02 to 0.18 mm in their ,longest dimensions. In table I are summarized the results of the various thermal treaments of the chilled pieces. Figs. 13 and 14 illustrate two of the treatments in the lower temperature ranges.

*All photomicrographs have been reduced one-third by the printer.

TABLE I

Temperature to which reheated, degrees C.	Time, hours	Size of tin-antimony crystals, millimeters		Sizd of tin-copper crystals, millimeters	
		Upper section	Lower section	Upper section	Lower section
550	4	0.28 – 0.55	0.25 – 0.50	0.10 – 2.50	0.10 – 2.50
550	4	0.36 – 0.56	0.34 – 0.50	0.15 – 2.50	0.12 – 2.00
550	1	0.30 – 0.55	0.20 – 0.45	0.10 – 1.40	0.10 – 2.00
550	1	0.24 – 0.48	0.20 – 0.46	0.06 – 1.20	badly broken
550	1	0.28 – 0.55	0.20 – 0.46	0.10 – 1.60	0.10 – 1.30
475	4	0.30 – 0.62	0.20 – 0.48	0.04 – 0.40	0.04 – 0.40
475	4	0.22 – 0.67	0.20 – 0.45	0.10 – 1.20	0.10 – 1.00
300	1	0.20 – 0.40	0.12 – 0.30	0.03 – 0.60	0.02 – 0.22
300	1	0.09 – 0.26	0.08 – 0.22	0.03 – 0.41	0.03 – 0.36
240	2	0.06 – 0.18	0.03 – 0.12	0.04 – 0.21	0.03 – 0.18
230	1½	0.03 – 0.13	0.03 – 0.09	0.03 – 0.18	0.03 – 0.18
225	3	0.05 – 0.14	0.04 – 0.10	0.04 – 0.23	0.03 – 0.20
220	4	0.025– 0.04	....	0.02 – 0.15	....
210	4	0.03 – 0.05	....	0.015– 0.125	....
200	6	0.03 – 0.05	....	0.02 – 0.13	....
180	6	0.03 – 0.05		0.02 – 0.12	....
160	4	0.03 – 0.05	0.015 – 0.035	0.02 – 0.17	0.02 – 0.10

Fig. 4.—Metal melted at 550° and poured on a warm iron plate. Upper surface. X 50

Fig. 5.—Same conditions as in Fig. 4. Upper surface. x 50

Fig. 6.—Same conditions as in Fig. 4. Upper surface. x 50

Fig. 7.—Same conditions as in Fig. 4. Upper surface. x 50

Fig. 8.—Same conditions as in Fig. 4. Lower surface, polished and etched. x 50

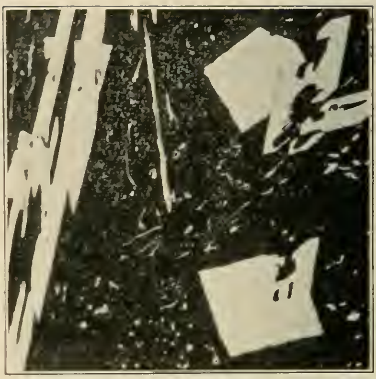


Fig. 9.—Heated to 800° C. for 1 hour, cooled in furnace. x 50

Fig. 10.—Heated to 800° C. for 1 hour, cooled in the furnace. x 50

Fig. 11.—Melted at 550° C. and cast in iron chilled mold. Vertical section. x 50

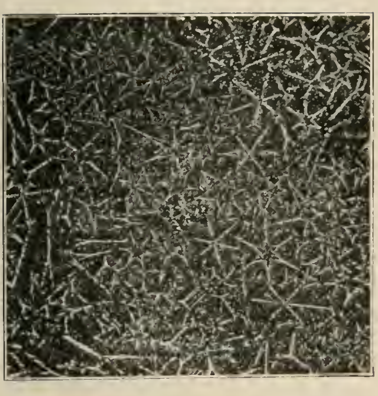


Fig. 12.—Melted at 550° C., cast in iron chilled mold. Horizontal lower section. x 50

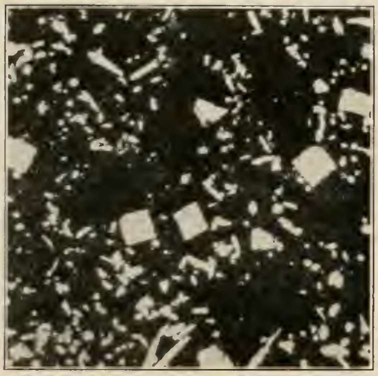


Fig. 13.—Chilled piece of Figs. 11 and 12 reheated at 230° C. for 1 hour. x 100

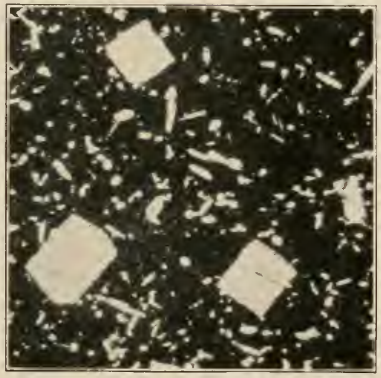


Fig. 14.—Chilled piece of Figs. 11 and 12 reheated to 240° C. for 2 hours. x 100

An inspection of the table and photomicrographs shows that appreciable growth and segregation take place even at temperatures as low as 225°, this temperature being practically at the lower boundary of the area of formation of ϵ-tin-copper and near the lower boundary of the γ-tin-antimony range. As this temperature is well below the liquidi for both binary systems involved in the alloy here used it will readily be seen that practical melting and casting of bearings of Babbitt metal is necessarily done at considerably higher temperatures, thus offering correspondingly greater opportunity for crystal growth and segregation. It may be remarked that Gallagher found* a very slight crystal growth after several weeks heating at 218° C., a temperature below the solidi for both binary systems.

*J. Phys. Chem., **10**, 93 (1906).

FERTILITY OF SOILS OF HANCOCK COUNTY, INDIANA.

BY

R. H. Carr, H. S. Copeland and E. Gentzler.

Purdue University.

There are at least six factors which are recognized as essential in crop production and all are thought to be of about equal importance; these are *light, moisture, temperature, seed, place for seed to grow*, and *sufficient food for its use*. Of these the one most easily controlled is the last mentioned or food for its use. There are at least ten food elements necessary to grow crops and of these sufficient carbon, hydrogen, oxygen and sulphur seem to be supplied naturally while iron is needed in small amounts from soils usually containing an abundant supply. The other five food elements nitrogen, phosphorus, calcium, magnesium and potassium are usually present in the soil in more limited quantities and are removed by cropping in a rotation to corn, wheat, oats and clover to the extent of about 75 lbs. of phosphorus, 160 lbs. of calcium, 318 lbs. of potassium, 65 lbs. of magnesium per rotation, and at least 150 lbs. of nitrogen for every 100 bu. of corn and its stalks.

The supply of potassium in the soil is usually 20,000 lbs. (per acre 6⅔ m's) or more in all but the unusual soils. The amounts of calcium and magnesium vary from 8,000 to 10,000 lbs. per acre whereas the amount of phosphorus is much more limited varying from 1,000 to 3,000 lbs. per acre and is usually the limiting factor in the production of crops. Nitrogen also is a very important element in crop production and is present in soils to the extent of 1,000 to 5,000 lbs. per acre. It too is often a limiting factor and one of the most expensive to replace unless returned through the aid of legume crops instead of commercial fertilizers. Thus it will be evident that only the system of farming which returns as much to the soil as the crops remove can be considered good farming and anything less must be termed "mining". A chemical invoice of part of the plant food in Hancock County, Indiana, has just been made, and is reported here.

Plan of Procedure.

One hundred representative soils were collected in the usual way in August, 1918, by Mr. Copeland and after being air dried were ground and analyses were made for total nitrogen, total phosphorus, volatile matter, amount of calcium or magnesium present as carbonate, acidity to litmus, and solubility of soil in dilute nitric acid. The carbon dioxide determination was made by treating 20 grams of soil with 10 per cent hydrochloric acid in such a manner that the volume of gas evolved could be determined. The data obtained from the above is contained in the tables which follow.

Discussion and Summary.

The data is so arranged as to put in one group all soils containing approximately the same organic content. This has been found desirable because it seems to classify a soil more accurately than any other single factor investigated. It will be noted from all tables that the nitrogen, phosphorus, acid soluble matter and crop yield increase as the per cent of organic matter increases.

The plant food soluble in dilute acid (n/5) is 1.98 per cent for soils in table 1 having a volatile content of 2 to 3% whereas that for table 7 containing 10% or over averages 7.83% soluble in this acid, besides the latter shows a high corn yield compared with that shown in tables 1 and 2.

It will be noted that nearly all soils produced some carbon dioxide gas (4 to 6 c. c.) when treated with hydrochloric acid including those slightly acid to litmus. This indicates that a small evolution of gas when treated with acid does not prove the soil is not acid as is often noted in the literature.

It will be noted also from tables 1, 2 and 3 containing low organic matter that the soils most acid to litmus belong in these three groups and embrace about 70 per cent of the total. In comparing the nitrogen content of the different groups of soils noted in tables 1 to 7 with that of counties previously reported in the Proceedings it is found that the *clay soils* with a volatile content of 0 to 4% contain the following amounts of nitrogen in lbs. per acre for the different counties. Elkhart County 2,049, Allen County 3,667, Hancock County 2,779, and Cass County 1,743.

Where the *clay loams* predominate with a volatile content of 4 to 6% Elkhart County contained 2,553 lbs. of nitrogen per acre, Allen County 3,985 lbs., Hancock County 3,372 and Cass County 2,700.

The *loam soils* with a volatile content varying from 6 to 10% were higher still—Elkhart County soils contained 4,213 lbs. per acre, Allen County 5,305, Hancock 5,259, and Cass County 4,411. The above figures were obtained from the analyses of over 400 samples of soils representing all townships in each of the counties.

RELATION OF PLANT FOOD CONTENT TO CORN YIELD

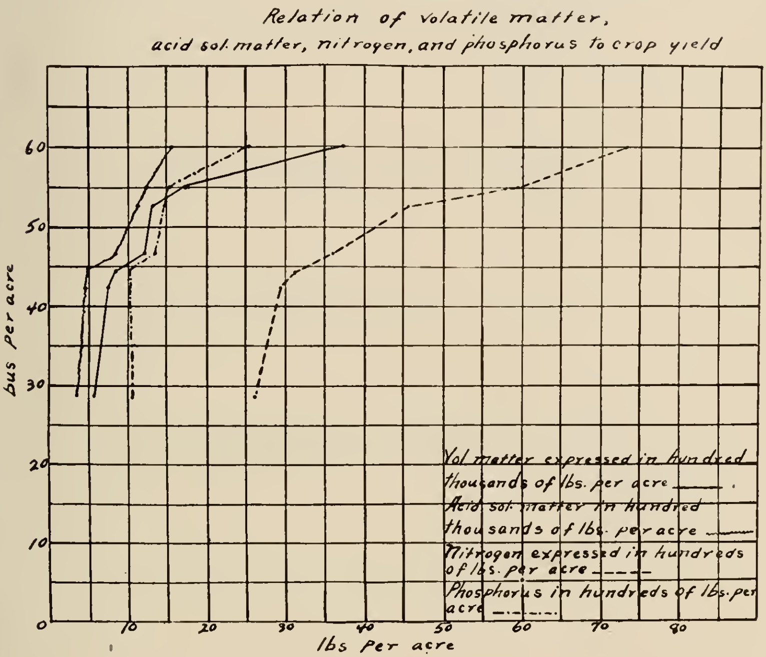


TABLE 1

Volatile matter 2–3%.

5 B. . . . . WA*	45	2.21	2081.	837.	1.41	1.01	10 5
IV. . . . . Y*	15	2.58	2595.	975.	2.26	0.70	4 5
5 Br. . . . . Y*	15	2.97	3115	1542.	2.48	0.45	. . .
12 Br. Sur. . . . . Y*	50?	2.95	2742.	917.	1 77	0.25	4 5
Average.	28.7	2.68	2634.	1068.	1.98	0.602	6.5

A = Acid.
X = Neutral or Slightly Acid.
Y = Basic.

TABLE 2.

Volatile Matter 3-4%

Soil Sample		Bu. Corn Per A	Per Cent Volatile Matter	Lbs. (N) Per A. 6⅔ In.	Lbs. (2) Per P. 6⅔ In.	Per Cent N/5 HNO_3 Sol. Matter	C. C. of N/5 HNO_3 Neut. by 1 gram soil	C. C. of CO_2 from 20 gram soil
4 J	X	50	3.80	2635.	936.	2.63	0.60	7.0
1 BC	Y	20	3.43	2375.	870.	3.64	0.20	8.0
8 BC	X	50	3.53	3625	1580	6.85	1.61	4.0
6 G	A	60	3.98	4280	1310.	3.70	1.11	10.0
8 G	A	50	3.53	4046.	1136.	2.40	0.75	
4 Br.	Y	60	3.82	3547.	1009	1.48	0.15	5.0
10 Br.	X	25	3.49	3815.	1198.	2.38	0.20	4.0
11 Br.	Y	25	3.75	2614.	1136.	2.27	0.30	4.0
12 Br Sub.	Y		3.55	2749.	964.	2.01	0.35	4.5
8 S.C.	A	20	3.79	2260.	825.	2.00	0.65	
4 V	Y	35	2.71	2509.	1007.	2.24	0.60	4.5
5 V	Y	30	3.53	3589.	804.	2.64	0.60	4.0
10 V	A	40	3.55	2915.	779.	1.96	0.60	6.0
8 Bu.	Y	65	3.99	2899.	1111.	1.36	1.21	7.0
10 Bu.	Y	40	3.94	2742.	1012.	1.58	1.01	4.5
2 BR.	Y		3.40	2748	1050	1.70	0.20	7.0
7 BR.	Y	75	3.16	2538	700	1.98	0.40	12.0
8 BR.	X	30	3.64	2066.	549.	1.86	0.40	9.0
2 C.	X	35	3.92	2660	1100.	2.46	0.35	6.0
11 C.	Y	50	3.98	2517.	1167.	1.64	0.45	7.0
Average		42.2	3.67	2924.	1018.	2.40	5.97	6.3

A = Acid
X = Neutral or slightly acid
Y = basic.

TABLE 3

Volatile matter 4–5%.

Soil Sample		Bu. Corn Per A.	Per Cent Volatile Matter	Lbs. (N) Per A. 6⅔ In.	Lbs. (2) Per P. 6⅔ In.	Per Cent $N/_5$ HNO_3 Sol. Matter	C. C. of $N/_5$ HNO_3 Neut. by 1 gram soil	C. C. of CO_2 from 20 gram soil
5 J	X	45	4.32	3898.	719.	2.53	0.35	5 0
8 J	A	30	4.01	3056.	1153.	1.84	0 30	4.5
11 J	A	40	4.95	2770.	747.	2.09	0.30	4.5
3 G	Y	65	4.98	5375.	1406.	2.55	0.70	5.5
9 G	Y	50	4.52	2239.	918.	1.93	0.50	...
10 G	Y	50	4.17	3119.	970.	2.37	0.81	...
11 G	Y	40	4.21	2620.	834.	2.74	0.81	8.5
6 Br.	Y	25	4.07	3895.	1133.	2.34	0.30	7.1
2 SC	A	40	4.13	3872.	1092.	4.89	0.50	4.0
3 Bu.	A	50	4.38	2859.	979.	2.10	0.91	7.2
6 Bu	Y	55	4.29	2690.	826.	1.86	1.21	6.5
7 Bu	X	50	4.69	3266.	1193.	2.92	1.61	5 0
9 Bu.	Y	40	4 27	2262.	1003.	1.97	1.11	5.5
4 BA.	Y	30	4 73	2629.	1239.	2.04	0 40	6.5
10 BA	Y	55	4 01	2489.	1046.	1.83	0.25	8.5
7 C.	A	50	4.43	2973.	1103.	8.24	0.15	6.5
9 C.	A	50	4 16	3085.	852.	3.20	0.30	5.5
4 C.	Y	40	4.87	2866.	963.	3.04	0.55	6.5
1 C.	Y	40	4 78	3057.	1128.	2.26	0.40	8 0
Average		44 4	4 17	3106.	1016.	3.31	0.608	6.16

A = Acid.
X = Neutral or slightly acid
Y = Basic.

TABLE 4.

Volatile matter 5-6%

Soil Sample		Bu. Corn Per A.	Per Cent Volatile Matter	Lbs. (N) Per A. 6⅔ In.	Lbs. (2) Per P. 6⅔ In.	Per Cent N/5 HNO_3 Sol. Matter	C. C. of N/5 HNO_3 Neut. by 1 gram soil	C. C. of CO_2 from 20 gram soil
8 C	X	50	5.43	3140.	1283.	5.46	0.86	7.0
1 BR.	X	40	5.66	3869	1271.	3.0	0.60	11.0
5 BR.	X	45	5.68	3926	1502	3.56	1.01	6.5
3 V	X	45	5.46	3482	1211	3.83	1.11	5.0
7 V	X	50	5.19	4785	1849	3.97	1.16	5.5
8 V	X	30	5.45	4864	1735	4.51	1.51	4.5
11 V	X	65	5.57	4483.	1404	4.64	1.31	16.0
1 SC	X	50	5.60	5305	1400.	3.01	0.75	16.0
5 SC.	Y	50	5.15	2578.	1284	2.89	0.91	6
3 BC	Y	40	5.08	3077.	959	3.80	0.40	7.5
1 J	X	50	5.05	3339.	1020.	3.28	0.96	6.0
6 J	X	40	5.35	30.	881.	2.92	0.70	9.0
7 J.	Y	50	5.04	3599.	1254	3.21	0.60	5.0
9 J	Y	50	5.29	4949.	1870.	2.96	0.65	5.0
7 Br. Sub.	X	..	5.80	1182	1512.	11.26	4.29	111.5
13 Br. Sub	X		5.67	2860	1313.	4.24	1.82	...
5 C.	A	50	5.78	3592	1211.	3.90	0.50	6.0
Average.		46.8	5.53	3637.	1356.	4.14	1.13	14.22

A = Acid.
X = Neutral or slightly acid.
Y = Basic.

TABLE 5

Volatile matter 6–8%

Soil Sample	Bu. Corn Per A.	Per Cent Volatile Matter	Lbs. (N) Per A. 6⅔ In.	Lbs. (2) Per P. 6⅔ In.	Per Cent N/5 HNO_3 Sol. Matter	C. C. of N/5 HNO_3 Neut. by 1 gram soil	C. C. of CO_2 from 20 gram soil
7 BR, sur. X	..	7.35	4431.	1472.	7.48	0.31	8.0
3 SC. X	25	6.20	4014.	1475.	5.29	1.82	6 0
1 G. A	65	6.0	5276.	2016.	1.44	1.61	7.0
2 G. A	50	7.25	6929.	1305.	3.71	1.31	...
4 BC. X	60	6.47	4198.	1352.	6.34	1.36	7.0
5 BC. X	60	7.76	4816	1332.	6.75	1.41	6.5
6 BC. Y	60	7.80	4816.	1313.	6.59	1.16	...
7 BC. A	50	6.95	2113.	886.	2.58	0.05	5 0
2 Bur. X	60	6.69	4601.	1607.	3.30	1.51	4.0
6 V. X	60	6.50	6005.	1397.	3.88	1.21	4.0
9 V. X	50	6.32	5369.	1610.	3.86	1.31	7.5
3 BR. Y	60	7.89	5489.	1922.	3.67	1.01	8.0
6 BR. sur. X	75	6.03	3091.	1499.	13.56	7.27	1.64
6 BR. sub X	..	6.16	3289.	1878.	13.69	5.30	1.91
9 BR. X	50	6.68	4342.	1257.	3.17	0.709	5.5
3 J. X	40	7.44	5411.	1370.	5 84	1.26	8.0
6 C. X	50	6.88	4052.	1292.	4.06	1.06	6.5
3 C. X	50	6.23	4391.	1479.	3.93	1.21	6.5
Average	52.8	6.76	4591	1470.	4.39	1.80	27.8

A = Acid.
X = Neutral or slightly acid.
Y = Basie.

TABLE 6

Volatile Matter 8–10%.

Soil Sample	Bu. Corn Per A.	Per Cent Volatile Matter	Lbs. (N) Per A. 6⅔ In.	Lbs. (2) Per P. 6⅔ In.	Per Cent $N/5$ HNO_3 Sol. Matter	C. C. of $N/5$ HNO_3 Neut. by 1 gram soil	C. C. of CO_2 from 20 gram soil
10 J ....Y	50	8.17	4844.	1560.	6.11	2.42	6.0
11 BR X	55	8.49	5507.	1531.	4.57	1.31	7.5
5 G ....A	65	9.60	7626.	1680.	8.10	3.23	12.0
10 C X	50	9.36	6235.	1832 16	5.16	1.41	6.5
2 BC X	30	9.64	5558.	1230.	9.25	2.67	13.0
2 Br. ....Y	75	8.25	6472.	1746.	4.49	1.46	8.0
14 Br ....Y	55	8.09	6167.	1444.	4.04	1.21	...
7 SC X	60	8.74	5011.	1061.	7.47	2.62	6.0
Average	55	8.79	5928.	1510.	6.15	2.04	8.40
Volatile Matter 10 % and Over.							
4 Bur X	..	10.89	5114.	1619.	1.87	2.72	5.0
4 G. sur ....A	25	40.92	8631.	3783.	15.20	7.22	31.0
7 G ....A	80	34.50	8460.	4798.	12.93	5.20	5.0
2 J X	Woods Pasture	11.76	8803.	1766.	6.06	1.36	7.0
12 C X	50	12.10	7888.	2021.	8.31	2.02	9.0
8 Br X	Woodland	10.75	6278.	1535.	4.83	1.21	5.5
2 V X	50	10.13	6139.	2093.	5.59	1.92	5.5
Average	60	18.72	7342.	2516.	7.83		

A = Acid.
X = Neutral or slightly acid.
Y = Basic.

CHECKS ON COMPUTATIONS IN THE SOLUTION OF TRIANGLES

A. M. KENYON

It is the purpose of this note to illustrate methods of checking the accuracy of the results when unknown parts of plane triangles are computed from given parts. Five place tables are used in the computations.

I. RIGHT TRIANGLES.

Let h represent the hypotenuse and a and b the other two sides of a right triangle Let R be the right angle and A and B the acute angles opposite a and b respectively. To fix ideas suppose A is not less than B.

Either of the following identities contains all five of the variable parts and can be used as a check formula when a right triangle has been completely solved.

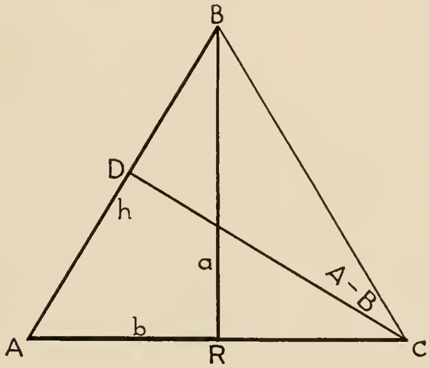


Fig. 1

$$(1) \qquad 2\,ab = h^2 \cos\ (A-B)$$

$$(2) \qquad (a+b)\ (a-b) = h^2 \sin\ (A-B)$$

To prove these produce AR (Fig. 1) to C making $RC = AR$, connect BC, and draw CD perpendicular to AB. Then $CB = h$ and angle $BCD = A-B$.

$$CD = h \cos\ (A-B) = 2b \sin\ A$$

Therefore $$h^2 \cos\ (A-B) = 2bh \sin\ A = 2ab$$

$$DB = h \sin\ (A-B) = h - 2b \cos\ A$$

Therefore $$h^2 \sin\ (A-B) = h^2 - 2bh \cos\ A = a^2 - b^2$$

It is evident that these formulas hold also when A is less than B.
If it is desired to check only the sides, either of the formulas

$$(3) \quad a = (h+b)\ (h-b) \text{ or } b^2 = (h+a)\ (h-a)$$

may be used.

Example 1. Given $A = 63°$, $h = 28.54$. Compute $B = 27°$, $\log a = 1.40533$, $a = 25.429$, $\log b = 1.11250$, $b = 12.957$.

Checks

$A = 63°$		$2ab = h^2 \cos (A-B)$
$B = 27°$	$\log 2 = 0.30103$	$\log h = 1.45545$
	$\log a = 1.40533$	1.45545
$A-B = 36$	$\log b = 1.11250$	$\log \cos (A-B) = 9.90796-10$
	2.81886	2.81886
$h = 28.54$		
		$(a+b)(a-b) = h^2 \sin (A-B)$
$a = 25.429$		
	1.58417	1.45545
$b = 12.957$	1.09594	1.45545
		9.76922-10
$a+b = 38.386$	2.68011	2.68012
$a-b = 12.472$		$a^2 = (h+b)(h-b)$
$h+a = 53.969$	1.40533	1.61802
	2	1.19265
$h-a = 3.111$	2.81066	2.81067
$h+b = 41.497$		$b^2 = (h+a)(h-a)$
$h-b = 15.583$	1.11250	1.73214
	2	0.49290
	2.22500	2.22504

Example 2. Given $A = 28°\ 40'.4$, $b = 20.71$ Compute $B = 61°19'.6$ $\log a = 1.057407$, $a = 11.326$, $\log h = 1.37300$, $h = 23.605$.

Checks

$B = 61°\ 19'.6$		$2ab = h^2 \cos (B-A)$
$A = 28°\ 40'.4$	0.30103	1.37300
	1.05407	1.37300
$B-A = 32°\ 39'.2$	1.31618	9.92528-10
	2.67128	2.67128
$h = 23.605$		
		$(b+a)(b-a) = h^2 \sin (B-A)$
$b = 20.71$		1.37300
	1.50564	1.37300
$a = 11.326$	0.97239	9.73204
	2.47803	2.47804
$b+a = 32.036$		
		$a^2 = (h+b)(h-b)$
$b-a = 9.384$		
	1.05407	1.64655
$h+a = 34.931$	2	0.46165
	2.10814	2.10820
$h-a = 12.279$		
		$b^2 = (h+a)(h-a)$
$h+b = 44.315$	1.31618	1.54321
	2	1.08916
$h-b = 2.895$		
	2.63236	2.63237

It appears that these checks are not all sensitive to the same degree. Experience will assist the computer in choosing the one best adapted to the problem at hand. For example, (1) is more sensitive than (2) when the difference of the angles is less than 45° and vice versa. Of (3) that one is better in which the factors are most nearly equal.

II. OBLIQUE TRIANGLES

When any triangle has been completely solved the formulas

$$(4) \qquad (a-b)\cos\tfrac{1}{2}C = c\sin\tfrac{1}{2}(A-B)$$

$$(5) \qquad (a+b)\sin\tfrac{1}{2}C = c\cos\tfrac{1}{2}(A-B)$$

$$(6) \qquad (a-b)(a+b)\sin C = c^2\sin(A-B)$$

together with those obtained from these by cyclic permutations of the letters representing the sides and angles, may be used as checks.

Formulas (4) and (5) may be proved as follows and (6) is readily deduced from them.

Let ABC be any triangle having two sides unequal, say $a>b$. With a radius b, the shorter of the two unequal sides, and centre C, the vertex of their included angle, describe a circle through A which cuts the side CB in a point D between B and C and also at a second point E beyond C. Draw EA and at B erect a perpendicular which meets EA produced in F. On DF as diameter construct a circle; this circle will pass through A and B. Then angle $BEF = \tfrac{1}{2}C$, $DFA = B$, $BFE = \tfrac{1}{2}(A+B)$, and $BFD = \tfrac{1}{2}(A-B)$.

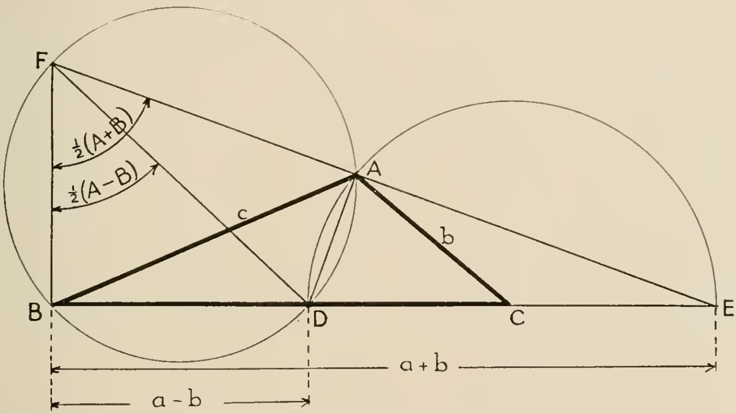


Fig. 2

In the triangle ABD,

$$\frac{a-b}{c} = \frac{\sin BAD}{\sin BDA}$$

but $\quad \sin BAD = \sin BFD = \sin\tfrac{1}{2}(A-B)$

and $\quad \sin BDA = \sin ADE = \cos AED = \cos\tfrac{1}{2}C$

Therefore

$$(a-b)\cos\tfrac{1}{2}C = c\sin\tfrac{1}{2}(A-B)$$

In the triangle ABE,

$$\frac{a+b}{c} = \frac{\sin BAE}{\sin AEB}$$

but $\quad \sin BAE = \sin BAF = \sin BDF = \cos BFD = \cos\tfrac{1}{2}(A-B)$

and $\quad \sin AEB = \sin\tfrac{1}{2}C$

Therefore

$$(a+b)\sin\tfrac{1}{2}C = c\cos\tfrac{1}{2}(A-B)$$

Case 1. Given a side and two angles.

Example 1. Given $a = 2.903$, $B = 79° 40'$, $C = 33° 15'$. Compute $A = 67° 5'$ and $\log b = 0.49146$, $b = 3.1007$, $\log c = 0.23757$, $c = 1.7281$, by the law of sines.

$b = 3.1007$
$c = 1.7281$

$b+c = 4.8288$

$b-c = 1.3726$
$B = 79° 40'$
$C = 33° 15'$

$B-C = 46° 25'$

$\frac{1}{2}(B-C) = 23° 12'.5$

$\frac{1}{2}A = 33° 32' 5$

CHECKS

$(b-c) \cos \frac{1}{2}A = a \sin \frac{1}{2}(B-C)$

0.13754	0.46285
9.92090−10	9.59558−10
0.05844	0.05843

$(b+c) \sin \frac{1}{2}A = a \cos \frac{1}{2}(B-C)$

0.68384	0.46285
9.74236−10	9.96335−10
0.42610	0.42610

$(b+c)(b-c) \sin A = a^2 \sin (B-C)$

0.68384	0.46285
0.13754	0.46285
9.96429−10	9.85996−10
0.78567	0.78566

Case 2. Given two sides and their included angle.

Example 1. $a = 22$, $b = 12$, $C = 42°$. Compute $c = 15.350$ by the law of cosines.

$a = 22$
$b = 12$
$c = 15.350$

$2s = 49.350$
$s = 24.675$

$s-a = 2.675$
$s-b = 12.675$
$s-c = 9.325$

Check $= 24.675$

CHECK

$s\,(s-c) \tan^2 \frac{1}{2}C = (s-a)(s-b)$

1.39226	
0.96965	
9.58418−10	0.42732
9.58418−10	1.10295
1.53027	1.53027

Compute $A = 106° 27'.7$ and $B = 31° 32'.4$ by law of sines.

$a+b = 34$
$a-b = 10$

$c = 15.35$

$A = 106° 27'.7$

$B = 31° 32'.4$

$A-B = 74° 53'.3$

$\frac{1}{2}(A-B) = 37° 27'.6$

$\frac{1}{2}C = 21°$

CHECKS

$(a-b) \cos \frac{1}{2}C = c \sin \frac{1}{2}(A-B)$

1.00000	1.18611
9.97015−10	9.78405−10
0.97015	0.97016

$(a+b) \sin \frac{1}{2}C = c \cos \frac{1}{2}(A-B)$

1.53148	1.18611
9.55433−10	9.89970−10
1.08581	1.08581

$(a+b)(a-b) \sin C = c^2 \sin (A-B)$

1.53148	1.18611
1.00000	1.18611
9.82551−10	9.98478−10
2.53699	2.53700

Example 2. Given $a = 34.645$, $b = 22.531$, $C = 43° 31'$.

$a = 34.645$	$\frac{1}{2}C = 21° 45'.5$	$\frac{1}{2}(A+B) = 68° 14'.5$
$b = 22.531$	Then compute	$\frac{1}{2}(A-B) = 27° 57'.6$
$a+b = 57.176$	whence	$A = 96° 12'.1$
$a-b = 12.114$	and	$B = 40° 16'.9$

Check

	$a \sin B = b \sin A$
1.53964	1.35278
9.81060–10	9.99745–10
1.35024	1.35023

Compute $\log c = 1.38014$, $c = 23.996$ by the law of sines, in two ways.

Checks

$(a-b) \cos \frac{1}{2}C =$	$c \sin \frac{1}{2}(A-B)$	$(a+b) \sin \frac{1}{2}C =$	$c \cos \frac{1}{2}(A-B)$
1.08328	1.38014	1.75721	1.38014
9.96790–10	9.67104–10	9.56902–10	9.94610–10
1.05118	1.05118	1.32623	1.32624

$(a+b)(a-b) \sin C =$	$c^2 \sin (A-B)$
1.75721	1.38014
1.08328	1.38014
9.83795–10	9.91817–10
2.67844	2.67845

Case 3. Given the three sides.

Example. Given $a = 2314$, $b = 2431$, $c = 3124$. Compute $\frac{1}{2}A = 23° 36'.8$, $\frac{1}{2}B = 25° 13'.8$, $\frac{1}{2}C = 41° 9'.4$ and check by taking their sum.

Checks

$a \sin B =$	$b \sin A$	$b \sin C =$	$c \sin B$
3.36436	3.38578	3.38578	3.49471
9.88716–10	9.86572–10	9.99608–10	9.88716–10
3.25152	3.25150	3.38186	3.38187

$a \sin C =$	$c \sin A$	$(c-a) \cos \frac{1}{2}B =$	$b \sin \frac{1}{2}(C-A)$
3.36436	3.49471	2.90849	3.38578
9.99608–10	9.86572–10	9.95646–10	9.47918–10
3.36044	3.36043	2.84495	2.84496

$c + a = 5438$

$c - a = 810$

$\frac{1}{2}(C-A) = 17° 32'.6$

$(C-A) = 35° 5'.2$

$(c+a) \sin \frac{1}{2}B =$	$b \cos \frac{1}{2}(C-A)$
3.73544	3.38578
9.62967–10	9.97932–10
3.36511	3.36510

$(c+a)(c-a) \sin B =$	$b^2 \sin (C-A)$
2.90849	3.38578
3.73544	3.38578
9.88716–10	9.75953–10
6.53109	6.53109

Case 4. Given two sides (say a and b) and the angle opposite one of them (say A).

Determine the number of solutions. Compute the angle B opposite the other given side, by the law of sines. If there are two solutions call the acute angle B_1, and the obtuse one B_2.

It is now possible to check by the law of tangents but this is in many cases not sensitive enough to be decisive. Find the third angle C by subtracting $A+B$ from 180°, and compute the third side c by the law of sines. If there are two solutions a check is given by the formulas,

(7) $B_1 = A + C_2,\quad c_1 + c_2 = 2b \cos A$

$B_2 = A + C_1,\quad c_1 - c_2 = 2a \cos B_2$

Example. Given $a = 301.35$, $b = 352.11$, $A = 33° 17'$.
There are two solutions. Compute log sin $B = 9.80701-10$, $B_1 = 39° 53'$, $B_2 = 140° 7'$. Check by the law of tangents.

$b+a = 653.46$	$(b+a)\tan\frac{1}{2}(B_1-A) =$	$(b-a)\tan\frac{1}{2}(B_1+A)$
$b-a = 50.76$	2.81522	1.70552
	8.76087–10	9.87053–10
$\frac{1}{2}(B_1+A) = 36° 35'$	1.57609	7.57605
	$(b+a)\tan\frac{1}{2}(B_2-A) =$	$(b-a)\tan\frac{1}{2}(B_2+A)$
$\frac{1}{2}(B_1-A) = 3° 18'$		
	2.81522	1.70552
$\frac{1}{2}(B_2+A) = 86° 42'$	0.12947	1.23913
	2.94469	2.94465
$\frac{1}{2}(B_2-A) = 53° 25'$		
Next compute	$C_1 = 106° 50'$,	$C_2 = 6° 36'$
	$A = 33° 17'$	$A = 33° 17'$
Check	$B_2 = 140° 7'$	$B_1 = 39° 53'$

Now compute c_1 and c_2 by the law of sines, log $c_1 = 2.72065$, $c_1 = 525.59$, log $c_2 = 1.80013$, $c_2 = 63.114$; whence $c_1+c_2 = 588.704$, $c_1-c_2 = 462.476$

CHECKS

$c_1+c_2 =$	$2b\cos A$	$c_1-c_2 =$	$2a\cos B$
	0.30103		0.30103
	2.54668		2.47907
	9.92219–10		9.88499–10
2.76989	2.76990	2.66509	2.66509

The triangles now being completely solved, any of the checks illustrated above may be used; for example

$(b+a)\sin\frac{1}{2}C_1 =$	$c\cos\frac{1}{2}(B_1-A)$
2.81522	2.72065
9.90471–10	9.99928–10
2.71993	2.71993

Purdue University, December 1, 1919

AN ARRANGEMENT OF THE ASCOMYCETES OF INDIANA.[1]

Bruce Fink and Sylvia C. Fuson.

In this second contribution toward a knowledge of the ascomycetes of Indiana, the authors present a classification of all the ascomycetes previously published for the state. The classification follows that used in the first paper, "Ascomycetes new to the flora of Indiana". So far as possible, the names of the counties from which the species have been collected are given. The list comprises 372 species from thirty-eight counties. Future studies will, of course, add largely to this number of species for the state.

While the main purpose of this paper is to bring together the names of all ascomycetes known in Indiana under a system of classification, other features are introduced as aids to mycologists who may refer to the paper. For this purpose, the distribution has been given so far as we have been able to ascertain it. Of the 372 species of ascomycetes known to occur in Indiana, 136 were recorded for the first time in our paper cited in the bibliography at the close of the present paper. The other 236 species were previously recorded for Indiana by other workers. We have determined from our collection of 630 specimens, 263 species of ascomycetes collected by us in Indiana. These are starred in the present paper. The other 109 species not starred are admitted on the determinations of others. We regret that we have not all the data at hand for giving the names of those who have determined these, but mycologists who are interested will get some clue from the bibliography. Among works of special reliability, we may mention those of Professor J. M. Van Hook and his students.

The herbarium material at the University of Indiana, at Purdue University, and at Wabash College we examined hastily; but it was not possible, in the short time available, to examine critically and verify or correct the determinations found in these collections. While a critical examination of the species found in the three herbaria would have added to the value of the present paper, it is hoped that the classification, the additions to the flora, the record of distribution, and some other features of our work may prove helpful in the further study and the final systematic account of the ascomycetes of Indiana.

ASCOMYCETAE.

PEZIZALES.

Pezizaceae.

*Geopyxis nebulosa (Cooke) Sacc.
    Montgomery, Parke.
*Humaria fusispora Berk.
    Jasper.
*Lachnea erinaceus Schw.
    Monroe (?)[2].

[1]Contributions from the Botanical Laboratories of Miami University. XVI.
[2]Monroe (?) signifies that the collections thus designated may have been made in Monroe County, Clark County, or Brown County.

*Lachnea hemispherica (Wigg.) Gill.
Tippecanoe.
*Lachnea scutellata (Sow.) Gill.
Monroe (?), Montgomery, Parke, Putnam, Union.
*Lachnea setosa (Nees) Phill.
Montgomery.
*Macropodia macropus (Peck) Fuck.
Putnam.
*Otidea aurantia (Pers.) Mass.
Monroe (?).
*Peziza bronca Peck.
Tippecanoe.
Peziza coccinea Jacq.
Monroe (?), Montgomery, Putnam.
Peziza occidentalis Schw.
Brown, Vigo.
*Peziza repanda Wahl.
Monroe (?).
Peziza succosa Berk.
Monroe (?).
*Peziza vesiculosa Bull.
Monroe (?).
*Urnula craterium (Schw.) Fries.
Monroe (?), Montgomery, Putnam, Tippecanoe, Vigo.

Ascobolaceae.

*Ascobolus atrofuscus Phill. and Plow.
Montgomery.
*Ascophanus carneus (Pers.) Boud.
Tippecanoe.
*Ascophanus testaceus (Moug.) Phill.
Tippecanoe.
*Saccobolus neglectus Boud.
Montgomery.

Helotiaceae.

*Chlorosplenium aeruginosum (Oed.) De Not.
Monroe (?), Montgomery, Putnam.
*Chlorosplenium chlora (Lam. and Schw.) Mass.
Montgomery, Parke, Tippecanoe.
*Dasyscypha virginea (Batsch) Fuck.
Montgomery, Putnam, Union.
*Helotium citrinum (Hedw.) Fries.
Monroe (?), Putnam, Union.
*Helotium fraternum Peck.
Parke.

*Helotium lutescens Fries.
Union.
*Lachnum leucophaeum (Pers.) Karst.
Montgomery.
*Lanzia helotioides Rehm.
Montgomery.
*Phialea scutula (Pers.) Gill.
Montgomery.
*Sarcoscypha floccosa (Schw.) Sacc.
Monroe, Tippecanoe, Union.
*Sarcoscypha occidentalis (Schw.) Sacc.
Monroe, Parke, Tippecanoe.
Sclerotinia cinerea (Bon.) Woron.
Tippecanoe.
*Sclerotinia fructigena Pers.
Monroe (?), Tippecanoe.
Sclerotinia libertiana Fuck .
Tippecanoe.
*Sclerotinia trifoliorum Eriks.
Clark, Fulton, Gibson, Henry.
*Sclerotinia tuberosa (Hedw.) Fuck.
Tippecanoe.

Mollisiaceae.

*Belonidium minutissimum Fries.
Union.
*Beloniella dehnii (Rabenh.) Rehm.
Tippecanoe.
Holwaya gigantea (Peck) Dur.
Monroe.
*Mollisia cinerea (Batsch) Karst.
Parke.
*Orbilia leucostigma Fries.
Montgomery, Parke, Tippecanoe, Union.
*Orbilia vinosa (Alb. and Schw.) Karst.
Montgomery, Union.
*Pseudopeziza medicaginis (Lib.) Sacc.
Monroe (?), Tippecanoe.
Pseudopeziza ribis Kleb.
Monroe.
Pseudopeziza trifolii (Bernh.) Fuck.
Marshall, Monroe (?).
*Tapesia cinerella Rehm.
Parke, Tippecanoe, Union.

Cenangiaceae.

*Dermatea carpinea (Pers.) Rehm.
Union.
*Sarcosoma rufa (Lam. and Schw.) Rehm .
Union.

Patellariaceae.

*Karschia fusispora (Cooke and Peck) Sacc.
Montgomery.
*Patellaria atrata (Hedw.) Fries.
Montgomery, Tippecanoe.

LECANORALES.

Lecideaceae.

*Bacidia inundata (Fries) Koerb.
Monroe, Montgomery, Putnam, Tippecanoe, Union.
*Bacidia rubella (Hoffm.) Mass.
Tippecanoe.
*Bacidia schweinitzii (Tuck.) Fink.
Union.
*Buellia myriocarpa (Lam. and D.C.) Mudd.
Franklin, Montgomery, Union.
*Buellia parasema (Ach.) Th. Fries.
Putnam.
*Lecidea albocaerulescens (Wulf.) Schaer.
Monroe, Parke, Putnam, Tippecanoe.
*Lecidea coarctata (J. E. Smith) Nyl.
Montgomery.
*Lecidea enteroleuca Ach.
Union.
*Lecidea myriocarpoides Nyl.
Monroe.
*Lecidea uliginosa (Schrad.) Ach.
Hendricks, Montgomery, Union.

Cladoniaceae.

*Cladonia bacillaris (Del.) Nyl.
Hendricks.
*Cladonia caespiticia (Pers.) Floerke.
Putnam.
*Cladonia cariosa (Ach.) Spreng.
Montgomery.
*Cladonia coniocraea (Floerke) Spreng.
Hendricks, Montgomery, Tippecanoe, Union.

*Cladonia cristatella Tuck.
Montgomery, Tippecanoe, Wayne.
*Cladonia fimbriata (L.) Fries.
Putnam, Wayne.
*Cladonia furcata (Huds.) Fries.
Parke, Putnam, Tippecanoe.
*Cladonia macilenta Hoffm.
Montgomery, Tippecanoe, Union.
*Cladonia mitrula Tuck.
Montgomery, Putnam, Tippecanoe, Union, Wayne.
*Cladonia pyxidata (L.) Fries.
Parke, Putnam.
*Cladonia squamosa (Scop.) Hoffm.
Wayne.
Cladonia symphycarpa Fries.
Putnam.

Collemaceae.

*Leptogium lacerum (Retz.) S. F. Gray.
Tippecanoe, Wayne.
*Leptogium pulchellum (Ach.) Nyl.
Parke, Wayne.
*Leptogium tremelloides (L.) S. F. Gray.
Montgomery.

Pyrenopsidaceae.

*Pyrenopsis fuscoatra Fink.
Montgomery.

Pannariaceae.

*Pannaria nigra (Huds.) Nyl.
Montgomery, Wayne.

Stictaceae.

*Sticta amplissima (Scop.) Mass.
Hamilton, Marion, Montgomery, Putnam, Wayne.
*Sticta pulmonaria (L.) Ach.
Hamilton, Marion, Owen, Putnam, Wayne.

Peltigeraceae.

*Nephroma helveticum Ach.
Putnam.
Nephroma laevigatum Ach.
Putnam.

*Peltigera canina (L.) Hoffm.
Parke. Putnam. Wayne.
*Peltigera horizontalis (L.) Hoffm.
Montgomery.
*Peltigera praetextata (Sommerf.) Fink.
Tippecanoe.

Acarosporaceae.

*Acarospora cervina (Wahl.) Koerb.
Montgomery.

Lecanoraceae.

*Lecanora dispersa (Pers.) Floerke.
Franklin. Montgomery, Union.
*Lecanora hageni Ach.
Monroe. Montgomery. Union.
*Lecanora pallescens (L.) Schaer.
Wayne.
Lecanora pallida (Schreb.) Schaer.
Putnam.
*Lecanora subfusca (L.) Ach.
Putnam.
Lecanora tartarea (L.) Ach.
Putnam.
*Lecanora varia (Hoffm.) Ach.
Hendricks, Montgomery, Union.

Pertusariaceae.

*Pertusaria communis Lam. and D. C.
Hendricks. Parke, Putnam. Union.
*Pertusaria pustulata (Ach.) Nyl.
Union.
*Pertusaria velata (Turn.) Nyl.
Putnam. Tippecanoe.

Parmeliaceae.

*Parmelia borreri Turn.
Tippecanoe, Union, Wayne.
*Parmelia caperata (L.) Ach.
Franklin, Hamilton, Hendricks, Marion, Montgomery, Putnam. Tippecanoe, Union, Wayne.
*Parmelia cetrata Ach.
Wayne.
*Parmelia ciliata (Lam. and D. C.) Fink.
Union.

Parmelia colpodes (Ach.) Nyl.
Putnam.
*Parmelia conspersa (Ehrh.) Ach.
Montgomery.
Parmelia laevigata (Smith) Nyl.
Wayne.
*Parmelia perforata (Jacq.) Ach.
Putnam.
*Parmelia rudecta Ach.
Franklin, Hendricks, Montgomery, Parke, Tippecanoe, Union.
*Parmelia saxatilis (L.) Fries.
Hamilton, Marion, Putnam.
*Parmelia tiliacea (Hoffm.) Floerke.
Putnam, Wayne.

Usneaceae.

*Ramalina calicaris (L.) Fries.
Hamilton, Marion, Putnam, Wayne.
*Ramalina fraxinea (L.) Ach.
Union.
*Usnea barbata (L.) Fries.
Brown, Hamilton, Marion, Marshall, Owen, Putnam, Wayne.
*Usnea florida (L.) Web.
Wayne.
Usnea angulata Ach.
Wayne.

Teloschistaceae.

*Placodium aurellum (Hoffm.) Fink.
Montgomery, Union.
*Placodium microphyllinum Tuck.
Montgomery, Union.
*Placodium pyraceum (Ach.) Fink.
Montgomery.
*Placodium sideritis (Tuck.) Fink.
Franklin, Montgomery, Putnam.
*Placodium ulmorum Fink.
Tippecanoe.
*Placodium variabile (Pers.) Nyl.
Franklin.
*Teloschistes concolor (Dicks.) Tuck.
Franklin, Montgomery, Putnam, Union.
*Teloschistes lychneus (Ach.) Tuck.
Montgomery.
Teloschistes parietinus Norm.
Wayne.

Physciaceae.

*Physcia adglutinata (Floerke) Nyl.
Union, Wayne.
*Physcia aquila (Ach.) Nyl.
Montgomery.
*Physcia astroidea (Fries) Nyl.
Franklin, Montgomery.
*Physcia endochrysea (Hampe) Nyl.
Hendricks, Montgomery, Tippecanoe.
*Physcia hypoleuca (Ach.) Tuck.
Tippecanoe, Wayne.
*Physcia leucoleiptes (Tuck.) Fink.
Franklin, Monroe, Montgomery.
*Physcia obscura (Schaer.) Nyl.
Franklin, Montgomery, Union.
*Physcia pulverulenta (Schreb.) Nyl.
Franklin, Montgomery, Union.
*Physcia speciosa (Wulf.) Nyl.
Tippecanoe, Union, Wayne.
*Physcia stellaris (L.) Nyl.
Franklin, Montgomery, Putnam, Wayne.
*Physcia tribacia (Ach.) Nyl.
Hendricks, Montgomery, Parke, Union.
*Pyxine sorediata (Ach.) Fries.
Montgomery.
*Rinodina lecanorina Mass.
Montgomery.

HELVELLALES.

Geoglossaceae.

Geoglossum gelatinosum (Pers.) Dur.
Monroe (?).
Geoglossum glabrum Pers.
Monroe.
*Leotia lubrica (Scop.) Pers.
Monroe (?), Tippecanoe.
*Leotia stipitata (Bosc.) Schröt.
Montgomery (?).
Microglossum rufum (L. and S.) Underw.
Monroe.

Helvellaceae.

*Gyromitra brunnea Underw.
Putnam.
Gyromitra gigas (Krombh) Cooke.
Monroe (?).

*Helvella crispa (Scop.) Fries.
Montgomery (?).
*Helvella elastica Bull.
Monroe, Montgomery.
Helvella lacunosa Afz.
Monroe.
*Helvella sulcata (Schäff.) Afz.
Montgomery.
Morchella conica Pers.
Monroe (?), Putnam.
*Morchella esculenta (L.) Pers.
Monroe (?), Montgomery, Putnam.
Morchella rimosipes D. C.
Putnam.
Morchella hybrida (Sow.) Pers.
Putnam.
*Morchella semilibera D. C.
Monroe (?).
Psilopezia nummularis Berk.
Putnam.

TUBERALES.

Tuber rufum Pico.
Monroe (?).

PHACIDIALES.

Stictidaceae.

*Stictis radiata (L.) Pers.
Montgomery.

Tryblidiaceae.

Tryblidium minor Cooke.
Putnam.

Phacidiaceae.

*Rhytisma acerina (Pers.) Fries.
Jasper, Marshall, Monroe, Putnam.
*Rhytisma andromedae (Pers.) Fries.
Fulton, Monroe (?).
Rhytisma ilicis-canadensis Schw.
Putnam, Marshall, Vigo.

HYSTERIALES.

Dichaenaceae.

*Dichaena faginea (Pers.) Fries.
Tippecanoe, Putnam.
Dichaena ferruginea (Pers.) Fries.
Monroe (?).

Hysteriaceae.

*Gloniopsis gerardiana Sacc.
Montgomery.
*Gloniopsis lineolata (Cooke) Sacc.
Hendricks.
*Glonium lineare (Fries) Sacc.
Union.
*Glonium nitidum Ell.
Montgomery.
Glonium simulans Ger.
Monroe (?).
*Glonium stellatum Muhl.
Montgomery.
*Hysterium insidens Schw.
Hendricks. Montgomery.
*Hysterographium cinerascens Schw.
Montgomery.
*Hysterographium gloniopsis (Ger.) Ell. and Cooke.
Monroe (?).
*Hysterographium lesquereauxii (Duby) Ell. and Ev.
Union.
*Hysterographium mori (Schw.) Rehm.
Monroe. Montgomery.
*Hysterographium rousselii De Not.
Montgomery.
*Hysterographium variabile Cooke and Peck.
Montgomery. Parke. Tippecanoe.

Graphidaceae.

Graphis dendritica Ach.
Wayne.
*Graphis scripta (L.) Ach.
Montgomery. Parke. Putnam. Union. Wayne.
*Opegrapha varia Pers.
Parke, Tippecanoe.

Arthoniaceae.

*Arthonia dispersa (Lam. and D. C.) Duf.
Montgomery, Union.
*Arthonia lecideella Nyl.
Hendricks. Montgomery. Parke. Tippecanoe, Union.
*Arthonia radiata (Pers.) Ach.
Tippecanoe.
*Arthothelium spectabile Mass.
Parke. Putnam. Union.

HYPOCREALES.

*Chromocrea gelatinosa (Tode) Seaver.
Parke.
*Claviceps microcephala (Wallr.) Tul.
Marion, Marshall, Tippecanoe.
*Claviceps purpurea (Fries.) Tul.
Clay, Hamilton, Marion, Montgomery, Putnam, Tippecanoe.
Cordyceps herculea (Schw.) Sacc.
Monroe (?).
Cordyceps militaris (L.) Link.
Monroe (?).
Cordyceps ophioglossoides (Ehrh.) Sacc.
Montgomery, Putnam.
*Epichloe typhina (Pers.) Tul.
Putnam, Tippecanoe.
Gibberella saubinettii (Mont.) Sacc.
Monroe.
Hypocrea citrina (Pers.) Fries.
Putnam.
Hypocrea gelatinosa (Tode) Fries.
Putnam.
*Hypocrea lenta (Tode) Berk. and Brown.
Montgomery.
Hypocrea rufa (Pers.) Fries.
Putnam.
*Hypocrea sulphurea (Schw.) Sacc.
Union.
*Hypomyces lactifluorum (Schw.) Tul.
Monroe (?).
Hypomyces rosellus (Alb. and Schw.) Tul.
Monroe (?).
*Nectria cinnabarina (Tode) Fries.
Carroll, Monroe (?), Montgomery.
Nectria ditissima Tul.
Nurseries.
*Nectria episphaeria (Tode) Fries.
Montgomery.
Nectria ipomeae Hals.
Franklin, Monroe, Tippecanoe.
*Nectria sanguinea Fries.
Montgomery.

DOTHIDIALES.

Dothidiaceae.

Dothidea collecta (Schw.) Ell. and Ev.
Putnam.
*Dothidea glumarum Berk and Curt.
Montgomery.

Dothidea linderae Ger.
Putnam.
Dothidella ulmea (Schw.) Ell. and Ev.
Kosciusko, Monroe, Montgomery.
*Dothidella ulmi (Duv.) Wint.
Decatur, Montgomery.
*Phyllachora graminis (Pers.) Fuck.
Hamilton, Johnson, Marion, Monroe, Montgomery, Putnam, Tippecanoe.
Phyllachora lespedezae (Schw.) Cooke.
Marshall.
Phyllachora pomigena (Schw.) Sacc.
Tippecanoe.
*Phyllachora potentillae Peck.
Montgomery.
*Phyllachora trifolii (Pers.) Fuck.
Johnson, Tippecanoe.
*Plowrightia morbosa (Schw.) Sacc.
Franklin, Montgomery, Putnam.

SPHAERIALES.

Chaetomiaceae.

*Chaetomium bastrychodes Zopf.
Tippecanoe.

Sordariaceae.

*Sporormia minima Auersw.
Montgomery.

Sphaeriaceae.

*Anthostomella ostiolata Ell.
Monroe (?), Montgomery.
Endothia parasitica (Murr.) Anders.
Benton, Marion.
Glomerella rufo-maculans Schrenk and Spauld.
Tippecanoe.
*Lasiosphaeria hirsuta (Fries) Ces. and De Not.
Parke.
*Lasiosphaeria hispida (Tode) Fuck.
Montgomery.
*Lasiosphaeria ovina (Pers.) Ces. and De Not.
Union.
*Leptosphaeria borealis Ell. and Ev.
Montgomery.
*Leptosphaeria doliolum (Pers.) Ces. and De Not.
Montgomery.
*Leptosphaeria dumentorum Niessl.
Montgomery.

*Leptosphaeria subacuta (Cooke and Peck) Sacc.
Montgomery.
*Leptosphaeria subconica (Cooke and Peck) Sacc.
Montgomery.
Massaria inquinans (Tode) Fries.
Monroe.
*Melanomma sporadicum Ell. and Ev.
Putnam, Union.
*Rosellinia aquila (Fries) De Not.
Boone, Monroe, Montgomery, Putnam.
Rosellinia glandiformis Ell. and Ev.
Boone, Monroe.
Rosellinia ligniaria (Grev.) Sacc.
Boone, Monroe.
Rosellinia mammiformis (Pers.) Ces. and De Not.
Monroe.
*Roselinia medullaris (Wallr.) Ces. and De Not.
Monroe, Montgomery.
Roselinia mutans (Cooke and Peck) (Sacc.)
Monroe.
Rosellina pulveracea (Ehrh.) Fuck.
Boone, Hamilton.
*Rosellinia subiculata (Schw.) Sacc.
Clark, Hamilton, Monroe, Montgomery.
Sphaerella fragariae (Tul.) Sacc.
Johnson, Monroe (?), Putnam.
Sphaerella fraxinicola (Schw.) Cooke.
Johnson.
Sphaerella thalictri Ell. and Ev.
Montgomery.
Sphaeria iridis Schw.
Montgomery.
*Teichospora obducens (Fries) Fuck.
Union.
*Trichosphaeria pilosa (Pers.) Fuck.
Montgomery.

Ceratostomaceae.

*Ceratostomella barbarostra (Duf.) Sacc.
Monroe.

Amphisphaeriaceae.

*Amphisphaeria incrustans Ell. and Ev.
Montgomery.
*Caryospora putaminum (Schw.) De Not.
Putnam, Tippecanoe.
*Trematosphaeria pertusa (Pers.) Fuck.
Owen, Tippecanoe.

Mycosphaerellaceae.

*Guignardia bidwellii (Ell.) Via. and Rav.
Johnson, Monroe, Owen, Putnam, Tippecanoe.
Mycosphaerella ulmi Kleb.
Johnson.

Pleosporaceae.

Didymella lophospora Sacc. and Speg.
Monroe.
*Ophiobolus acuminatus (Sow.) Duby.
Montgomery.
*Ophiobolus anguillides (Cooke) Sacc.
Montgomery.
*Ophiobolus solidaginis (Fries) Sacc.
Montgomery.
Venturia cerasi Aderh.
Kosciusko.
Venturia inaequalis (Cooke) Wint.
Tippecanoe (?).
*Venturia pomi (Fries) Wint.
Franklin, Monroe.
Venturia pyrina Aderh.
Montgomery, Tippecanoe.

Gnomoniaceae.

*Gnomonia ulmea (Schw.) Thüm.
Johnson, Montgomery.

Valsaceae.

*Diaporthe albocarnis Ell. and Ev.
Montgomery.
Diaporthe batatatis Hart. and Field.
Franklin, Tippecanoe.
*Diaporthe orthoceras (Fries) Nits.
Montgomery.
*Eutypa ludibunda Sacc.
Montgomery.
*Eutypa spinosa (Pers.) Tul.
Montgomery, Putnam.
*Eutypella cerviculata (Fries) Ell. and Ev.
Tippecanoe.
Eutypella platani (Schw.) Sacc.
Putnam.
Valsa leucostoma (Pers.) Fries.
Monroe (?).

Melanchonidaceae.

Valsaria exasperans (Ger.) Ell. and Ev.
Monroe. Putnam.
Valsaria quadrata (Schw.) Sacc.
Putnam.

Diatrypaceae.

*Diatrype albopruinosa (Schw.) Cooke.
Monroe (?), Tippecanoe. Vigo.
*Diatrype asterostoma Berk. and Curt.
Union.
*Diatrype stigma (Hoffm.) Fries.
Monroe (?), Montgomery.
*Diatrype virescens (Schw.) Ell. and Ev.
Monroe (?), Montgomery, Putnam.
Diatrypella cephalanthi (Schw.) Sacc.
Putnam.
*Diatrypella prominens (Howe) Ell. and Ev.
Monroe, Montgomery.

Melogrammataceae.

*Botryosphaeria sumachi (Schw.) Cooke.
Montgomery.

Xylariaceae.

*Daldinia concentrica (Bolt.) Ces. and De Not.
Monroe (?), Montgomery, Putnam.
Hypoxylon annulatum (Schw.) Mont.
Monroe, Putnam.
*Hypoxylon atropunctatum (Schw.) Mont.
Monroe, Montgomery, Orange, Putnam.
Hypoxylon atropurpureum Fries.
Monroe, Owens.
Hypoxylon coccineum Bull.
Monroe, Montgomery, Putnam.
*Hypoxylon coherans (Pers.) Fries.
Monroe, Montgomery, Putnam.
Hypoxylon effusum Nits.
Monroe.
Hypoxylon fuscopurpureum (Schw.) Berk.
Monroe.
*Hypoxylon fuscum (Pers.) Fries.
Monroe, Montgomery, Tippecanoe, Union.
Hypoxylon howeianum Peck.
Monroe.
*Hypoxylon insidens Schw.
Montgomery.

Hypoxylon investiens (Schw.) Berk.
Monroe (?).
Hypoxylon marginatum (Schw.) Berk.
Monroe, Putnam.
*Hypoxylon multiforme Fries.
Monroe, Montgomery.
Hypoxylon perforatum (Schw.) Sacc.
Monroe, Putnam.
Hypoxylon petersii Berk. and Curt.
Monroe (?), Putnam.
*Hypoxylon rubiginosum (Pers.) Fries.
Clark, Monroe, Montgomery, Putnam.
*Hypoxylon sassafras (Schw.) Berk.
Monroe, Putnam.
*Hypoxylon stigmateum Cooke.
Montgomery, Union.
Hypoxylon turbinulatum (Schw.) Berk.
Monroe.
*Nummularia bulliardi Tul.
Brown, Clark, Hendricks, Monroe, Putnam.
Nummularia discreta (Schw.) Tul.
Hendricks, Monroe, Putnam.
Nummularia microplaca (Berk. and Curt.) Cooke.
Monroe.
Nummularia repanda (Fries) Nits.
Clark, Monroe, Putnam.
Nummularia tinctor (Berk.) Ell. and Ev.
Monroe.
*Ustulina vulgaris Tul.
Monroe (?), Montgomery, Parke, Putnam, Union.
*Xylaria castorea Berk.
Hendricks, Monroe (?).
*Xylaria corniformis Fries.
Monroe, Montgomery, Putnam.
*Xylaria digitata (L.) Grev.
Montgomery.
Xylaria hypoxylon (L.) Grev.
Monroe (?), Putnam.
*Xylaria polymorpha (Pers.) Grev.
Hamilton, Marion, Monroe (?), Montgomery, Putnam, Tippecanoe, Union.

PYRENULALES.

Verrucariaceae.

*Verrucaria epigea (Pers.) Ach.
Union.
*Verrucaria muralis Ach.
Franklin, Monroe, Montgomery, Putnam.

*Verrucaria nigrescens Pers.
Montgomery, Putnam, Tippecanoe.
*Verrucaria rupestris Schrad.
Montgomery.
*Verrucaria sordida Fink.
Montgomery.
*Verrucaria viridula Ach.
Montgomery.

Pyrenulaceae.

*Pyrenula cinerella (Flot.) Fink.
Union.
*Pyrenula leucoplaca (Wallr.) Karst.
Parke.
*Pyrenula nitida (Weig.) Ach.
Parke.

Dermatocarpaceae.

Endocarpon miniatum Fries.
Owen, Wayne.
*Endocarpon pusillium Hedw.
Franklin, Montgomery, Union.
*Thelocarpon prasinellum Nyl.
Union.

Trypetheliaceae.

*Trypethelium virens Tuck.
Tippecanoe.

PERISPORIALES.

Erysiphaceae.

*Erysiphe cichoracearum D. C.
Johnson, Marshall, Monroe, Montgomery, Putnam, Tippecanoe, Union.
*Erysiphe communis (Waalr.) Fries.
Johnson, Marshall, Montgomery, Owen, Putnam.
Erysiphe galeopsidis D. C.
Fulton, Johnson, Marshall, Montgomery, Putnam.
*Erysiphe graminis D. C.
Johnson, Monroe, Montgomery, Putnam.
Erysiphe horridula Lev.
Montgomery.
Erysiphe lamprocarpa (Wallr.) Lev.
Montgomery.
Erysiphe liriodendri Schw.
Montgomery, Putnam, Wabash.
*Erysiphe polygoni D. C.
Monroe, Montgomery, Parke, Putnam, Tippecanoe, Union.

Erysiphe tortilis (Wallr.), Link.
Montgomery.
*Microsphaera alni (D. C.) Wint.
Fulton, Johnson, Marshall, Monroe, Montgomery, Putnam, Tippecanoe, Union.
Microsphaera densissima Cooke and Peck.
Montgomery.
*Microsphaera diffusa Cooke and Peck.
Marshall, Montgomery.
*Microsphaera elevata Burr.
Monroe, Owen, Putnam, Tippecanoe.
Miscrosphaera erineophila Peck.
Marion, Putnam.
*Microsphaera euonymi (D. C.) Sacc.
Tippecanoe.
*Microsphaera euphorbiae (Peck) Berk. and Curt.
Steuben, Tippecanoe.
Microphaera extensa Cook and Peck.
Montgomery (?).
Microsphaera friesii Lev.
Montgomery.
*Microsphaera grossulariae (Wallr.) Lév.
Johnson, Montgomery.
*Microsphaera quercina (Schw.) Burr.
Johnson, Marshall, Montgomery, Putnam, Vigo.
Microsphaera platanii Howe.
Montgomery.
Microsphaera ravenelii Berk.
Johnson, Marion, Montgomery, Owen, Putnam, Vigo.
*Microsphaera russellii Clint.
Johnson, Montgomery, Owen, Putnam, Vigo.
Miscrosphaera semitosta Berk. and Curt.
Johnson, Vigo.
Microsphaera symphoricarpi Howe.
Montgomery, Putnam.
Microsphaera vaccinii (Schw.) Cooke and Peck.
Marshall, Montgomery, Owen, Putnam, Tippecanoe.
*Phyllactinia corylea (Pers.) Karst.
Carrol, Johnson, Montgomery, Putnam.
*Phyllactinia suffulta (Reb.) Sacc.
Johnson, Marshall, Montgomery, Putnam, Shelby, Vigo.
*Podosphaera biuncinata Cooke and Peck.
Putnam.
*Podosphaera leucotricha (Ell. and Ev.) Salm.
Sullivan.
*Podosphaera oxycanthae (D. C.) De Bary.
Floyd, Fountain, Johnson, Marshall, Monroe, Montgomery, Owen, Putnam, Tippecanoe.

Sphaerotheca castagnei Lév.
Johnson, Marshall, Monroe, Montgomery, Putnam, Tippecanoe.
*Sphaerotheca humuli (D. C.) Burr.
Marshall, Monroe, Montgomery, Putnam, Tippecanoe.
*Sphaerotheca humuli fuliginea (Schlecht.) Salm.
Montgomery.
Sphaerotheca mors-uvae (Schw.) Berk. and Curt.
Montgomery.
*Sphaerotheca pannosa (Wallr.) Lév.
Elkhart, Fayette, Johnson, Monroe (?), Putnam.
*Sphaerotheca phytoptophila Kell. and Swing.
Montgomery, Putnam, Tippecanoe.
Uncinula aduncta Lév.
Montgomery (?).
Uncinula americana Howe.
Montgomery.
Uncinula ampelopsidis Peck.
Montgomery, Tippecanoe.
*Uncinula circinata Cooke and Peck.
Johnson, Marshall, Montgomery, Putnam.
*Uncinula clintonii Peck.
Montgomery, Putnam.
*Uncinula flexuosa Peck.
Hamilton, Johnson, Montgomery, Putnam.
*Uncinula geniculata Ger.
Johnson, Monroe, Montgomery.
*Uncinula macrospora Peck.
Johnson, Montgomery, Owen, Putnam, Wabash.
*Uncinula necator (Schw.) Burr.
Johnson, Monroe, Montgomery, Putnam.
*Uncinula parvula Cooke and Peck.
Johnson, Marion, Putnam.
*Uncinula salicis (D. C.) Wint.
Marshall, Monroe, Montgomery, Putnam, Tippecanoe.

Perisporiaceae.

Dimerosporium collinsii (Schw.) Thüem.
Monroe (?).
*Scorias spongiosa (Schw.) Fries.
Monroe (?), Owen, Putnam.

ASPERGILLALES.

Aspergillus glaucus (Wigg.) Link.
Tippecanoe.
*Penicillium crustaceum Link.
Tippecanoe.

EXOASCALES.

Exoascaceae.

Exoascus deformans (Berk.) Fuck.
Monroe, Montgomery, Putnam, Tippecanoe, Vigo.
*Exoascus mirabilis Atkins.
Jefferson, Orange.
Exoascus potentillae Farl.
Putnam, Vigo.
Exoascus pruni (Tul.) Fuck.
Monroe, Tippecanoe.
*Taphrina caerulescens (Mont.) Tul.
Montgomery.
*Taphrina potentillae (Farl.) John.
Vigo.
*Taphrina virginica Sad. and Seym.
Putnam, Vigo.

BIBLIOGRAPHY.

Brannon, M. A. Some Indiana mildews. Proc. Ind. Acad. Sci. *1898*: 291—295. 1899.

Fink, Bruce and Fuson, Sylvia C. Ascomycetes new to the flora of Indiana. Proc. Ind. Acad. Sci. *1918*: 264—275. 1919.

Haines, Mary P. List of ferns, mosses, hepaticae, and lichens collected in Wayne county. Ind. Geol. Surv. *1878*: 235—239. 1878.

Ludwig, C. A. Fungous enemies of the sweet potato in Indiana. Proc. Ind. Acad. Sci. *1912*: 103, 104. 1912.

O'Neal, Claude E. Some species of Nummularia common in Indiana. Proc. Ind. Acad. Sci. *1914*: 235—241. 1914.

Osner, Geo. A. List of plant diseases. Proc. Ind. Acad. Sci. *1916*: 327—332.. 1916.

———, ——— ———. List of plant diseases. Proc. Ind. Acad. Sci. *1917*: 145—147. 1917.

Owens, Charles E. A monograph of the common Indiana species of Hypoxylon. Proc. Ind. Acad. Sci. *1911*: 291—308. 1911.

Pipal, F. J. List of plant diseases. Proc. Ind. Acad. Sci. *1915*: 379—397. 1915.

Ramsey, Glen B. The genus Rosellinia in Indiana. Proc. Ind. Acad. Sci. *1914*: 251—259. 1914.

Rose, J. N. The mildews of Indiana. Bot. Gaz. *11*: 60-63. 1886.

Underwood, L. M. List of cryptogams at present known to inhabit the state of Indiana. Proc. Ind. Acad. Sci. *1893*: 30-67. 1893.

———, ——— ———. Report of the botanical division of the Indiana state geological survey for 1894. Proc. Ind. Acad. Sci. *1894*: 144—156. 1894.

Van Hook, J. M. Indiana fungi, Proc. Ind. Acad. Sci. *1910*: 205—212. 1910.

——— ———. ——. ——. Indiana fungi II. Proc. Ind. Acad. Sci. *1911*: 347—354. 1911.

——— ———. ——. ——. Indiana fungi III. Proc. Ind. Acad. Sci. *1912*: 99-101. 1912.

——— ———. ——. ——. Indiana fungi IV. Proc. Ind. Acad. Sci. *1915*. 141—146. 1915.

Wilson, Guy West. Flora of Hamilton and Marion counties Indiana. Proc. Ind. Acad. Sci. *1894*: 156—176. 1894.

INDIANA PLANT DISEASES, 1919.[1]

Max W. Gardner.

INTRODUCTION.

The parasitic fungi of economic importance in Indiana have been previously recorded by Pipal[3] and by Osner[4,5]. While additions to this list will be included in subsequent reports the nature of the report will be essentially altered so that it will constitute a somewhat detailed account of the general crop pathology and the diseases of considerable economic importance during the season in question. Relative prevalence, geographical distribution, local epidemics, new or unusual features observed, and losses incurred, especially specific instances, will be among the data included. It is hoped that by such an annual procedure, a clearer understanding of Indiana plant disease conditions may be obtained. For this report no claim of completeness is made. Diseases of forest trees and ornamentals are not included. Diseases not reported in the previous lists are enumerated in the summary.

WEATHER CONDITIONS.

Because of the very intimate bearing of the weather upon crop pathology, it is deemed not out of place to present a brief resumé of the weather conditions prevailing during the 1919 growing season as summarized by Mr. J. H. Armington in the monthly reports of the Weather Bureau at Indianapolis.

Very warm weather early in April advanced vegetation very rapidly and caused fruit to blossom in the central and southern portions of the state. Consequently the freezing temperatures attained April 25th. to 27th. resulted in very serious injury to peaches, cherries, plums, apples, wheat, and rye. After this followed a month of cool, cloudy, wet weather resulting in a marked retardation of grains, a yellowing of wheat and rye in wet soil, a subsequent lodging of wheat, and a delayed planting of corn and truck crops.

June and July were exceptionally hot and dry. The rainfall during June was in the form of local thunder storms and was deficient in the east and central portions of the state. In general, however, the weather during June was not unfavorable to crops. Except for a light rain, July 14th., there was practically no rain at all during that month until the 31st. This prolonged drouth, coupled with the excessive heat, resulted in severe retarda-

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[3]Pipal, F. J. A list of plant diseases of economic importance in Indiana with bibliography. Proc. Ind. Acad. Sci. 1915 :379-413. 1916.

[4]Osner, Geo. A. Additions to the list of plant diseases of economic importance in Indiana. Proc. Ind. Acad. Sci. 1916 :327-332. 1917.

[5]Osner, George A. Additions to the list of plant diseases of economic importance in Indiana. Proc. Ind. Acad. Sci. 1917 :145-147. 1918.

[1]Contribution from the Botanical Department of Purdue University Agricultural Experiment Station, Lafayette. Indiana.

[2]The writer wishes to acknowledge the assistance of Prof. H. S. Jackson, Mr. F. J. Pipal, Mr. G. N. Hoffer, Dr. C. T. Gregory, and E. B. Mains in preparing this report.

tion and drouth injury of corn and truck crops. The heavy rainfall of July 31st. and August 1st. was state-wide and relieved the drouth situation to a large extent although certain localities continued to suffer.

There was hail injury to truck crops and strawberries at Madison, June 12th, and to truck crops, corn and oats at Berne and Winona Lake, July 19th.

August was not especially hot and local rains were frequent. The rainfall was, however, below normal and was insufficient, especially in certain localities, to offset the drouth injury of July. The first half of September was also hot and dry, thus further injuring potatoes and truck crops. Heavy rains, September 18th, to 22nd., followed by an exceptionally warm, wet, and late fall, with no frost until late in October, resulted in a very favorable late growing season.

To summarize briefly, we have had this year an early period of warm weather in April followed by a destructive freeze, a cold wet May, an exceptionally hot and dry June and July period, followed by a generally favorable growing season lasting until late in October. Certain types of parasitic plant diseases are markedly influenced by such weather conditions. For example, the cold wet weather of May was especially favorable to certain fruit diseases such as apple scab, the subsequent hot dry weather to the Fusarium root diseases such as cabbage yellows, and the late growing season resulted in a prolonged exposure of crops to certain types of disease such as the Septoria leaf-spot of tomato which increase in prevalence and severity as the season advances.

DISEASES ARRANGED BY HOSTS.

Alfalfa.

Leaf-spot caused by *Pseudopeziza medicaginis* was generally prevalent.

Apple.

Blotch caused by *Phyllosticta solitaria* was the most serious disease in the southern part of the state on the susceptible varieties, Northwestern and Rhode Island Greenings, Stark, Ben Davis, Smith Cider, Duchess, and Arkansas Red, according to C. L. Burkholder who further reports that blotch was much worse than usual this year. According to J. Oskamp, C. L. Burkholder, and F. P. Cullinan, the northern limit of blotch as an important commercial factor in Indiana could be repre.ented by a line across the state north of Indianapolis through the counties of Fountain, Montgomery, Boone, Hamilton, and Madison. The disease occurs, however, on the Stark and Northwestern Greening to a considerable degree as far north as the Wabash valley. The above observers also report that, in the badly infested southern half of the state, the disease seemed to be most severe in the southwestern corner and along the Ohio River. Oskamp reports severe blotch at Solon, Indiana. Blotch was found in neglected orchards about Lafayette and in sprayed orchards at Bedford, Mooresville, Greenfield, and Knightstown.

At Greenfield cankers on 1918 wood were not at all common. Counts made September 18th at Greenfield showed fruit infection ranging from 45 to 72%, at Knightstown, 78 to 86%, and at Mooresville, 77 to 96%. Petiole infection ranged between 57 and 74% at Mooresville. In the Greenfield orchard blotch was found on two young Grimes trees that were overhung by diseased Greenings, indicative of drip infection. Good control of blotch on the fruit was secured by the Bordeaux sprays, but no success was had with the concentrated lime sulphur dormant spray.

Scab, caused by *Venturia inaequalis*, is the most important apple disease in Indiana and seemed to be equally prevalent throughout the state. Because of the wet weather in May, scab was particularly severe on the foliage and blossoms. It was not, however, as severe on the fruit as the early infection led one to expect. However, it was generally prevalent on fruit in the northern part of the state. H. H. Swaim reports difficulty in finding scab-free fruit in a sprayed orchard near South Bend. Cullinan found in an experimental orchard at Peru, practically 100% defoliation and no fruit in unsprayed check plots as a result of scab. He further reports that the Ben Davis variety suffered severely from this disease. Burkholder found scab worse this year in southern Indiana than he had previously noted. Owing to the very early and vigorous start made by the disease, spray control was less successful than usual.

Taking the state as a whole, black rot caused by *Sphaeropsis malorum* was by far the most prevalent disease. The frog-eye leaf-spot was particularly ubiquitous and destructive, and the blossom-end type of fruit rot was rather common on certain varieties. The latter condition was noticed in an orchard at Knightstown, June 17th., and on Summer Rambo in an orchard near Bedford, July 15th. Cullinan found black rot very severe on Ben Davis apples in an orchard at Bicknell in August in the shape of a blossom-end rot associated with a heavy San Jose scale infestation of the calyx ends which had caused cracking of the fruit. While this disease is usually worse on old unpruned trees, it was found very severe in a large orchard of young trees near Paoli, May 28th., resulting in a noticeable yellowing of the foliage. Considerable defoliation was caused by this disease and in cases carefully noted it was found that five or six lesions were sufficient to cause the leaf to drop.

Early in the season, fire blight caused by *Bacillus amylovorus* occasionally was noted to be severe in apple trees, particularly those near diseased pear trees. A striking example of this was noted near Knightstown, June 17th., where there was a row of badly blighted pear trees along one side of an orchard. The apple trees along this side were badly blighted, while farther over there was not much blight to be found. In a dooryard in Orleans, a case was observed where there was considerable blight on one side of an apple tree, the side adjoining a blighted pear tree. In a small orchard of young trees near Indianapolis, the extreme susceptibility of the Winter Banana variety to fire blight was clearly indicated.

Sooty blotch caused by *Leptothyrium pomi* occurred rather commonly in the central and southern parts of the state. Considerable sooty blotch was noted on the fruit from an orchard near Mooresville.

Rust caused by *Gymnosporangium juniperi-virginianae* was rather severe, according to Pipal, in the southeastern part of the state. The abundance of the red cedar in southern Indiana is of course very conducive to rust epidemics.

Oskamp reports that blister canker due to *Nummularia discreta* is increasing in importance in Indiana and further reports its extreme severity on the Ben Davis variety near Greencastle. It is also reported to be present on that variety in an orchard near Peru.

According to the observations of Oskamp and Pipal, bitter rot caused by *Glomerella cingulata* was not as destructive as usual this year. Bitter rot occurs mainly in southern Indiana.

A serious root trouble occurs to a considerable extent in central and southern Indiana, especially on the Grimes variety. This root rot usually results in the death of the affected trees and cases are on record where whole orchards have been destroyed in the southern part of the state. Whether or not this is the Xylaria root rot has not been ascertained.

Frost injury to apple blossoms was of course severe in certain sections of the state and caused a marked reduction in yield. A very bad case of this was noted in a large orchard near Goshen where absolutely all of the blossom clusters were killed. A peculiar crinkling of apple leaves due to the death of the lower epidermis was very widely noted during June and was attributed to freezing injury. There was a marked prevalence of frost marking of the fruit in the central and southern parts of the state in all stages from narrow frost bands and blossom-end russet to russeting of the entire surface of the fruit, and even malformation of the fruit. So prevalent was this type of injury that it assumed considerable significance as a blemish in the prize exhibits in the shows.

The lace-like russeting of the fruit resulting from Bordeaux injury and arsenical burning of the foliage was found in sprayed orchards.

Asparagus.

Rust caused by *Puccinia asparagi* was not found in the Indianapolis market gardens but was noted at Lafayette.

Aster.

Fusarium wilt was severe locally.

Barley.

Thirty-six barley fields in 15 counties were examined in the federal cereal disease survey. Ergot caused by *Claviceps purpurea* was found in two fields. Spot blotch caused by *Helminthosporium sativum* was reported from eight fields, net blotch caused by *Helminthosporium teres* from 11 fields, and stripe caused by *Helminthosporium gramineum* from two fields. Spot blotch is the most serious of these diseases in Indiana and was very abundant in the eight fields above noted, all of which were in Madison, Delaware and Noble counties. Scab caused by *Gibberella saubinetii* was found in 19 or

53% of the 36 fields with an average incidence of 3.3%. One field in Madison County showed 35% scab. This field was in corn in 1918.

Leaf rust caused by *Puccinia simplex* was found in six out of the 36 fields with an average incidence of 1.2% and a maximum of 20%. Stem rust caused by *Puccinia graminis* was found in 13 fields with an average incidence of 2.1% and a maximum of 20%. Neither of these diseases was of any considerable economic importance.

Covered smut caused by *Ustilago hordei* was found in 10 of the 36 fields with an average incidence of less than ½% and a maximum of 8%. Loose smut due to *Ustilago nuda* was found in 30 or 83% of the fields with an average incidence of 1.6% and a maximum of 25%. None of the 36 fields examined had been planted with treated grain.

Bean.

The garden crop suffered severely from drouth injury, which was evidenced by a downward curling and extreme distortion of the leaves accompanied by marginal browning. Bacterial blight caused by *Pseudomonas phaseoli* was generally present in all gardens and constituted a serious loss-producing factor. Late in the season, the mosaic disease became very prevalent. Its symptoms may have been masked by the universal drouth injury earlier in the season. The leaf spot caused by *Phyllosticta phaseolina* was found at Lafayette.

Beet.

The sugar beet crop of Lake County seemed to be more or less free from disease except for some leaf-spot caused by *Cercospora beticola*. A little scab due to *Actinomyces scabies* was found, and crown gall was reported by growers. A crown rot of the roots was noted in DeKalb County.

Garden beets throughout the state were generally infected with the leaf-spot due to *Cercospora beticola*, but as a rule the attack was not particularly severe.

Blackberry.

Orange rust due to *Gymnoconia peckiana* was very widespread and abundant throughout the state in late May and early June.

Bluegrass.

The slime mold, *Physarum cinereum*, caused conspicuous patches in lawns early in the spring.

Cabbage.

The limiting factor in the cabbage crop of Indiana this season was the yellows disease caused by *Fusarium conglutinans*. The extremely hot weather was especially favorable to this disease and it was widespread throughout the state both in small gardens and in truck fields. In certain of the market gardens near Indianapolis, the early crops of Wakefield and

Copenhagen were failures because of yellows and market growers about Shelbyville reported that yellows was forcing them entirely out of the cabbage industry. In the Lake County truck region near Highland, yellows was found to a greater or less extent in a rather large number of fields of kraut cabbage examined and no fields were found to be free from it. Yellows is frequently present in seed beds and the use of diseased transplants is a prolific means of dissemination of this disease. Especially is this the case when one grower secures plants grown by another, a practice commonly indulged in.

Clubroot caused by *Plasmodiophora brassicae* was found in several (5) fields near Highland in Lake County and where it occurs a heavy reduction in yield results. In one instance a grower had knowingly introduced both yellows and club root into clean soil with his purchased transplants.

Black-leg caused by *Phoma lingam* was found in a few fields near Highland, but was not very destructive. Black rot due to *Pseudomonas campestris* was not noted. Black leaf-spot caused by *Alternaria brassicae* was noted in Lake County. In the early crop in the Indianapolis market gardens there was some loss due to a rot of the stem and leaf bases caused by *Sclerotinia libertiana*. The same fungus was observed earlier in the season on seedlings in a greenhouse. Likewise there was noted a damping-off of cabbage seedlings due to Rhizoctonia.

A non-parasitic tip-burn of the leaves was found in Lake County, in September, which was not confined to the exterior leaves, but occurred also on interior leaves as well. This disease caused a considerable loss. Affected heads are unmarketable because the killed leaf margins almost invariably become infected with rot-producing fungi such as Botrytis.

Cantaloupe.

Fields were examined in Knox, Jackson and Marion Counties. The most important disease was wilt due to *Bacillus tracheiphilus*. This caused the death of a small percentage of the plants early in the season. It was found actively spreading June 26, and July 24 its ravages were attested by numerous blanks and dead plants. It was not serious in the Indianapolis market gardens but was generally recognized at Decker and Vallonia as the worst cantaloupe disease. No indications of Fusarium wilt were found.

Leaf blight or "rust" due to *Alternaria brassicae* var. *nigrescens* was very generally prevalent in all fields examined. It was severe in the Decker region, even as early as June 26th., and by July 24th, was killing the older foliage extensively. On many of the fields in this district cantaloupes have been grown for the last 20 to 30 years and the severity of leaf blight may be largely due to this lack of crop rotation.

The mosaic disease, characterized by dwarfed vines and mottled leaves was found in several fields in Knox County. This disease reduces the yield very materially.

White porcelain-like areas due to sunscald were found on the upper surfaces of melons in the field, July 24th. In the packing shed, melons were discarded as culls because of deep cracks and because of a rot resulting from scab-like lesions on the side of the melon that was in contact with the soil in the field.

Carrot.

Leaf-spot caused by *Cercospora apii* var. *carotae* was found in the Indianapolis market gardens.

Catalpa.

Leaf-spot due to *Macrosporium catalpae* was widespread.

Celery.

The most serious disease of celery as observed near Lafayette and Indianapolis was the root trouble known as the "stunting disease"[1-2], "crown rot," or "yellows". This is caused by a soil fungus, Fusarium, and is essentially similar in its effects to the cabbage yellows disease. Affected plants show a yellow color or premature bleaching of the older leaves usually on one side, exhibit all degrees of stunting, and may die early in the season or continue a sickly existence. The fungus persists in the soil and the diseased areas enlarge year by year. The disease is confined chiefly to the highly desirable Golden Self-blanching variety and green or late varieties are practically immune. In 1914 this disease was so prevalent in the celery marshes at Kalamazoo, Michigan, and Goshen, Indiana, that the industry was threatened with failure. Steam soil sterilization was found to be effective but rather impracticable, and the situation was relieved by the discovery that the Easy Bleaching variety, though slightly less desirable commercially, was highly resistant to the disease. This variety has now completely supplanted the Golden Self-bleaching variety at Kalamazoo and Goshen. At present the disease is just gaining a foothold in the Indianapolis market gardens. This season it caused one grower to plow under his celery, and caused a practical failure for another. A small area was found in a third field, and in another case two diseased plants were found in the cold frames early in the season and a few scattered plants in the field later. In this disease, as in cabbage yellows, dissemination is largely by means of diseased transplants.

In the Goshen crop, early blight caused by *Cercospora apii* was very destructive as observed in early September. Late blight due to *Septoria petroselini* occurred in a garden in Rush County in September. The bacterial leaf-spot was found near Lafayette, August 11th., and in some of the Indianapolis market gardens, August 22nd. Some nematode injury was found at Goshen where there is a large area of muck soil so badly in-

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[1]Coons, G. H. ' The Michigan plant disease survey for 1914. Mich. Acad. Sci. 17th. Ann. Rpt. :126-127. 1915.
[2]Coons, G. H. Michigan plant disease survey for 1917. Mich. Acad. Sci. 20th. Ann. Rpt. :444, 1918.

fested with nematodes that its use for truck crops has been discontinued. This nematode infestation has been present at least five years.

Cherry.

Leaf-spot caused by *Coccomyces hiemalis* was the most serious cherry disease and was generally prevalent and widespread. It was responsible for a marked yellowing of the foliage and consequent defoliation. Undoubtedly leaf-spot is a limiting factor in cherry production in Indiana. C. L. Burkholder reports that a successful spray control was secured by R. A. Simpson at Vincennes, using Bordeaux 2-4-50.

Brown rot due to *Sclerotinia cinerea* was reported by one grower near Indianapolis to be very severe on the Ox-heart variety.

Powdery mildew due to *Podosphaera oxyacanthae* was found in Jackson County.

Clover.

Anthracnose due to *Colletotrichum trifolii* was very serious on red clover. A badly diseased field was noted near Hartford City.

Leaf-spot caused by *Pseudopeziza trifolii* was found in Hancock County.

A spotting of sweet clover due to *Ascochyta caulicola* was found in Jefferson County.

Corn.

The most serious disease of corn was the root rot due to Fusarium species. G. N. Hoffer reports that this disease was state-wide in distribution but was worst in Shelby, Noble, and Bartholomew counties. It is worse in the lighter soils and in clay spots in the fields. The disease causes firing of the lower leaves and results in barrenness and nubbin production. The loss in yield due to root rot is estimated at 5% to 10%. The fungus is carried in the seed and also persists in the soil.

Leaf sheath, nodal, ear and root infection with the fungus *Gibberella saubinetii* has been the cause of much loss this year according to Hoffer. The most important injury is due to the shank infection which causes the ears to lop over and to the root rot. This is the same fungus which causes wheat scab.[1]

Hoffer also reports that corn ear rots due to Fusarium and Diplodia were not prevalent this year because of the fact that the weather was very favorable for the ripening of the grain. October and November floods in southern Indiana have caused much loss in seed corn, however, due to molding of the ears both on the stalk and in the shock.

Smut caused by *Ustilago zeae* was present in the usual abundance. It was worse in sweet corn and in fields where corn was grown in 1918.

Rust caused by *Puccinia sorghi* was less abundant than usual and was most common in the late plantings of sweet corn.

Stewart's disease caused by *Bacterium stewartii* was found near Ladoga,

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[1]Hoffer, G. N., Johnson, A. G., and Atanasoff, D. Corn root—rot and wheat scab Jour. Agr. Research *14*:611-612. 1918.

Shelbyville, and Indianapolis. Hoffer reports that the infection was rather light, ranging from 2 to 3%.

Drouth injury to corn became very severe in July and a marked firing of the leaves especially on the lighter soils was one of the results. Certain localities suffered worse than others in this regard.

Cucumber.

Bacterial wilt caused by *Bacillus tracheiphilus* occasioned heavy losses in certain greenhouses near Indianapolis and Terre Haute and was common in the field crop in Lake County. In the greenhouse crop heavy infestation of fruits on diseased vines was noted.

Mosaic was of considerable importance in the greenhouse and cold-frame crop but was not as prevalent as usual in the pickle crop.

Anthracnose caused by *Colletotrichum lagenarium* was very destructive in certain greenhouses where overhead watering was practiced. The disease was very destructive on all of the foliage up as high as the watering pipes.

Angular leaf spot due to *Bacterium lachrymans* was noted in the field crop but was not found in the greenhouses. This disease was prevalent in the pickle crop about Plymouth, LaPaz, and Lakeville in 1917 and 1918.

Powdery mildew caused by *Erysiphe cichoracearum* was noted occasionally in greenhouses and was more prevalent on the fall crop.

Downy mildew caused by *Peronoplasmopara cubensis* was found to a limited extent on the fall crop in one greenhouse.

Nematodes are one of the worst difficulties encountered in growing cucumbers in the greenhouse. One grower reports that the inroads of this trouble occasioned the installation of a system of control which entailed an original outlay of $15,000 and an annual operation cost of $500.

Eggplant.

Leaf-spot and fruit rot caused by *Phomopsis vexans* was found in the Indianapolis market gardens. More serious, however, was a wilt disease of undetermined origin.

Kale.

Yellows due undoubtedly to *Fusarium conglutinans* occurred in certain of the Indianapolis market gardens.

Lettuce.

In the greenhouses, downy mildew caused by *Bremia lactucae* was prevalent in the winter crops. It has been found that a low temperature greatly favors spore germination and this may explain why the disease is not so severe in the spring crop under glass and is absent in the field crop. Downy mildew affects mainly the older leaves and not only renders the older leaves unfit for market, but also predisposes them to a Botrytis rot. Botrytis not only attacked these older leaves, but also caused a stem rot which usually resulted in the death of the affected plants.

Drop caused by *Sclerotinia libertiana* occurred to a serious extent in some greenhouses in the late crop during cloudy weather.

A leaf-spot, probably of bacterial origin, and a rosette probably due to Rhizoctonia were also found in the greenhouse crop.

Maple.

Sunscald or drouth injury was severe on hard maples along city streets. The injury occurred in July and its effects were visible for several weeks. The leaves turned brown about the margins and between the veins and curled upward.

Oak.

Sunscald similar to that on maples occurred on shade trees during July.

Oats.

Leaf-spot or spot blotch caused by *Helminthosporium avenae* was reported from 28 out of the 254 fields of oats examined in the federal cereal disease survey. R. V. Allison found it very abundant in fields in Madison, Delaware, Wabash, Noble and Lagrange counties. Septoria leaf-spot was found in four of these fields, bacterial blight in six, and scab caused by *Gibberella saubinetii* was found in eight with a maximum incidence of 45%. Blast was reported from 92 of the fields and was found very abundant in Noble, Lagrange, Wabash, Delaware and Madison counties.

Covered smut caused by *Ustilago levis* was reported from eleven fields. Loose smut caused by *Ustilago avenae* was found in 208 or 82% of the fields examined, with an average incidence of 3.3% and a maximum of 24%. Out of 30 fields, the seed for which was treated by the wet formaldehyde method, 13 showed loose smut with an average incidence of 0.2% and a maximum of 2%. Out of 26 fields planted with seed treated by the dry formaldehyde method, 22 showed loose smut with an average incidence of 0.8% and a maximum of 8%.

Leaf rust caused by *Puccinia coronata* was reported from 197 or 77% of the 254 fields with an average incidence of 17% and a maximum of 100%.

Stem rust caused by *Puccinia graminis* was found in only 17 fields, with an average incidence of 0.6% and a maximum of 30%.

Onion.

Smut caused by *Urocystis cepulae* has been found by C. T. Gregory in a few fields at Hammond just across the state line from an area of infection in Illinois.

Smudge caused by *Colletotrichum circinans* was found on white bulb onions in the Indianapolis market gardens.

Pink root and Fusarium bulb rot were found in one field near Garrett in Dekalb County.

In Dekalb and Fulton counties there was considerable difficulty with onions in muck soils due to a severe stunting of a large percentage of the plants which resulted in a marked irregularity of the stand and consequent lack of uniformity in the size of the bulbs. In addition there was in the field a distinct bleaching and burning of the leaf tips. This trouble could not be attributed to any parasitic attack and was quite likely due to an excess of soluble salts in the surface soil, according to S. D. Conner. The latter[1] has found that there is an accumulation of soluble salts in the surface layers of muck soils, composed largely of nitrates, and in comparative analyses of soil from areas where onions were not growing well and from the rest of the field, he has found the concentration of nitrates three times as great in the surface inch of the diseased areas. In such concentrations there is a toxic effect upon the plant.

June 17th., there was observed in one field in Dekalb County a peculiar type of injury characterized by a bleached area and constriction of the leaf just above the ground line. The leaves usually broke over at this lesion. This trouble is likewise due probably to injury resulting from a temporary concentration of soluble salts in the surface soil.

Localized nematode infections were found in one field in Fulton County. Instead of root galls the effect was a clump of secondary roots at the point of infestation.

Parsnip.

Leaf-spot due to *Cercospora apii* was found rather abundant in the fall near Lafayette.

Pea.

The bacterial spot and the blight caused by *Ascochyta pisi* were found in small gardens.

Canners report serious trouble in their crops. It is quite likely that this will prove to be a soil difficulty due to a Fusarium. Hoffer reports that specimens received in previous years showed root infestation by Fusarium species.

Peach.

Early in the season there was a particularly widespread and destructive epidemic of peach leaf curl caused by *Exoascus deformans*. The disease was noted in nine counties. A very high percentage of the foliage on diseased trees was infected.

Later in the season the leaf-spot and shot-hole caused by *Bacterium pruni* became the most serious disease. It occurred in Greene and Hancock counties and was found in abundance in Knox county where defoliation was clearly attributable to this disease. In the last case, the attack on the fruit was not at all severe, however.

Cankers and twig blight due to *Sclerotinia cinerea* were noted early in the season in Tippecanoe and Orange counties. This disease seems to be most common on neglected farm yard trees. Growers report that brown rot is apt to occur in the hollows in the orchards.

[1]Conner, S. D. Excess soluble salts in humid soils. Jour. Am. Soc. Agronomy, *9*:297-301. 1917.

Twig lesions of the scab disease caused by *Cladosporium carpophilum* were found very common on the 1918 wood and were noted in four counties. In the Knox County crop, fruit infection was rather abundant but occurred too late to be of economic importance except as a minor blemish.

A root rot caused by *Armillaria mellea* was found in Brown County.

The severe winter injury of 1917-18 is conspicuous in the peach orchards near Paoli, which were rendered practically worthless. Frost injury to the blossoms reduced the Indiana crop severely this season.

Pear.

Fire blight caused by *Bacillus amylovorus* was very severe early in the summer, especially in the southern half of the state. Pipal reports that fire blight is ruining orchards in Tippecanoe and Gibson counties. Some of these have yielded no fruit for several years.

Leaf-spot caused by *Septoria pyricola* is common on dooryard trees.

Scab caused by *Venturia pyrina* occurred locally.

Pepper.

Sunscald of the green fruits was undoubtedly the cause of the greatest losses in this crop. The scalded areas are readily invaded by rot-producing fungi.

Mosaic was rather common late in the season.

Plum.

Brown rot caused by *Sclerotinia cinerea* was severe on farm yard trees in general. Twig blight due to the same fungus was noted also.

The leaf-spot caused by *Bacterium pruni* was noted in Blackford, Floyd, and Marshall counties. It was found quite serious near Plymouth, June 3rd.

Black knot due to *Plowrightia morbosa* was found in White County and Pipal reports a case in an orchard in Hendricks County in which every tree is being killed by black knot.

Twig injury caused by *Exoascus pruni* was very severe in an orchard in Hancock County early in the season.

Frost injury to the blossoms reduced the yield. Russet and cracking of the fruit due to frost injury was noted at Plymouth, June 3rd.

Potato.

The hot dry summer season was very unfavorable to the potato crop. The vines as a rule remained undersized, the leaves were small with a tendency to roll upwards, and the yield was low.

The weather conditions which prevailed this season were especially conducive to the non-parasitic disease known as tip-burn, which was prevalent throughout both the early and late crops. Undoubtedly soil and seed stock have some influence on the severity of this disease. The relative importance of the leaf-hopper as a causal agent in connection with tip-burn is still in question. C. T. Gregory and F. C. Gaylord found that a combined spray of

Bordeaux and nicotine sulphate seemed to result in improved vine vigor and yield where no fungous leaf diseases were present. This is hard to explain except upon the basis of the partial leaf-hopper control secured or the possible stimulation of the plant by the copper.

Fungous diseases of the foliage were of no importance in the Indiana crop this year. Late blight was not reported. Early blight caused by *Alternaria solani* was found in Marion and Blackford counties in June and in Clark and St. Joseph counties in October, but was evidently of no economic importance.

Fusarium wilt was, however, the cause of serious losses in the late crop and was by far the most important fungous disease of Indiana potatoes. The percentage of yellowing or dead plants or shoots to be noted late in the season was very high in many fields in the northern part of the state. The disease seemed to be especially destructive near Valparaiso. The vascular discoloration in the base of the main stem and in the stolons was pronounced. Tubers from diseased plants usually showed vascular discoloration at the stem end frequently accompanied by a rotted area externally visible as a sunken, wrinkled region about the stem end. The effect of wilt on the amount of yield is not known, but tubers showing the incipient stem end rot do not endure storage. Whether or not this disease as it occurs in Indiana, is primarily due to soil or to seed infestation is not known. There was undoubtedly a high incidence of infection due to soil infestation but in addition there was striking evidence of seed carriage of disease in fields planted with seed from different sources as observed by Gregory. For example, in a field near Valparaiso, seed from Wisconsin showed less than 1% of wilt August 13th., field run Indiana seed, 25% wilt, and Indiana seed selected for freedom from Fusarium infection, only 5% wilt.

There was also in many fields a great abundance of localized root lesions in connection with which the relative importance of Rhizoctonia and Fusarium as causative factors has not yet been determined. Unmistakable Rhizoctonia cankers with the cracked brown tissue were of frequent occurrence on the lower stem and with these were associated similar root lesions. Lateral roots were found entirely cut off by these lesions and in severe cases the root system was severely reduced. In Lake County this type of root trouble was very bad and apparently resulted in an uneven stand. Cases of a red discoloration of the rootlets suggesting Fusarium attack were also frequently found.

Black leg caused by *Bacillus phytophthorus* was found by Gregory in a small percentage of plants in one field near Indianapolis.

Among the tuber diseases, in addition to the Fusarium stem end rot associated with wilt, common scab, black scurf, and russet scab were of importance. Common scab caused by *Actinomyces scabies* was very severe in the heavier soils, but was successfully controlled by seed disinfection. In a test field in Dekalb county, 59% of the tubers grown from untreated seed were scabby, as compared with 5 to 17% from treated seed. Black scurf caused by *Rhizoctonia solani* is of very general occurrence. A fairly successful control of this disease was also secured by the mercury bichloride treatment. In an experimental plot in Dekalb county, untreated seed yielded tubers showing 87% infection of black scurf as compared with 41% from treated seed. In a similar test in Lake county, there was 69% black scurf where untreated seed was used as compared with 6 to 13% where treated seed was used.

Russet scab was found in Lake County. Its cause is not well understood. Silver scurf caused by *Spondylocladium atrovirens* was found on seed stock in Dekalb County. Leak caused by Pythium was found at Lafayette in freshly dug tubers kept in a warm place.

A rather careful search of the state for the black wart disease accompanied by educative propaganda to enlist the assistance of the growers and consumers in the search was made in cooperation with the federal plant disease survey by J. H. Weghorst. None of the disease was found.

Radish.

Black-root attributed to *Rheosporangium aphanidermatus* was the most serious disease of radishes and was an important loss-producing factor in the culture of the white varieties especially in heavy clay soils. Not only are the blackened lesions objectionable in themselves, but are generally invaded by rot-producing organisms.

White rust caused by *Cystopus candidus* was prevalent in certain greenhouses. A rot of the leaf bases due to *Sclerotinia libertiana* was also noted in greenhouses.

Raspberry.

Orange rust due to *Gymnoconia peckiana* was of widespread occurrence early in the summer.

Anthracnose caused by *Gloeosporium venetum* was very severe this year and was the worst disease of black raspberry in Indiana. It was especially important in Fountain County. In a plantation near Silverwood this disease has been so severe that it has led to a method of culture in which the vines are forced until two or three good crops are secured after which they are destroyed and replaced.

The non-parasitic yellows disease occurred locally.

Rhubarb.

Leaf-spot caused by *Ascochyta rhei* was of general occurrence.

Rose.

Powdery mildew (*Sphaerotheca pannosa*) was very destructive in greenhouses, especially on the Killarney variety. It was also prevalent on the Ramblers in June.

Black spot caused by *Actinonema rosae* was found in the greenhouse crop and was most serious on the Russell variety.

Rye.

Twenty-eight fields in 17 counties were examined in the course of the federal cereal disease survey. Septoria on the heads was reported from three of these fields. Ergot caused by *Claviceps purpurea* was reported from 15 fields but was not nearly as prevalent as in 1918.

Pipal reports that anthracnose, caused by *Colletotrichum cereal* was serious in southern Indiana. The disease was also found in Cass County.

Scab caused by *Gibberella saubinetii* was found in 24 or 85% of the 28 fields above mentioned, with an average incidence of 5.4% and a maximum of 40%. In addition, the disease was found in two counties not included in that survey.

Leaf rust (*Puccinia dispersa*) was found in nine of the 28 fields with an average incidence of 4.4% and a maximum of 45%. It is quite likely, however, that leaf rust occurred to some extent in all fields. Mains reports that leaf rust was very severe on rye cover crops late in the fall of 1918, citing one case near Logansport where a field was quite yellow with the rust. Stem rust (*Puccinia graminis*) was found in 5 fields with an average incidence of less than 1% and a maximum of 15%.

Stem smut caused by *Urocystis occulta* was found to a very limited extent in Lake and St. Joseph counties. One head of loose smut was found in the latter county by Gregory.

Snapdragon.

Rust (*Puccinia antirrhini*) is steadily increasing in prevalence in Indiana, according to H. S. Jackson.

Strawberry.

Leaf-spot caused by *Mycosphaerella fragariae* was very generally found in all plantings but was not especially destructive since its attack did not become severe until after the fruit was picked. Pipal reports that the disease was prevalent in the commercial crop at Borden, Clark County.

Sweet Potato.

Black rot due to *Sphaeronema fimbriatum* occurred in Jay County where it caused losses on several farms.

Tomato.

Leaf-spot can ed by *Septoria lycopersici* was the most important disease of field tomatoes and was present in almost all fields to a greater or less degree. This disease usually does not become destructive until late in the season. By killing the lower leaves the disease not only reduces the leaf area of the plant but exposes the fruit to sunscald. Tests with copper sprays conducted by W. B. Clark of the U. S. Bureau of Plant Industry at Paoli indicate that leaf-spot may be held in check to some extent but not satisfactorily controlled by spraying. This is largely owing to the impossibility of thoroughly covering the foliage after the plants become large. Increases in yield were secured by spraying, however. Leaf-spot was much worse in the region near Paoli than in the Indianapolis region. The disease was found to some extent in greenhouses near Indianapolis.

Early blight caused by *Alternaria solani* occurred to some extent in plant beds causing a leaf-spot and also an elongated, blackened stem lesion. Later the disease became rather prevalent in the field. In central Indiana early blight did not become a serious factor but about Paoli it assumed some importance late in the season. August 8th. there were found in the fields near Paoli numerous spindling plants which showed a dry blackened stem lesion about the stem at and below the ground line. Whether or not these plants were the result of using transplants with the elongated stem lesions above noted is not known.

Wilt caused by *Fusarium lycopersici* caused severe losses to certain growers and seems to be becoming more prevalent in the state. It was unquestionably the most serious disease of greenhouse tomatoes and numerous instances of complete or partial crop failure due to this disease were found in the Indianapolis region. Owing to the persistence of this disease in the soil, its high virulence under greenhouse temperatures, and the extreme susceptibility of the Bonny Best variety, the greenhouse situation is especially deplorable. In the field crop in central Indiana, the wilt occurred to a considerable extent locally in areas of various sizes and as scattered infected plants in the fields.

At Frankfort, August 14th., a field was observed in which there was a large area of dead plants surrounded by a narrow zone of plants showing all stages of Fusarium infection. An experimental field near Frankfort was planted with seed from a large number of varieties and single plant selections, one to each row. There were scattered plants in this field killed by wilt, a few rather definite areas of wilt, and a single striking case of one row, a single plant strain, showing practically 100% wilt. In a 100-acre field of tomatoes near Indianapolis no wilt was found and the Paoli region was practically free from the disease. Quite likely this disease, like the Fusarium root diseases of cabbage and celery, is disseminated by means of diseased transplants.

Leaf mold caused by *Cladosporium fulvum* was exceedingly serious in many greenhouses, the infection being so general in some instances as to cause the death of the plants. The disease was at its height during the ripening period of the summer crop and was favored by the high temperature and humidity existing in the houses at that time. Leaf mold appeared in epidemic form in the fall greenhouse crop at Lafayette and Terre Haute. Bordeaux spray and sulphur dust seem to be ineffective as control measures and a lime sulphur spray has been recommended. The disease was found to a limited extent late in the fall in an experimental field at Frankfort.

A bacterial spot disease previously reported from Michigan[1] as "canker" was widespread and abundant in central Indiana late in the season. This disease is characterized by conspicuous black lesions on the fruit and by rather inconspicuous black lesions on the leaves, petioles and stems. The black fruit lesions are very objectionable from the canner's point of view and the disease assumed considerable economic importance this year.

Buckeye rot of the fruit caused by *Phytophthora terrestria* was found in one greenhouse near Indianapolis. Only the lower fruits in certain areas were affected.

Anthracnose caused by *Colletotrichum phomoides* was noted on the ripe fruit at an Indianapolis canning factory.

The mosaic disease became generally prevalent throughout central Indiana during the last half of the season. The disease was not noted to any extent in the Paoli region nor in Lake County, but was found in Knox, Marion, Clinton and Tippecanoe counties. It also occurred very generally in the greenhouses early in the summer and has already (November) become epidemic in the fall crop in one house. Most fields showed from 50 to 100% infection. Except for the low percentage of fern-leaf plants which yield no marketable fruit whatever, the effect of the disease upon yield is not known. The attack seemed to have occurred too late to noticeably reduce the yield this season. However, the disease has extremely destructive possibilities and should be considered a distinct danger to the tomato industry. No resistant strains or varieties have been found.

The non-parasitic blossom-end rot was prevalent in the greenhouse summer crop and in the first fruit set in the canning crop, especially in the Paoli region. The non-parasitic injury is almost invariably invaded by some rot-producing fungus, such as Alternaria or Fusarium, so that affected fruits are a total loss. A very considerable reduction in yield may be attributed to this trouble. In a series of fertilizer plot tests at Paoli, no difference was noted in the incidence of blossom-end rot.

In the field crop later in the season, the non-parasitic growth cracks were very prevalent and were responsible for a large proportion of the fruit rot since these cracks are subject to invasion by rot-producing organisms. While the loss due to growth crack invasion was considerable this year, especially in canning stock shipped by rail, it was not nearly as heavy as in years which are characterized by frequent rains during the picking season.

Sunscald was rather common in the market garden crop which was badly affected with leaf-spot and to some extent in the canning crop as a result of the hot weather early in September. Sunscald also affords an avenue of invasion for rot-producing fungi.

Catface, a disfiguration of the blossom-end of the fruit, was very common in the canning crop. This does not predispose the fruit to rot. A very shallow, brown, lace-like blemish on mature fruit, called "blotch" because of the shape of the lesion, was found rather commonly.

Among locally grown fruit on the sorting belts in a canning factory at Indianapolis, September 30th, 10% showed infected growth cracks, 5%-bacterial spot, 5%-blotch, 3%-sunscald, 1%-catface, 0.5%-anthracnose.

Hollow stem was of common occurrence this year where spindling transplants were used. Hollow stem was also caused by the extreme drouth, the moisture being absorbed from the pith to supply the needs of the green tissue. A conspicuous upward curling of the leaves and premature death of the older leaves among garden tomatoes has also been attributed to drouth.

Nematode root infestation was found in certain greenhouses. Affected

[1]Coons, G. H. Michigan plant disease survey for 1917. Mich. Acad. Sci. 20th. Am. Rep. 446. 1918.

plants are checked in their growth, the lower leaves die prematurely, and the whole plant usually wilts and dies before maturing fruit so that infested plants are practically a total loss.

Turnip.

Peronospora parasitica was found causing darkened regions within the roots late in the storage season. The diseased tissue is readily invaded and rotted by Rhizoctonia or the soft rot bacteria.

Watermelon.

The limiting factor in the watermelon industry in Indiana is the Fusarium wilt disease. This soil trouble has rendered much land unfit for water melon culture and necessitates the use of new soil each year. Wilt has caused the growers in many districts to give up watermelon growing entirely. For example, Vallonia was once an important watermelon shipping point, but now practically no watermelons are grown in that district. The disease is serious in Knox County, also.

Anthracnose caused by *Colletotrichum lagenarium* was not at all prevalent this year and was found only in two fields, one near Vincennes and the other near Vallonia. A number of fields about Vincennes were planted with treated seed.

In one instance of a small watermelon patch in a large cantaloupe field, the leaf blight caused by *Alternaria brassicae* var. *nigrescens* occurred on the watermelons as well as the cantaloupes.

There was considerable rotting of the fruits in the field in Knox County due to infection through the non-parasitic blossom-end rot by Fusarium and Diplodia. Stem-end rot is not encountered in shipments of Indiana melons, according to J. R. Cavanaugh.

Wheat.

Very general concern was occasioned by the discovery of a foot rot of wheat much resembling the Australian "take-all" disease.[1] This disease was first found in Madison County, Illinois, where a considerable acreage was involved. In Indiana the disease was found in one field in Tippecanoe County, in five fields near Laporte, and in six fields in Porter County between Valparaiso and Wanatah. All but two of these fields were planted with Salzer's Red Cross Variety.

This disease occurs either in well defined spots in the field or may involve more or less all of the field. When first noted during May the diseased plants were distinctly stunted, being only a few inches high while normal plants were knee high. The affected plants showed excessive tillering and the rosette effect as well as a darker green color were very marked. A large percentage of plants were killed outright. Closer examination showed a dark brown discoloration and rotting of the leaf sheaths and stem just above the ground line.

In some cases this disease was so destructive that the crop was plowed under. In other fields a fair yield was secured. In order to prevent a spread of the disease, state authorities compelled the burning of the straw from the infested fields and a thorough disinfection of the grain in formaldehyde. None of the grain was allowed to be used for seed. Growers were advised not to plant wheat in these fields for several years. The cause of the disease has not been determined.

In connection with the rather careful statewide search made for the above disease, a very considerable amount of frost injury to wheat was found. This was evidenced by a shriveling and brown discoloration of the stems just above the nodes.

Wheat scab caused by *Gibberella saubinetii* was the most serious wheat disease and was an important loss-producing factor this season. As a result of the federal cereal disease survey, scab was found in 442 or 74% of the 596 fields examined with an average incidence of 17%. James Dickson, in charge of this survey, reports cases of infection as high as 90% in Orange and Posey Counties. Pipal reports authentic cases in Vanderburg, Knox, and Posey counties where the crops were not even harvested and he estimates that there was a 50% loss in badly infected fields in general.

Since recent investigation indicates that the wheat scab fungus lives over winter on corn stalks the following observations are of interest. Pipal reports an instance of a farm near Martinsville where 35% scab occurred in wheat following corn and only a trace in the other field on fallow ground. On another farm the corn stalks were carefully removed from one acre in a large field planted to wheat. This acre later showed 3% scab as compared with 10% in the rest of the field. From Dickson's report it appears that out of the 13 fields examined in Hancock County, the percentage of scab ranged from 5 to 45% in the six fields where wheat followed corn, with an average of 20%, while in the seven fields which were not in corn in 1918, the percentage of scab ranged from 5 to 75% with an average of 29%. Among the latter is a case of 60% scab following clover and another of 75% following wheat. From the same report it further appears that in the 10 fields surveyed in Posey County, there was an average of 77% scab in the four fields which were in corn in 1918 and an average of 65% in the other six fields. Furthermore, in the 10 fields surveyed in Orange County, there was an average of 45% scab in the six fields in corn in 1918 and 13% in the other four fields. The evidence therefore is not conclusive and factors other than the corn must be considered. It seems quite likely that other plant residues are also of importance as a source of infection. Dickson gives as his opinion that the two important factors are the abundance of the parasite, and the presence of organic matter such as plant residues on the soil for the propagation of the parasite. He intimates that the preparation of the soil is as important as the crop rotation utilized. According to Hoffer, seed from diseased heads yields weak plants but does not constitute an important means of dissemination of the scab fungus.

[1]Humphrey, Harry B. and Johnson, Aaron G. Take-all and flag smut, two wheat diseases new to the United States. U. S. Dept. Agr. Farmers' Bul. 1063:1-8. 1919.

A seedling disease characterized by a yellow stripe extending the entire length of the leaves was found rather commonly during the last half of May. The cause of this disease is unknown.

A slight infection of ergot was found on Red Wave wheat in Noble County, July 10th., by R. V. Allison. Powdery mildew (*Erysiphe graminis*) was abundant in the latter part of May, probably owing to the prolonged wet weather. The bacterial disease, black chaff, was found in Morgan County.

The Septoria leaf-spot was very prevalent early in the season. Later the Septoria on the glumes became widespread. Out of the 596 fields examined in the course of the federal cereal disease survey, these diseases were found in 133.

Anthracnose caused by *Colletotrichum cereale* was reported from 10 of the 596 fields above mentioned. A field very badly affected with anthracnose was found near Lafayette, June 26th., by Allison. The affected plants in this field were already killed at this time.

Leaf rust (*Puccinia triticina*) was as usual very severe in Indiana, especially in the southern part of the state. Very heavily infected fields were seen in Martin County, May 28th., and in Hendricks County, June 26th. Leaf rust was reported from 214 or 35% of the 596 fields examined in the federal survey, with an average incidence of 1.4% and a maximum of 75%. It is probable that leaf rust occurred to some extent in all fields, however.

Stem rust (*Puccinia graminis*) was reported from 202 or 33% of the 595 fields above mentioned, with an average incidence of 6.2% and a maximum of 100%. This rust was not epidemic except in the neighborhood of barberries. Pipal reports cases of epidemic outbreaks near barberries in Randolph, Spencer, Knox, and Lagrange Counties.

Bunt or stinking smut caused by *Tilletia foetans* was reported from 90 or 15% of the 596 fields above mentioned with an average incidence of less than 1%. Pipal reports that the disease was serious only in the northeast corner of the state (Steuben and Lagrange Counties). As to the control of the disease it is of interest to note that out of 39 fields planted with seed treated with wet formaldehyde, bunt was found in seven and in these cases to the extent of not over 1%. Out of eight fields planted with seed treated by the dry method (formaldehyde), a trace of bunt was found in 1 field. In the 45 fields for which the seed was treated by the hot water method, bunt was found in only one field, and only to the extent of 1%.

This season was especially favorable to loose smut caused by *Ustilago tritici* and the disease was especially prevalent. According to Pipal's observations and to the results of the federal cereal disease survey, it was found in 760 fields in the state with an average incidence of about 3% and a maximum of 30%. Loose smut was most severe in the area comprising the following counties: Morgan, Marion, Hancock, Shelby, Rush, Bartholomew, Decatur and Jennings. The greatest losses were suffered in Shelby County where the average infection, according to Pipal, on 33 farms ob-

[1]Prevalence of the loose smut of wheat in Indiana in 1919. Proc. Ind. Acad. Sci. 1919.

served was about 10%. As is elsewhere reported by Pipal[1], a striking control of loose smut was secured in certain districts with the hot water seed treatment.

SUMMARY.

The plant diseases of outstanding economic importance as observed during the season are as follows:

Apple: Blotch; scab; frost injury.

Bean: Drouth injury.

Cabbage: Yellows.

Cantaloupe: Bacterial wilt; leaf blight.

Celery: Yellows or stunting disease.

Cherry: Coccomyces leaf-spot.

Clover: Anthracnose.

Corn: Fusarium root rot; local infection of *Gibberella saubinetii*.

Cucumber: Bacterial wilt; mosaic.

Eggplant: Wilt.

Maple: Sunscald.

Onion: Soil salt injury.

Peach: Leaf curl; black leaf-spot; frost injury.

Pear: Fire-blight.

Pepper: Sunscald.

Plum: Brown rot; frost injury.

Potato: Fusarium wilt; Fusarium tuber rot; common scab; Rhizoctonia root and stem infection.

Radish: Black-root.

Raspberry: Anthracnose; orange rust.

Rose: Powdery mildew.

Tomato: Septoria leaf-spot; Fusarium wilt; leaf mold; mosaic; blossom-end rot; fruit rot from infected growth cracks.

Watermelon: Fusarium wilt.

Wheat: Foot rot; scab; loose smut; frost injury.

Plant diseases found in 1919 which have not been previously listed by Pipal and Osner are as follows:

Celery: Yellows or stunting disease due to a Fusarium; nematode root injury; bacterial leaf-spot.

Sweet clover: *Ascochyta caulicola*.

Corn: Root rot due to Fusarium; Local infection with *Gibberella saubinetii*; Stewarts' disease due to *Bacterium stewartii*.

Eggplant: Wilt (cause not determined).

Kale: Yellows due to *Fusarium conglutinans*.

Oats: Scab due to *Gibberella saubinetii*; blast.

Onion: Pink root and bulb rot due to a Fusarium; soil salt injury; nematode injury.

Parsnip: Leaf-spot due to *Cercospora apii*.

Peach: Root rot due to *Armillaria mellea*.

Pepper: Sunscald.

Potato: Black leg due to *Bacillus phytophthorus;* leak due to Pythium.

Radish: Black-root, petiole rot due to *Sclerotinia libertiana.*

Rye: Septoria disease of heads; scab caused by *Gibberella saubinetii.*

Tomato: Buckeye rot due to *Phytophthora terrestria*; bacterial spot; fruit rot due to infected growth cracks; sunscald; hollow stem; nematode wilt.

Watermelon: Blossom-end rot.

Wheat: Foot-rot resembling "take-all"; black chaff.

NOTES ON OUR INDIANA DODDERS.

T. G. Yuncker.

Dodder is the popular or common name ordinarily applied to species of *Cuscuta*. This genus belongs naturally to the Convolvulaceae. The remarkable embryogeny; the structure of the mature plants; the manner in which they secure their nourishment and their peculiar ecological relationships make them subjects of particular scientific interest.

There are in North America about fifty known native and five introduced species. Of the natives less than a half dozen are reported as harmful to economically important crops, and, of these, but one or two are of much importance. Of the introduced species four are distinctly harmful. Because of the trouble caused by this minority the whole genus is frequently considered in ill repute. Some authors, however, attempt to show that the harm done by a few members of the group is offset by the good done by the others in parasitizing harmful weeds and thus retarding their growth.

In the state of Indiana we have seven native and possibly two introduced species. Of these, one native, *C. pentagona*, and both of the introduced species are harmful to crops. The amount of harm caused by these parasites becomes considerable if they are not checked, in some cases causing nearly the total loss of the crop. The grower finding these plants in his fields should take immediate steps to destroy them.

In the proper identification of the species one must ordinarily make a careful dissection of the flowers. After the flowers have been pressed and dried this usually means that they require softening by boiling and the subsequent dissection in water. Because of the lack of other vegetative characters of diagnostic value and the trouble attendant on the flower dissection many of the collections show no attempt at all towards identification. Certain species frequently show wide specific limitations that is apt to confuse one not perfectly familiar with the genus. The nomenclature of the group is also quite confused.

It is believed that a key using those characters that are ordinarily visible with the aid of a hand lens will be of value. The following key aims at the identification of the species found in Indiana without the necessity of making flower dissections.

1. Stigmas capitate. (Native species). 2.
   Stigmas linear. (Introduced species). 8.
2. Flowers subtended by numerous bracts and ordinarily in a close, compact inflorescence. 3.
   Flowers not subtended by bracts and ordinarily in a more loosely clustered inflorescence. 4.
3. Inflorescence dense, rope-like, tightly wound about the host; bracts acute with recurved tips ....1. *Cuscuta glomerata.*
   Inflorescence less dense and not particularly rope-like; bracts obtuse, closely appressed ....2. *Cuscuta compacta.*
4. Flowers commonly 4-parted (or 3-parted). 5.
   Flowers commonly 5-parted. 7.
5. Withered corolla remaining more or less persistant as a cap at the apex of the capsule; infrastaminal scales well developed ....3. *Cuscuta Cephalanthi.*
   Withered corolla remaining at the base of the capsule, about it, or early deciduous; infrastaminal scales rudimentary. 6.

6. Flowers fleshy, with the cells convex-lens shaped; corolla lobes upright, tips inflexed ....4. *Cuscuta Coryli.*
   Flowers not as above...............................5. *Cuscuta Polygonorum.*
7. Capsules globose or depressed-globose (not pointed); corolla lobes reflexed, acute, with inflexed tips..........................6. *Cuscuta pentagona.*
   Capsules ovoid or globose-pointed; corolla lobes upright to spreading, obtuse ....7. *Cuscuta Gronovii.*
8. Usually found parasitizing legumes (ordinarily clover or alfalfa); styles, including the stigma, exceeding the length of the ovary 8. *Cuscuta Epithymum.*
   Usually parasitizing flax; styles, including the stigma, not exceeding the length of the ovary...................................9. *Cuscuta Epilinum.*

1. Cuscuta glomerata Choisy. Glomerate dodder.

Fig. I.—Cuscuta glomerata. x4.

[Figure I.]

C. glomerata Choisy, Mem. Soc. Phys. et Hist. Nat. Genève, *9*:280. *pl. 4, fig. 1.* 1841

Indiana marks the eastern limits of this, the most conspicuous of our species. The yellow, rope-like clusters of the flowers are not infrequently one to one and a half inches in thickness. It produces but few seeds, most of the ovules being abortive. Bessey (Amer. Nat. *18*: 1145. 1884) pointed out the fact that the flowers are produced endogenously breaking forth in two more or less parallel lines. This species favors tall Compositae.

Specimens examined:—Lake Co., Whiting (*Chase 422*); Floyd Co., New Albany (*Clapp*); Marshall Co., Lake Maxinkuckee (*Clark* in 1909); Wells Co. (*Deam* in 1901); McCallon's (*Clapp* in 1837).

2. Cuscuta compacta Jussieu. Compact dodder.

C. compacta Jussieu in Choisy, Mém. Soc. Phys. et Hist. Nat. Genève, *9*:281. *pl.* D, *fig.* B. 1841.

The flowers of this well marked species are often produced endogenously like those of *C. glomerata* and, while they are usually formed into dense, compact clusters about the host, the inflorescence does not have the rope-like appearance of the former. The flowers of this are usually of a much darker color than are those of *C. glomerata*. This species prefers woody hosts such as *Cephalanthus*, *Sassafras*, *Salix*, etc., and seems to be limited to the southwestern part of the state.

Specimens examined:—Gibson Co. (*Schneck* in 1904); Lawrence Co., Mitchell (*Deam 18,499*); Sullivan Co., Grayville (*Deam 29,369*); Posey Co., Mt. Vernon (*Deam 24,280, 29,076*); Dubois Co., Huntingburg (*Deam 28,253*); Jackson Co., Chestnut Ridge (*Deam 9,520*).

Fig. II.—Cuscuta Cephalanthi. x4.

3. Cuscuta Cephalanthi Engelmann. Buttonbush dodder.

[Figure II.]

C. Cephalanthi Engelmann, Amer. Journ. Sci. & Arts, *43*:336. *pl. 6, figs. 1-6.* 1842.

This little dodder is commonly mistaken for *C. Gronovii*, an error that should not occur, however, if one compares the capsules which are pointed with *C. Gronovii* and depressed with this species. It is frequently found with the flowers formed endogenously. It grows on *Cephalanthus*, *Salix*, Compositae and numerous other hosts.

Specimens examined:—Lake Co., Clarke (*Umbach* in 1898), Whiting (*Hill* in 1891); Dune Park (*Chase 1,982*); Wells Co. (*Deam* in 1899, 1903 & 1905), Murray (*Deam 490*); Porter Co., Baum Bridge (*Deam 26,482*); Adams Co., Decatur (*Deam 5,363, 5,364* in part); Randolph Co., Deerfield (*Deam 15,382*); Parke Co. (*Deam 9,889*); Steuben Co., Lake James (*Deam 15,476*); Allen Co., Robinson Park (*Deam 1,582*); Carroll Co. (*Deam 15,304*).

Fig. III.—Cuscuta Coryli. x 1.

4. CUSCUTA CORYLI Engelmann. Hazel dodder.

[FIGURE III.]

C. Coryli Engelmann, Amer. Journ. Sci. & Arts, *43*:337. *pl. 6, figs. 7-11.* 1842.

This species is sometimes confused with *C. indecora* which has never, to the writer's knowledge, been found so far east as Indiana. The flowers of this, the smallest of our Indiana species, are not infrequently formed endogenously. It seems to prefer shrubby hosts.

Specimens examined:—Blackford Co., (*Deam 190*), Hartford City (*Deam 512*); Lake Co., (*Hill 95-1897, 124-1897*); Wilsons (*Hill 100-1897*); Dune Park (*Chase 522*); Kosciusko Co., Winona Lake (*Deam 444*); Lagrange Co., Adam's Lake (*Deam 14,856*); Vermilion Co., Hillsdale (*Deam 9,817*).

5. CUSCUTA POLYGONORUM Engelmann. Smartweed dodder.

C. Polygonorum Engelmann, Amer. Journ. Sci. & Arts, *43*:342. *pl. 6 figs, 26-29.* 1842.

This species does not appear common in collections from Indiana. Numerous collections of it have been made in adjacent states and it is to be expected anywhere in Indiana. It is a less conspicuous plant than some of the other dodders which may account for the lack of collections. It is ordinarily found most predominant on species of *Polygonum*.

Specimens examined:—Lake Co., Whiting (*Hill* in 1891); Vigo Co. (*Deam 22,-182*); Franklin Co., Brookville (*Deam* in 1903); Grant Co., Lake Galacia (*Deam 15,-269*).

Fig. IV.—Cuscuta pentagona. x4.

6. Cuscuta pentagona Engelmann. Field dodder.

[Figure IV.]

C. pentogona Engelman, Amer. Journ. Sci. & Arts, *43*:340. *pl. 6 figs, 22-24*. 1842.

This species is ordinarily treated in the Manuals under the name of *C. arvensis* Beyr. It is one of the most widespread of our North American species doubtless due to the introduction of the seeds with those of clover and alfalfa. This species becomes a troublesome weed in some localities where it becomes established in clover or alfalfa fields. It is thought by some that it is capable of wintering over in the crowns of the host plants thus obtaining an early start in the spring.

Specimens examined:—Gibson Co. (*Schneck* in 1906); Lake Co., Clarke (*Umbach* in 1898); Putnam Co., Greencastle (*Yuncker* in 1919); Bartholomew Co., Columbus (*Deam 12,403*); Spencer Co., Lake (*Deam 28,370*), Enterprise (*Deam 28,-400*); Posey Co., Mt. Vernon (*Deam 25,430*); Ripley Co., Versailles (*Deam 7,101*); Vermilion Co., Hillsdale (*Deam 9,871*); Orange Co., Paoli (*Deam 17,384*).

7. Cuscuta Gronovii Willdenow. Common dodder.

[Figure V.]

C. Gronovii Willdenow in Roemer & Schultes Syst., *6*:205. 1820.

This is the commonest of our Indiana species. It is frequently found in low wet places forming large mats of entangled, yellow stems. It seems to prefer *Impatiens* or *Salix*, but will utilize any host within reach having been found on one occasion coiling about and penetrating the stems of *Equisetum*. It has been reported as causing slight damage to onions grown in muck soil.

Fig. V.—Cuscuta Gronovii. x4.

Specimens examined:—Delaware Co., Muncie (*Brady* in 1896); St. Joseph Co., Notre Dame (*Nieuwland 11,500*), Clear Lake (*Deam 26,391*); Olio (*Wilson* in 1897); Jefferson Co., Hanover (*Coulter* in 1876), Manville (*Deam 18,784*); Franklin Co., Brookville (*Deam* in 1903); Posey Co., Mt. Vernon (*Deam 22,339*); Vigo Co., Atherton (*Deam 24,014*); Dubois Co., Huntingburg (*Deam 28,267*); Jackson Co., Vallonia (*Deam 30,240*); Knox Co., Vollmer (*Deam 26,575*); Marion Co., Indianapolis (*Yuncker* in 1916); Porter Co., Waverly Beach (*Deam 29,812*); Wayne Co., Richmond (*Deam 23,860*); Clark Co., (*Deam 5,473 & 7,600*), Jeffersonville (*Deam 23,800*); Harrison Co., Elizabeth (*Deam 26,831*); Adams Co., Decatur (*Deam 5,364*, in part); Whitley Co., Shriner Lake (*Deam* in 1897), Blue River Lake (*Deam 21,696*); Steuben Co., Clear Lake (*Deam* in 1904), Gage Lake (*Deam* in 1906); Brown Co., Helmsburg (*Deam 12,225*); Noble Co., Albion (*Deam 14,701*); Lagrange Co., Pretty Lake (*Deam 14,888*); Hamilton Co., Noblesville (*Deam 12,129*); Decatur Co., St. Paul (*Deam 9,535*); Carroll Co., Monticello (*Deam 15,339*).

8. Cuscuta Epithymum Murray. Clover dodder.

C. Epithymum Murray, Linn. Syst., 13 ed., p. 140, 1774.

This species is usually found parasitic on leguminous crops, principally alfalfa and clover. In herbaria it is commonly labelled as *C. trifolii*, a species that is now considered as being either synonymous with or at most but a variety of *C. Epithymum*. It is also confused with *C. pentagona* because of the fact that both species show a predilection for the same kind of hosts. This species has become very wide spread in North America having been found from the Atlantic to the Pacific and from Canada to Mexico. Its wide distribution is accounted for by the fact that its seeds are frequently found as a contaminant of those of leguminous crops. While collections of this species have been made in adjoining states none have been seen by the writer from Indiana.

Fig. VI.—Cuscuta Epilinum. x4.

9. CUSCUTA EPILINUM Weihe. Flax dodder.

[FIGURE VI.]

C. Epiliinum Weihe, Archiv d. Apoth., *8* :50-51. 1824.

This species, so far as known to the writer, has never been found in Indiana. It has been seen from Ohio and Michigan and is to be looked for wherever flax is grown. All of the specimens have been parasitic on flax.

The private herbarium of Mr. Chas. C. Deam of Bluffton, Indiana, was the largest single collection of Indiana dodders seen by the writer. I desire to express my thanks for the loan of this and other collections which were sent me for study.

DEPAUW UNIVERSITY,
Dec. 5, 1919.

APPARATUS FOR AERATING PLANTS.

BY

F. M. ANDREWS.

I have made use of the well known Bunsen pump with some additions or modifications for the purpose of aerating water cultures. Sometimes I have used it for aerating cultures not grown in water also with good results. In a previous paper[1] I have shown the advantageous effect that the passing of air through a water culture has on the plant. A like beneficial effect was also found when air was passed through soil in which the corn plant was growing. In the paper just referred to the Kekulé apparatus as described by Ostwald was also used for some experiments with equally favorable results. Of the Kukulé and Bunsen apparatus for the purpose of aerating the latter, as I arranged it, will furnish by far the greater amount of air to be passed through a culture. So far as convenience is concerned, however, in other respects there is the further advantage of the Bunsen apparatus in that much less space is required to operate it. The perpendicular tube which conveys the chain of bubbles of air and water downward must be of such a length that the sum of the lengths of the short columns of water in this perpendicular tube between the columns of air will more than equal the depth of the solution through which the air is to be passed. This necessitates a perpendicular tube of considerable length. In the Kukulé apparatus I used the perpendicular tube has a length of 120 cm. while the culture solution had a depth of only 20 cm. Of course the length of the perpendicular tube and the speed with which the chain of air and water will pass through it can be made to depend somewhat on the length of the single columns of water for sometimes these columns of water are short and sometimes long depending on the quantity of water which enters the tube in the form of individual drops. Another drawback to the Kekulé's apparatus is that the perpendicular tube is often rapidly clogged completely with algae of various kinds, mostly those belonging to the Cyanophyceae, and with iron deposits as well as some sediment. In the Proceedings of the Indiana Academy of Science for 1916 Mr. C. C. Beals[1], who carried out a piece of work on aeration under my direction, has shown a brief sketch of the Kekulé apparatus. At b in his diagram he shows the perpendicular tube in question. In order to form bubbles readily this tube as arranged should not be over 4 mm. in diameter. This smallness of size of the tube, however, contributes to the accumulation and stoppage of the tube. The algae as well as the iron can be quickly cleaned out of the tube by using 50% or 60% HCl. Weaker strengths as 10% and 15% HCl were tried at first to clean the tube but they were not effective. Experiments are in progress to try to prevent this troublesome phase of the accumulation of material in the tube. Its stoppage often occurred in a few days; at other times in two weeks. This necessitated the disconnecting

[1]The Effect of Soaking in Water and of Aeration on the Growth of Zea Mays. Bulletin of the Torrey Botanical Club, 1919, Vol. 46, PP. 94-100.

[1]Beals, C. C.—The effect of Aeration on the Roots of Zea Mays. Proc. nd. Acad. of Science. 1916, P. 177.

of the apparatus to effect the cleaning. The bubbles produced by the Kekulé apparatus as well as that by Bunsen should be as small as possible. However, it is not possible to constrict the submerged end of the tube much, otherwise the resistance to the passage of the bubbles and the water necessary to convey them will be so great as to prevent a sufficiently rapid flow. The Kekulé appartus while useful for airing a few cultures, is too small to furnish sufficient air for a series having a large number of cultures. I have therefore used for airing a series of seven or more cultures the Bunsen apparatus above referred to. The pump portion of the Bunsen apparatus was constructed by using the ordinary form of a large sized Chapman's brass air pump. For the tube below the Chapman pump I used an old condenser which had been broken and which had a diameter of about 5 cm. This I cut off so that it had a length of 45 cm. leaving near the end one of the lateral tubulares for the escape of air from the apparatus. This length of tube gave a column of water of sufficient height to easily force the air through the water culture solution in the 1.5 L capacity culture jars in which the depth was 20 cm. From the Bunsen appartus arranged as just described I conducted the air through a lead tube having a bore of .5 cm. and an external diameter of 1 cm. a distance of about 11 meters to the water cultures. These cultures, in many cases 14 in number, were placed about the center of the greenhouse in order to obtain the best light; otherwise they would have been placed nearer the pump. In order to prevent any possibility of water being blown over from the pump into the cultures a bottle was arranged so that the air passed into it and then out at the top before entering the cultures. This acted as a catch basin or pocket for the water in case any should pass through the lead pipe. In the use of the apparatus thus far, however, I have not observed that any water has been carried over to the bottle. This is probably because the lead pipe rises to a height of 2 meters or more before the air enters the cultures. If water should enter the culture solution after passing through the lead pipe it would, of course, be poisonous to the plants. If water should pass from the Bunsen pump so used to the water culture, it would be less poisonous to the plants than if it were distilled water, because as distilled water it is in the form of hydroxide of lead and would contain more lead, whereas in the case of natural water it is then in the form of carbonate of lead, which is less soluble and would contain less lead.

In the form of the apparatus as first used to distribute the air to the individual jars containing the culture solution I used a piece of cypress 5 cm. broad by 55 cm. long which carried two rows of T-tubes having seven T-tubes in each row. The cypress board was perforated with holes which allowed the central arm of each set of seven T-tubes to project through the board on each side. These T-tubes were connected with one another and to the glass tubes that conveyed the air down through the culture solutions by rubber tubing. There were in all about 45 rubber tube connections. These were troublesome to keep free from leaks owing to the cracking of the rubber tubing. The life of the rubber tubing in such situations as here used varied from one to several weeks. To obviate at least part of this difficulty I selected a heavy brass tube having an inside diameter of 1.5 cm. and a length of 120 cm. Into this tube directly opposite one another were threaded air tight small brass tubes having an internal diameter of 4 mm. an outside diameter 7 mm. and a length of 55 mm. This tube was supported at the center, between two rows of water cultures, by a ring-stand. This arrangement eliminated the breakage that often occurred with the glass T-tubes and by being fastened together in one piece it also eliminated 27 of the 45 rubber tubing connections, besides being more convenient in other ways as to neatness, compactness, etc. The Bunsen pump as I have it arranged and when working at full capacity will send through the above mentioned tubes 4 liters of air per minute overcoming at the same time the resistance offered by a column of water 20 cm. in depth. This would amount, if the pressure of the water mains remains constant, to 240 liters per hour or 5,760 liters per day when the pump continues to work at full capacity. As, however, only about one liter per hour was generally used, at this rate, about 240 separate cultures could be aerated simultaneously with this apparatus if properly arranged and adjusted. This will depend, as before mentioned, somewhat on the size of the glass tubes which conduct the air through solutions in the culture jars. If these tubes are very small or much constricted at the end so as to make small bubbles, which is desirable, so much back pressure will be generated in moving a large quantity of air that most of it will escape at the pump. In my experiments so far, however, only about seven to fifteen cultures have been aired at once and such a size of tubes used that the difficulty just mentioned did not occur.

A STUDY OF POLLEN II.

BY

F. M. Andrews.

Since the appearance of the first of these two accounts on investigations made on pollen of various kinds, further studies have been in progress in order to study some of the points there indicated on a greater number of plants. In the first paper which appeared in 1917 I had investigated 435 plants. Since that time I have extended my study of the pollen so that now I have investigated 508 plants. This list of phanerogams include plants of many and distantly related families all of which have been subjected to the same conditions in order to ascertain how their pollen would behave. All of the pollen of these plants, as in the first paper, have been put under favorable cultural conditions in cane sugar. This medium was supplied to them in solutions of different strengths from weak to strong. Of the 73 plants so investigated since my first account appeared in 1917, about the same proportion of plants showed a response as there indicated.

The pollen of one of the plants showed an unusually rapid response in the form of a very sudden rise in its hydrostatic pressure. That plant was Scabiosa atropurpurea which belongs to the Dipsaceae. Instantly almost, or before any measure of time could be made, when the pollen of this plant was placed in distilled water it instantly put out 4 tubes about the length of the diameter of the pollen grains. No further change took place no matter how long they were left undisturbed in distilled water. On the average 96 pollen grains in each 100 put out tubes suddenly in the way just described. For rapidity of response in this way the pollen of Scabrosa excells all other pollen thus far investigated. To be sure pollen

Andrews, F. M. Proceedings of the Indiana Academy of Science 1917, P. 163.

grains will often burst in a short time when placed in distilled water and the contents, as is well known, will be forced out more or less rapidly but none of them do so with the almost instantaneous action of Scabiosa. Nor do they maintain a tube form characteristic of the usual germinating methods in pollen. This sudden endosmotic action shown by the pollen of Scabiosa is an illustration of how quickly a membrane may be permeable even if only a slight amount of liquid enters. No change in the wall of the pollen as a dissolution had taken place.

A WARMING NEEDLE FOR ARRANGING SPECIMENS IN PARAFFIN.

BY

F. M. Andrews.

The arranging of specimens in paraffin in the box of whatever kind used, must be done quickly and orderly before the cooling process begins. When the paraffin begins to chill in the box it becomes opaque due to air. At the same time when an ordinary needle is used that is not warmed to the same temperature or above the temperature of the paraffin in the embedding box the paraffin chills on the needle and accumulates on it with each attempt to such an extent that it must be cleaned continually or it is useless. This difficulty I have overcome by the use of what I have termed an electrical needle.

The needle itself consists of a No. 10 copper wire about 19 cm. long, a small silver wire would be better, and is tapered to a point at the end which is to touch the specimens to be arranged. The other end is fastened to the electric wires. Beginning at this end the copper needle is wound with No. 22 enamelled resistance wire to within 3 cm. of the point of the needle. This small wire is connected with the direct electric current and both the needle and enamelled resistance wire wrapped together with tape to a distance of 6.5 cm. from the point. This needle was connected to the current with four 100 watt electric lamps in arranged multiple series which gave the necessary amount of heat. I found by experiment that the needle arranged as described acquired within about one minute 52 to 55 C. which is sufficient to keep the paraffin melted. If a higher or a lower temperature than 52 C. was desired then lamps having a greater or a less resistance can be put in the series for this purpose. The needle was attached to an electric wire about 2 meters long and could thus be used at any point about the work table or hung up out of the way when not in use. The use of a warming needle of this kind is much more convenient than the old method generally used and more rapid.

HYDROGEN ION CONCENTRATION AND TITRATABLE ACIDITY IN RELATION TO BACTERIOLOGICAL MEDIA.

I. L. Baldwin.

It has long been recognized that the reaction of media is a very important consideration in the cultivation of bacteria. The bacteriologist is confronted with the problem of determining or measuring this reaction in two instances. First, in the adjustment of the original reaction of the media and secondly in the measurement of acid production by bacteria.

In the past two methods of measurement have been used, based on two different chemical phenomena. The older method of the two is the titration of the media with a standard acid or basic solution, using phenolphthalien as an indicator. In using this method media was almost universally made +1 to phenolphthalein, or 1% of normal acid was added after the neutrality point was reached. This method was based on a measurement of the total acid or base in the solution. The newer method is a measure of the concentration of the free hydrogen ions in the solution. This may be accomplished by either the electrolytic or the colorimetric method. The electrolytic method is the more accurate of the two, but requires more time and complicated apparatus, to which the bacteriologist rarely has access. The colorimetric method, since the introduction by Clark and Lubs of a series of phthalein indicators whose sensitive ranges have been accurately determined, is accurate enough for bacteriological work, is applicable to the solutions with which the bacteriologist is working and is quick and simple in operation.

Since it is the concentration of free or disassociated hydrogen ions and not the total amount of acid present that affects the bacterial growth, it is readily seen that a method which measures hydrogen ion concentration is preferable to one which measures titratable acidity. Also it should be clearly understood that a determination of the titratable acidity gives no indication of the hydrogen ion concentration. A single example using two common acids will illustrate this point. Normal acetic acid has ten times the titratable acidity of tenth normal hydrochloric acid, yet tenth normal hydrochloric acid has about 22.4 times the hydrogen ion concentration of normal acetic acid.

Another very serious source of error in the determination of the reaction of media by the old method of titrating with a standard solution lies in the buffer effect of various ingredients of the media. By the buffer effect of a substance we mean its ability to combine with an acid or base in the unionized condition. Peptone, mainly due to the proteoses and phosphates which it contains, has a marked buffer effect. Thus the addition of an acid or a base to a peptone solution may change the hydrogen ion concentration but very slightly. Also the extent of the buffer effect of a peptone solution is dependent upon the brand of the peptone and the technic followed in making up the solution. As mentioned above, the buffer effect of peptone is largely due to its content of proteoses and phosphates, according to Kligler's work the proteoses will be in a large measure precipitated out if the acidity becomes greater than Ph 5.4, while the precipitating point for the phosphates is around Ph 8.8.

In an effort to determine just what the variations in the final result might be, between the use of the two methods, a number of samples of media were made up according to the American Public Health Association standards and the reaction determined by both methods. The procedure they laid down was used in making the media +1, and the colorimetric method, using the indicators and standards of Clark and Lubs, was followed in determining the hydrogen ion concentration.

From the accompanying table it may be seen that the actual amount of base necessary to make the media neutral was less than that indicated by the phenolphthalein titration in all cases except the bouillon made up with Wittes Peptone. Also the results of this experiment show that the media made up with Difco Peptone was practically neutral as made, however due to the buffer effect of the peptone the phenolphthalein titration indicated that it was necessary to add base. In the case of the agar media where two per cent peptone was used, the difference between the actual amount of base necessary to bring the media to neutrality and the amount indicated by the phenolphthalein titration is greater than in the bouillon. In the gelatin media the bouillon was neutralized before the gelatin was added and as a result there is no difference indicated between the two peptones, however, there is a great difference shown between the two methods of determining the reaction.

The results of these tests show that the method of making media +1 to phenolphthalein can not be depended upon to bring it to neutrality and that in the case of all careful work the reaction must be determined by measurement of the hydrogen ion concentration.

References.

Clark, Wm. M. and Lubs, H. A.
"The Colorimetric Determination of the Hydrogen Ion Concentration and Its Applications in Bacteriology."
Jour. Bact. 1917, Vol. 2, 1-34, 109-136, 191-236.

Kligler, I. J.
"The Effect of Hydrogen Ion Concentration on the Production of Precipitates in a Solution of Peptone and Its Relation to the Nutritive Value of Media."
Jour. Bact. 1917, Vol. 2, 351-353.

Cohen, B. and Clark, Wm. M.
"The Influence of the Ph of Media upon the Reproduction of some Common Bacteria."
Proceedings of the Amer. Soc. Bact. 1917.

Clark, Wm. M.
"The Adjustment of the Reaction of Culture Media."
Proceedings Amer. Soc. Bact. 1916.

Conn, H. J., Harding, R. A., Kligler, I. J., Frost, W. D., Prucha, M. J. and Atkins, K. N.
"Methods of Pure Culture Study."
Jour. Bact. 1919, Vol. 4, 107-131.

A COMPARISON OF THE TWO METHODS OF ADJUSTING THE REACTION OF BACTERIOLOGICAL MEDIA

Sample No.	Media	Witte Peptone cc of N/1 Base to make		Difco Peptone cc of N/1 Base to make	
		+1	Ph 7	+1	Ph 7
1	Bouillon	1.0	0.8	3.0	0.3
2	....	1.0	1.0	1.0	0.0
3	....	1.0	1.0	1.0	0.0
4	....	2.0	2.0	2.0	0.0
Ave.	....	1.25	1.2	1.75	0.08
1	Agar......	7.0	1.3	6.0	0.0
2	....	5.0	1.2	6.0	0.0
3	....	4.0	1.2	6.0	0.0
4	....	7.0	1.3	5.0	0.0
Ave.	....	5.75	1.25	5.75	0.0
1	Gelatin ...	13.0	5.0	15.0	5.2
2	....	15.00	5.4	13.0	5.3
3	....	14.0	5.3	13.0	5.0
4	....	14.0	5.2	14.0	5.1
Ave.	....	14.0	5.22	13.75	5.15

THE PARASITIC FUNGI OF MONTGOMERY COUNTY. I.

H. W. AND P. J. ANDERSON.

Ten years ago the writers became interested in fungi and began collecting and preserving the parasitic forms which thrive on the rich native and cultivated flora of Montgomery county. No season during that decade has failed to add materially to the number of species collected. College years at Wabash, summers on the farm near Ladoga, vacation excursions to The Shades, Pine Hills and other country stations have been made more interesting and profitable in the hunt for previously uncollected fungi. Even after both of the writers took up their work in other states, at least one month of each year has been spent in Montgomery County, and many collecting trips have added to the growing number of species. The abundance of fungi varies greatly from year to year but hardly a flowering plant can be found which is not parasitized at some time by at least one fungus and frequently by many of them. To be sure, many of these fungi have been previously reported from the county, many more from other counties of the state, others only from other states, but a considerable number have not been reported before from North America and even a few seem to be species new to science.

Non-parasitic forms have also been collected and preserved and it was the original intention to include all in this list. Since, however, the study and determination of the saprophytes has been much more limited, they have been reserved for a future presentation after more collecting and study. In order that this paper may be more useful to students of fungi it has been thought best to include not only all our own collections, but also those of all others who have collected or reported fungi from the county.

The paper is presented with a threefold object: (1) as a contribution to the biological survey of the state, a worthy enterprise, started over twenty-five years ago but the cryptogamic part of which has made little progress during the last two decades; (2) as a help to plant pathologists in determining the range and prevalence of pathogenes; (3) as a reference and finding list for local students of fungi, amateurs and professionals, who will find determination of newly found species much facilitated by the use of the appended host index. This list, however, undoubtedly does not include all the parasites of the county. A summer day spent in the woods or along the low banks of the streams still yields the excitement of finding many a new one and will continue to do so for years to come. Nor have the collecting possibilities of the orchard, garden and flower bed been by any means exhausted. The list of species on plants of economic importance will seem meager to the experienced plant pathologist; for example only one parasite is reported on potato. This is due to the fact that less attention was paid to the common economic fungi than to the rarer parasites on wild plants. It is hoped that other students will find the pursuit as alluring as the writers have and will continue to add to this list and increase its usefulness.

The first published record of fungi collected or observed in Montgomery county is a short paper, "Mildews of Indiana", by J. N. Rose in the Botanical Gazette for 1886 (Bot. Gaz. 11:60-63). He lists and makes notes on 12 species of Erysiphaceae on 30 different hosts which he collected about Crawfordsville during the previous season and deposited in the herbarium of Wabash College.

In 1889, M. A. Brannon read a paper before the Ind. Acad. Sci. entitled "Some Indiana Mildews". He included 7 species of Erysiphaceae on 11 hosts from Montgomery County. Most of these had previously been reported by Rose. Brannon's paper was not published but a list of his collections was secured by Underwood and included in his catalog of 1893.

In 1890, E. M. Fisher read a paper before the Academy entitled "Parasitic Fungi of Indiana", based on collections he made for the Division of Vegetable Pathology, U. S. Dept. of Agriculture. The specimens were deposited in the herbarium of the Department of Agriculture. The paper was never published but his collections were listed by Underwood. He collected rather extensively in Montgomery County as indicated in our list below.

In 1893 the Indiana Academy of Science began a biological survey of the state. L. M. Underwood, at that time professor of botany at DePauw University, was appointed director for the division of botany on the survey. In his first report (Proc. 1893:30-67), he published "A List of Cryptogams at Present Known to Inhabit the State of Indiana". This list was supplemented by another in 1894 (Proc. 1894: 147-154) and by a third short one in 1896 (Proc. 1896:71-72). The name of county and collector is indicated for each species of fungus and host. He included a total of 160 species of fungi on 268 hosts for Montgomery. These figures cannot be regarded as exactly accurate because a number of his species, especially in the rusts, have been shown since that time to be identical with others in his list. Outside the collections by Brannon and Fisher, nearly all the species which he listed from Montgomery were collected by E. W. Olive who was at that time a student in Wabash College. In 1894, M. B. Thomas, professor of botany at Wabash College, stated at the meeting of the Academy (Proc. 1894:65) that the list of parasitic fungi from the vicinity of Crawfordsville had been increased by Olive until there were now 175 species and 250 hosts.

In 1898 J. C. Arthur read before the Academy a list of the rusts of Indiana. He presented another one in 1903. A more complete list was presented by Jackson in 1915 (Proc. 1915: 429-475). The third one of these papers included all the species reported in the first two. In a second paper "Uredinales of Indiana II", (Proc. 1917:133-137), Jackson added 4 more species from as many hosts from Montgomery making a total of 58 species of rusts on 98 hosts from that county. In another paper "The Ustilaginales of Indiana", presented at the same time (Proc. 1917:119-132), Jackson lists four smuts from Montgomery occurring on as many hosts.

Since Underwood had reported in his list 103 parasites, outside the smuts and rusts, on 171 hosts we get the grand total for the county of 165 parasites on 273 hosts. In the present paper this number has been raised to 336 parasites on 560 hosts. There are 371 different host species. A number of new species collected during the last few years have not been included in this list but will be described separately in a future publication.

The cryptogamic herbarium of Wabash College contains many exsiccati specimens collected by students and instructors for thirty years. Much of the material has been lost or destroyed by use or the data lost, but all specimens which were in recognizable condition and for which data were present were carefully gone over and included here. All other exsiccati on which this list is based are in the private herbaria of the writers. Most of the collections have been from the neighborhoods of Crawfordsville, Ladoga and The Shades but in general the southern and central parts of the county have been pretty thoroly covered. Very few collections have been made in the northern edge of the county.

The nomenclature used in this list is in the main, that of Saccardo, but for the Erysiphaceae, Salmon's Monograph has been followed, Ellis & Everhart's "North American Pyrenomycetes" for the other Pyrenomycetes and Clinton's Ustilaginales in N. A. Flora for the smuts.

The writers are indebted to Professors J. C. Arthur and H. S. Jackson of Purdue University for identification of some of the Uredinales and for other favors.

LIST OF FUNGI COLLECTED.

In the following list the species are arranged alphabetically under the orders of the fungi. The following abbreviations for names of collectors are used throughout: (A)=H. W. & P. J. Anderson, (Bk)=Walter Burkholder, (Br)=M. A. Brannon, (D)=H. B. Dorner, (F)=E. M. Fisher, (Ftz)=H. M. Fitzpatrick, (H)=A. Hughart, (J)=H. M. Jennison, (O) =E. W. Olive, (T)=M. B. Thomas, (CT)=Cecil Thomas. The short abbreviation for the month of collection is used but the date of the month, although on the original packet, is omitted here because it is less essential. The exact station of collection is also omitted in the list because not considered of great importance when all collections were within the boundaries of one county. Exsiccati material representing many of the early collections by Rose, Fisher and Brannon and some of those by Olive and M. B. Thomas were not available for examination. Such are included in this list on the authority of the published records, and the month of collection, not being stated in the published records, is necessarily omitted from our list. In the case of a number of very common fungi the collections were too numerous to include here and some have been omitted, but we have retained those which show the widest range in time of occurrence and number of collectors.

PHYCOMYCETES.

CHYTRIDALES.

1. **Synchytrium decipiens Farl.**
   Amphicarpa monoica. Au 1918 (A).

2. **Albugo Bliti (Biv.) Kze.**
Amaranthus spinosus. S 1893 (O).
Amaranthus retroflexus. Au 1910 (A).

3. **Albugo candida (P.) Kze.**
Brassica nigra. Jy 1894 (T).
Capsella Bursa-pastoris. S 1893 (O), Jy 1910 (A).
Cardamine bulbosa. Je 1894 (O).
Dentaria diphylla. Je 1893 (H).
Lepidium campestre. My 1915 (A).
Lepidium virginicum. Je 1893 (O), Je 1898 (T).
Radicula Armoracia. Au 1893 (T). Au 1918 (A).
Raphanus sativus. Au 1918 (A).
Sisymbrium canescens. Je 1915 (A).
Sisymbrium officinale. Je 1898 (T), Je 1915 (A).

4. **Albugo Ipomoeae-panduranae (Schw.) Swing.**
Ipomoea hederacea. S 1894 (O), Au 1912 and Au 1915 (A).
Ipomoea pandurata. Jy 1894 (O).

5. **Albugo Portulacae (DC.) Kze.**
Portulaca oleracea. S 1893 (O), Au 1910 and Au 1916 (A).

6. **Albugo Tragopogonis (DC.) S. F. Gray.**
Ambrosia artemisiaefolia. Au 1918 (A).
Senecio aureus. My 1913 (A).

7. **Basidiophora entospora Roze & Cornu.**
Erigeron annuus. Je 1919 (A).

8. **Bremia Lactucae Regel.**
Lactuca scariola. My 1915 (A).

9. **Peronospora Arthurii Farl.**
Oenothera biennis. My 1893 (T), My 1913 (CT), Au 1919 (A).

10. **Peronospora Corydalis de Bary.**
Corydalis aurea. My 1892 (T).
Dicentra Cucullaria. My 1893 (H).

11. **Peronospora effusa Rabh.**
Chenopodium album. Au 1910 and Au 1918 (A).

12. **Peronospora Ficariae Tul.**
Ranunculus recurvatus. My 1893 (H).

13. **Peronospora parasitica (P.) de Bary.**
Arabis hirsuta. Ap 1919 (A).
Arabis laevigata. My 1914 (A).
Capsella Bursa-pastoris. My 1915 (A).
Dentaria laciniata. My 1910 (A).
Lepidium virginicum. Je 1910 (A).

14. **Peronospora Polygoni Thuem.**
Polygonum Convolvulus. Je 1910 (A).

15. **Peronospora Potentillae de Bary.**
    Potentilla nonspliensis. My 1916 (A).
16. **Plasmopara australis (Speg.) Swing.**
    Sicyos angulatus. Au 1918 (A).
17. **Plasmopara Halstedii Farl.**
    Ambrosia artemisiaefolia. Au. 1916 (A).
    Ambrosia trifida. Au 1909 (A).
    Bidens frondosa. S 1909 (A).
    Bidens laevis. 1893 (T).
    Helianthus annuus 1893 (O).
18. **Plasmopara Geranii (Pk.) Berl. & de Toni.**
    Geranium maculatum. 1893 (T).
19. **Plasmopara obducens Schroet.**
    Impatiens biflora. 1893 (T). My 1914 (A).
20. **Plasmopara viticola Berl. & de Toni.**
    Vitis cordifolia. Au 1910 (A).
    Vitis cinerea. Au 1919 (A).
    Vitis Labrusca. 1893 (O), Au 1915 (A).
21. **Pseudoperonospora cubensis (B. & C.) Rostew.**
    Cucumis sativus. Au 1914 (A).

ASCOMYCETES.

PROTODISCALES.

22. **Exoascus deformans (Berk.) Fckl.**
    Prunus Persica. Ap 1910 (A), 1893 (O).

PEZIZALES.

23. **Mollisia Dehnii (Rabh.) Karst.**
    Potentilla monspeliensis. 1893 (T), O 1910 and My 1913 (A).
24. **Fabraea maculata (Lev.) Atk.**
    Cydonia vulgaris. S 1910 (A).
25. **Pseudopeziza Medicaginis (Lib.) Sacc.**
    Medicago sativa. Je 1919 (A).
26. **Pseudopeziza Ribes Kleb.**
    Ribes Grossularia. Au 1916 (A).
    Ribes vulgare. Au 1916 (A).
27. **Pseudopeziza Trifolii (P.) Fckl.**
    Trifolium pratense. Au 1919 (A).
28. **Sclerotinia cinerea (Bon.) Wor.**
    Prunus Cerasus. Je 1916 (A). Many other collections.
    Prunus domestica " " " "
    Prunus Persica " " " "
    Pyrus Malus. Au 1919 (A).

PHACIDIALES.

29. **Coccomyces hiemalis Hig.**
Prunus Cerasus. Au. 1918 (A).
Prunus americana Au 1918 (A).

30. **Coccomyces Prunophorae Hig.**
Prunus hortulana. S 1910 (McCullough).

31. **Rhytisma Acerinum Fr.**
Acer rubrum. S 1910 (A).

PLECTASCALES.

32. **Plectodiscella veneta Burk.**
Rubus idaeus var. aculeatissimus. Au 1916 (A).
Rubus occidentalis. Au 1916 (A).

PERISPORIALES.

33. **Diplocarpon Rosae Wolf.**
Rosa (cult.). S 1912 (CT and Bk).
Rosa setigera. Au 1918 (A).

34. **Erysiphe cichoracearum DC.**
Actinomeris alternifolia. S 1907 (D). Au 1918 (A).
Ambrosia artemisiaefolia. S 1893 (O).
Ambrosia trifida. O 1893 (O), O 1909 (A).
Aster azureus. O 1893 (O).
Aster ericoides. S 1893 (O).
Aster Novae-angliae. O 1893 (O).
Aster paniculatus. O 1893 (O).
Aster sp. 1889 (Br.).
Cirsium altissimum. 1886 (Rose).
Eupatorium perfoliatum. O 1893 (O).
Eupatorium purpureum. S 1894 (O).
Helianthus annuus. 1886 (Rose). S 1893 (O).
Helianthus decapetalus. 1890 (F).
Helianthus doronocoides. 1886 (Rose).
Helianthus strumosus. O 1894 (O). Au 1918 (A).
Helianthus tuberosus. 1890 (F).
Hydrophyllum appendiculatum. Je 1893 (O).
Hydrophyllum canadense. My 1893 (O).
Hydrophyllum macrophyllum. Je 1892 (O).
Hydrophyllum virginianum. 1893 (O).
Parietaria pennsylvanica. S 1894 (O).
Phlox divaricata. S 1907 (D).
Phlox paniculata. Ap 1890 (F).
Pilea pumila. O 1893 (O).
Plantago major. Au 1918 (A).
Rudbeckia laciniata. S 1918 (A).

Rudbeckia triloba. Au 1919 (A).
Solidago canadensis. S 1893 (T).
Solidago latifolia. 1893 (O).
Verbena stricta. S 1893 (O), S 1909 (A).
Verbena urticaefolia. S 1893 (O).
Vernonia altissima. Au 1918 (A).
Vernonia fasciculata. S 1894 (O).
Xanthium strumarium 1893 (O).

35. **Erysiphe Galeopsidis DC.**
Scutellaria lateriflora. Au 1893 (O).

36. **Erysiphe graminis DC.**
Poa pratensis. N 1893 (O).
Triticum vulgare Je 1918 (A).

37. **Erysiphe Polygoni DC.**
Amphicarpa monoica. O 1907 (D).
Anemone sp. 1886 (Rose).
Aquilegia canadensis. O 1907 (D), Au 1919 (A).
Brassica nigra. Au 1919 (A).
Clematis virginiana. 1886 (Rose). 1889 (Br.).
Geranium maculatum. O 1919 (A).
Liriodendron tulipifera. O 1909 (A).
Polygonum aviculare. O 1909 (A).
Polygonum Convolvulus. O 1909 (A).
Polygonum erectum. S. 1907 (D).
Ranunculus abortivus. S 1893 (O).
Ranunculus recurvatus. S 1893 (O).

38. **Microsphaera Alni Wallr.**
Carpinus caroliniana. 1889 (Br.).
Evonymus atropurpureus. Au 1919 (A).
Gleditsia triacanthos. S 1913 and S 1914 (A).
Juglans nigra. O 1910 (A).
Platanus occidentalis. O 1893 (O), S 1909 (A).
Quercus rubra. S 1909 (A).
Quercus velutina. O 1909 (A).
Quercus sp. 1889 (Br).
Syringa vulgaris. S 1892 (O), S 1909 (A), numerous others.

39. **Microsphaera Alni var. Vaccinii Schw.**
Catalpa speciosa. O 1907 (D), O 1909 (A).

40. **Microsphaera diffusa Cke & Pk.**
Symphoricarpus orbiculatus. O 1894 (O).

41. **Microsphaera Euphorbiae (Pk.) B. & C.**
Euphorbia marginata. O 1907 (D).

42. **Microsphaera Grossulariae (Wallr.) Lev.**
Sambucus canadensis. 1886 (Rose), O 1893 (O).

43. **Microsphaera Russellii Clint.**
Oxalis corniculata. S 1893 (O), S 1909 (A).

44. **Phyllactinia Corylea (P.) Karst.**
Carpinus caroliniana. 1890 (F).
Catalpa bignonoides. 1893 (O).
Celastrus scandens. 1890 (F).
Cornus florida. 1886 (Rose).
Corylus americana. 1886 (Rose), 1890 (F).
Fraxinus americana 1893 (O).
Fraxinus nigra. S 1913 (A).
Liriodendron tulipifera. 1893 (O).
Ostrya virginiana. 1890 (F).
Quercus coccinea. 1890 (F).
Quercus palustris. N 1909 (A).
Zanthoxylum americanum. 1893 (O).

45. **Podosphaera Oxacanthae (DC) de Bary.**
Cydonia vulgaris. 1886 (Rose).
Diospyrus virginiana. 1886 (Rose).
Prunus Cerasus. Au 1910 (A).

46. **Sphaerotheca Humuli (DC.) Burr.**
Agrimonia gryposepala. 1890 (F). Je 1919 (A).

47. **Sphaerotheca Humuli var. fuliginea Schl.**
Bidens frondosa. 1893 (Underwood), Au 1910 (A).
Bidens laevis. 1893 (O).
Erigeron sp. 1886 (Rose), 1889 (Br).
Hieracium sp. 1886 (Rose).
Lactuca sp. 1886 (Rose).
Prunella vulgaris. O 1907 (D), Au 1918 (A).
Taraxacum officinale. O 1909 (A).

48. **Sphaerotheca Mors-uvae (Schw.) B. & C.**
Ribes Cynosbati. 1893 (H).

49. **Sphaerotheca Phytoptophila Kell. & Swing.**
Phytopus fascicles on Celtis occidentalis. 1893 (O).

50. **Uncinula circinata C. & P.**
Acer rubrum. 1886 (Rose).
Acer saccharinum. O 1909 (A).
Acer saccharum. 1893 (O).

51. **Uncinula Clintonii Pk.**
Tilia americana. 1890 (F). Je 1910 (A).

52. **Uncinula flexuosa Pk.**
Aesculus glabra. 1889 (Br), 1893 (O), S 1909 (A).

53. **Uncinula geniculata Gerard.**
Morus rubra. 1890 (F), 1893 (Underwood).

54. **Uncinula macrospora Pk.**
Ulmus americana. 1893 (O).
Ulmus fulva. 1893 (O).

55. **Uncinula necator (Schw.) Burr.**
Psedera quinquefolia. 1893 (O), S 1909 and Au 1918 (A).
Vitis cordifolia. S 1909 (A).
Vitis vulpina. 1894 (O).
Vitis Labrusca. 1886 (Rose).

56. **Uncinula Salicis (DC.) Wint.**
Salix cordata. 1893 (O).
Salix sericea. 1890 (F).
Salix sp. 1889 (Br), S 1909 (A).

57. **Cleistothecopsis circinans (Berk.) Stev.**
Allium cepa.

HYPOCREALES.

58. **Claviceps purpurea (Fr.) Tul.**
Elymus striatus. Au 1918 (A).
Elymus virginicus. Au 1918 (A).
Festuca elatior. Je 1918 (A).
Phalaris arundinacea. 1893 (T).
Phleum pratense. Au 1917 (A).
Secale cereale. Je 1918 (A).

59. **Epichloe typhina (P.) Tul.**
Grass. Je 1908 (Ftz).

60. **Gibberella saubinettii (Durieu & Mont.) Sacc.**
Zea Mays. Ap 1919 (A).
Triticum vulgare. Je. 1919 (A).

61. **Nectria cinnabarina (Tode) Fr.**
Sambucus canadensis. D 1919 (A).

62. **Pleonectria berolinensis Sacc.**
Ribes vulgare. Au 1916 and D 1918 (A).

DOTHIDEALES.

63. **Phyllachora graminis (P.) Fckl.**
Bromus ciliatus. 1893 (T).
Elymus canadensis. 1890 (F).
Elymus striatus. 1910 (A).
Elymus virginicus. Ja 1910 (A), S 1907 (Ftz).
Elymus sp. Au and S 1907 (Ftz).
Hystrix patula. 1893 (Underwood).
Muhlenbergia sp. S 1907 (D).

64. **Phyllachora Trifolii (P.) Fckl.**
Trifolium pratense. Je 1903 (Ftz), Au 1910 (A).
Trifolium repens. Au 1918 (A).

65. **Plowrightia morbosa (Schw.) Sacc.**
Prunus domestica. N 1907 (Ftz), F 1913 (A).

SPHAERIALES.

66. **Botryosphaeria Ribis Gros. & Dug.**
Ribes vulgare. D 1918 (A).

67. **Glomerella piperata (E. & E.) S. & S.**
Capsicum annuum. Au 1916 (A).

68. **Gnomonia Caryae Wolf.**
Carya ovata. S 1918 (A).

69. **Gnomonia leptostyla (Fr.) Ces. & de N.**
Juglans cinerea. Au 1918 (A).
Juglans nigra. Au 1918 (A).

70. **Gnomonia ulmea (Schw.) Thuem.**
Ulmus americana. 1893 (O), Au 1907 (Ftz), Ja 1910 (A).
Ulmus fulva 1890 (F)?

71. **Gnomonia Veneta (Sacc. & Speg.) Kleb.**
Platanus occidentalis. Au 1919 (A).
Quercus alba. Au 1919 (A).

72. **Guignardia Aesculi (Pk.) Stew.**
Aesculus glabra. Au 1918 (A).

73. **Guignardia Bidwellii (Ell.) V. & R.**
Psedera quinquefolia. S 1909 (A).
Vitis cordifolia. Je 1911 (A).
Vitis Labrusca. O 1910 (A).

74. **Leptosphaeria Coniothyrium (Fckl.) Sacc.**
Rubus occidentalis. D 1918 (A).

75. **Mycosphaerella Fragariae (Schw.) Lind.**
Fragaria virginiana. Au 1918 (A).

76. **Mycosphaerella Grossulariae (Fr.) Lind.**
Ribes aureum. Au 1912 (A).
Ribes gracile. S 1910 (J).
Ribes Grossularia. Au 1916 (A).
Ribes vulgare. Au 1910 (A).

77. **Mycosphaerella sentina (Fr.) Schl.**
Pyrus communis. S 1912 (A).

78. **Mycosphaerella Ulmi Kleb.**
Ulmus americana. Au 1918 (A).

79. **Physalospora Ambrosiae E. & E.**
Ambrosia trifida. Au 1918 (A).

80. **Physalospora Cydoniae Arn.**
Pyrus Malus. Au 1919 (A).

81. **Venturia inaequalis (Cke) Aderh.**
Pyrus Malus. Jy 1903 (Ftz), Au 1916 (A).

82. **Venturia Pyrina Aderh.**
Pyrus communis. 1893 (O), Au 1919 (A).

BASIDIOMYCETES.

USTILAGINALES.

83. **Schizonella melanogramma DC.**
Carex pennsylvanica. My 1913 (Kern), My 1913 (A).

84. **Tilletia laevis Kuhn.**
Triticum vulgare. Je 1919 (A).

85. **Urocystis Anemones (Pers.) Wint.**
Hepatica acutiloba. My 1919 (A).

86. **Urocystis occulta (Wallr) Rab.**
Secale cereale. Je 1919 (A).

87. **Ustilago anomala J. Kunze.**
Polygonum scandens. S 1908 (V. B. Stewart).

88. **Ustilago Avenae (Pers.) Jens.**
Avena sativa. My 1910 (A). Numerous other collections.

89. **Ustilago levis (Kell. & Swing.) Magn.**
Avena sativa. My 1910 (A).

90. **Ustilago neglecta Niessl.**
Setaria glauca. Au 1910 (A).

91. **Ustilago Rabenhorstiana Kuhn.**
Digitaria sanguinalis. S. 1913 (A). Numerous other collections.

92. **Ustilago Tritici (Pers.) Rostr.**
Triticum vulgare. Je 1919 (A). Numerous other collections.

93. **Ustilago Zeae (Beckm) Unger.**
Zea Mays. Au 1918 (A). Numerous other collections.

UREDINALES.

94. **Aecidium Boehmeriae Arth.**
Boehmaria cylindrica. My 1899 (Arthur).

95. **Aecidium Dicentrae Trel.**
Dicentra cucullaria. Je 1893 (H).

96. **Aecidium hydnoidium B. & C.**
Dirca palustris. Je 1892 (T).

97. **Aecidium Tithymali Arth.**
Euphorbia commutata. My 1910 (A).

98. **Colesosporium Campanulae (Pers) Lev.**
Campanula americana. Au 1907 (D). Au 1918 (A).

99. **Coleosporium delicatulum Hedg. & Long.**
Solidago lanceolata S 1909 (A).

100. **Coleosporium Ipomoeae (Schw.) Burr.**
Ipomoea pandurata. S 1910 (A).

101. **Coleosporium Solidaginis (Schw.) Thum.**
Aster azureus. 1890 (F).
Aster cordifolius. 1890 (F).
Aster ericoides var. villosus. Au 1918 (A).
Aster Novae-angliae. O 1893 (O).
Aster paniculatus. 1890 (F).
Aster sagittifolius. Au 1918 (A).
Aster Shortii. 1890 (F).
Callistephus hortensis. Au 1916 (A).
Solidago altissima. Au 1918 (A).
Solidago arguta. 1894 (O).
Solidago bicolor. 1893 (O).
Solidago caesia. 1890 (F).
Solidago canadensis. S 1894 (O) Au 1918 (A).
Solidago latifolia. O 1886 (Rose).
Solidago patula. 1890 (F).
Solidago ulmifolia. 1907 (Ftz).

102. **Coleosporium Vernoniae B. & C.**
Vernonia altissima. S 1909 (A). Au 1918 (A).
Veronia fasciculata. S 1893 (O). S 1906 (D).

103. **Gymnoconia interstitialis (Schlect) Lagerh.**
Rubus allegheniensis. Je 1911 (A).
Rubus occidentalis. Je 1911 (A).
Rubus villosus. My 1910 (A).

104. **Gymnosporangium globosum Farl.**
Crataegus coccinea. 1893 (O).
Crataegus Crus-galli. 1894 (O).
Crataegus punctata. 1893 (O).
Crataegus sp. Jy 1908 (A).

105. **Gymnosporangium Juniperi-virginiana Schw.**
Juniperus virginiana. 1893 (O). My 1910 (A).
Pyrus malus. 1901 (Whetzel).

106. **Kuehneola Uredinis (Link) Arth.**
Rubus allegheniensis. My 1913 (A). Au 1918 (A).

107. **Melampsora Bigelowii Thum.**
Salix cordata. 1893 (O).
Salix discolor. 1893 (O).
Salix longifolia. S 1893 (O).
Salix nigra. S 1907 (D).
Salix sp. S. 1909 (A). S 1907 (D).

108. **Melampsora Medusae Thum.**
Poplus balsamifera. 1890 (F).
Poplus deltoides. S 1894 (O).
Populus tremuloides. S 1894 (O).
Populus sp. S 1909 (A).

109. **Phragmidium Rosae-setigerae Diet.**
Rosa setigera. Au 1910 (A) Au 1916 (A).

110. **Phragmidium triarticulatum (B. & C.) Farl.**
Potentilla canadensis. Au 1918 (A), Ap 1919 (A).

111. **Pileolaria toxicodendri (Berk & Rav.) Arth.**
Rhus toxicodendron. My 1894 (O).

112. **Pucciniastrum Agrimoniae (Schw.) Tranz.**
Agrimonia gryposepala. 1893 (O), S 1909 (A) Au 1918 (A).

113. **Pucciniastrum Hydrangeae (B. & C.) Arth.**
Hydrangea arborescens. S 1909 (A) Au 1917 (A).

114. **Puccinia Anemones-Virginianae Schw.**
Anemone virginiana. Au 1918 (A) Ap. 1919 (A).

115. **Puccinia angustata Pk.**
Scirpus atrovirens. Au 1918 (A).

116. **Puccinia Antirrhinii Diet. & Holw.**
Antirrhium majus. D 1914 (C. C. Rees).

117. **Puccinia Asparagi DC.**
Asparagus officinale. S 1909 (A). Other collections.

118. **Puccinia Asteris Duby.**
Aster cordifolius. 1890 (F), S 1907 (D).
Aster paniculatus. 1890 (F) O 1907 (D).
Aster sp. O 1909 (A).

119. **Puccinia Bardanae Corda.**
Arctium Lappa. Au 1918 (A).

120. **Puccinia Bolleyana Sacc.**
Carex Frankii. Au 1917 (A).
Carex trichocarpa. N 1906 (Reddk).
Sambucus canadensis. My 1893 (H), Je 1911 (A), Ap. 1908 (Miller).

121. **Puccinia Circaeae Pers.**
Circaea lutetiana. S 1894 (O), S 1914 (A).

122. **Puccinia Cnici Mart.**
Circium lanceolatum. My 1913 (A).

123. **Puccinia Convolvuli (Pers.) Cast.**
Convolvulus sepium. Je 1895 (O), O 1909 (A).

124. **Puccinia coronata Corda.**
Avena sativa. Au 1910 (A). Au 1918 (A).

125. **Puccinia Cyperi Arth.**
Cyperus strigosus. Au 1907 (Barrus) O 1907 (D).
Cyperus Schweinitzii. 1893. (Underwood).

126. **Puccinia Dayi Clint.**
Steironema ciliatum. Au 1911 (A).

127. **Puccinia dispersa Ericks.**
Secale cereale. Je 1919 (A).

128. **Puccinia Eatoniae Arth.**
Ranunculus abortivus. Ap.1903 (T), Ap. 1910 (A).

129. **Puccinia Eleocharidis Arth.**
Eleocharis palustris. S 1907 (D).

130. **Puccinia emaculata Schw.**
Panicum capillare. O 1893 (O), S 1909 (A).

131. **Puccinia extensicola Plowr.**
Aster cordifolius. Je 1893 (T), My 1892 (T).
Aster sagittifolius. My 1892 (T).
Aster shortii. My 1907 (D).
Erigeron annuus. 1889 (Arthur).
Solidago arguta. Je 1894 (O).
Solidago caesia. Jy 1886 (Rose) 1893 (O).

132. **Puccinia graminis Pers.**
Agrostis alba. Au 1918 (A).
Avena sativa. Au 1918 (A).
Phleum pratense. Jy 1910 (A), Au 1918 (A).
Triticum vulgare. Je 1918 (A).

133. **Puccinia Helianthi Schw.**
Helianthus annuus. S 1893 (O), S 1909 (A), Au 1918 (A).
Helianthus divaricatus. 1890 (F).
Helianthus grosse-serratus. S 1893 (O).
Helianthus hirsutus. Au 1918 (A).
Helianthus strumosus. O 1894 (O).
Helianthus parviflorus. Au 1919 (A).
Helianthus trachiifolius. 1893 (O).

134. **Puccinia Hieracii (Schum) Mart.**
Hieracium scabrum. My 1913 (A).

135. **Puccinia Impatientis Arth.**
Elymus striatus. Au 1918 (A).
Impatiens biflora. My 1908 (Miller).

136. **Puccinia Iridis (DC) Arth.**
Iris Virsicolor. S 1909 (A).

137. **Puccinia Lobeliae Ger.**
Lobelia syphilitica. S 1907 (D), Au 1918 (A), S 1913 (A).

138. **Puccinia ludibunda E. & E.**
Oenothera biennis. Au 1910 (A), My 1914 (A), Je 1894 (O).

139. **Puccinia Malvacearum Bert.**
Althaea rosea. S 1915 (A).

140. **Puccinia Mariae-Wilsoni Clint.**
Claytonia virginica. My 1907 (T).

141. **Puccinia marilandica Lindr.**
Sanicula canadensis. S 1907 (Barrus).

142. **Puccinia Menthae Pers.**
Blephilia hirsuta. 1890 (F), Au 1919 (A).
Mentha canadensis. Au 1894 (O), Au 1918 (A).
Monarda fistulosa. N 1893 (O), O 1909 (A), Au 1917 (A).

143. **Puccinia Muhlenbergiae Arth.**
Muhlenbergia tenuiflora. 1915 (Mrs. Arthur).

144. **Puccinia obscura Schroet.**
Luzula campestris. My 1913 (A).

145. **Puccinia obtecta Pk.**
Scirpus validus. 1893 (O).

146. **Puccinia patruelis Arth.**
Lactuca canadensis. 1894 (O).

147. **Puccinia Poarum Niess.**
Poa pratensis. D 1918 (A). Numerous other collections.

148. **Puccinia Podophylli Schw.**
Podophyllum peltatum. Ap 1910 (A). Numerous other collections.

149. **Puccinia Polygoni-amphibii Pers.**
Polygonum acre. S 1909 (A).
Polygonum convolvulus. Au 1918 (A), S 1909 (A).
Polygonum Muhlenbergii. S 1894 (O).

150. **Puccinia Phingsheimiana Kleb.**
Carex pubescens. S 1907 (D).
Ribes Cynosbati. Je 1911 (A), Je 1893 (H).
Ribes floridum (?). Je 1894 (O).
Ribes oxyacanthoides. 1899 (Arthur).

151. **Puccinia Pruni-spinosae (Pers) Arth.**
Hepatica acutiloba. Ap 1893 (O).
Hepatica triloba. My 1910 (Dietz), Ap 1908 (Miller).

152. **Puccinia punctata Link.**
Galium concinnum. S 1894 (O), Au 1918 (A), S 1907 (D).
Galium triflorum. 1893 (Underwood).

153. **Puccinia pustulata (Curt) Arth.**
Commandra umbellata. Je 1893 (H).

155. **Puccinia Ruelliae (B. & Br.) Lagh.**
Ruellia ciliosa. Au 1918 (A).
Ruellia strepens. S 1909 (A), Au 1918 (A).

156. **Puccinia Silphii Schw.**
Silphium perfoliatum. Au 1918 (A).

157. **Puccinia Sorghi Schw.**
Oxalis corniculata. My 1897 (Taylor).
Zea mays. Au 1910 (A). Numerous other collections.

158. **Puccinia Taraxaci (Reb) Plowr.**
Taraxacum officinale. My 1893 (O), O 1909 (A). Numerous other collections.

159. **Puccinia Thalictri Chev.**
Thalictrum dioicum. My 1894 (O).

160. **Puccinia tomipara Trel.**
Anemonella thalictroides. My 1894 (O).
Bromus ciliatus. S 1907 (D).
Clematis virginiana. 1893 (O).

161. **Puccinia triticina Ericks.**
Triticum vulgare. Au 1918 (A). Numerous other collections.

162. **Puccinia Violae (Schum.) DC.**
Viola blanda. S 1909 (A).
Viola cucullata. Ap 1910 (A).
Viola papllionacea. S 1906 (D).
Viola pubescens. My 1908 (Miller).
Viola striata. S 1886 (Rose), My 1907 (D).

163. **Puccinia verrucosa (Schult) Link.**
Agastache nepetoides. Au 1918 (A).

164. **Puccinia Windsoriae (Schw) Kze.**
Ptelea trifoliata. Je 1892 (T).
Tridens flavus. S 1907 (D).

165. **Puccinia Xanthi Schw.**
Xanthium canadense. Au 1908 (A). Numerous other collections.

166. **Uromyces appendiculatus (Per) Lev.**
Phaseolus vulgaris O 1910 (D). Numerous other collections.
Strophostyles helvola. S 1909 (A).

167. **Uromyces Caladii Farl.**
Arisaema Dracontium. Je 1919 (A).
Arisaema triphyllum. My 1910, (A). Numerous collections.

168. **Uromyces caryophyllinus (Shrank) Wint.**
Dianthus caryophyllus. O 1907 (Barrus).

169. **Uromyces Fabae (Pers) DeB.**
Lathyrus palustris. Je 1893 (O).

170. **Uromyces fallens (Des) Kern.**
Trifolium pratense. Au 1910 (A), Au 1918 (A).

171. **Uromyces Hedysari-paniculati (Schw) Farl.**
Desmodium canescens. 1893 (O).
Desmodium Dillenii. 1893 (Underwood).
Desmodium laevigatum. 1890 (F).
Desmodium paniculatum. S 1909 (A).

172. **Uromyces Howei Pk.**
Asclepias incarnata. Au 1918 (A).
Asclepias purpurascens. 1893 (O).
Asclepias syriaca. Au 1909 (A).

173. **Uromyces Lespedezae-procumbentis (Schw) Lagh.**
Lespedeza fructescens. S 1907 (D).
Lespedeza procumbens. S 1907 (D).

174. **Uromyces Polygoni (Pers) Fuckl.**
Polygonum aviculare. 1893 (O).

175. **Uromyces proeminens (DC) Lev.**
Euphorbia dentata. Au 1918 (A).
Euphorbia humistrata. 1906 (T).
Euphorbia maculata. 1886 (Rose).
Euphorbia Preslii. S 1909 (A). Au 1918 (A).

176. **Uromyces Rudbeckiae Arth & Holw.**
Rudbeckia laciniata. S 1894 (O), Au 1918 (A).

177. **Uromyces Scirpi (Cast.) Burr.**
Scirpus americanus. Jy 1895 (O).

178. **Uromyces Trifolii (Hedw) Lev.**
Trifolium procumbens. Au 1918 (A).

FUNGI IMPERFECTI.

SPHAEROPSIDALES.

179. **Actinonema Rosae (Lib.) Fr.**
See Diplocarpon Rosae Wolf.

180. **Ascochyta Lappae Kab. & Bub.**
Arctium Lappa. Je 1919 (A).

181. **Ascochyta caulicola Lau.**
Melilotus alba. Au 1918 (A).

182. **Ascochyta Violae Sacc. & Speg.**
Viola cucullata. Je 1919 (A).

183. **Cincinnobolus Cesatii de Bary.**
Mycelium of Erysiphaceae on Solidago arguta, S. latifolia, Aster Shortii, Rudbeckia triloba, Hydrophyllum virginicum. 1893 (F).
Sphaerotheca Humuli var. fuliginea on Taraxicum officinale. 1893 (O).
Phyllactinia corylea on Liriodendron tulipifera. 1893 (O).

184. **Coniothyrium concentricum Desm.**
Yucca. 1894 (O).

185. **Coniothyrium Fuckelii Sacc.**
See Leptosphaeria Coniothyrium.

186. **Darluca filum (Biv.) Cast.**
Uredinia of Puccinia Menthae on Monarda fistulosa. Au 1918 (A).

187. **Dendrophoma obscurans And.**
Fragaria virginiana Au 1916 (A).

188. **Leptothyrium Pomi (Mont. & Fr.) Sacc.**
Pyrus Malus. Au 1916 (A).
Rubus idaeus var. aculeatissimus. Au 1916 (A).

189. **Melasmia hypophylla (B. & Rev.) Sacc.**
Gleditsia triacanthos. Au 1907 (Ftz), S 1907 (D), Au 1918 (A).

190. **Phoma herbarum West.**
Solidago canadensis. Ap 1919 (A).

191. **Phyllosticta Asiminae E. & K.**
Asimina triloba. S 1913 (A).

192. **Phyllosticta Bridgesii Speg.**
Lobelia siphilitica. Au 1918 (A).

193. **Phyllosticta Caryae Pk.**
Carya ovata. Au 1919 (A).

194. **Phyllosticta Catalpae E. & M.**
Catalpa speciosa. O 1908 (A).

195. **Phyllosticta Celtidis E. & K.**
Celtis occidentalis. Au 1918 (A).

196. **Phyllosticta cercidicola Ell.**
Cercis canadensis. Au 1918 (A).

197. **Phyllosticta Chenopodii Sacc.**
Chenopodium album. My 1894 (O).

198. **Phyllosticta Commonsii E. & E.**
Paeonia officinale. S 1893 (T).

199. **Phyllosticta Coryli West.**
Corylus americana. Au 1916 (A).

200. **Phyllosticta cruenta (Fr.) Kickx.**
Polygonatum biflorum. Au 1918 (A).
Smilacina racemosa. Je 1894 (O), My 1914 (A).

201. **Phyllosticta decidua E. & K.**
Nepeta hederacea. Je 1919 (A).

202. **Phyllosticta Desmodii E. &. K.**
Desmodium rotundifolium. 1894 (O).

203. **Phyllosticta fraxinicola Curr.**
Fraxinus americana. S 1913 (A).

204. **Phyllosticta guttulata Hals.**
Oxalis corniculata. Je 1919 (A).

205. **Phyllosticta Hydrangeae E. & E.**
Hydrangea arborescens. S 1893 (O).

206. **Phyllosticta Labruscae Thuem.**
See Guignardia Bidwellii.

207. **Phyllosticta Liriodendri Cke.**
Liriodendron tulipifera. S 1907 (D).

208. **Phyllosticta minima (B. & C.) E. & E.**
Acer saccharum. Au 1918 (A).

209. **Phyllosticta Oakesiae Dear. & House.**
Uvularia perfoliata. Au 1918 (A).

210. **Phyllosticta Paviae Desm.**
See Guignardia Aesculi.

211. **Phyllosticta Podophylli Wint.**
Podophyllum peltatum. My 1894 (O).

213. **Phyllosticta Quercus Sacc. & Speg.**
Quercus macrocarpa. S 1893 (O).

214. **Phyllosticta Rosae Desm.**
Rosa setigera. 1894 (O).

215. **Phyllosticta smilacina (Pk.) Dearn.**
Smilax hispida. Au 1918 (A).
Smilax rotundifolia. 1893 (O).

216. **Phyllosticta solitaria E. & E.**
Pyrus Malus. Au 1916 (A).
Pyrus coronaria 1893 (Underwood).

217. **Phyllosticta straminella Bres.**
Rheum Rhaponticum. Au 1916 (A).

218. **Rhabdospora Solidaginis C. & E.**
Solidago canadensis. Ap 1919 (A).

219. **Septoria Agrimoniae Boum.**
Agrimonia gryposepala. 1894 (O). Je 1919 (A).

220. **Septoria asclepiadicola E. & E.**
Asclepias incarnata. Je 1919 (A).

223. **Septoria Cacaliae E. & K.**
Cacalia atriplicifolia. S 1893 (O), O 1907 (Barrus).
Cacalia reniformis. 1894 (O).

224. **Septoria Cannabis (Lasch.) Sacc.**
Cannabis sativa. 1890 (F).

225. **Septoria Cerastii Rob. & Desm.**
Cerastium viscosum. My 1914 (A).

226. **Septoria Cirsii Niessl.**
Cirsium altissimum. O 1919 (A).

227. **Septoria consocia Pk.**
Polygala Senega. 1894 (O).

228. **Septoria conspicua E. & M.**
Steironema ciliatum. Je 1918 (A).

229. **Septoria cornicola Desm.**
Cornus florida. Au 1919 (A).

230. **Septoria Cryptotaeniae E. & Rau.**
Cryptotaenia canadensis. 1894 (O), Au 1918 (A).

231. **Septoria Dentariae Pk.**
Dentaria laciniata. 1893 (O).

232. **Septoria Erigerontis Pk.**
Erigeron annuus. 1893 (O), S 1907 (D), Ap 1919 (A).
Erigeron philadelphicus. 1894 (O).

233. **Septoria Helianthi E. & K.**
Helianthus annuus. 1893 (O).
Heliopsis helianthoides. 1893 (O).

234. **Septoria Heucherae Pass.**
Heuchera americana. 1894 (O).

235. **Septoria irregularis Pk.**
Rhus toxicodendron. Au 1916 (A).

236. **Septoria Lactucae Pass.**
Lactuca canadensis. Au 1918 (A).
Lactuca sativa. Au 1916 (A).
Lactuca scariola. 1894 (O), Au 1918 (A).

237. **Septoria Lapparum Sacc.**
Arctium Lappa. 1893 (O), Je 1919 (A).

238. **Septoria Lycopersicae Speg.**
Lycopersicon esculentum. Au 1910 (A).

239. **Septoria noctiflorae E. & K.**
Silene antirrhina. Je 1919 (A).

240. **Septoria miscrospora E. & E.**
Hystrix patula. 1890 (F).

241. **Septoria Oenotherae West.**
Oenothera biennis. O 1909 (A).

242. **Septoria Phlogis Sacc. & Speg.**
Phlox divaricata. 1894 (O).

243. **Septoria Pillae Thuem.**
Pilea pumila. Au 1918 (A).

244. **Septoria podophyllina Pk.**
Podophyllum peltatum. 1893 (O), My 1912 (A).

245. **Septoria Polygonorum Desm.**
Polygonum hydropiperoides. 1894 (O).
Polygonum Muhlenbergia. 1894 (O).
Polygonum pennsylvanicum. S 1909 (A).

246. **Septoria Pteleae E. & E.**
Ptelea trifoliata. 1894 (O).

247. **Septoria piricola Desm.**
See Mycosphaerella sentina.

248. **Septoria recurvata E. & Hals.**
Trillium erectum. 1894 (O).

249. **Septoria Ribis Desm.**
See Mycosphaerella Grossulariae.

250. **Septoria Rubi West.**
Rubus allegheniensis. 1893 (O).
Rubus idaeus var. aculeatissimus. Au 1916 (A).
Rubus occidentalis. Au 1916 (A).

251. **Septoria sambucina Pk.**
Sambucus canadensis. 1894 (O), My 1915 and Au 1918 (A).

252. **Septoria Scrophulariae Pk.**
Scrophularia marilandica. 1893 (O), S 1907 (D), My 1912 (A).

253. **Septoria Sicyi Pk.**
Echinocystis lobata. O 1893 (O).

254. **Septoria Trillii Pk.**
Trillium cernuum. 1893 (O), Je 1911 (A).
Trillium recurvatum. 1893 (O).
Trillium sessile. 1893 (O).

255. **Septoria Tritici Desm.**
Triticum vulgare. Je 1919 (A).

256. **Septoria Urticae Desm.**
Laportea canadensis. 1894 (O).

257. **Septoria Violae Westd.**
Viola cucullata. 1893 (O).

258. **Sphaeropsis malorum Pk.**
See Physalospora Cydoniae.

259. **Sphaeropsis Sambuci Pk.**
Sambucus canadensis. D 1918 (A).

260. **Sphaeropsis Linderae Pk.**
Benzoin aestivale. Ap 1919 (A).

261. **Stagnospora Chenopodii Pk.**
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262. **Vermicularia albo-maculata Schw.**
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263. **Vermicularia Dematium Fr.**
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264. **Vermicularia trichella Fr.**
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265. **Vermicularia circinans Berk.**
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266. **Vermicularia Violae E. & E.**
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267. **Colletotrichum lagenarium (Pass.) Ell. & Hals.**
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Cucumis Melo. Au 1916 (A).
Cucumis sativus. Au 1916 (A).

268. **Colletotrichum Lindemuthianum (Sacc. & Magn.) Bri. & Cav.**
Phaseolus vulgaris. Au 1916 (A).

269. **Colletotrichum nigrum E. & H.**
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270. **Colletotrichum Peckii v. Violae rotundifoliae (Sac.) Anders.**
Viola cucullata. 1893 (O). Ap 1914 (A).

271. **Cylindrosporium Iridis E. & H.**
Iris versicolor. 1893 (O).

273. **Cylindrosporium officinale E. & E.**
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274. **Cylindrosporium Padi Karst.**
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275. **Gleeosporium affine E. & K.**
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276. **Gloeosporium caulivorum Kirch.**
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277. **Gloeosporium piperatum E. & E.**
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278. **Gloeosporium Rumicis E. & E.**
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279. **Gleosporium septorioides Sac.**
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280. **Gloeosporium nervisequum (Fckl.) Sacc.**
See Gnomonia veneta.

281. **Gloeosporium Caryae E. & D.**
See Gnomonia Caryae.

282. **Gloeosporium Ribis (Lib.) Mont. & Des.**
See Pseudopeziza Ribis.

283. **Gloeosporium venetum Speg.**
See Plectodiscella veneta Burk.

284. **Marssonia Delastri (De Lacr.) Sacc.**
Agrostemma Githago. Je 1919 (A).

285. **Marssonia Juglandis (Lib.) Sacc.**
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286. **Marssonia Martinii Sacc. & Ell.**
Quercus alba. 1890 (F).
Quercus bicolor. 1890 (F). Au 1918 (A).
Quercus Muhlenbergia. 1890 (F).
Quercus rubra. 1890 (F).
Quercus velutina. Au 1918 (A).

287. **Marssonia Thomasiana Sacc.**
Evonymus atropurpureus. Au 1919 (A).

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288. **Alternaria Brassicae (Berk.) Sacc.**
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289. **Alternaria crassa (Sacc.) Rands.**
Datura Stramonium. Au 1910 and Au 1918 (A).

290. **Alternaria Solani (E. & M.) Jones and Grout.**
Solanum tuberosum. Au 1918 (A).

291. **Alternaria Violae Gall. & Dor.**
Viola cucullata. S 1909 (Schramm).

292. **Cercospora Acalyphae Pk.**
Acalypha virginica. Au 1919 (A).

293. **Cercospora althaeina Sacc.**
Althaea rosea. Au 1916 (A).
Malva rotundifolia. Au 1918 (A).

294. **Cercospora amphakodes E. & H.**
Phlox divaricata. 1894 (O).

295. **Cercospora Apii Fres.**
Apium graveolens. Au 1916 (A).

296. **Cercospora Apii var. Carotae Farl.**
Daucus Carota. Au 1919 (A).

297. **Cercospora Apii var. Pastinacae Farl.**
Pastinaca sativa. Au 1918 (A).

298. **Cercospora Armoraciae Sacc.**
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299. **Cercospora beticola Sacc.**
Beta vulgaris. Au 1910 and Au 1916 (A).

300. **Cercospora cana Sacc.**
Erigeron annuus. Je 1919 (A).

301. **Cercospora caulophylli Pk.**
Caulophyllum thallictroides 1894 (O).

302. **Cercospora chionea E. & K.**
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303. **Cercospora citrullina Cke.**
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304. **Cercospora clavata (Ger.) Cke.**
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305. **Cercospora Cleomis E. & H.**
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306. **Cercospora cruciferarum E. & E.**
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307. **Cercospora Davisii E. & E.**
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308. **Cercospora Diantherae E. & K.**
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309. **Cercospora Echinocystis E. & M.**
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310. **Cercospora elongata Pk.**
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311. **Cercospora Eupatorii Pk.**
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Eupatorium purpureum. 1893 (O), Au 1918 (A).

312. **Cercospora flagellaris E. & M.**
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313. **Cercospora granuliformis E. & H.**
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314. **Cercospora Hydropiperis (Thuem.) Speg.**
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315. **Cercospora Lippiae E. & E.**
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316. **Cercospora Lobeliae Kell. & Swing.**
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317. **Cercospora Nasturtii Pass.**
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318. **Cercospora Penstemonis E. & K.**
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319. **Cercospora Physalidis Ell.**
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320. **Cercospora Prenanthis E. & K.**
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321. **Cercospora Pteleae Wint.**
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322. **Cercospora racemosa E. & M.**
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323. **Cercospora Resedae Fckl.**
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324. **Cercospora rhoina C. & E.**
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325. **Cercospora Sagittariae E. & K.**
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326. **Cercospora Smilacis Thuem.**
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327. **Cercospora sordida Sacc.**
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328. **Cercospora umbrata E. & H.**
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329. **Cercospora varia Pk.**
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330. **Cercospora variicolor Wint.**
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331. **Cercospora Vernoniae E. & K.**
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332. **Cercospora Violae Sacc.**
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333. **Cercospora Xanthoxyli Cke.**
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335. **Cladosporium tenuissimum Cke.**
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336. **Clasterosporium caricinum Schw.**
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337. **Didymaria fulva E. & E.**
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339. **Heterasporium gracile (Wallr.) Sacc.**
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341. **Macrosporium Catalpae E. & M.**
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343. **Macrosporium Porri Ell.**
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345. **Ovularia rigidula Del.**
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346. **Piricularia grisea (Cke.) Sacc.**
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348. **Ramularia Armoraciae Fckl.**
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350. **Ramularia arvensis Sacc.**
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PIPETTES FOR HOLDING AND MEASURING FLUIDS.

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There are many applications in bacteriology and especially in serology for pipettes which will serve the double purpose of holding and measuring fluids. We have devised such pieces of apparatus which are simple in construction, easy and convenient to operate and which have proved to be satisfactory in our laboratory.

Figure I represents the pipette for use when it is desired to handle sterile liquids. The glass parts and rubber connections are sterilized in the usual way and assembled aseptically.

By releasing the clamp (C) on rubbering-tubing connection (D) the sterile fluid contained in the reservoir (B) which may be of any suitable shape, will flow into the pipette (G) which is of the desired calibration.

The side-arm (E) which is plugged with sterile cotton (F) to avoid air contamination, compensates for the air displaced by the liquid entering the calibrated tube (G) or replaced when the clamp (J) on rubber-tubing connection (I) is released thus permitting the measured fluid to flow thru the capillary-tubing (K). The latter may be protected by a sterile test-tube (M) plugged with cotton (L).

Applying negative or positive pressure by means of the rubber-tubing (H) which is connected to the side-arm, the liquid which remains in the capillary-tubing or pipette proper or in both may be removed. The small amount of sterile liquid which may be discharged from time to time from the same may be collected in sterile tubes or flasks and thus prevent waste of fluid. However, it is not advisable to return such material to the stock solution in the reservoir for fear of contamination.

After the opening in the capillary-tubing has been sealed in the flame the liquid is stored by placing the appartus in the refrigerating-room. When more fluid is to be used a file-scratch is made near the sealed end of the capillary-tubing. It is broken off, the opening sterilized by flaming and the pipette is manipulated as before. It may be advisable to warm the liquid before so doing. Of course, sterile fluid may be taken directly from the reservoir.

Evaporation of the material may be cut down to a negligible quantity by covering the cotton stopper (A) in the holding-chamber with a rubber cap or by inverting a test-tube over it etc., and by tying a knot in the rubber-tubing (H).

In this way a sterile liquid may be conveniently stored with a minimum amount of evaporation and used in definite quantities without becoming contaminated.

In serological work where sterility is not necessary but where it is essential to bring the reacting substance to an equal volume by adding physiological salt solution the pipette as shown in figure II may be used to an advantage because of its convenience in operation and time saving.

The apparatus is entirely glass in construction and in operation is similar to the pipette previously considered. A rack holding the tubes containing the reacting substances is placed under the pipette and the required amount of physiological salt solution is added to each tube.

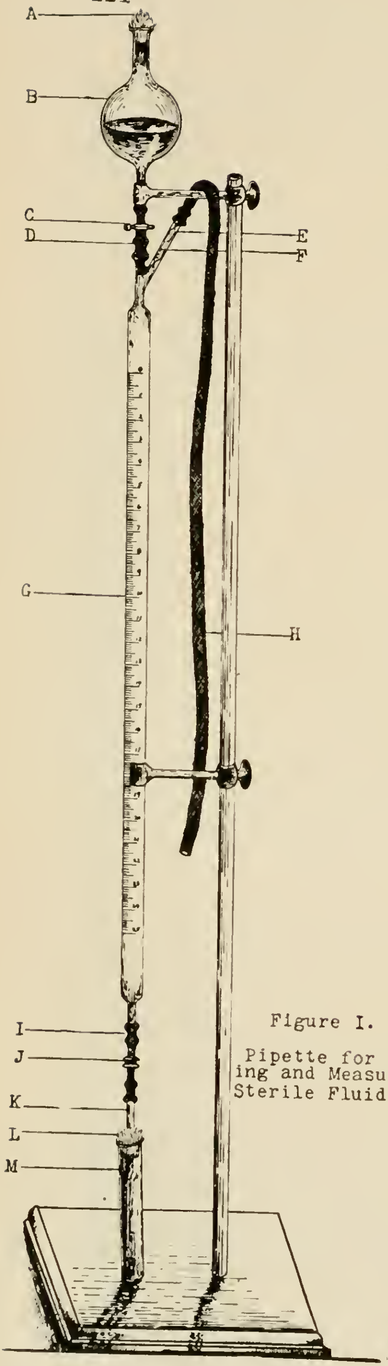

Figure I.

Pipette for Holding and Measuring Sterile Fluids.

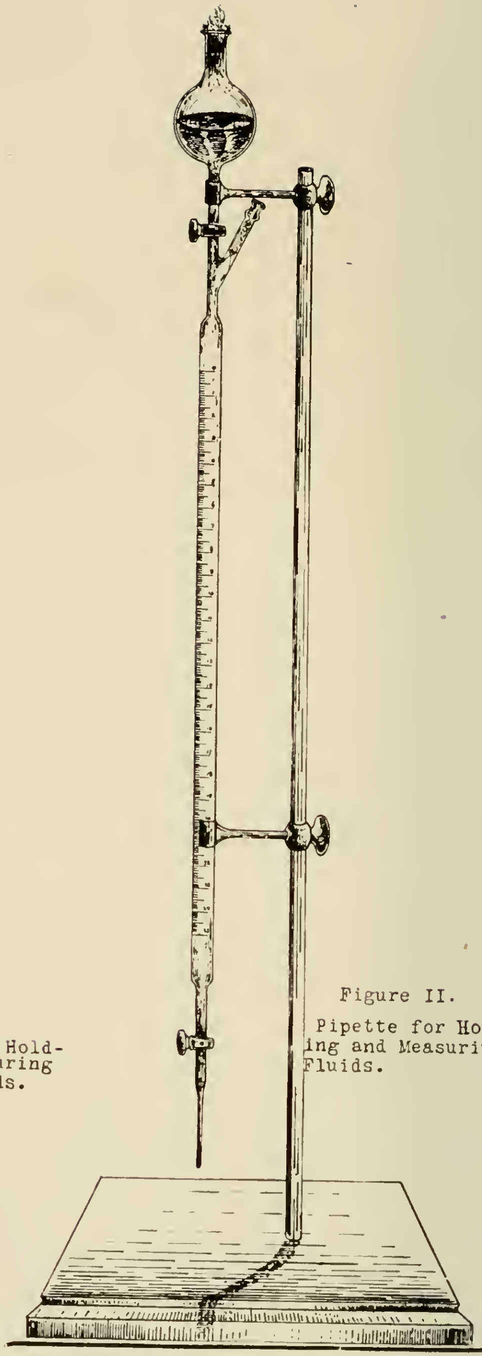

Figure II.

Pipette for Holding and Measuring Fluids.

THE CULTIVATON OF SPIROCHAETA NOVYI* WITHOUT THE USE OF TISSUE FROM ANIMAL ORGANS.

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In 1909 Schereschewsky[1] by deeply imbedding a piece of human tissue containing Spirochaeta Pallida in gelatinized horse serum, first demonstrated that the treponema might be cultivated *in vitro*. He was not able to obtain a pure culture of the organism, for bacteria grew along with the pallidum, nor did he succeed in reproducing syphilitic lesions by inoculating animals.

In 1910, Muhlen[2] obtained the first generation of the spirochaete by utilizing the above mentioned method. By the use of horse serum agar, he further succeeded in obtaining a culture devoid of bacteria. Muhlen's pure cultures also were evidently non-pathogenic.

During the same year, Bruchner and Galasesco[3] succeeded in cultivating "young impure cultures" by using Schereschewsky's medium. But upon inoculating rabbits with the material which also contained the original spirochaetal tissue, syphilitic lesions were produced. They were, however, unable to obtain a second generation of these organisms.

In 1911, Hoffman[4] succeeded in getting pure cultures of the spirochaete by the utilization of Schereschewsky's and Mühlen's methods. Although his cultures were morphologically typical, he, like the above mentioned experimenters, was not able to demonstrate their pathogenic properties.

Also at this time, Sowade[5] succeeded in procuring impure virulent cultures by using the gelatinized horse serum or gelatinized ascitic fluid. This inocuable material also still contained the original pallidum tissue.

In 1911, Noguchi[6] was able to cultivate pure virulent cultures *in vitro* of this organism. He accomplished this by placing a small piece of fresh sterile rabbit kidney or testicle tissue into each tube containing about sixteen cubic centimeters of serum water (one part of serum and three parts of distilled water) which was previously fractionally sterilized. A layer of sterile paraffin oil was added to each sterile tube containing this cultural medium and placed under strict anaerobiosis and incubated at 35-37° Centigrade. Under these conditions the spirochaetes which were morphologically typical and virulent were obtained and cultivated for many generations.

In the following year, Noguchi[7] cultivated for the first time the following relapsing-fever spirochaetes: Spirochaeta Duttoni, Spirochaeta Kochi, Spirochaeta Obermeieri and Spirochaeta Novyi.

In 1912, Treponema macrodentium and microdentium[8], Treponema Refringens[9], Treponema mucosum[10], Spirochaeta Phagedenis[11], and Spirochaeta Gallinarum[12] were likewise successfully cultivated.

The media used in their cultivation was of a similar nature to that used in the pallidum cultural work. It was not essential in some instances to

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*The author is greatly indebted to Dr. F. G. Novy, Ann Arbor, Michigan, thru whose kindness this strain of Spirochaete was obtained.

resort to strict anaerobiosis, but it was however, necessary to employ the use of sterile animal tissue in all cases. In the cultivation of pallidum, macrodentium, microdentium, mucosum, refringens, and phagedenis strict anaerobic conditions were required. Quite the opposite seems to be true for the relapsing-fever spirochaetes.

Noguchi's method of obtaining cultures of the latter is briefly as follows: A piece of sterile fresh rabbit kidney is placed in a sterile test-tube to which is added a few drops of citrated infected hearts blood of a rat or mouse. About fifteen cubic centimeters of sterile ascitic or hydrocle fluid is then added. Some of the medium is covered with sterile paraffin oil. The culture tubes thus prepared are incubated at 35-37° Centigrade. Maximum growth occurred on the fourth to the ninth day.

The use of sterile tissue being employed in all of this cultural work, of course, entails in many cases the killing of rabbits for their kidney tissue only. For this reason as well as being intensely interested along these lines in view of the fact that we attempted the cultivation of the relapsing-fever organisms three years previous to Noguchi's first publication and after obtaining cultures without difficulty by Noguchi's method, we deemed it advisable to attempt cultivation without the use of sterile tissue from animal organs. After various attempts we were finally able to obtain initial cultures without such tissue. These cultures as well as those which were obtained by the employment of the tissue medium, could be transplanted, with success, to ascitic fluid to which a small amount of sterile undefibrinated blood only, had been added.

The medium employed by us differs considerably from that used by Noguchi. Approximately eighteen cubic centimeters of sterile Ascitic fluid are transferred to each of a number of sterile test-tubes (tubes 20 by 1.5 centimeters were used). The pipette for holding and measuring sterile fluids[13] may be conveniently used in transferring this fluid to the tubes. It is very important as Noguchi also notes that the ascitic fluid does not contain bile, but forms a loose fibrin. Specimens of this fluid which do not possess this property or which have been sterilized by passing thru a Berkefield filter are entirely worthless for this work.

Rats were inoculated with a small amount (about one-eighth cubic centimeter) of spirochaetal blood obtained from the heart or tail of an infected rat. The blood of these rats is conveniently examined by clipping off the end of their tails. When it reveals the presence of from twenty-five to one hundred spirochaetes per field, (one-twelfth oil immersion lense), before large agglutinating masses of the organisms are seen, usually requiring from eighteen to twenty-four hours after inoculation, they are bled from the heart by means of a small bulb capillary pipette[14].

The blood thus obtained is transferred before coagulation takes place to the bottom of the tubes containing ascitic fluid which have been previously warmed to a temperature of thirty-seven degrees centigrade. It is most important that whole undefibrinated blood is used. The inoculated tubes are then incubated at thirty-seven degrees centigrade. No perceptible growth occurs at twenty-five degrees centigrade.

Multiplication apparently begins in the neighborhood of seventy-two hours after inoculation and the maximum growth is reached in from six to eight days. Material for examining the cultures is obtained by introducing a capillary pipette[15] near the bottom of the tubes.

The organisms are perpetuated by transferring about one-half cubic centimeter of the cultures from the positive tubes to fresh undefibrinated blood ascitic fluid medium, preferably just before the cultures reach their maximum growth (five to seven days). These transplants are made by sucking up the material in a capillary pipette which is introduced about one inch from the bottom of the culture tube, thus avoiding a large number of so-called skeleton forms.

By the means above described we have been able to cultivate Spirochaeta Novyi and to carry the same thru six generations without the use of sterile tissue.

If the positive tubes are covered with paraffin oil and placed in the ice box (0-10° centigrade) just before the maximum growth results, successful subcultures may be made ten to twelve days later. These iced paraffin oil covered cultures will also exhibit pathogenic properties two or three weeks later. As a matter of fact, whenever motile forms are present, although the greater part of the culture has degenerated into granules and skeleton forms, they are pathogenic. It is advisable to warm the cultures in order to ascertain motion.

One hundred percent infection resulted when rats were injected with generations one to six inclusive. The period of incubation is somewhat longer in the case of culture infected rats than in rats receiving the blood type of spirochaetes. The period of incubation in the former generally is from seventy-two to ninety-six hours, while that of the latter is usually eighteen to twenty-four hours. Once the infection is established the cultural spirochaete form is identical in appearance with the straight blood type. Besides the period of incubation being somewhat longer, the disease thus induced seems also to be less fatal for out of twelve rats receiving culture material of various generations, (one to six) no deaths resulted.

In cultures approximately ninety-six hours old there are actively motile spirochaetes of various description. Some have two or three irregular curves, while others have six or eight. Degenerated skeleton and granular forms and highly refractive granules are also present at this time but more especially in tubes a week or more old. The spirochaetes may occur singly, in pairs or chains, but there is a tendency for them to form agglutinated masses. These cultures do not stain as easily nor as distinctly as the blood type by the Wright or Romanowsky methods.

SUMMARY.

Spirochaeta Novyi has been cultivated *in vitro* by employing a medium devoid of tissue obtained from animal organs.

Undefibrinated blood, ascitic fluid free from bile and capable of forming a loose fibrin are necessary for obtaining and maintaining such cultures.

The activity of these cultures is prolonged by covering the medium with sterile paraffin oil and chilling (0-10° Centigrade) just before their maximum growth (five to seven days) is reached.

These cultures are pathogenic, altho, apparently their virulence is lowered as indicated by a longer period of incubation and no fatalities.

The cultural type differs from the normal blood type of the spirochaete morphologically and in its staining properties.

This culture of Spirochaeta Novyi has been perpetuated upon ascitic fluid containing undefibrinated normal blood for six generations.

REFERENCES.

1. Deutsch. Med. Wchnschi., 1909 XXXV, 835.
   ibid., 1260.
   ibid., 1652.
2. ibid., 1261.
   Klin. Jahr., 1910, XXiii, 339.
3. Compt. rend. Soc. de biol., 1910 LXViii, 684.
4. Ztschi. f. Hyg. u. Infectionschrankh., 1911 LXViii, 27.
5. Deutsch. Med. Wchnschi., 1911 XXXVii, 682.
6. Jour. of Exper. Med. 1911 XIV, 99.
7. ibid., 1912, XV, 199.
8. ibid., XV, 81.
9. ibid., XV, 466.
10. ibid. XVI, 194.
11. ibid., XVI, 261.
12. ibid., XVI, 620.
13. Proc., Ind. Acad. of Sci. 1919. 223
14. ibid. 1916 267
15. ibid., 266

NOTES ON THE BIOLOGY OF THE FIREFLIES.

Walter N. Hess.

(DePauw University.)

During the past year I became interested in studying the biology of the fireflies, and after looking up the literature on the group I concluded that little was known regarding them except what had been learned from a study of the adults.

The following species were studied: *Photinus consanguineus* Lec., *Photinus scintillans* Say, *Photurus pennsylvanicus* DeGeer, and *Pyropyga fenestratis* Mels. Most attention, however, was given to *Photurus pennsylvanica*, and this paper will be limited to a discussion of that species.

This firefly, *Photurus pennsylvanica*, is one of the largest and most common of our native species. As is common of our luminous fireflies, the adults are usually found only at night since they spend the day concealed underneath moss or grass, although occasionally specimens were found clinging to the underside of leaves of low vegetation. Like many other insects, this species has well defined centers of distribution, it being rarely found except along marshy or moist localities. Some of the smaller species of fireflies, however, seem to prefer the drier regions.

Many insects during their adult life eat little or no food, but the adults of this species, especially the females, are very voracious in their feeding habits. These females were commonly observed devouring other species of fireflies, and not infrequently the males of their own species.

In the case of nearly all our luminous fireflies the female never flies, but remains on or near the ground and there awaits her mate. In this species, however, the female is also an active flier.

It is agreed by most students of fireflies that the light-emissions serve to bring the two sexes together. In our smaller native species there is a definite interchange of flashes, by which the male is able to find the female. In this species both sexes are active fliers and they flash frequently whether in the presence of each other or not. In no case was there observed a definite exchange of flashes between the sexes of this species. Yet, on several occasions while holding females in my hand, males flew to them, and on two occasions while holding males, females flew and alighted beside the captured males. This would lead one to believe that there is a definite sexual attraction between the sexes of this species, and that the females having become active fliers, are also attracted to the males.

The characteristic place for the oviposition, by the females, is at the base of grass or moss in damp loamy soil. The eggs which are deposited about the first of June are usually placed in little cracks or depressions in the earth, and there they remain for a period of approximately 26 days, when they hatch into little larvae. These little larvae, which hatch about July first, require nearly two years to complete their growth before they transform into adults.

The larvae resemble to a considerable extent the habits of the adults as they are active only at night. This makes it rather difficult to study their feeding habits in the field. On several occasions, however, larvae were taken while feeding on snails, which they had evidently killed a short time before being discovered. Numerous larvae were taken into the laboratory where they were placed under as nearly normal conditions as possible for the purpose of determining the nature of their food. On six different occasions a slug (*Agriolimax campestris* Binney) was placed with six larvae of *Photuris pennsylvanica* and in every case it had been eaten before morning. A slug (*Agriolimax agrestris* L.) and a snail (*Succinea avery* Say) were put with six larvae. The snail was eaten during the first night, but the slug was not killed and eaten until the third night. On two different occasions two small earthworms (*Lumbricus terrestris* L.) were placed in a jar without earth, which contained eight larvae. One was killed and eaten the second night, and the other on the fifth night. On two occasions a very large specimen of *Lumbricus terrestris* was placed with twelve firefly larvae. In each case the earthworm was not eaten, though it remained with the firefly larvae for over a week, and they received no other food during that time. On two occasions a cutworm larva of each of the following species: (*Paragrotis messoria* Harris, *Paragrotis tessellata* Harris, and *Peridroma margaritosa* Haworth) were placed in jars with six larvae and in every instance they were eaten the first night. Finally, on four different nights, two second and two third stage squash-bug nymphs (*Anasa tristis* DeGeer) were placed with six larvae, and in each instance they were eaten before morning. Some of the hard-bodied Arthropods which normally live on the ground, such as sowbugs (*Oniscus asellus* Paulmier), wireworm larvae (*Agriotes mancus* Say), ants (Formica sp.) and coleopterous beetles including the common ground beetles (*Nebria Pallipes* Say and *Chlaenius pennsylvanicus* Say) were placed with these larvae, but they were never eaten.

These experiments lead one to conclude that the firefly larvae probably eat any soft bodied insect larva, Mollusk or Annelid, that they happen to find in their nocturnal wanderings. Slugs, snails, cutworm-larvae, and small earthworms are probably their chief foods.

The larvae of many of the fireflies as well as certain other more or less widely separated groups of insects digest their food entirely or partially outside of their bodies. This is accomplished by the digestive juices being exuded through the mouth and hollow mandibles upon the food which is later eaten by the larva in a nearly completely digested condition. Such is true of the larva of *Photurus pennsylvanica*. When this larva first pierces its prey it immediately injects a substance by means of its mandibular canals into its body, which seems to paralize it.

As was said before, the larva of *Photurus Pennsylvanica* lives for nearly two years before transforming to a pupa. During the cold winter months from about November first to March fifteenth it lies concealed underneath stones, logs or something similar. During the warm summer months it wanders about at night in search of food, while during the day it remains concealed.

About the middle of May of the second year when the larva is approximately twenty-two months old, it chooses a suitable spot on the surface of the ground and builds a lattice work of soft earth over itself in the shape of a small dome, by which means it conceals itself in about a day. In the construction of this cell the larva removes earth from underneath itself by means of its mandibles. This it masticates in its mouth for a short time, after which it regurgitates it in the form of a short ribbon-like mass, which it applies to the walls of the chamber.

Almost as soon as this chamber is completed the larva becomes sluggish and transforms to a pupa. The extent of the pupal period was found to vary from sixteen to eighteen days, at the end of which time the pupae transformed to adults and emerged.

So far as the economic importance of fireflies is concerned it is generally believed that they are of little or no importance. This conception is far from correct. It is true that the adults are of little value as most of them probably eat comparatively little, and most of the insects upon which they feed are not injurious. The larvae, on the other hand, are voracious little creatures which feed largely upon injurious species of animals, such as cutworm larvae, slugs, snails, etc. Most of the soft bodied animals living on the ground are injurious (unless it is the earthworm), and as the food of firefly larvae is probably limited to these small animals, they necessarily do much economic good in killing them. The slugs and cutworm larvae are among our worst economic pests, and it seems evident that they furnish a large part of the food of these larvae. Most of our fireflies live two years as larvae, hence the number of larvae that are feeding on the ground during any season is approximately twice that of the adult fireflies. Any one who has been out during a June or July evening, knows that the fireflies are one of our most abundant insects, which together with the voracious habits of the larvae leads one to the belief that they are of much more economic importance than has been attributed to them heretofore.

THE ORTHOPTERA OF NORTHEASTERN AMERICA.

BY

W. S. BLATCHLEY.

In 1885, when I was a sophomore at Indiana University, Dr. J. C. Branner first taught me that an insect has six legs. About the same time I first learned through Dr. D. S. Jordan that insects, birds and other animals have definite scientific names and that they can be arranged and classified into orders, families, genera, species, etc. Previous to that time I had about as much knowledge of or interest in such things as the king of Zululand has in logarithms.

While Dr. Branner was professor of Geology, he was at the same time interested in Entomology, and in the spring term of 1885 formed a class in that subject and gave lectures two or three times a week. Of the members of that class I remember definitely but three, Chas. A. Bollman, Jerome McNeill and myself. We three occasionally went forth and studied insects at first hand. The 17-year locusts were on hand that spring and the first insects I ever collected to keep were some of these, which I pinned on ordinary pins and stuck on the walls of my room. I have a few of them yet.

When once started, I soon saw the advantage of a private collection, one that I could call my very own, so I secured a dozen empty cigar boxes, split some corn pith and placed a layer in the bottom of each box, and began to collect every thing from chiggers up to Cecropian moths. That collection has gradually grown until now I live in the biggest "bug house" in Indiana.

As grasshoppers were common and easily collected, McNeill and I became especially interested in them. He afterward kept up that interest and in time published a number of valuable papers on the group.

The great bugbear of our work was lack of literature. We could get specimens, but at that time we could not make books. The University library had burned in 1883, and in restocking its shelves the authorities did not take kindly to bug books. We had access only to such works as Harris' "Injurious Insects of Massachusetts", and Packard's "General Entomology". I was working my way through college and had all I could do to furnish fuel for my body, none to spare for expensive out of print works on Entomology. On a trip to Indianapolis in 1886, I happened upon a copy of Thomas' "Acrididae of North America" in a second hand book store, which for four bits became my personal property. I took it home and was able from it to name the majority of my species of grasshoppers or, rightfully, locusts. From that time on my interest in the order Orthoptera increased. I collected them in all parts of the State, and between 1887 and 1894, while living in Terre Haute, published a series of papers on the Acrididae of Indiana in the Canadian Entomologist. As the literature on the other families of the order was widely scattered, I prepared works on the Indiana Gryllidae, Blattidae and Locustidae, which were issued in the Proceedings of this Academy for the years 1892 and 1893. These were my first contributions to those Proceedings.

In 1903. I published in the 27th Annual Report of the Indiana Geological and Natural Resources Survey a paper of 350 pages on Indiana Orthoptera which included keys, descriptions and full notes on habits of all the species known in the State. This gave Indiana students interested in the group a single work with which they could identify and arrange their specimens, something that I had long desired for my own use but which was not extant and therefore not available to me. After that time, for a dozen or more years, I gave my attention to Coleoptera and did little along Orthopteran lines.

Since 1910 I haxe spent eight winters in Florida and while there have collected such Coleoptera, Orthoptera and Heteroptera as I could find at that season. My captures there between October 25 and April 15—the earliest and latest dates which I have been in the State—aggregate about 1.500 species of Coleoptera, 150 of Orthoptera and perhaps 400 of Hemiptera-Heteroptera, the last named group as yet not studied or even in great part mounted.

During the last ten years the study of Entomology has become one of the most, if not the most important among the different divisions of Zoology—this in great part due to its economic phases, its bearing upon the production of food, and therefore upon that of the H. C. L. Among injurious insects the Orthoptera take high rank. The economic entomologist, in studying the life history, food habits and other facts regarding any insect, and in devising methods for its eradication, and putting them before the public, must have a handle, a scientific name for it. He cannot call it as he would a man, John Jones of Smithville, Ind., and let it go at that, but must call it by its correct scientific handle, so that other entomologists, the world over, may know with just what species he is dealing. Our present knowledge of the Orthoptera of the eastern United States is scattered throughout hundreds of papers, the majority of them out of print and difficult to obtain. The economic entomologist is in need of a single work—a manual of Orthoptera which will give him this knowledge.

Being out of a job and realizing the truth of the old adage that "An idle brain is the devil's workshop," or, if not that, the "workshop of a soul of discontent," I saw this need and three years and more ago began the preparation of a work in which all species of Orthoptera known from the United States east of the Mississippi River or from Canada east of the 90th meridian, are treated in detail, with full diagnoses of families, tribes and genera, keys to and descriptions of all species, distribution, habits, etc., etc. Many of the 353 species and 58 varieties or races recognized from the territory covered, occur of course in the region west of the Mississippi—but there had to be a "dead-line" somewhere, and that stream furnished the one most available.

Of the more than 400 forms treated, I have collected personally in the field 307, and have seen or studied either in my own collection or elsewhere, all but five, so that the work is based principally upon first-hand knowledge. The 58 varieties are, for the most part, treated as species by other writers, but my field work, taken in connection with my ideas of geographical variation, caused me to reduce them to varieties or races. Where a well known species ranges over a large area, the different environments, due to altitude, variation in mean annual temperature, atmospheric conditions, difference in topography, drainage and soils, varied food plants and many other causes, are sure to bring about certain changes in its external structure. If only the extremes of these variants be at hand, they are often so different in appearance as to cause them to be considered races or even different species. However, where a large series from all parts of the range are present, intermediates are almost sure to be found and there is little use and often much resulting confusion in giving or recognizing a specific name for each slightly variable form.

The Orthoptera of the territory covered I have placed in eight families of which I will make brief mention, comparing the members of each as represented in the faunas of Indiana and Florida.

FAMILY I.—FORFICULIDAE.—The Earwigs. Narrow, flat Orthopterons, with either short outer wings or none at all, their abdomen ending in a pair of forceps-like appendages. They are mostly subtropical in distribution and occur beneath bark or in crevices in houses and ships. Twelve species are known from eastern North America, nine occurring in Florida, three in Indiana, one common to both states and one not found in either. The name earwig was given them by the peasants of Europe, who believe that they often enter the ears of humans and injure the hearing, such belief being of course nonsensical. They often do much damage by eating ripe fruit, tender shoots and corollas of flowers, etc.

FAMILY II.—BLATTIDAE.—The Cockroaches. Examples of these are familiar to all. Their distribution is mainly tropical and of many species cosmopolitan. In the houses of the poorer classes of the tropical countries they form the most annoying and disgusting of insect pests. They are omnivorous in choice of food, but live chiefly upon animal and vegetable refuse. In some parts of Brazil they are said to eat the eyelashes of the children, biting them off irregularly, often quite close to the lid, and as the children have very long black eye-lashes, their appearance thus defaced is very grotesque. Where abundant in a house, cockroaches leave a fetid, nauseous odor, well known as the "roachy odor" which is persistent and defiles both food and dishes. One writer has thus quaintly written of them and other house-dwelling insects in the screenless hotels of India:

"On every dish the booming beetle falls,
The cockroach plays, or caterpillar crawls;
A thousand shapes of variegated hues
Parade the table or inspect the stews.
When hideous insects every plate defile
The laugh how empty and how forced the smile."

While hundreds of species of cockroaches occur in the tropics, only 43 and two varieties are residents of the United States. Of these 30 species and both varieties are known east of the Mississippi, 24 species and one variety occurring in Florida, 11 species in Indiana, seven common to both states, and two species and one variety not known from either.

FAMILY III.—MANTIDAE.—This family comprises the "soothsayers" or "spraying mantids," long, ungainly bodied forms having the fore legs raptorial or fitted for grasping other insects and conveying them to the mouth. They are the tigers and cannibals among Orthoptera, living mainly upon living insects and often upon one another. A male kept in captivity in New York ate in one day three large grasshoppers and a daddy long-legs and then tackled another mantis from which he was separated with difficulty. Nine species of mantids occur in the eastern United States, seven in Florida, two in Indiana, both of which are among the seven Floridian species, and two introduced species in the outside States.

FAMILY IV.—PHASMIDAE.—The members of this family are known as walking-sticks. They simulate twigs or leaves in form of body, and often lie stretched out in such a manner as to deceive a close observer. All are vegetable feeders and often do much damage to the foliage of trees and shrubs. They also are mainly tropical in distribution, only 11 species occurring in the Eastern States. But two of these are known from Indiana and five from Florida—one common to both states and five outside of either.

FAMILY V.—TETRIGIDAE.—This family comprises those minute grouse or pygmy locusts which have the pronotum extending back to or beyond the tip of abdomen and the fore and middle tarsi with only two joints. They live mainly along muddy or sandy flats or on dry open wooded hillsides and are the only Indiana locusts which pass the winter as adults. About 450 nominal species are known from all parts of the earth. Only 16 species and eight varieties are recognized from the Eastern States. Of these eight species and five varieties occur in Indiana, nine species and three varieties in Florida, six species and one variety being common to both states, and five species and one variety not occurring in either.

FAMILY VI.—ACRIDIDAE.—This family comprises the dominant group of our eastern Orthoptera. While commonly called "grasshoppers," they are in reality the locusts mentioned in the bible—the ones of which the prophet Joel wrote:

"The land is as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them."

Several of these locusts, at times, after one or two favorable seasons, increase in such numbers as to do enormous damage, the fully winged forms often congregating and migrating in vast droves, stopping wherever food appears abundant and stripping the country bare in a few hours. Of one of these migrations the poet Southey wrote:

> "Onward they came, a dark continuous cloud
> Of congregated myriads numberless,
> The rushing of whose wings was as the sound
> Of a broad river headlong in its course
> Plunged from a mountain summit, or the roar
> Of a wild ocean in the autumn storm,
> Shattering its billows on a shore of rocks."

There is an Arab legend to the effect that "A locust unto Mahomet said: "We are the army of the great God; we produce ninety-nine eggs; if the hundred were completed, we should consume the whole earth and all that is in it."

These locusts or short-horned grasshoppers are the Orthoptera which are so common in our meadows and pastures, on our city lawns, and along our roadsides from mid-April until late November. From the eastern United States 130 species and 21 varieties of the Family Acrididae are recognized by me, 51 species and ten varieties belonging to the single genus *Melanoplus*. Of the entire number 50 species and three varieties occur in Indiana, 52 species and 11 varieties in Florida, 22 species and one variety being common to both states and 50 species and eight varieties of the eastern forms not known from either of the two states.

FAMILY VII.—TETTIGONIIDAE.—This family, formerly known as Locustidae, comprises our Orthoptera commonly known as katydids, long-horned green grasshoppers, cone-head grasshoppers, camel crickets, stone crickets, etc. Some of the larger green-winged forms—the true katydids—are either known to you in person or through their strident notes, one of them being quoted by Holmes as saying:

"I sit among the leaves here, when evening zephyrs sigh,
And those that listen to my voice I love to mystify;
I never tell them all I know, altho' I'm often bid,
I laugh at curiosity and chirrup, 'katy-did.' "

There are many characters separating the Tettigoniidae from the locusts or Acrididae, one of the most interesting being that the auditory organ or ear is situated on the basal ring of the abdomen in the locust and on the tibiae of the front pairs of legs in the katydids, as also in the crickets. The males only of the winged forms stridulate, the note being a sexual or love call, but both sexes possess the auditory organ. In the wingless form of all Orthopterons both stridulating organs and ears are absent. As I have mentioned on another occasion before this Academy; These katydids and crickets were the first musicians of the earth, as by means of their shrilling organs they enlivened the solitudes of the strange old Devonian forests with their love calls and wooing notes.

Ninety-seven species and 14 varieties of Tettigoniidae are recognized from the Eastern States, 40 species and three varieties occurring in Indiana, 46 species and nine varieties in Florida, ten species and one variety being common to both states and 21 species and three varieties not found in either.

FAMILY VIII.—GRYLLIDAE.—*The Crickets.*—Some of the members of this family, as the ground and field crickets, are very common insects and familiar to all. Others, as the mole crickets, the tree crickets and bush crickets, are more often heard than seen. One of the smallest of our eastern species occurs only in the nests of ants. All are chiefly vegetable feeders and in the aggregate do much damage to forage and other crops.

Forty-seven species and 14 varieties or subspecies of crickets are known from the Eastern States. Of these 22 species and six varieties occur in Indiana, 29 species and eight varieties in Florida, 11 species and four varieties being common to the two states, and seven species and four varieties of our eastern forms not occurring in either state.

While the aggregate number of forms of Orthoptera occurring in Northeastern America is few as compared with the Coleoptera, they often apparently make up in individuals what they lack in number of species. Those with which we are most familiar are diurnal and move freely from before the intruder on their domains. Those which are nocturnal we know best by their strident notes which form the great bulk of the music of that autumnal choir which fills the air at night from mid-July until the hoar frosts of autumn have brought death to the musicians. Blot the Orthoptera from our insect fauna and the weird music of nature would almost wholly disappear.

The trills of crickets—black Gryllids, brown Nemobids and white Oecanthids—seem to form most of the night sounds, though the note of the broad-winged or true katydid is the loudest and most strident of them all. By day the songs of the green grasshoppers—our meadow musicians par excellence—ring out from every swale and lowland meadow in unbroken symphony as long as the afternoon sun shines brightly upon the choir.

By day also the males of our common locusts chirrup and call from their grassy retreats, some while at rest, others while winging their way from one point to another and still others while hovering a few feet above the supposed hiding places of the opposite sex. All in all, the order Orthoptera comprises one of the most interesting groups of the great class of insects.

BIRDS SINGING IN THE NIGHT.

BY

M. L. Fisher.

(Purdue University.)

These notes were taken in the summer of 1918. On June 19th, the writer went to the northeast part of Monroe county near the Brown county line to spend his summer vacation. Having forgotten his camp-cot it was necessary to sleep on the ground for about a week. Not being used to sleeping on the ground the bumps on the surface were not conducive to sound slumber; also, the deadly fear which the writer has for snakes, of which rattlesnakes and copperheads were reported to be plentiful, tended to keep him sensitive to every little noise. Being so easily aroused the writer was attracted by the bird notes which were noticeable at all hours of the night. The following are some of the observations:

June 19th.

The yellow-breasted chat seemed to be almost as noisy at night as in the daytime, for every few minutes he would cackle in his characteristic way.

At 10:30 and at 2:30 (Daylight Saving Time) the cawing of the crow was noted.

In the early part of the night the whip-poor-wills were exceedingly lively, but about 11:00 o'clock their notes stopped.

June 20th.

The yellow-breasted chat again made the night musical, although not so frequently as on the previous night.

At various intervals the tufted titmouse and yellow-billed cuckoo added to the night noises.

June 21st.

The yellow-billed cuckoo was noticed at 10:15.

June 22nd and 23rd.

The whip-poor-wills were noisy throughout both nights, from early in the evening until early morning. The writer noted that very frequently the note of the whip-poor-will would be repeated more than a hundred times without pausing. Very frequently the pause would be but for an instant, and then it would be continued as long as previously. This would be kept up sometimes until several series had been sounded.

June 24th.

This was a rainy night and no bird notes were noted.

It was evident that a rainy night depressed the spirit of the songsters so that they were comparatively quiet.

June 25th.

Whip-poor-wills were noted at 4:00 o'clock A. M.

June 29th.

Whip-poor-will noted at 12:15. Also, the barred owl. The hooting of the barred owl was very interesting. He seemed to be located on a hill at some distance to the left of the writer's tent. He gave his notes of "Whoo-whoowho-are-you"; then off to the right came back the echo "Whoo-are-you".

At 12:25 the yellow-billed cuckoo gave forth his notes again.

July 1st.

The Carolina wren sounded its notes at about 4:00 A. M.

No further notes were made until July 30th when at 12:00 o'clock A. M. the Carolina wren was again noted.

At 2:30 on this morning the field sparrow trilled out its characteristic song.

It was quite noticeable that after the first of July the bird singing was much less by day and rarely observable at night. Doubtless if notes could have been taken earlier in June a larger number of species would have been noted. Also, if the writer had been more familiar with bird notes, a larger number would have been noted, for at the time when these observations were taken many bird notes were heard that he could not identify.

WILD OR INDIAN RICE.

BY

Albert B. Reagan.

Along the swampy borders of streams and in the shallow water of the numerous small lakes throughout the Great Lake region and on westward through Minnesota to the Red River valley in that state, grows the water oats or Indian rice, *Zizania aquatica* L. This plant belongs to the grass family. It is an annual; flowers monoecious; the staminate and pistillate both 1-flowered spikelets in the same panicle. Glumes 2, subtended by a small cartilaginous ring, herbaceous-membranaceous, convex, awnless in the sterile, the lower one tipped with a straight awn in the fertile spikelets. Palet none. Stamens 6. Stigmas pencil-form. A large reed-like water-grass. Spikelets jointed upon the club-shaped pedicels, very decidous. Culms 3 to 9 feet high; leaves flat, 2 to 3 feet long (and lie flat on the water when they first emerge; later they stand erect and finally decline at the tips), linear lanceolate; lower branches are of the ample pyramidal; panicle staminate, spreading; the upper erect, pistillate; lower glums long awned, rough; styles distinct; grain linear, slender, 6″ long.

I became acquainted with this plant at Nett Lake, Minnesota, where I had charge of the Bois Fort Indian Reservation as Superintendent and Special Disbursing Agent from 1909 to 1914. Nett Lake, the lake that bears that name, covers three-fourths of a township in area and is the shape of a great lobster's paw with the claws pointing eastward, the major claw being the northern member. It is very shallow, the greater part being less than four feet in depth. In this the wild rice grows in such quantities that the lake looks like a great barley field.

The rice does not ripen all at once, so can not be cut like a barley field. But as the grains drop from the stalk very easily when ripe, it can be pounded off into a canoe with a stick and the green still left to ripen.

The rice begins to ripen in the latter part of August. As soon as it begins to ripen, the Indians have a secret ceremony and much powowing. Then the chief medicine man gives permission for the Indians to go out and gather rice.

With canoes, the Indians go among the rice and beat the heads over the canoe with short clubs. This they keep up till they have a canoe full of rice. They then go to the village with it.

At the village the rice, which has just passed the milk stage when gathered, is parched and scorched in a large iron kettle inclined over the fire so that a squaw can stir the rice the while to keep it from burning. By this scorching process the hulls are burned from the kernels, or are so dried and charred that they can be loosened and removed by the next process.

As soon as the scorched rice is removed from the kettle and is cold enough to handle, it is placed in a cylindrical hole in the ground that has been lined with cement or marl from the lake. Then the Indian man of the house gets into this hole and tramps the hulls off with his bare feet. (Some people say they wash their feet—after they get through the tramping.)

After the tramping is completed, the chaff, dust, and ashes are winnowed from the rice by the women. The product is then sacked and is ready for sale as breakfast food. It sold for not less than ten cents a pound before the war at the village; and as high as twenty-five cents per pound in the cities.

This rice is prepared and baked as gem cakes. It is also used to stuff ducks and other fowls when preparing them for dinners. A man in Salt Lake City sent all the way to Minnesota for wild rice for dressing for ducks for his Thanksgiving dinner.

In preparing it as breakfast food, it is prepared and cooked the same as white rice and can be cooked in as many different ways. The preferable way, however, is to take a cupful of the rice and pour a cupful of boiling water on it at bedtime and then cover it up so as to keep the steam in and let it set till morning. Then put it on the stove and evaporate the remaining water. It is then "puffed-rice" and is delicious with sugar and cream.

"The Ojibwa (Chippewa) sometimes boil the excrements of the rabbit with rice 'to season it' and are said to esteem it as a luxury. To make the dish still more palatable, and one of the highest epicurean dishes, they occasionally take a partridge, pick off the feathers, and without any further dressing except pounding it to the constituency of jelly, throw it into the rice, and boil it in that condition." (Winchell, Aborigines of Minnesota, p. 595.)

THE INFLUENZA AND THE NAVAJO.

BY

Albert B. Reagan.

The Walketon (Ind.) Independent and The Indian School Journal both report: "Dispatches from Phoenix, Arizona, state that two thousand Navajos, residing on that part of the reservation in Apache County, under the jurisdiction of Fort Defiance (representing about one-fifth of the Navajo country) have died of influenza. The chief clerk of the Navajo agency made the report."

It is the writer's belief that the above statement is a gross exaggeration; yet the death-rate was appalling. Probably no other people in the United States suffered from the ravages of this plague at all comparable with them.

The Navajos belong to the Athapascan stock of Indians and are full cousins of the Apache. In the 17th century, they appropriated the farm lands of the Tewa Indians of New Mexico, called Navahu, and engaged in farming. To distinguish them from the other and more roving Apaches, they were called Apaches de Navajo or "great seed sowings" by the Spaniards. In time, the first part of the name was dropped, leaving the name "Navajo" as the tribal signification, though at the present time it is a misnomer as they are now a pastoral people. This name is not used by the Navajos except when they try to speak English. In fact, many of the tribe do not know it and only the educated part of the tribe can pronounce the word correctly, as "v" is a sound unknown in their language. They call themselves "Dine" (the people), which, in its variable forms, is the general tribal name of the whole Athapascan family.

They believe that they were created by the gods of Arizona and Utah about 500 years ago, though they believe that the earth was previously peopled with human beings most of whom were destroyed by demon giants. They probably wandered into Arizona and New Mexico in small bands from the north. A joining of these groups enabled them to make a successful war on their neighbors. By this means and by adoption of the captured women into the tribe, they soon became a powerful people. Besides the addition of several Athapascan bands that joined them of their own free will, their stock is now made up of descendants of captured Pueblos, Shoshoneans, Yumans, and Aryans. Their language is a modified Dine dialect of copious vocabulary and intricate grammatical construction, exhibiting many words, phrases and constructions from outside sources. Also in appearance, the Navajos have no prevailing type which gives further evidence of their composite origin. The population of the tribe is estimated to be in the neighborhood of 35,000.

They have several kinds of houses, among which are the hogan (dwelling), the medicine lodge, and sweat-house. They are all cone-shaped, built of upright poles or logs placed horizontally in polygonal, worm-fence shape over which branches, grass, and earth are placed. A smoke-hole at the apex serves as a chimney for each kind except the sweat-house which is warmed by rocks heated without. When any one dies in a hogan or near it, it is at once destroyed, being considered a "devil house." Brush corral, windbreaks, lean-tos, and open sheds, serve as dwellings in summer.

They are quite religious. Their deities are nature gods, animal gods, and local gods. The most reverenced deity is Estsanatlahi (the ever-changing year), called a woman who changes or rejuvenates herself.

They have great stores of legendary and mythic lore, innumerable songs, and prayer-chants. They are very fond of games and races. Their principal dance lasts nine nights and parts of ten days. The culminating performance in the medicine cultus is the Yavachai ceremonies in which pictures of their deities are painted in dry powders on the floor of the medicine lodge.

They were quite warlike when we began to learn about them in the 17th century. At that time and until the occupancy of their country by the United States, they kept up an almost continual marauding war against the Pueblos and whites. The United States made treaties with them in 1846 and '49 but these were both outrageously broken. "Kit" Carson cornered them in 1863—killed all their sheep, captured practically the whole tribe, and took them to Fort Summer at Bosque Redondo on the Rio Pecos in New Mexico where they were kept till 1867. They were then returned to their own land and given a new supply of sheep. Since then, they have remained at peace. They are now a prosperous people.

They are jovial and much given to merriment and jest, and are not stoical like the eastern Indian. On the whole, "they are celebrated for their intelligence and good order." They are also great and shrewd traders and are considered "the noblest of the American aborigines."

Their reserved lands, known as the "Navajo Country," cover 25,725 square miles, or an area of sixty-three square miles larger than the District of Columbia, Delaware, New Jersey, Vermont, the Panama Canal Zone, Guam, our possessions in the Samoan group, Rhode Island, and Porto Rico combined—about one thousand square miles larger than Greece. For the purpose of administration, this vast area is divided into the following reservations: Pueblo Bonito, Hopi (whose inhabitants are partly Pueblos), San Juan (Shiprock), Western Navajo, Navajo (Fort Defiance), and Navajo Extension.

They have never been under very severe discipline of the government. They are wanderers in the full sense of that word. Like the Irishman's flea, they are here this moment but where will they be the next sun? Though placed on the largest body of reserved land in the United States, they wander off of it at will and many isolated families live beyond the reservation boundaries in all directions. Like the noble Arab, they move about with their flocks of sheep and goats, horses and a few cattle. They may be in a certain wash or canyon today and miles from there in another tomorrow, as the scarcity of grass and water necessitates. They have but few traps of any sort, so that moving from place to place is an easy and ever round of life. In a few favored places, they may raise a little corn and a few melons, the extent of their agricultural efforts. Also, like the men of Arabia, they are very independent by nature and wish to be let alone. Moreover, the medicine men doctor them when sick and also prepare them for the Happy World in the hereafter.

The influenza broke out at the boarding-school at Tuba City, Western Navajo Agency (Arizona), October 12, and in the other reservations of the Navajo country at about the same time. At the school, there were 138 cases at one time but due to prompt action on the part of Dr. N. O. Reynalds, the agency physician, and the ever vigilant and careful work of the other employes in taking care of the pupils—many employes doing nurse work to save the children even when they themselves were running a high fever—only two deaths then occurred and only one since from complications due to the disease. Most of the other Navajo schools fared worse. The school at Fort Defiance is reported to have lost 67 pupils.

At the time the malady was raging at the school, the Hopi Pueblo of Moencopi, two miles from the school, was stricken with the plague. At one time, 181 of its 300 population were down with the disease. At the same time, all the government employes at the place but one became sick. At this critical moment, some nurses arrived from Flagstaff and attempted to look after the Indians' needs; but, with the best of intentions, they made a failure of their efforts. Not understanding the Indian character, they made the villagers so angry that they would not allow them to give them medicine or attention. The "principals" of the place also followed them around and forbade every one to take their remedies. Consequently, they gave up the task as hopeless. By this time, the pupils at the school were so convalescing that a force of school and agency employes could be spared for taking care of the Hopis. These took food from the school to the village; and, gaining the good will of the Indians, soon had them taking all the medicine needed and receiving all the necessary care. As a result, of the 300 sick only 16 died.

By the time the people of Moencipi began to recover from the disease, the epidemic had begun to spread to the Navajo settlements on the reservation. Aid was at once sent them in every possible way. Hospitals were established at every convenient place to which the sick were taken for treatment. The hogans were also visited. But the work was difficult.

When the disease reached the Navajos, they fled from the places where it appeared. Those at the "Fields" in Moencopi wash south of Tuba fled westward and northwestward to Black and Navajo mountains. In this panic, they often abandoned everything, even their sheep in some cases. One Navajo is alleged to have abandoned his sick wife and several children to die of starvation. Several families are alleged to have abandoned sick members of their family. While sick with the disease, a Navajo woman gave birth to a baby girl. Five days later, it becoming evident that she would die, she and the baby were abandoned. Later they were found by a government party, both still alive. They were both brought to the hospital into which the Marsh Pass school had been converted but the mother died that same evening, and the little one had been so starved that it succumbed two days later. Other similar cases of abandonment are reported. One is an instance where the husband abandoned several children by the side of his dead wife, all of whom are reported to have starved to death. It might be added that among the Navajo if the mother dies the children are virtually orphans, though the father survives. They are not considered his children but the children of the clan to which his wife belonged. In addition, he inherits none of his wife's or of his children's property in case of their death, same diverting to the clan of the wife. Hence the children from the Navajo standpoint are not his in the same sense that a white man's children are his.

The disease was astoundingly fatal. Whole families were wiped out, leaving their flocks wandering over the hills at the mercy of the wolves. Several related families living together all died but one small boy who was found herding the combined flocks of sheep; and, it is now reported that the agent of the San Juan reservation, under whose jurisdiction he belonged, has recommended that this boy inherit the combined sheep droves he saved from the coyotes. At another place, a family of eight were picking pinyon nuts when the disease reached them. Later their dead bodies were found around their wagon. A Piute woman died on their reservation north of the San Juan river. Fleeing from the place of the dead, the husband and five children crossed the river into the Navajo country with their sheep where they died one by one along the trail. Only one little boy survived and he is so small that he is unable to give his parents' name.

No people have a greater dread of ghosts and mortuary remains. Consequently, to prevent a stampede, the two pupils who died at the boarding-school, both dying at night, were carried out of the dormitory as soon as dead, with lights darkened so that the pupils could not see what was being done. The dead pupils were also buried in the early hours of the morning for the same reason. At the hospital at the Marsh Pass school—which was filled with sick adults—a patient died near sunrise one morning. Immediately, the death-wail was struck up and pandemonium took possession of the sick. With eyes wide and staring, they strove to leave the place. Even a sick man, who could hardly hold his head up the evening before, sprang from his bed as he trembled from head to foot and started to run out of the room. Luckily there was another hospital room to which they were all speedily moved. To prevent a like occurrence, the deathly sick were put in a building by themselves, and when one died he was buried at night so as not to arouse the superstition of the Indians any more than possible.

The Indians were so terribly afraid of the dead or so weakened by the disease themselves that they fled from the "chindi Hogan" (devil's house), as they termed a place where a Navajo died. Many were left where they died in the hogan and were simply covered over with a few shovels full of dirt right where they expired. In one case, that of the only Indian stone house in 60 miles of Kayenta post office, the relatives of the deceased (wife) threw some dirt over the corpse near the fire-place where she died; then in panic they fled, leaving the door open. Later, they begged a party of government officials to close the door, which they did. Many other dead were abandoned and left unburied, the scared Indians begging the whites to inter them. If there were no whites in the vicinity, they were left unburied. The agency and school people interred many Indians who had thus been abandoned. The Kayenta policeman was buried by a government party after he had been dead in an abandoned hogan eight days. Also, in the week closing April, the government stockman interred two influenza victims who had lain in their respective hogans since last fall.

When sick, the Navajo think one should eat a whole lot. If one can not eat, it is expected he will die. Stuffing in sickness is usually practiced as a remedy and is often the cause of much trouble and many deaths. At one place on the reservation, during the plague, meat balls the size of the end of one's thumb were forced down the patients who were too weak and sick to eat until no more could be forced down them. The stomach of an influenza victim at another place, who had been abandoned and partly eaten by the wolves, was seen to contain about a quart of corn which had probably been boiled before it was forced down him. Such stuffed patients usually died.

When sick, the medicine man often gives the patient the juice of the Arizona jimpson and same was much used during the inflenza epidemic. This makes the pulse run high and causes the patient to be delirious. It is used as one of the last resorts. One jimpson victim examined by the agency physician had a pulse running as high as 240. The Indians also killed horses and made horsetail soup as a remedy to combat the disease. This was a good thing in a way as it helped get rid of some of the worthless ponies. The main remedy, however, was the powwow, Yavachai ceremonies, accompanied by elaborate sand-paintings.

In making these paintings, all but the patient in the respective household concerned is removed from the hogan, usually to a corral-like brush wind-protection—provided a regular medicine-lodge is not erected for the ceremony. The drawing is then made around the central fire or about it; each medicine man has his own system and places the drawing to suit his own taste and whims. Usually, the parts of the drawing are in concentric bands whose separating rings represent rainbows. The inter-rainbow spaces are filled with crude figures of human-mythical beings called "chindes." When completed, the nude patient is smeared from head to foot with a blackish, medicinal concoction. He is then placed either on or near the drawing. Then elaborate singing and praying follows. As a faith cure, it is a good remedy, but it failed to cure the influenza. This failing, the final and last remedy was a massage, contorting process. As the disease usually terminated in pneumonia and consequently the lungs became "tight," the medicine man jumped on the chest to loosen up the lungs. The result can be imagined!

After the final abatement of the malady, the Indians rode over the reservation, scattering sacred meal and corn pollen in prayer over their stone altars on every high point, to prevent the epidemic from returning. It is to be hoped that the deities will listen to their earnest supplications.

A TRIP IN THE LITTLE FORK, NETT RIVER COUNTRY, MINNESOTA

BY

Albert B. Reagan.

On May 13th Mr. Charles Hartman, Register of the Duluth Land Office, and myself set out from the Indian Agency at Nett Lake, Minnesota, on a trip in the Little Fork and Nett Lake river valleys. We had camping outfit and had hired three Indians with canoes to take us from place to place as we desired. We left the agency at about 2 P. M. and canoed westward five miles across Nett Lake and descended Nett river. That night we stayed at Glen Thompson's homestead on the west side of the Bois Fort reserve. The next day we camped where the D. R. L. & W. Ry. Co. switch from the main line at Kinmount crossed Nett river in the logging days of 1908 on the reservation. At this juncture we sent two Indians back to the agency for more supplies. This delayed us a day, most of which was spent in camp and in visiting the country in the vicinity of the same. May 16th and 17th found us at the falls on Nett river. On the 18th we went on down the river to where it joins the Little Fork to Dead Man's rapids and on Monday I walked overland to Celler's rapids still further up stream. On the 21st we descended the Little Fork 65 miles to the town of Little Fork. Here we paid off the Indians and Mr. Hartman and myself proceeded on to Big Falls on the Big Fork river by railway, some 20 miles southwest of Little Fork post office. We spent the 22d at Big Falls and then took the evening train northward for home by way of International Falls. Mr. Hartman stopped a day at the latter place, but I went on the first train south from Ranire over the D. R. L. & W. Ry., arriving at Nett Lake May 23.

We had been out in all less than ten whole days. We had traveled more than 200 miles by water and a little less than 100 miles by railroad. We also saw much country that has hitherto received but little mention.

From its confluence with Little Fork river from where it leaves Nett lake, Nett river is a very crooked, much meandering stream. It is some fifty miles in length as it runs, while a footman can walk from its mouth to its source in one day by cutting across the meanders. The general direction of the stream is north of west. Sixteen miles from where it leaves Nett lake, as it runs, are a series of pronounced falls, three in number. The distance between the first falls and the third is approximately one mile. The first and second falls are over Laurentian granites and allied Archaeon rocks. The third falls are over upturned lower Huronian rocks along fault lines, crossing the river at right angles to its course.

Nett river has but little fall from where it leaves Nett lake to the fall line. Its banks do not average four feet in height and much of the region adjacent to the river is a swamp. There is evidence that in very recent geological time Nett lake extended to the falls and covered an area of 500,000 acres instead of ¾ of a township as it does now. Furthermore, should an earth disturbance raise the falls twelve feet, it would convert the region back into a huge lake and the lowering of the same falls twelve feet would soon make Nett lake dry.

On account of the little fall in Nett river in its upper course and its numerous meanders, the stream is blocked by thirteen log jams in as many miles.

Nett lake and river have 17,000,000 feet of pine tributary to it and as many million feet of hardwood, not to say anything about the cords of pulp wood. It is proposed to dam Nett river at the upper falls, the dam to be four feet in height. The river at present is forty to sixty feet wide and very shallow most of the year, especially at the intake from the lake. This would raise it so that logs could be driven down it. The numerous meanders of the stream are also proposed to be cut through, thus shortening the stream and increasing its flow-current. This improving the river should not exceed $6,000.

A mention of the falls has been made. The three falls each aggregate approximately fifteen feet respectively. These could be utilized for generating water power and I judge that each is capable of producing 10,000 horse-power. These, no doubt, will be used in the installing of mills and electric plants, when the region becomes settled.

Below the falls in Nett river the stream has incised its channel till near its confluence with the Little Fork, its banks are fifty feet high. And as a consequence, its tributary side streams make the region have quite a bluffy appearance. Throughout its entire course its channel is incised in glacial material except at the falls and the few rapids. Its banks below the falls are mostly in clays of the Lake Agasiz series.

Little Fork river has a considerable fall, but is also a much meandered stream. At one place a meander is between 7 and 9 miles around while a trail across its neck is less than forty rods. The stream is nearly 100 feet wide and rather deep. It has numerous rapids but no falls. Its rapids are in places where the stream cuts across the upturned edges of fault blocks of Huronian and Archaeon rocks. The rapids were once falls, but have been worn down to rapids by the rapid current and ice action. The more rapid current accounts for the falls of this stream being worn down to rapids while those of Nett river are still falls. The country adjacent to the stream (Little Fork river) is not swampy from Celler's landing to Little Fork post office. Northward from there, however, it crosses the "Great Muskeg." The Little Fork country is settled near the river, as is lower Nett river. The valley of this stream, for the most part, is incised in clays of glacial age, mostly of the Lake Agasiz stage, though the meandering stream itself is cut in deposits laid down by itself on its own valley floor.

The timber of the region amounts to many hundred millions of feet B. M. The industry of the region today is in the main lumbering. We passed 1,000,000 feet of logs in the river on our trip, all being driven northward to Rainy River and International Falls to be sawed into lumber or made into paper. The timber adjacent to the river is mostly hard wood and cedar. Three acres of cedar poles at the mouth of Nett river netted $1,400 as it stood in the woods. A homesteader or a buyer of land along either of these streams will usually have timber enough on the land to pay for clearing up and improving the land, furnish a handsome living for the settler while clearing same.

The soil in the region is varied, but ranges from a sand-loam clay, black-loam soil to peat-loam soil, usually underlaid with clay, making it rich in plant life. We made repeated inquiries of the settlers as to the crops. Dent and Northwestern corn were said to mature. Wheat yielded well, as did rye and barley. Clover and grasses also yielded two to three tons per acre. There is no reason why people who go into this region for the purpose of making a living farming should not succeed. But too many men have taken up land with no other intention than to sell it to the timber people (or any other possible buyer) as soon as they could prove up on same. Improvements, therefore, are not what they should be and too few settlers have cows and chickens in a country where both do well and bring profitable returns. Furthermore, there is no reason why farmers who intend to farm and make a home should not go to this region. There are some homesteads yet to be had. In addition, land is cheap that is owned privately or by the state of Minnesota.

In a mineral way nothing is known of this region. Float coal is said to have been found in the stream beds, but no veins have ever been located. Quartz rock formation, exposed both on the Little Fork river near the town of the same name and also on the Big Fork river near Big Falls, is often sprinkled with gold that is said to assay well. Placer deposits have also been found that run high in gold locally. Geologically speaking, the region seems to be underlaid with Lower and Middle Huronian rocks (Couchiching formation) plus Archaéon rocks. The Huronian rocks are likely to contain iron deposits. In fact iron boulders have been found in many places and all the streams are impregnated with iron.

The region is crossed by the Minnesota and International Railroad, the terminal points being Bamidji and International Falls with the towns and railroad centers of Little Fork in Little Fork valley and Big Falls in the Big Fork region. Otherwise the region is practically in the virgin state.

A TRIP AMONG THE RAINY LAKES.

BY

ALBERT B. REAGAN.

I arrived at International Falls, Minnesota, on the morning of the 18th of October last, but found that the "International", the lake boat, would not run up the lakes until the 20th. So I bided my time visiting Fort Frances, Ontario, also the International Pulp mills at International Falls on Rainy river, said to be the largest paper mills in the world. On the 20th I took boat. Our course lay nearly east. For eight hours we steamed up the lakes a distance of more than 50 miles. Our course lay among islands and projecting points and through narrows and wide open spaces. The day was beautiful and the mirrored shadows of the shore line, rocks, trees, and entangled vines brought forth to view the doubled beauty of the wonderful scenery. Also as we journeyed along in and out through this chain of lakes, the sea birds gathered about us and the captain threw bread and crackers and other eatables on the water for them. And without fear the birds hovered about and darted here and there for the floating morsels. And they were disappointed when the boat whistled for Kettle Falls, our destination.

Our boat had hardly anchored when an Indian woman by the name of Ke-me-tah-beake was canoeing me over to Kettle Falls on the British side; and on the next day I proceeded on to Moose river and Capitogama lake, finding myself that evening in the Indian village of Moose River. I had moose meat for supper and our Indian guide killed a dear about dark. So we had plenty of venison the rest of our stay in the country.

We were in the Indian country and Indian scenes were to view on every hand.

While strolling about the Indian village on the day of our arrival I found two Indians playing the Bowl Game—the Chippewa dice game. The players had a symmetric, nicely finished, hemispheric bowl of some 13 inches in diameter and 6 inches in depth, a bowl made of a large round nodule of a maple root, fashioned solely with the aid of an ax and a knife. This bowl is about an inch in thickness in the bottom but tapers considerably towards its rim. In this game there are 40 counters. These are made of trimmed sticks about 12 inches in length and usually ⅛ of an inch in thickness. Half of these are colored red, half white. The dice used in the game are some variously carved, very small, thin pieces of bone, with sides variously colored.

When I arrived, the bowl containing these dice was being lightly tapped on the ground to flip the dice. Bets were being made and the staked property was to view. And as both spectators and players sang, the game went on. A "Smart" tap of the bowl might change the whole game. While thus playing, the players tapped the bowl alternately until one person won all the counters, both the white and the red. He then had won the game.

The value of the throws as played were:
First throw (tap) 3 white dice and 5 red, 1 count.
Second throw, 4 white dice and 4 red, a draw.
Third throw, 8 red dice and 0 white, 40 counts.
Fourth throw, 2 white dice and 6 red, 4 counts.
Fifth throw, 1 white dice and 7 red, 20 counts.

I watched this game till one of the players who had sold some hay for $180 the day before was staking a handful of nails on the game.

Turning from this game, I heard a vigorous drum tap in one of the houses and on entering the house I found several Indians playing the Moccasin Game. It is a curious affair and resembled our "shell game" in many respects. A blanket was spread on the floor and on it in front of the player were four inverted moccasis. The player had four bullets in his hand, one of which was marked and was the winning bullet. As the winners sang, this actor (player), to disconcert his opponents, shrugged his shoulders, waved his hands and went through various contortions and slight-of-hand performances, as he slipped one bullet after another under a moccasin. When all had been placed, the guessing then began. An opponent went through various preliminaries with a long stick to see if he could detect from the action of the hider of the bullets under which moccasin he had hid the marked bullet. Then with this stick he struck the moccasin under which he thought the marked bullet was hid. Sometimes he won and got the moccasins and the bullets, and his opponents began to guess. Each time the guesser failed to guess right, he lost a tally count. Forty tally counts gave the winner the game.

While watching this moccasin game, my attention was attracted to a deep sounding drum beat beyond a little raise of ground. So I repaired to the spot from whence the sound came. There I saw the medicine fraternity initiating a "subject" into the medicine lodge, called "Medawin" (lodge) by the Indians. The medicine ceremonies were being held in a long drawn-out wigwam of 100 feet or more in length, a wigwam all but having the bark roof on it. I went close to the lodge and saw the people eating puppy soup with a relish. And soon thereafter the dance was begun, or rather resumed, as they had been dancing previous to the dog-feast period. Two old men began to chant in the minor key, while both beat a crude drum. As soon as the chant reached a fairly high pitch, the dancers began to line up in column style, the "navitiate" heading the column. The dance was a forward movement encircling the central space of the lodge, the movement being a tripping, gliding dance. As each one thus danced, he waved some medicine trophy in each hand, usually the skin of a bird or some animal. As they thus waved the medicine things, they gave forth peculiar utterances in grunting style and glided, tripped on.

As I was watching this dance, I noticed that through the center of the lodge longitudinally there were hung blankets and much bright colored calicos, the navitiate's price to join the order. And at the close of the ceremony, I noticed further that the medicine men took these medicine gifts up themselves, as a price of their services.

My attention was next called to where an aged Indian was repeating the myth stories of his race to an eager listening audience. The story he was telling was about his god Manabush and was as follows:

"In the early days of the earth Manabush was god as he is now. He lived then in the East at the coming of the rising sun. He was the maker, the creator of all things. He made the trees, the animals, the birds, the land, the water, the clouds, the air, the sky, and all things we see. He is god. He also made the earth as it is and the sky as it is and prepared places for the living and places of habitation for the dead peoples. The whole universe as he created it is one whole thing. It is as though he had created it as we would make a cheese box and put shelves in it; only the universe, as Manabush created it, he made five places, or shelves, of habitation one above another, the earth occupying the middle-shelf position. The gods live in and on the shelf above this one and the dead people live in the world just below the shelf on which we live—the people of the dead live toward the south in that world. The gods (manidos) also travel about the whole universe at will. They visit all the places of habitation, as they wish.

"After Manabush had created all things he went to live with his grandmother in the brilliantly colored regions in the vicinity of the setting sun and he lives there still. He is the guardian for all the Indians and he holds in reserve for them the things of the earth and lets them have them as he thinks they need them. He is to the Indian in a spiritual way the same as the Honorable Commissioner of Indian Affairs is to them in a material way. He conserves for his peoples the things of earth and allows them to have them as they can show that they need them. When the Indians wish anything they ask Manabush for it in dancing, drumming and praying. When they wish to hunt they dance and drum and pray to him to give them plenty of game to kill. They do the same when they wish a good fishing season, a good crop of berries, and so on. Manabush owns all things and if he is made to know or believe that the one who is praying to him and dancing before him (for Manabush is everywhere) really needs the things prayed for, he allows them. But sometimes he can not be induced to allow the things. The man may ask the things but may not be a worthy person. The man may wish much game in the hunt and may dance and drum and pray and may go hunting and get no game at all. But the man may dance and drum and pray again—they always dance and drum and pray four or five days. The man may do this till he wears out the patience of Manabush and Manabush may get angry and give it to him—allow him success in his undertaking." (This accounts for the reason why an Indian never quits on any proposition. I have known an Indian to ask the government for a certain thing and be told that it could not be allowed and on the very next mail he would demand it again. Furthermore, the Indian will confer charges against employes and inspectors will come and investigate same and find that the Indian has falsified in the full of the cloth and dismiss the case. And before the inspector is hardly out of sight the Indian has reconferred the old charges in a new form and demanded a new investigation. He never quits. The same is true with his dealings with the government.

He abrogated treaties and signed new ones and now he demands settlement by each treaty and is keeping at it till he will get it (?)—get paid twice or more times for the same thing. Many Chippewas believe that Manabush is the Great Spirit ("Chee Manido").)

"After Manabush had created all things, he set about going over the earth. He was unfortunate. He lost his bow and broke his arrows. Consequently, he could not kill any game. He therefore got very hungry. One day as he was traveling, he met Mr. Lion and, as he had a good bow and some arrows, he had him lend them to him. He went hunting. He had traveled about only a short time when he came near a caribou that was browsing in a near-by bushy area. So he slipped up to it and took deadly aim and let fly not one arrow but three. The poor beast fell dead after making just one leap. So Manabush took the caribou and skinned it. He then cut it in pieces and suspended same from the boughs of a fir tree. He then built a big fire beneath the tree and by it cooked the meat. He then took the meat down and sat down to eat. He was hungry. He had eaten only a few bites when he heard the groaning of one tree rubbing against another near-by. This groaning disturbed him. He had rendered out a tray of tallow from the caribou. This he took and determined to stop the groaning by greasing the parts that rubbed over each other. He went to the trees that were in trouble. A high wind was blowing and the groaning was intense and ear-grating. He sat the tray of tallow down and quickly climbed up one of the trees. Reaching the place where they rubbed together, he put his hand between them to pry them apart so he could put the tallow on the rubbing surfaces. At this moment the wind stopped blowing and he found his hand fast. He could not release it. So he had to remain there in the tree branches.

"As he was held fast by the trees holding his hand between them in a crushing grip, wolves were seen approaching in great numbers. He told them to go away, but, instead, they came on, having smelled the fresh meat. They came to where the cooking had been done and ate every bit of the meat, leaving nothing but the bones. They then began to smell about and finally discovered the tray of tallow and started to go to it. Manabush hallooed to them to go away; but, not minding him at all, they came on and licked up all the tallow. Then they galloped off into the woods and were soon out of hearing.

"Soon after the wolves had left, the wind began to blow again, thus releasing Manabush's hand. He then climbed down to find that not a bit of the caribou he had killed was left but the bones and a little meat around the eyes and in the inside of the skull that neither the wolves nor himself in his human form could get. He was hungry. For a considerable time he tried to get some meat from these bones. Then he changed himself into a snake and crawled into the skull. In this form he could get plenty to eat for one meal. He ate there till he was satisfied then started to get out of the skull by backing out of it. He had gotten nearly out when he suddenly was changed back into the human form; but—his head was still in the skull and he could not get it out. Furthermore, his head was so far in it that he could not see, but he had to go somewhere. So he, blind so far as being able to see anything was concerned, commenced wandering about in the woods trying to get to his friends, if possible. He wandered about in the woods here and there, now falling over logs, now falling into pits, and so on. At last he came to a tree. He felt of it. 'You are Cedar,' he addressed it (all things had a mind then and could talk), "show me which way to go and give me the direction to the water. You grow by the lake.'

"'Keep on going,' answered Cedar.

"So Manabush took two more steps and fell head-foremost into twenty feet of water in a big lake. He at once began to flounder about. He swam here and there for a considerable time somewhat towards shore, as he was a good swimmer. His head, as he swam, brought the caribou head and horns to view. The Indians on the shore saw it and supposed it to be a caribou swimming. So they set out in their canoes to attack it. There was quite a chase and many arrows were dispatched at the head of the supposed beast; but Manabush outswam his pursuers and finally came to shallow water. He then stood upright and waded ashore. In his hurry and his not being able to see, he fell down over several boulders along the shore. He finally fell headlong over a large rock and struck the caribou skull on his head on another boulder that laid ahead of him in the direction he fell. This rock cracked and broke open the caribou skull and Manabush drew forth his head. He was at once recognized and taken to the village and feasted.

"He is our god and lives in the brilliantly colored sunset sky." The next day found me in Indian village of Nett Lake where I took in another grand medicine lodge dance scene, similar to the one mentioned above. Towards evening I took a canoe and went out to Picture Island and examined the chiseled pictures of the long ago. As I was examining the various pictured scenes night closed over the land, and before another day I was on my way to civilization. But I had enjoyed my trip.

In Nett lake about a quarter of a mile off shore to the north the Indian village of Nett Lake, Koochiching and St. Louis counties, Minnesota (the county line runs through the center of the village), is an island of something like half an acre in area. Its western and southern slopes are wooded with poplar, birch, elm, and some shrubs and some viny species. There is also some grass and quite a profusion of flowering plants scattered here and there. Its northeastern part has an exposure of bare rocks, pitching into the lake on that side. Its central part reaches an elevation of some ten feet above the surface of the water of the lake. The island is surrounded by rice fields intermingled with cane brakes and flags, except on the southwest where the water is too deep for rice to grow. In the ages past this island, as well as the surrounding country, was glaciated. At the time of the glaciation, the northern sloping rocks on the northeastern part of the island were polished to an almost perfect smoothness.

The rock of this island is of the Koochiching (Couchiching) formation, being composed of mica schist and gneiss cut by granite intrusions. The whole is then cut by a large green stone dike running in an approximately north and south direction, from which stringers have been sent out across and through the other rocks. The dike itself is faulted in one place. As seen, it strikes about north and south; the mica schists strike N. 58 degrees E. and dips to the south of this direction at an angle of 70 degrees, except just at the northeast point where the rocks, as we have seen, dip northeast into the lake.

In the revolving years following the glacial epoch the region was inhabited by Indians. These peoples visited this picturesque island. There the medicine man danced and "made medicine", and the Indian wooed his squaw in the squaw dance. From there the deities called the dusky inhabitants to partake with them the eternal bliss of the happy hunting ground. Furthermore, to commemorate the events of that far away time, the medicine man chiseled the then life scenes on the polished rock surface of their island home. These are pictographs of human beings, dance scenes, and outlines of the animal gods worshiped by the men making the pictures. These have been preserved to the investigator, though all history of their purpose has vanished and but only a very faint legendary history of the people who made them can be had from the legends of the aborigines who now occupy the country. The pictographs, thus preserved, are of dance scenes, medicine ceremonies, scenes of the hunt, and dream scenes.

This island has one peculiar feature. The polished rock area is hollow beneath; and, on walking over it, it gives a hollow, drum-like sound. For this reason it is considered sacred by the Indians of the reservation even to this day. They say it is the home of their god and that he "drums" whenever they go on the island to tell them they are on sacred ground. Consequently, to appease this god and keep his good will and to have their lives more happy, they place "medicine", tobacco, and smelling herbs in the crevices and the "hollow" place in the rock as an offering to him.

This island is also called "Ghost Island." Tradition has it that in the second generation back a corpse in a coffin was taken there for interment. There it was left for a little while, while the people went back to the village in accordance with their burial customs. When they returned, the corpse had disappeared. "The god of the island had taken him to his abode."

It is also a fact that in the old times and even now God and the drum have a close relationship among Indians in this northern country. In the old times there was a drum house; and some one was always left to keep charge of the drum. To lose the drum was to incur the enmity of the gods. Their reverence for the drum has had influence, no doubt, in causing them to worship the "drum place" on this island and cause them to honor it with their sacred drawings.

Who made the pictographs of this island? The drawings seem to be similar to those at Pipestone, Minnesota, which are known to be Siouan. Furthermore, the Chippewas of the region say: "Our people did not make the 'rock pictures;' but have this tradition as to what beings made them (undoubtedly a mythical account of the fleeing of the Sioux from Nett Lake on the approach of the Chippewas):

"When the first Chippewa came to the region," (after the terrible battle of Elbow Falls near Gheen, Minnesota, where the Sioux were disasterously defeated according to other Chippewa traditions), "he crossed over Pelican Lake portage from Farmer John's landing and entered Nett Lake by way of Lost creek. On approaching Picture Island, it was found to be inhabited by innumerable beings that were half fish and half sealion. Upon the approach of the Chippewa, these became panic-stricken, and, diving into the water, they swam with all speed across the lake southwestward; the Chippewa followed them by the muddied water they stirred up in their mad flight. On reaching the southwestern shore of the lake, they fled up a little creek, and, coming to its source and having been caught as in a net, they dove down into the earth and are there yet. You can see the water bubbling up (in a huge spring) today where the earth swallowed them up. We know this region as holly ground. Because of these beings being caught as in a net, we call our lake 'Netor As-sab-aco-na' (Nett lake). When the pursuers returned from chasing the half fish, half sealion beings, they found these rock pictures on the rocks of this island. They are the pictures of these beings our people found here."

BRYOZOAN FAUNAS OF THE STONES RIVER GROUP OF CENTRAL TENNESSEE.

BY

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(Geological Laboratory, Chicago University.)

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Introduction.

In 1915 the State Geological Survey and the University of Tennessee employed Dr. J. J. Galloway and the writer to make a survey of the geology and soils in the central part of the state. A county was chosen as the unit of area for this work. The study of the geology of Rutherford County was completed the first season, and the results published in a report written by Dr. Galloway. It contains a discussion of the topography, descriptive, structural, and historical geology, and natural resources of the area, with an areal geological map and numerous diagrams.

Collections of fossils from the separate divisions of the Stones River beds were made at every favorable locality during the first field season (1915) and during the second (1916) when the writer returned to complete the soil mapping. A study of the material collected was made at Indiana University under the efficient and authoritative direction of Dr. E. R. Cummings and aided by the useful suggestions of Dr. J. J. Galloway. The results of the paleontologic work forms the basis for this paper. The identifications and a portion of the descriptions were completed before making a visit to the U. S. National Museum to compare the new and old forms with the unpublished material of Dr. E. O. Ulrich and Dr. R. S. Bassler. It was discovered that they had the following species described and photographed:

Ceramoporella grandis, new species.
Ceramoporella ingenua, new species.
Monticulipora compacta, new species.
Monticulipora discula, new species.
Monticulipora intersita, new species.

In order to avoid complications of nomenclature by introducing new names for the used but unpublished ones the following given by Ulrich and Bassler were adopted:

*Anolotichea *explanata*.
*Mesotrypa *crustulata*.
*Mesotrypa *dubia*.
*Constellaria *lamellosa*.
*Nicholsonella *frondifera*.
*Hallopora *spissata*.
*Batostoma *subcrassum*.
Batostoma *dendroidea*.
Bastostoma *conferta*.
Batostoma *inutilis*.
*Stromatotrypa *lamellata*.
*Rhinidictya *tabulata*.
*Stictoporella *cribrilina*.

Photographs of those above marked with an asterisk (*) were furnished by Dr. Bassler. The descriptions are the individual work of the writer and where the new forms were independently recognized from his collections a cotype was used. For the privilege to publish the descriptions of the new species prepared by Ulrich and Bassler, which increases the value of this paper as a paleontological contribution, expressions of gratitude are due to Dr. Ulrich and Dr. Bassler.

GENERAL GEOLOGY OF THE STONES RIVER GROUP OF CENTRAL TENNESSEE.

The formations of the Stones River group outcrop upon the crest and west slope of Nashville dome in Rutherford, Wilson, Bedford, Marshall, Davis, Cannon, Williamson and Murray counties, where the Stones, Duck, Harpeth and Cumberland rivers have eroded their valleys through the younger beds.

In 1851 J. M. Safford[1] studied the limestones in central Tennessee and gave the name Stones River to the series of beds that appeared at the surface in the bluffs along that stream. In 1869[2] he published a description of the formations and considered the group equivalent in age to the Trenton of New York at which time he abandoned the name he had formerly used.

Twenty-eight years later Winchell and Ulrich[3] revived the name Stones River and included within the group the Carters' limestone, and in 1900 Safford and Killebrew[4] redefined the group and published a brief description of the formations.

The upper member of the Stones River group occurs in the Columbia, Tennessee, quadrangle and was studied by Hayes and Ulrich[1] in 1903, and lists of fossils from the lower members are published in the folio.

The Carters limestone was transferred from the Stones River to the Black River group in 1915 by Mr. Ulrich.[2] Further study and mapping of the limestones of Stones River age was done by Ulrich and Bassler during 1908 in the Woodbury, Tennessee, quadrangle, but a report has not yet been published.

The following table gives the names and chronological order of the divisions of the Stones River group as developed in central Tennsesee: (Formations present are given in *italics*.)

Cenozoic				
Mesozoic				
	Permian			
	Pennsylvanian			
	Mississippian			
	Devonian			
	Silurian			
		Cincinnatian		
Paleozoic		Mohawkian		*Lebanon*
	Ordovician	Chazyan	Blount	*Ridley*
			Stones River	*Pierce*
		Big Buffalo series		*Murfreesboro*
	Canadian			Mosheim
	Ozarkian			
	Cambrian			
Proterozoic				

Murfreesboro limestone. Safford referred to the Murfreesboro limestone as the "Central limestone" in his Geology of Tennessee published in 1869[1], because it occurred in the center of the state. The name of this formation was changed to Murfreesboro limestone in 1900 by Safford and Killebrew[2] when they believed that the city of Murfreesboro was near the center of its

[1]Am. Jour. of Sci. and Arts, 2nd ser., Vol. XII, p. 352.
[2]Geol. of Tenn., p. 258.
[3]Geol. of Minn., Vol. III, Pt. II, p. xc, (1897).
[4]Elem. Geol. of Tenn., p. 125, (1900).
[1]U. S. Geol. Survey Folio 95 (1903).
[2]U. S. Nat. Bull. 92, Pl. II.

circular outcrop, but they confused the Murfreesboro and Ridley limestones at this time.

The Murfreesboro limestone is the oldest formation exposed on the Nashville dome and outcrops only in Rutherford County upon the crests of secondary upfolds that occur along the valleys of Stones River and its tributaries. Thus, instead of a single area in which the formation appears at the surface, there are numerous small and isolated localities.

The beds consist of thick layers of bluish gray, dense, bituminous limestones with much disseminated chert which appears upon weathered surfaces in small irregular masses. At Lascassas, Rutherford County, the lower fifteen feet of the twenty-seven feet exposed consists of sandy, laminated, ripple-marked and sun-cracked limestone, which is evidence that the sea was shallow and the shore line probably not far distant during the closing stage of the deposition of the Murfreesboro limestone.

Fossils are few and difficult to obtain from the unweathered limestone; but in the residuum resulting from the weathering of many feet of the formation, and in the cherty masses upon the surface of the exposed rock, silicified specimens occur in considerable abundance. Some of the best localities are near the Central Normal School, at Murfreesboro, and upon the bluffs of Stones River near the Nashville pike. *Salterella billingsi, Lophospira perangulata, Liospira abrupta, Helicotoma tennesseensis, H. declivis* are the most abundant species and are characteristics of the formation.

The maximum exposure of this limestone is seventy feet, with the basal beds not exposed.

Pierce limestone. This formation was named by Safford[1] in 1869, from the splendid outcrop near Pierce's Mill, one-half mile south of Walter Hill, Rutherford County. It consists of several lithological members as follows: The lower four to six feet is a massive dove-colored, coarsely crystalline limestone. The next one to two feet consists of thin bedded dense light blue limestone interbedded with coarsely crystalline layers which are fossiliferous. Upon this lies a massive coarsely crystalline bed having a thickness of four feet and containing few fossils. The upper fifteen to eighteen feet is made up of thin beds of dense unfossiliferous calcareous layers interbedded with coarsely crystalline limestone two to three inches thick and containing abundance of fossils. Seams of shale separate the numerous layers.

The total thickness of the formation varies from twenty-five to twenty-eight feet, it outcrops in narrow irregular belts about the areas of the Murfreesboro limestone, and it is easily recognized by the great abundance of fossils of which there is a predominance of bryozoa. The following forms are characteristic and abundant: *Nicholsonella pulchra, N. frondifera, Anolotichia explanata, Stictoporella cribrilina.*

The Pierce limestone apparently lies conformably upon the Murfreesboro

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[1]Geol. Tenn. (1869), p. 259.
[2]Elem. Geol. Tenn. (1900).
[1]Geol. Tenn. (1869), p. 261.

except at Lofton, Rutherford County, where the upper ten feet of the Murfreesboro is absent.

Ridley limestone. This limestone was named by Safford[1] in 1869 from the exposure at Ridley's Mills (now Davis' mill) near Jefferson, Tennessee. Only the lower thirty feet of the formation are exposed at this locality. The Ridley limestone has a much wider surface distribution than the older formations of the Stones River group. It accurs in Rutherford, Wilson, Bedford, Marshall, Williamson, and Davidson counties. Its thickness varies from 95 to 120 feet.

The formation consists of massive, dense, light blue, bituminous limestone with considerable chert, appearing upon the weathered surfaces. These characters are much like those of the Murfreesboro limestone, and it is not surprising that Safford confused the formations lithologically. The faunas, however, are decidedly different, but in many outcrops fossils do not occur and correlation is uncertain except where the contacts with either the Pierce or the Lebanon are seen.

The Ridley limestone is in most places apparently conformable upon the Pierce, except near Jefferson, Rutherford County, where the contact is slightly undulating. The small variation in thickness of the Pierce limestone does not indicate a prolonged period of erosion. The following are among the most characteristic and abundant fossils: *Camerella varians, Hebertella bellarugosa, Gonioceras anceps, Orbignyella sublamellosa, Liospira convexa, Protorhyncha ridleyana* and *Stromatocerium rugosum.*

Lebanon formation. This formation was called the "glade limestone" by Safford in 1869[1], since it is the surface rock beneath the extensive "cedar glades" of central Tennessee. In 1900 Safford and Killebrew[2] changed the name to "Lebanon limestone" presumably from the splendid outcrops of the formation in the town of Lebanon, Wilson County. The thickness measured by Safford[3] near Readyville, Rutherford County, is 118 feet. Other measurements in other localities show a variation from 80 to 120 feet.

The outcrops of this limestone extend over a considerable area in Rutherford, Wilson, Cannon, Bedford, Marshall, Maury, Williamson, and Davidson counties, and almost everywhere valuable cedars grow in the shallow Lebanon soil. The formation consists of thin layers of dense, light blue, fossiliferous limestone separated by seams of shale. In some sections a massive coarsely crystalline unfossiliferous bed of limestone occurs near the base. Ripple-, rill- and wave-marks are common in different parts of the formation, indicating that shallow water conditions prevailed at different times during the deposition of the beds.

Some layers of the formation are made up almost wholly of a single species of *Plectambonites* as seen two miles south of Murfreesboro. Other abundant and characteristic fossils are: *Scenidium anthonense, Batostoma libana, Escharopora briareus, Phragmolites grandis,* and *Zygospira saffordi.*

The Lebanon lies with apparent conformity upon the Ridley.

[1]Geol. Tenn. (1869), p. 261.
[1]Geol. Tenn. (1869), p. 258.
[2]Elem. Geol. Tenn. (1900), p. 125.
[3]Geol. Tenn. (1869), p. 263.

PALEONTOLOGY OF THE STONES RIVER GROUP OF CENTRAL TENNESSEE.

In correlating the formations of Stones River age in other localities with the beds in central Tennessee, it has been found necessary to have available a complete list[1] of the fossils described from the Murfreesboro, Pierce, Ridley, and Lebanon formations.

Murfreesboro Limestone.

Ctenodonta gibberula Salter.
Cyclonema (? Gyronema) praeciptum Ulrich.
Cyrtoceras ? stonense Safford.
Cryptospira tortilis Ulrich.
Dinorthis deflecta (Conrad).
Eccliomphalus contiguus Ulrich.
Ectomaria prisca extenuata Ulrich.
Eotomaria canalifera Ulrich.
Eotomaria labiosa Ulrich.
Gonioceras occidentale Hall.
Helicotoma declivis Ulrich.
Helicotoma subquadrata Ulrich.
Helicotoma tennesseensis Ulrich and Scofield.
Leperditia fabulites (Conrad).
Liospira abrupta Ulrich and Scofield.
Liospira americana (Billings).
Liospira decipiens Ulrich.
Liospira progne (Billings).
Liospira subconcava Ulrich.
Lophospira bicincta (Hall).
Lophospira centralis Ulrich.
Lophospira perangulata (Hall).
Lophospira procera Ulrich.
Lophospira (?) trochonemoides Ulrich.
Maclurites magnus Lesueur.
Maclurites nitidus (Ulrich and Scofield).
Modiolopsis (?) consimilis Ulrich.
Nicholsonella frondifera, new species.
Nicholsonella pulchra Ulrich.
Ophiletina sublaxa depressa Ulrich and Scofield.
Orthis tricenaria Conrad.
Pianodema subaequata (Conrad).
Plectoceras bondi (Safford).
Pterygometopus troosti (Safford).
Raphistomina modesta Ulrich.

[1]The list of fossils is compiled from Bulletin 92 U. S. Nat. Mus. and from the study of collection made from the different formations of the Stones River group.

Salterella billingsi Safford.
Tetranota bidorsata (Hall).
Trochonema bellulum Ulrich.
Whiteavesia saffordi (Ulrich).
Zittelella varians (Billings).

Pierce Limestone.

Anolotichia explanata, new species.
Batostoma conferta, new species.
Batostoma dendroidea, new species.
Batostoma inutilis, new species.
Batostoma ramosa, new species.
Batostoma subcrassum, new species.
Ceramoporella grandis, new species.
Caramoporella ingenua, new species.
Chasmatopora sublaxa (Ulrich).
Coeloclema consimile, new species.
Coeloclema inflatum, new species.
Coeloclema pierceanum, new species.
Columnaria alveolata, Goldfuss.
Constellaria lamellosa, new species.
Corynotrypa delicatula (James).
Corynotrypa tennesseensis, Bassler.
Dinorthis deflecta (Conrad).
Diplotrypa catenulata, new species.
Eccyliomphalus contiguus, Ulrich.
Escharopora angularis Ulrich.
Escharopora confluens Ulrich.
Eurychilina subradiata Ulrich.
Graptodictya dendroidea, new species.
Graptodictya fruticosa, new species .
Hallopora florencia, new species.
Hallopora spissata, new species.
Hebertella bellarugosa (Conrad).
Helopora spiniformis (Ulrich).
Hemiphragma irrasum (Ulrich).
Heterotrypa patera, new species.
Heterotrypa stonensis, new species.
Leperditia fabulitis (Conrad).
Liospira americana (Billings).
Liospira progne (Billings).
Lophospira bicincta (Hall).
Maclurites magnus Lesueur.
Mesotrypa crustulata, new species.
Mesotrypa dubia, new species.
Monticulipora compacta, new species.

Monticulipora discula, new species.
Monticulipora intersita, new species.
Nicholsonella frondifera, new species.
Nicholsonella pulchra Ulrich.
Orbignyella multitabulata, new species.
Orbignyella sublamellosa Ulrich and Bassler.
Orthis tricenaria Conrad.
Pachydictya cf. fimbriata.
Pachydictya cf. foliata.
Pachydictya senilis, new species.
Paleocrinus culcatus Safford.
Pianodema stonensis (Safford).
Pianodema subaequata (Conrad).
Protorhyncha ridleyana (Safford).
Pterygometopus troosti (Safford).
Rafinesquina incrassata (Hall).
Rhinidictya nashvillensis (Miller).
Rhinidictya tabulata, new species.
Stictoporella cribrilina, new species.
Stromatotrypa incrustans, new species.
Stromatotrypa lamellata, new species.
Stromatotrypa regularis, new species.
Strophomena incurvata (Shepard).
Tetradium syringoporoides Ulrich.
Zygospira saffordi Winchell and Schuchert.

Ridley Limestone.

Anolotichia explanata, new species.
Camarella varians, Billings.
Chasmatorpora sublaxa (Ulrich).
Constellaria lamellosa, new species.
Ctenobolibina subcrassa, Ulrich.
Dekayella ridleyana, new species.
Dianulites cf. petropolitanus.
Dinorthis deflecta (Conrad).
Drepanella ampla, Ulrich.
Eccyliomphalus contiguus Ulrich.
Escharopora suberecta (Ulrich).
Gonioceras anceps Hall.
Hallopora spissata, new species.
Hebertella bellarugosa (Conrad).
Helopora spiniformis (Ulrich).
Hemiphragma irrasum (Ulrich).
Leperditia fabulites (Conrad).
Liospira americana (Billings).

Liospira convexa Ulrich and Scofield.
Liospira progne (Billings).
Lophospira bicincta (Hall).
Maclurites magnus Lesueur.
Monticulipora discula, new species.
Nicholsonella frondifera, new species.
Orbignyella sublamellosa Ulrich and Bassler.
Orthis tricenaria Conrad.
Pachydictya cf. foliata.
Pianodema stonensis (Safford).
Pianodema subaequata (Conrad).
Protorhyncha ridleyana (Safford).
Pterygometopus troosti (Safford).
Rafinesquina incrassata (Hall).
Rhinidictya nashvillensis (Miller).
Rhinidictya tabulata, new species.
Stictoporella cribrilina, new species.
Stromatotrypa lamellata, new species.
Stromatocerium rugosum Hall.
Strophomena incurvata (Shepard).
Tetradium syringoporoides Ulrich.
Zittella varians (Billings).

Lebanon Limestone.

Arthroclema striatum Ulrich.
Batostoma libana (Safford).
Camarotoechia orientalis (Billings).
Ceramoporella grandis, new species.
Ceraurinus scofieldi (Clarke).
Chasmatopora sublaxa (Ulrich).
Cleiocrinus tessellatus (Troost).
Columnaria alveolata Goldfuss.
Corynotrypa delicatula (James).
Corynotrypa tennesseensis Bassler.
Dinorthis deflecta (Conrad).
Drepanella elongata Ulrich.
Drepanella macra Ulrich.
Eccyliomphalus contiguus Ulrich.
Escharopora briareus (Ulrich).
Escharopora libana (Safford).
Escharopora ramosa (Ulrich).
Eurychilina subradiata Ulrich.
Fletcheria incerta (Billings).
Hebertella borealis (Billings).
Hebertella bellarugosa (Conrad).
Helopora spiniformis (Ulrich).

Hemidictya lebanonensis, new species.
Hudsonaster narrawayi (Hudson).
Leperditia fabulites (Conrad).
Liospira americana (Billings).
Liospira progne (Billings).
Lophospira bicincta (Hall).
Maclurites magnus Lesueur.
Monticulipora discula, new species.
Nicholsonella frondifera, new species.
Nicholsonella pulchra Ulrich.
Orbignyella nodosa, new species.
Orthis tricenaria Conrad.
Pachydictya cf. foliata.
Phragmolites grandis (Ulrich).
Pianodema subaequata (Conrad).
Primitiella limbata Ulrich.
Pterotheca saffordi (Hall).
Pterygomatopus troosti (Safford).
Rafinesquina incrassata (Hall).
Rhinidictya basalis (Ulrich).
Rhinidictya lebanonensis, new species.
Rhinidictya tabulata, new species.
Rhinidictya trentonensis (Ulrich).
Scenidium anthonense Sardeson.
Schmidtella subrotunda Ulrich.
Solenopora compacta (Billings).
Streptelasma (?) parasiticum Ulrich.
Stromatotrypa lamellata, new species.
Strophomena incurvata (Shepard).
Tetradium syringoporoides Ulrich.
Tetranota sexcarinata Ulrich and Scofield.
Trigonidictya irregularis, new species.
Trochonema eccentricum Ulrich.
Trochonema umbilicatum latum Ulrich.
Zygospira saffordi Winchell and Schuchert.

STRATIGRAPHY AND PALEONTOLOGY OF THE STONES RIVER LIMESTONE (OUTSIDE OF CENTRAL TENNESSEE).

Eastern Tennessee. In the "Revision of the Paleozoic System"[1] Dr. Ulrich advocates the idea of compensatory oscillation of the various basins or troughs in eastern Tennessee during the early Ordovician period and in this manner accounts for the absence in one and the presence in another area of the different beds of the Stones River and later formations.

The Mosheim basin covered an area which became a number of separate troughs during later stages. The deposit made at this time is referred to the lowest Stones River and is older than any formation exposed in the central basin of Tennessee. Little has been published concerning the fauna of the Mosheim and apparently its age is determined by its occurrence upon the upper Knox of Canadian age and below the Lenoir limestone of undoubted Stones River age.

The Lenoir limestone was identified by Safford and Killebrew and referred to by them in the Elementary Geology of Tennessee (1900) as the "Maclurea limestone" from the abundance of *Maclurites magnus* which it contains. A fossil list of twenty-two species consisting of brachiopods, gastropods, trilobites, ostracods, corals, and sponges is published in Bulletin 92 of the United States National Museum. In comparing this list with the faunas of the Central Basin it is found that two species, *Maclurites magnus* and *Zittela varians*, which are characteristic of the middle Stones River, occur in both areas. Zittela variens is found in the Ridley limestone and Maclurites magnus in all divisions of the Stones River in the Central Basin area, which indicates that the Lenoir limestone is probably equivalent in age to more than the Pierce formation as expressed by Dr. Ulrich. It is possible that the bryozoan fauna concerning which little is published will further restrict the boundaries.

Virginia. The Stones River group is present in the western part of Virginia, where it is represented by a thickness of 900 feet of heavily bedded dolomitic layers interbedded with pure, dove-colored limestones. The thickness diminishes southward. The presence of the dove-colored beds and the growth of cedars in the soil upon the formation are conspicuous characters that distinguish the Stones River from other limestones of this region, features which are identical with the type area of the Stones River in central Tennessee.

Until the study of the fossils from the limestones in West Virginia was made by Dr. Bassler,[1] all the beds were included within the Chickamauga limestone, but he has correlated the lower part of the series with the Stones River of eastern Tennessee, on the basis of the occurrence of *Leperditia fabulites* (Conrad), *Lophospira serrulata* (Salter), *L. perangulata* (Hall), and a single *Tetradium*, probably *Tetradium syringoporides* Ulrich and also because of lithologic similarity and stratigraphic position. The group of fossils undoubtedly determines the age to be equivalent to that of the Stones River limestone in the central basin of Tennessee.

West Virginia, Maryland and Pennsylvania. At Martinsburg, West Virginia, 675 feet of limestone is referred by Ulrich and Stoss to the Stones River. They measured the following section:[1]

4. Light to dark drab limestone banded with thin earthy or magnesian seams	275	feet
3. Similar beds, less well exposed	200	feet
2. Dark gray to dove-colored fine even-grained pure limestone (quarried)	100	feet
1. Similar fine-grained, dove-colored limestone increasing downward in magnesium (quarried)	100	feet
Total	675	feet

[1]Bulletin Geol. Soc. of Amer. Vol. 22.
[1]Cement Resources of Virginia. Bull. II—A, 1909.

The thickness of the Stones River limestone increases as traced northward into Maryland and Pennsylvania reaching 1000 feet in the Mercersburg-Chambersburg quadrangle. In these states it outcrops in elongated areas due to the great amount of faulting, folding, and erosion. Massive and thin-bedded limestones interbedded with magnesian layers and dove-

[1]U. S. Geol. Survey Folio 170, p. 7.

colored purer limestones with considerable chert characterizes the formation lithologically.

The following fossils identified from collections made at Guilford Springs, Pennsylvania, are from the dove-colored, cherty limestone members:[1]

Girvanella cf. chazyensis.
Tetradium syringoporides.
Hebertella borealis.
Hebertella vulgaris.
Dinorthis cf. platys.
Strophomena aff. charlottae.
Maclurites magnus.
Lophospira bicincta.
Isochilina cf. amiana.
Ampyx halli.

A comparison of this list with those from the Stones River group in central Tennessee indicates an equivalent age.

Near Bellefonte, Pennsylvania, J. L. Collie[2] has referred 253 feet of fossiliferous limestone to the Stones River. From the lower horizon of these beds *Bathyrurus extans*, *Strophophema filitexta* and *Protorhyncha ridleyana* were identified which correlates the bed with the Ridley limestone of Central Tennessee. The beds above were regarded as of Lebanon age from the occurrence of *Lophospira milleri* and the great abundance of *Leperdita fabulites*. Below the Ridley beds and above the highest fossiliferous horizon containing Beekmantown species, there are 2335 feet of unfossiliferous dolomite the upper part of which may be equivalent in time to the Murfreesboro and Pierce limestones of the Central Basin area in Tennessee.

Eastern New York and Western Vermont. Through the work of Raymond and others upon the lower Chazy of New York and Vermont (Day Point and Crown Point limestones), there is made available a considerable faunal list which is published in Bulletin 92 of the United States National Museum. A comparison of the 64 species from the Day Point limestone with other Chazyan faunas shows that it is more closely related to the Appalachian Stones River than to the limestones of the interior area. *Camarella longirostris* Billings, *Bumastus globosus* (Billings) *Bucania sulcatina* Emmons, *Eurychilina latimarginata* Raymond, *Holopea scrutator* Raymond, *Scenella pretensa* Raymond, *Stylaria parva* (Billings) are characteristic Chazyan forms of the Appalachian-Champlain embayment and are found in the Day Point limestone of New York and the Lenoir limestone of eastern Tennessee.

The Crown Point limestones apparently lie conformably upon the Day

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[1]U. S. Geol. Survey Folio 170, p. 8.
[2]Geol. Soc. of Amer. (1908).

Point. One hundred five species are identified from the collection made from this formation of which the following appear in the Lenoir limestone of eastern Tennessee:

Camarella varians Billings.
Dinorthis platys Raymond.
Dinorthis strophomenoides (Raymond).
Eurychilina latimarginata (Raymond).
Hebertella vulgaris Raymond.
Holopea scrutator Raymond.
Leperditia limatula Raymond.
Maclurites magnus Lesueur.
Rafinesquina incrassata (Hall).
Raphistoma stamineum (Hall).
Scenella robusta Raymond.
Stylaria parva (Billings).

The comparison leads to the conclusion that the Chazy basin of New York and of eastern Tennessee were directly connected and inter-migration took place freely. Only three of the above species occur in central Tennessee, these being the only representatives of the migrants from the Atlantic coastal area that reached the Gulf of Mexico Embayment and the basins of the eastern Chazyan seas.

Kentucky, Central New York and Canada. The beds deposited during the Stones River time in the state of Kentucky are exposed at the base of the falls at Highbridge. The following species collected from that locality are characteristic of the Lebanon:

Drepanella ampla Ulrich.
Drepanella elongata Ulrich.
Eurychilina aequalis Ulrich.
Eurychilina granosa Ulrich.
Liospira progne (Billings).

There is no known deposit of Stones River age outcropping in the state of Ohio, but the distinctly Stones River fauna occurring in the Pamelia limestone of central New York indicates that a passageway existed which connected the latter area with Kentucky and Tennessee.

The following is a list of fossils occurring in the Pamelia limestone as recorded in Bulletin 92, United States National Museum:

Bathyurus acutus Raymond.
Cyrtodonta breviuscula Billings.
Helicotoma whitcaresiana Raymond.
Isochilina ? clavigera (Jones).
Isochilina clavigera clavifracta (Jones).
Leperditella ? labellosa Jones.
Leperditia amygdalina Jones.
Leperditia balthica primaeva Jones.
Leperditia fabulites (Conrad).

Liospira americana (Billings).
Liospira decens (Billings).
Liospira progne (Billings).
Lophospira bicincta (Hall).
Maclurites magnus Lesueur.
Nanno kingstonensis Whiteaves.
Orthis tricenaria Conrad.
Pianodema subaequata (Conrad).
Pterygometopus troosti (Safford).
Strophomena incurvata (Shepard).
Tetradium syringoporoides Ulrich.

Of these twenty species, ten occur in the divisions of the Stones River in Tennessee. Ostracods are abundant throughout the formation, and gastropods, cephalopods, corals, and trilobites are common in the lower part.

A pebbly conglomerate and sandstone occurs at the base of the Pamelia and extends northward beyond the limit of the limestone into Canada, where it is named Rideau sandstone.

Near L'Original, Canada, the following species have been collected from limestones that are equivalent in age to the Pamelia of New York:

Leperditia amygdalina Jones.
Leperditia balthica primaeva Jones.
Leperditia fabulites Conrad.
Liospira decens (Billings).
Liospira progne (Billings).
Nanno kingstonensis Whiteaves.

STRATIGRAPHIC CORRELATIONS.

The sea in which the Stones River beds of the interior area of North America were deposited is designated as the Gulf of Mexico Embayment[1]. It came in from the south, spreading from the Gulf of Mexico region to Oklahoma and central Tennessee during the early Stones River time where the Simpson formation and the Tennessee limestone of that age were respectively deposited. The embayment spread northward into Kentucky and covered central New York and southern Canada during the Lebanon time. The basal conglomerate at the bottom of the Pamelia (the New York deposit), the thinness of that formation, its increasing near-shore facies as it is traced northward into Canada, its apparent conformity beneath the lower Chambersburg beds of Valcour age in Pennsylvania, and the numerous fossils which it contains that are similar to the upper Stones River fossils of Tennessee, has led to the correlation of the Pamelia with the Lebanon beds, by Ulrich.

The Appalachian and Champlain troughs had direct connections with the Atlantic and the faunas of the one mingled freely with the other, but the marked differences of the faunas of the interior basin suggest the existence of a barrier separating the eastern and interior Chazyan seas. Cush-

[1]See Paleographic Maps, pages 305-307.

ing[1] states that in New York during the early Stones River time deposition was confined to the Champlainian trough, and following the retreat of that sea to the northwest into the St. Lawrence Gulf at the close of the Crown Point stage, the Gulf of Mexico Embayment came into central New York from the south, bringing in species and genera similar to the southern interior faunas. During the upper Pamelia time the gulf connections were restricted and somewhat later the sea was drained from the New York region and the Champlain trough became again the area of deposition during the upper Chazyan (Valcour stage).

BRYOZOAN FAUNAS OF THE STONES RIVER GROUP[2].

The earliest known bryozoan, *Heteronema priscum*, is a ctenostomatous form and occurs in the Ungulite sandstone at Jegelecht Falls, Esthonia, Russia. In Sweden this standstone has been referred to the basal Ordovician by Swedish geologists from the presence of the fossil *Obolus apollinis*. The earliest American form is a species of Nicholsonella from the Beekmantown of Arkansas. Following these occurrences in chronological succession comes the earliest prolific fauna of the Stones River limestone in central Tennessee. Considerable work has been done on the bryozoan faunas of the early Mohawkian beds that occur in different places in North America but up to this time very little has been published. The description of several species collected from the Stones River of the Central Basin area in Tennessee and published in the "Final Report of the Geological and Natural History Survey of Minnesota," Volume 3, 1893, by E. O. Ulrich, is the most important paleontological contribution. The published work on the bryozoan fauna in other localities has been of a general nature and in many cases the author only suggested that a considerable fauna of bryozoa was indicated by the numerous fragments of this class of fossils. In other cases collections containing abundance of bryozoa have been made and laid aside until more time was available to study them. The present report is the most extensive publication up to this time based upon new and described forms of the Stones River bryozoa. The full value of the work cannot be realized until the faunas of other areas have been studied in detail and some of the conclusions reached may be modified when the information from other areas is available. Considerable work has already been done by the writer upon the bryozoa from the Chazy of New York which will form the basis of a subsequent paper.

Murfreesboro fauna. The bryozoa collected are few and poorly preserved and it is only the large trepostomatous species that can be identified from the exterior surface, which are included in the table showing the range and distribution of all the Stones River forms. The interior structure of all of the observed specimens is destroyed by silicification. No gtenostomata are reported from the Murfreesboro or later divisions of the Stones River.

Pierce fauna. Bryozoa are very abundant in the Pierce limestone. The Order Cyclostomata is represented by five genera and nine species. All

[1]Geol. Soc. of Amer. (1901).
[2]Reference table, page 308.

forms are members of the family Ceramoporidae. The twelve trepostomatous genera are represented by twenty-four species. The Batostoma, Hallopora and Nicholsonella are most abundant and appear in every locality from which collections have been made. Seven genera and twelve species belong to the order Cryptostomata. Graptodictya, Rhinidictya and Escharopora are the most abundant in number of specimens.

Ridley fauna. Bryozoa in the Ridley limestone are not usually conspicuous. Orbignyella occurs in many of the outcrops of the formation, but good collecting localities for the other forms are rare.

Lebanon fauna. In many localities bryozoans are abundant. The Cryptostomata are most abundant in genera and species, but the large Trepostomatous forms are most conspicuous.

Arthoclema striatum Ulrich. Numerous species that are identical with the Black River forms are found in the Lebanon formation.

Chasmatopora sublaxa (Ulrich). This species is a long ranged simple cryptostomatous bryozoan. It is very abundant in the Pierce beds and is common in all other divisions of the Stones River.

Escharopora briareus (Ulrich), *E. libana* (Safford), *E. ramosa* (Ulrich), are common and characteristic of the Lebanon formation. The forms in the Pierce have been referred to *E. angularis* Ulrich, and *E. confluens*, which are common in the Black River of Minnesota.

Helopora spiniformis (Ulrich) is common in the Pierce, Ridley, and Lebanon limestones.

Numerous examples of Pachydictya resembling in all important features the *P. foliata* of the Black River of Minnesota, are compared with that species. It is abundant and grows slightly larger than the Minnesota forms.

Corynotrypa delicatulata (James) is reprsented by numerous and well preserved specimens in the Pierce and Lebanon limestone. *Corytrypa tennesseensis* Bassler is not so abundant as *C. deliculata* but many small fragments of zoaria occur in the Pierce outcrop at Ward's Mill, Rutherford County.

Mitoclema cinctosum Ulrich occurs in many places in the Ridley limestone and is abundant at Almaville, Tennessee.

Batostoma libana (Safford) was described by Safford in 1869 and is redescribed in this paper as a common and characteristic fossil of the Lebanon limestone. *Batostoma suberasum*, new species, has not been described from the Chazy of New York but specimens in the collections made by Dr. E. R. Cumings are similar to the Tennessee species.

Dianulites cf. *petropolitanus* is very abundant in the Ridley limestone and is usually poorly preserved. It is closely related to *D. petropolitanus* Dybowoski.

Hemiphragma irrasum (Ulrich) is abundant in the Pierce and Ridley limestone. It shows slight variations from the Black River species of Minnesota but it is not thought advisable to suggest a new name at this time.

Nicholsonella pulchra Ulrich and *N. frondifera* new species, are the very abundant and most conspicuous trepostomatous bryozoa of the Stones River beds. Forms apparently identical to these occur in the lower Chazy of New York.

Orbignyella nodosa, new species, is very abundant in the Lebanon limestone near Big Spring, Tennessee.

Orbignyella sublamellosa Ulrich and Bassler, was first described from the Pierce beds near Murfreesboro, Tennessee, but further stratigraphic study of the Stones River group has shown that it is much more abundant and widely distributed in the Ridley limestone than any other species in that formation.

RANGE AND DISTRIBUTION OF OTHER SPECIES OF THE STONES RIVER GROUP IN CENTRAL TENNESSEE.

The table (page 310) is given to express briefly the relation of the Mollusca, ostracode sponge and coral faunas from the Central Basin region with the faunas of Stones River age from other localities and those of younger age found in Tennessee and elsewhere.

DESCRIPTONS OF GENERA AND SPECIES ORDER CYCLOSTOMATA BUSK.

The arangement of the zooecia, the form of the zoarium, and the presence or absence of interstitial cells and vesicular tissue are the important characters upon which the families and genera of this order is founded.

The zooecia are simple and short, with minutely porous calcareous walls. Diaphragms are absent. The apertures are rounded, slightly raised, bent outward, and inoperculate. Ovicells are present.

Family Ceramoporidae Ulrich.

Members of this family may be identified by the more or less oblique aperture with an elevated lunarium often developed into a hood. The cell walls are minutely porous and composed of irregularly laminated and intimately connected tissue. Maculae of mesopores or of zooecia longer than the average occur at regular intervals. Diaphragms are few; mesopores are generally present, irregular and free from tabulation.

Genus Ceramoporella Ulrich. Genotype: Ceramoporella distincta Ulrich. Ceramoporella Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 156. Miller, N. A. Pal., 1889, p. 297. Ulrich, Geol. Surv. Illinois, 8, 1890, pp. 380, 464; Geol. Minnesota, 3, 1893, p. 328. Procta, Syst. Sil. Centre Boheme, 8, pt. 1, 1894, p. 15. Ulrich, Zittel's Textb. Pal. (Engl. ed.), 1896, p. 267. Simpson, 14th Ann. Rep. State Geol. New York for 1894, 1897, p. 564. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 23. Bassler, ibid., 292, 1906, p. 20. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 121. Cummings, 32d Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 742. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 81; Zittel-Eastman Textb. Pal., 1913, p. 327.

Zoarium consists of incrustations often superposed, forming masses, zooecial tubes are short and thin-walled, with apertures that are more or less oblique, oval, surrounded by mesopores; the lunarium is developed into a prominent hood-structure.

Ceramoporella grandis n. sp. Plate I, Figs. 4-6. The colony grows into very irregular small masses, epithecated below and composed of superimposed contorted layers. Zooecial apertures are but slightly oblique, generally appearing somewhat rhomboidal at the surface. The lunarium is thick but not very prominent in the specimen described. It occupies one-third of the circumference of the aperture. Maculae are scarcely distinguishable. The interior walls are rather thick, including numerous rounded mesopores; the number of these varying, however, in different parts. The zooecia are subovate with irregularly laminated walls; diaphragms are wanting.

This species is distinguished from *C. robusta* by its inconspicuous maculae, somewhat smaller and exteriorly less rounded cells and more numerous mesopores. The latter are rarely seen at the surface, being apparently included within the subquadrate zooecial wall, for which reason the species is probably related to *C. inclusa* and *C. ingenua*, but separated from those species by its laminae growth, thicker layers, heavier walls and less oblique apertures. The orifices of *C. grandis* are not bidenticulate as in *C. inclusa* and *C. ingenua*.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: 54581 U. S. Nat. Mus.

Ceramoporella ingenua n. sp. Plate I, Figs. 1-3. The zoarium forms thin laminae, contorted, covered below by a concentrically striated epitheca; as far as observed it does not grow in superposed layers. The cell is of the *C. inclusa* type, the elliptical zooecial aperture itself together with generally three mesopores being included within a raised rim somewhat rhomboidal in outline. Maculae are quite inconspicuous.

C. ingenua is distinguished from *C. inclusa* by free habit of growth and larger zooecial spaces, these being as 3:4 or 4:5. The walls of *C. ingenua* are somewhat thicker than *C. inclusa*.

In *C. grandis* the cell mouths do not show the mesopores and the ovate zooecial aperture as in *C. ingenua*.

Occurrence: Pierce limestone, Stones River group, Murfreesboro, Tennessee.

Holotype: 54579 U. S. Nat. Mus.

Genus Coeloclema Ulrich. Genotype: Diamesopora vaupeli Ulrich.

Coeloclema Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 137; 7, 1884, p. 49 (not defined). Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, pp. 24, 211. Bassler, Bull. U. S. Geol. Surv., 292, 1906, p. 21. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 122. Cumings, 32d Ann. Rept., Dept. Geol. Nat. Res. Indiana, 1908, p. 742. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 83; Zittel-Eastman Textb. Pal., 1913, p. 328.

Diamesopora (part) Ulrich, Geol. Surv. Illinois, 8, 1890, pp. 380, 467; Geol. Minnesota, 3, 1893, p. 330; Zittel's Textb. Pal. (Engl. ed.), 1896, p. 268.

Zoarium forms hollow branches lined with a striated epitheca; zooecia are short, tubular and thick-walled; apertures are oval, oblique, with a hood-like lunarium.

Coeloclema piercecanum n. sp. Plate II, Figs. 1-2. The zoarium consists of hollow, cylindrical branches, lined with a wrinkled epitheca, and averaging 1 to 1.5 mm. in diameter. The inner cavity is usually filled with clay and fragments of foreign organic remains.

The lunaria are well developed, thick, distinct, and form four-fifths to nine-tenths of a complete circle about .1 mm. in diameter. The apices of the lunarium cause a decided constriction in the aperture and in a few cases nearly separate it, making the resemblance of the zooecial openings to the figure eight quite striking.

The zooecia are irregularly distributed over the surface, in some parts separated by mesapores, and in others, in contact on one or two sides; four to six zooecia occur in 2 mm. The zooecial tubes are short; the earlier portion is recumbent on the thecal membrane for a short distance and then turning outward, approach the surface perpendicularly.

Mesopores are irregular in shape and size and thick-walled as shown in tangential sections.

No diaphragms were observed in either the zooecia or mesopores.

Occurrence: Pierce limestone Walter Hill, Rutherford County, Tennessee.

Holotype: 238-14. Indiana University.

Coeloclema inflatum n. sp. Plate II, Figs. 3-5. The zoarium consists of hollow, cylindrical, branching stems, 1.5 to 2.5 mm. in diameter. The inner surface is lined with wrinkled epitheca and the cavity usually filled with fragments of foreign material. The zooecial layer is from .5 to .8 mm. in thickness.

Mesopores are few, small and unequally distributed among the zooecia, being more numerous in the inconspicuous maculae where they frequently separate the zooecial walls.

The apertures are oval and irregularly distorted forms surrounded by thick walls.

The lunarium is thin, broadly curved, often as wide as the short diameter of the aperture. The ends of the crescent are inflated, turn outward, and lie imbedded in the wall of the zooecia.

The primitive zooecia have thin walls, and lie along the thecal lining for a slight distance (.1 to .3 mm.), then turn outward and approach the surface nearly perpendicularly.

Diaphragms are absent in both zooecia and mesopores.

Occurrence: Pierce limestone, one and one-fourth miles south of Florence, Rutherford County, Tennessee.

Holotype: 240-20. Indiana University.

Coeloclema consimile n. sp. Plate II, Figs. 6-7. The zoarium consists of cylindrical, ramose, hollow stems from 1.5 to 2.5 mm. in diameter. The zooecial layer varies from .5 to 1 mm. in thickness and rises from a wrinkled epitheca.

The zooecial apertures are distorted ovals in cross-sections, with thick walls and almost completely separated by the numerous small mesopores and interstitial tissue.

The lunaria are thick, of slightly greater curvature than the walls of the aperture, and forms a semicircle. The attenuated ends of the crescent are bluntly rounded. Within the lunarial curve the aperture is narrowed sufficiently to accommodate the thickness of the lunarium, but is not distinctly constricted as in *Coeloclema pierceanum* n. sp.

The zooecial tubes in *C. consimile* bend outward in a more uniform and broader curve from the thecal membrane than in the associated forms.

Mesopores are more numerous in this species than in C. alternatum of the Eden of Cincinnati.

Occurrence: ,Pierce limestone, 1 mile southwest of Lascassas, Rutherford County, Tennessee.

Holotype: 241-17. Indiana University.

Genus Anolotichia Ulrich. Genotype: Anolotichia ponderosa Ulrich. Anolotichia Ulrich, Geol. Surv., Illinois, 8, 1890, pp. 381, 474; Geol. Minnesota, 3, 1893, p. 326; Zittel's Textb. Pal. (Engl. ed.), 1896, p. 268. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 24. Brabau and Shimer, N. A. Index Fossils, 1, 1907, p. 123. Bassler Bull. U. S. Nat. Mus., 77, 1911, p. 91; Zittel-Eastman Textb. Pal., 1913, p. 328.

Zoarium ramose, digitate, laminate or incrusting; zooecial tubes are comparatively large, subpolygonal, long and intersected by more or less remote diaphragms; lunarium slightly elevated at the surface and traversed internally by two to six minute vertical, closely tabulated tubes; mural pores present.

Anolotichia explanata n. sp. Plate III, Figs. 1-4. Zoarium is explanate, and lamellose, forming dome-like masses by the superposition of laminar expansions which vary from one to three mm. in thickness. The largest specimen observed is 70 mm. in diameter and from 10 to 30 mm. in depth.

The surface is smooth with about 5 inconspicuous maculae of large zooecia in one sq. mm.

The tangential section shows the zooecia to have large, direct, polygonal, relatively thin-walled apertures; four to five in 2 mm. Mesopores are few, occurring more frequently in the maculae than elsewhere. Lunaria are distinct crescents with ends projecting slightly into the zoecial cavity. Three to six vertical tubuli traverse internally each lunarium.

In the longitudinal section the zoecial tubes rise at an acute angle from a thin epithelium and bend almost immediately directly towards the surface. Thin complete diaphragms one to three tube diameters apart cross the zoecial tubes. The wall structure as shown in the figure, is characteristic of the genus.

Anolitichia explanata is distinguished from *A. ponderosa* and *A. impolite* by the form of the zoarium, and from the expansive species of the European types by its more robust growth, greater length of the zoecial tubes and more diaphragms.

Occurrence: Pierce limestone, Murfreesboro, Tennessee. 1¼ m. N. W.

of Salem, and $1\frac{1}{4}$ m. S. E. of Blackman, Rutherford County, Tennessee. Ridley limestone: Sulphur Springs, 4 m. N. W. of Murfreesboro, Tennessee.

Holotype: U. S. Nat. Mus.

Paratypes: 239-2, 3, 4, 5; 240-1, 23. Indiana University.

TREPOSTOMATA.

Family Monticuliporidae Nicholson (emended Ulrich).

The most important character of this family as defined by Ulrich is the occurrence of the cystiphragms in the zooecial tubes. In Mesotrypa and Orbignyella these structures appear as curved diaphragms. The zoarium has a lamellate, massive, ramose, bifoliate incrusting or frond method of growth.

Genus Monticulipora D'Orbigny. Genotype: Monticulipora D'Orbigny, Prodr. Pal., 1, 1850, p. 25. Edwards and Haime, Mon. British Foss. Corals, Pal. Soc., 1854, p. 264, footnote. Pictet, Traiti de Pal., 2d ed., 4, 1857, p. 443. Milne-Edwards, Hist. at. des Corall, 3, 1860, p. 272. Eichwald, Leth. Rossica, 1, 1860, p. 492. Salter, Cat. Camb. Sil. Foss., 1873, p. 108. Dekoninck, Nouv. Rech. Anim. Foss. Terr. Carb. Belgique, 1872, p. 141. Lindstrom, Ann. Mag. Nat. Hist., 4th ser., 18, 1876, p. 5. Nicholson, Pal. Tabulate Corals, 1879, p. 269. Zittel Handb. Pal., 1, 1860, p. 614. Nicholson, genus Monticulipora, 1881, p. 99. Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, pp. 153, 232. Roemer, Leth. geog., pt. 1, Leth. Pal., 1883, p. 468. Foord, Contr. Micro-Pal. Cambro-Sil., 1883, p. 7. Frech, zeits. d. d. geol. gesell., 37, 1885, p. 951. Waagen and Wentzel, Pa. Indica, 13th ser., 1886, p. 874. James, Amer. Geol., 1, 1888, p. 386. James and James, Jour. Cin. Soc. Nat. Hist., 10, 1888, p. 158. Miller, N. A. Geol. Pal., 1889, p. 197. Reminger, Amer. Geol., 6, 1890, pp. 102-121. Ulrich, Geol. Surv. Illinois, 8, 1890, pp. 370, 407; Amer. Geol., 10, 1892, p. 57; Ulrich, Geol. Minnesota, 3, 1893, p. 217. James, Jour. Cincinnati Soc. Nat. Hist., 15, 1893, p. 155; Zittel's Textb. Pal. (Engl. ed.), 1896, p. 103, 272. Lindstrom, Kongl. Sven. Vet. Akad. Handb., 32, No. 1, 1899, p. 52. Sardeson, Neues Jahrb. Min., Geol. Pal., Beilage-Band, 10, 1896, p. 347. Simpson, 14th Ann. Rep. State Geol. New York for 1894, 1897, p. 577. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 28. Procta, Syst. Sil. du Centre Boheme, 8, pt. 2, 1902, p. 312. Ulrich and Bassler, Smiths. Misc. Coll., Quart., 47, 1904, p. 15. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 127. Cumings, 32d Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 750. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 179; Zittel-Eastman Textb. Pal., 1913, p. 331.

Peronopora (in part) Nicholson, genus Monticulipora, 1881, p. 215.

The early reference given refer to Monticulipora in its broader sense at the time it contained a heterogeneous collection of species. Its present limitation is due to the work of Ulrich, which places the genus on a definite basis with the following principal differentiating characters: Cystiphragms occur both in the peripheral and axial region; the walls of the zooecia and mesopores have a granulose structure; acanthopores are usually numerous but may be wanting, having a granulose character, an indefinite outline, and no central perforation; mesopores are variable in number; diaphragms occur in both sets of tubes. The zoaria consist of frond, ramose, massive, laminate and incrusting types.

Monticulipora intersita, Ulrich and Bassler. Plate IV, Figs. 1-2. The zoarium consists of parasitic expansions, 1 to 3 mm. thick, with faintly distinguished clusters of larger zooecia on the surface.

The zooecia are thin walled and angular with the usual granular wall structure.

The diaphragms and cystiphragms are crowded much as in *M. discula* except that the opening left by the cystiphragms is nearly always open on one side and subtriangular in shape. Mesopores are abundant and closely tabulated, having generally three diaphragms in the same distance in which two cystiphragms occur in the zooecial tubes. Acanthopores are wanting.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: 43878, U. S. Nat. Mus.

Monticulipora discula, Ulrich and Bassler. Plate IV, Figs. 3-4. The zoarium forms small discs that are attached to foreign bodies. They are less than 12 mm. in diameter and about .5 mm. in thickness. The zooecia are thin walled, angular, and nine of the average size occur in 2 mm. A cross-section of the cystiphragms tangentially forms large oval openings. The zooecial tubes are crowded with diaphragms (3 to 4 in a tube diameter). Acanthopores are apparently wanting. Mesopores are very few and occur in clusters only.

Occurrence: Pierce limestone, Morfreesboro, Tennessee.

Holotype: (103) U. S. Nat. Mus.

Monticulapora compacta. Ulrich and Bassler. Plate IV, Figs. 5-6. The colony grows into an upright ramose zoarium with compressed solid branches. The surface is even with maculae of the larger zooecia rather indistinct.

There are eight to nine apertures in 2 mm. The wall and acanthopore structure is similar to the *M. incompta*. The acanthopores are strong, occurring at most angles of the zooecia and in various horizons within the axial region of the zooarium.

Mesopores are few and scattered.

Diaphragms and cystiphragms are closely crowded, 2 to 3 in a tube diameter in the axial region and becoming more numerous towards the surface where there are from 25 to 30 in 2 mm.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: (21) U. S. Nat. Mus.

Genus Orbignyella, Ulrich and Bassler. Genotype: Orbignyella sublamellosa Ulrich and Bassler. Orbignyella Ulrich and Bassler, Smiths. Misc. Coll. (quart. issue), 47, 1904, p. 18. Bassler, Bull. U. S. Geol. Surv., 292, 1906, p. 26; Bull. U. S. Nat. Mus., 77, 1911, pp. 181, 182.

Monticulipora (part) Ulrich. Jour. Cincinnati Soc. Nat. Hist., 5, 1822, pp. 153, 232; Geol. Surv. Illinois, 8, 1890, pp. 370, 407.

Zoarium consists of parasitic and laminate expansion which in some species rises into domed or globular masses. The wall structure resembles the Heterotrypidae more than the Monticuliporidae. The acanthopores are well developed and sharply defined. The cystiphragms, which appear as curved diaphragms, form the basis for the assignment of the genus to the family Monticuliporidae.

Orbignella nodosa. n. sp. Plate V, Figs. 1-2. The zoarium forms small and large incrusting expansions, that rise into nodular masses of irregular forms and sizes, by superposition of layers; nodules are unequally distributed. Slabs have been collected on which there are numerous colonies that are contiguous and overlap one another, forming an incrustal covering of many square inches. The nodules vary in height from .5 mm. to 10 mm., with a corresponding variation in width.

The surface is even; twenty-four maculae of large zooecia occur in one sq. cm.

The zooecia are polygonal, and have relatively thick wall; 8 to 9 occur in 2 mm. Mesopores are absent. Acanthopores are about as numerous as the zooecia, located at the tube angles, and of large size, causing slight inflection of the zooecial walls in most cases.

The zooecial tubes of each laminar expansion are about .7 mm. long, with 3 to 4 horizontal or from 1 to 3 cystoid diaphragms in the space of one tube diameter.

The nodular zoarium, lack of monticules, and more numerous cystoid diaphragms distinguish the species from *Obignyella weatherbyi*. *Orbignyella lamellosa* has large zooecia, less curved diaphragms, and much longer zooecial tubes than *O. nodosa*. The large acanthopores and zoarial forms of *O. nodosa* are distinct differences which separate it from *O. sublamellosa*.

Occurrence: Lebanon limestone, Big Springs, Rutherford County, Tennessee.

Holotype, 248-16. Indiana University.

Orbignyella multitabulata. n. sp. Plate V, Figs. 3-4. Zoarium, lamniated, depressed, conical domes, rising from a wide base. The lower surface of the mass is covered with a wrinkled epitheca. The type specimen is 9.5 cm. in diameter and 2.5 cm. high. The surface is smooth, with inconspicuous clusters of large zoecia.

Mesopores are very few, occurring in the maculae only. The zoecia are angular, thin-walled; 8 to 8½ in 2 mm. Large well developed acanthopores with distinct lumen are present at most every tube angle.

The zooecial tubes of a single lamina are 1 to 3 mm. long, crossed by 4 to 5 horizontal diaphragms in the space of one tube diameter. Cystoid, curved or infundibular diaphragms occur in every tube.

The crowded horizontal diaphragms, thickness of laminae, large acanthopores, and manner of zooecial growth, are a combination of characters not found in any other species of the genus yet described.

Occurrence: Pierce limestone; in sink hole at Almaville, Rutherford County, Tennessee.

Holotype: 244-17. Indiana University.

Genus Mesotrypa Ulrich. Genotype; Diplotrypa infida Ulrich. Diplotrypa (in part Nicholson, Paleozoic Tabulate corals, 1879, p. 312; genus Monticulipora, 1881, pp. 101, 155. Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 153. Foord, Contr. Micro-Pal. Cambro-Sil., 1883, p. 13. Ulrich Geol. Surv. Illinois, 8, 1890, p. 378.

Mesotrypa Ulrich, Geol. Minnesota, 3, 1893, p. 257. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, p. 30. Bassler, Bull. U. S. Geol. Surv., 292, 1906, p. 27. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 130. Hennig, Archiv. fur Zool., 4, No. 21, 1908, p. 29. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 196.

Zoarium hemispheric, conical, discoidal or incrusting. It is generally free with an epithica covering the base; zooecia are polygonal or circular with curved, and sometimes funnel-shaped diaphragms, which are probably modified cystiphragms; zooecia more or less separated by angular mesopores, which become smaller with age, and are intersected by numerous diaphragms; acanthopores generally present.

Mesotrypa crustulata n. sp. Plate V, Figs. 5-6. The zoarium of this species forms incrusting expansions about 2 mm. in thickness. In the type specimen the zoarial mass consists in part of superimposed layers and attains a height of 8 to 10 mm. On the surface small low monicules of large zoecia and numerous mesopores are irregularly distributed, varying from 1 to 3 mm. apart. In places the surface rises into conical-like tubercles .5 to 1 mm. high, and from 8 to 12 mm. apart.

The zoecia are thick-walled at the surface, circular, regularly arranged, and in contact on 3 or 4 sides; 7½ to 8 intermonticular and 5½ monticular zooecia occur in 2 mm.

The acanthopores are small, inconspicuous, and unequally distributed, 6 to 7 about a zooecia in some areas and in others no acanthopores are present.

Mesopora are abundant; more numerous at the base than in the mature zone. Diaphragms are closely set; 13 to 15 in the distance of one mm.

The diaphragms in the zooecia are in rather definite parallel transverse horizons, separated by a distance equal to 1½ to 2½ tube diameters. Two to six diaphragms ¼ to ½ tube-diameters apart are present in each zooecia at the elevation of the common horizons. Curved and cystoid diaphragms occur in the mature part of the zooecial tube only.

The segregation of the small and inconspicuous acanthopores into areas closely associated with the monticular zooecia, the zonal arrangement of the diaphragm and the localization of the curved and cystoid diaphragms in the peripheral portion of the zoarium are the conspicuous differentiating characters of the species.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: (92) U. S. Nat. Mus.

Mesotrypa dubia. n. sp. Plate VI, Figs. 1-2. Zoarium consists of thin expansions 2 mm. in thickness. Small inconspicuous maculae, consisting of zooecia slightly larger than the average and less number of mesopores than are present in the intermacular area, occur on the surface at intervals of 2 mm.

Mesopores are abnudant, slightly beaded, irregular in shape, size and distribution; about 15 diaphragms cross the tubes in the distance of one mm.

The zooecia are relatively thin-walled, subcircular or polygonal, in contact on 2 or 3 sides mostly, less frequently on four; 7 or 8 occur in 2 mm.

The acanthopores are few and of medium size. There are rarely more than one or two in two square mm. The central lucid spot is distinct; the outer boundary is definite.

Curved and horizontal diaphragms are present throughout the zooecial tube, separated from ½ to 1 tube-diameter apart.

The irregular distributed zooecia and mesopores, the few acanthopores of medium size, and form of zoarium are distinguishing combination of characters for this species.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: (93) U. S. Nat. Mus.

Family Heterotrypidae Ulrich.

This family includes those trepostomatous bryozoans having zooecia with straight diaphragms, clearly defined acanthopores, and walls of a dual character; the outer wall is amalgamated with the outer one of the adjacent zooecia and shown as a light colored band lying between the inner and distinctly zooecial walls of darker and finely laminated tissue.

Dekayella Ulrich. Genotype: Dekayella obscura Ulrich. Dekayella Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 155; ibid., 6, 1883, p. 90. Miller, N. A. Geol. Pal., 1889, p. 184. Ulrich, Geol. Surv. Illinois, 8, 1890, p. 372; Geol. Minnesota, 3, 1893, p. 269; Zittel's Textb. Pal. (Engl. ed.), 1896, p. 273. Simpson, 14th Ann. Rep. State Geol. New York for 1894, 1897, p. 589. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 31. Cumings, Amer. Geol., 29, 1902, p. 200. Ulrich and Bassler, Smiths. Misc. Coll., 47, 1904, p. 24-27. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 132. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 205; Zittel-Eastman Textb. Pal., 1913, p. 333.

This genus has been briefly and adequately described by Ulrich and Bassler in 1904 as follows:

"Zoarium erect, ramose or frondescent; two sets of acanthopores, large and small; mesopores variable, generally more or less numerous; diaphragms numerous."

Dekayella ridleyana, n. sp. Plate VI, Figs. 3-4. The zoarium consists of large, thick, irregular fronds. The type specimen varies from 8 to 12 mm. in thickness. The greatest observed height is 80 mm.

The surface is even and maculae of large mesopores are small and inconspicuous.

The zooecia are polygonal, thick walled; 9 to 9½ apertures in 2 mm.

Mesopores are few and seldom observed in shallow tangential sections of old specimens.

Acanthopores are numerous, 2 to 6 about a zooecium, and of two sizes.

In the tangential sections the walls appear amalgamated and a distinct crenulation is observed from the longitudinal section in the axial region.

Diaphragms are few and unequally distributed in the immature zone and close set in the mature where 2 to 4 cross the tube in the space of one tube diameter.

The method of growth of this species distinguishes it from the associated forms.

Occurrence: Ridley limestone, 2½ miles northwest of Salem, Rutherford County, Tennessee.

Holotype: 245-6, 10. Indiana University.

Genus Heterotrypa Nicholson. Genotype: Monticulipora frondosa D'Orbigny. Heterotrypa (in part) Nicholson, Pal. Tabulate Corals, 1879, p. 291; genus Monticulipora, 1881, pp. 101, 103. Zittel, Handb. Pal., 1, p. 615. Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 155; ibid., 6, 1883, p. 83. Foord, Contr. Micro-Pal. Cambro-Sil., 1883, p. 20. Ulrich, Jour. Cincinnati Soc. Nat. Hist., 6, 1883, pp. 83-85. Roemer, Leth. geog., pt. 1, Leth. Pal., 1883, p. 471. Rominger, Amer. Geol., 6, 1890, pp. 114, 119. Ulrich, Geol., Surv. Ill., 8, 1890, pp. 371, 413; Geol. Minnesota, 3, 1893, p. 267. Zittel's Textb. Pal. (Engl. ed.), 1896, p. 104. Ulrich, Zittel's Textb. Pal. (Engl. ed.), 1896, p. 273. Simpson, 14th Ann. Rept. State Geol. New York for 1894, 1897, p. 579. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 31. Cumings, Amer. Geol., 29, 1902, p. 199. Ulrich and Bassler, Smith. Misc. Coll., Quart., 47, 1904, pp. 24, 25. Bassler, Zittel-Eastman Textb. Pal., 1913, p. 333.

Zoarium erect (ramose or) frondescent; acanthopores of one kind; small; mesopores varying in number, generally abundant, sometimes wanting almost entirely. With the addition of the words enclosed in parenthesis the description of the genus is taken from the "Revision of the Paleozoic Bryozoa" by Ulrich and Bassler.

Heterotrypa patera n. sp. Plate VI, Figs. 5-6. Zoarium ramose, about 5 to 10 mm. in diameter. Surface is smooth, with small maculae composed of mesopores, surrounded by zooecia slightly larger than the average; about 4 in ¼ sq. cm.

Tangential sections show the zooecia to be subcircular and thick-walled. A very thick cingulum consisting of laminated secondary tissue, surrounds each aperture. A thin dark line separates the cingulum from the true zooecial wall which forms an angular boundary between the zooecia and appears finely granular, light colored and amalgamated. The acanthopores are small, with a distinct, minute central lucid spot and an indefinite outer boundary; 5 to 10 among 10 zooecia.

The zooecia in the axial region are crossed by diaphragms from 1 to 3 tube-diameters apart. From the immature region the zooecial tubes proceed outward in a gradual curve, increasing sufficiently in the peripheral zone to cause the zooecia to open perpendicularly at the surface. The walls and cingulum increase in thickness from the early mature region to the periphery, closing the mesopores and rounding the apertures of the zooecia. Two to three diaphragms occur in the zooecia of the mature zone in the distance of one-tube diameter.

Many of the characters of *H. patera* are very similar to *H. microstigma* from the Richmond, but the much less number of acanthopores and the absence of inflections of the zooecial walls by the acanthopores in H. patera serve to differentiate them.

Occurrence: Pierce limestone: 2 miles northwest of Murfreesboro, Tennessee, at Stokes Gannon's ford.

Holotype: 242-4. Indiana University.

Heterotrypa stonensis n. sp. Plate VIII, Figs. 1-2. Zoarium ramose; 7 to 15 mm. in diameter. The surface is smooth; monticules are absent; small inconspicuous maculae of clusters of large zooecia are numerous, .2 to .5 mm. across and 2 to 2.5 mm. apart, measured from center to center.

The zooecia are thick-walled, and subcircular. A completely developed cingulum is present in each zooecia. The true zooecial wall is angular, finely granular, amalgamated and separated from the cingulum by a distinct dark line of contact; 8 to 9 zooecia occur in 2 mm.

The acanthopores are of medium size, with indefinite boundary; 2 to 3 about each zooecia. The central lumen is very small and mostly indistinct.

Mesopores are very few, being absent in most of the tangential sections.

The zooecial tubes in the immature region are thin-walled and crossed by very few diaphragms. They turn outward in a slight curve to the initial mature region where the bending is subangular and short. Thruout the deep mature zone the tubes proceed directly to the surface.

Diaphragms in the mature region are spaced about one-fourth to one-half tube diameter apart. Coalesced and infundibular diaphragms are present.

The scarcity of diaphragms in the axial region, the thinner cingulum and inconspicuousness and zooecial composition of the maculae of *Heterotrypa stonensis* separates it from *H. patera*.

The greater abundance of acanthopores, presence of numerous diaphragms in the axial region and the well developed maculae of *H. microstigma* distinguish it from *H stonensis*.

Occurrence: Pierce limestone; two miles northwest of Murfreesboro, Tenn., at Stokes Gannon's ford.

Holotype: 242-5. Indiana University.

Family Constellaridae. Ulrich.

The zooarium is ramose, frondescent, laminar or incrusting. The stellate maculae is probably the most obvious character of this family but greater importance is assigned to the granular wall structure in the mature region, and the presence of hollow spines or granules which occur in the place of true acanthopores. Mesopores are angular and usually abundant.

Genus Constellaria Dana. Genotype: Ceriopora constellata (Van Cleve, M. S.), Dana. Constellaria Dana, Zoophyta, 1846, p. 537. Edward and Haime, Mon. d. Polyp. Foss. d. Terr. Pal. (Arch. Mus. d'Hist. Nat., 5), 1851, pp. 154, 278. Pictet, Traite de Pal., 2d ed., 4, 1857, p. 154. Nicholson, Pal. Ohio, 2, 1875, p. 214; Pal. Tab. Corals, 1879, p. 292. Zittel, Handb. Pal., 1, 1880, p. 615; Genus Monticulipora, 1881, p. 97. Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 156; 6, 1883, p. 265. Roemer, Leth. geog., pt. 1, Leth. Pal., 1883, p. 485. James and James, Jour. Cincinnati Soc. Nat. Hist., 11, 1888, p. 29. Ulrich, Geol. Surv. Illinois, 8, 1890, pp. 374, 423. Rominger, Amer. Geol., 6, 1890, p. 113. Ulrich, Geol. Minnesota, 3, 1893, p. 311; Zittel's Textb. Pal. (Engl. ed.), 1896, p. 276. J. F. James, Jour. Cincinnati Soc. Nat. Hist., 18, 1896, p. 117. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 34. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 135. Cumings, 32d Ann. Rept., Dept. Geol. Nat. Res. Indiana, 1908, p. 742. Bassler, Bull. U. S. Nat. Mus., 77, 1911, pp. 218, 219; Zittel-Eastman Textb. Pal., 2d ed., 1913, p. 334. Stellipora Milne-Edwards Hist. Nat. des Corall, 3, 1860, p. 281 (in part). Dybouski, Du Chaetetiden d. Ostbalt, Silur.-Form., 1877, p. 42.

The following definition is from the Zittel-Eastman textbook as given by Bassler:

"Zoaria growing erect (into solid branches) from attached local expansion. Surface with depressed stellate maculae, the spaces between the rays elevated and occupied by two or three short rows or clusters of closely approximated zooecial apertures. Mesopores aggregate in the maculae, internally with gradually crowding diaphragms."

The words in parentheses were added by the author.

Constellaria lamellosa n. sp. Plate VII, Figs. 3-5. The zoarium consists of thin laminar expansions, .3 to 1.5 mm. in thickness. The base is covered with a wrinkled epitheca that assumes the general form of the object upon which the colony grows. Cylindrical, tubular stems grow upward from the expanded portion.

The maculae are irregular stellate, aggregations of mesopores that are raised slightly above the surface; about 9 in 1/4 sq. mm. The macular rays are of variable size and shape and extend between clusters of contiguous subangular zooecia. The intermacular zooecia are circular and completely separated by mesopores; about 8 in 2 mm.

Diaphragms in the zooecial tubes are few, more numerous in the peripheral region than in the earlier portion. The mesopores are crowded with diaphragms throughout, about 7 in .5 mm. The mesopores originate in the early primitive zone and extend to the surface.

The internal structure of this species agrees completely with the generic description, and for that reason is assigned to Constellaria. The manner of growth of the zoarium is quite different from any other described species of the genus.

Occurrence: Pierce limestone, Murfreesboro, Tennessee; 1 mile southwest of Lascasses, at Stones River Bridge, Rutherford County, Tennessee.

Holotype: 53993 U. S. Nat. Mus.

Paratypes: 241,—10, 24, 25; 245-15. Indiana University.

Genus Nicholsonella Ulrich. Genotype: Nicholsonella ponderosa Ulrich.

Nicholsonella Ulrich, Geol. Surv. Illinois. 8, 1890, pp. 374. 421. Miller, N. A. Geol. Pal., 1889, p. 313. Ulrich, Geol. Minnesota, 3, 1893. p. 313; Zittel's Textb. Pal. (Engl. ed.), 1896, p. 276. Simpson, 14th Ann. Rept. State Geol. New York for 1894. 1897, p. 590. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900. p. 34. Bassler, Bull. U. S. Geol. Surv., 292, p. 37. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 136. Cumings, 32d Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 751. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 224; Zittel-Eastman Textb. Pal., 1913, p. 334.

Zoaria consist of flattened branches, fronds or laminations. Mesopores are usually numerous. The walls of both zooecia and mesopores are traversed longitudinally by minute tubuli, which appear at the surface as granular acanthopore-like structures. A calcareous deposit in the outer zone obscures the walls of the mesopores. Because of the granular structure which is present in the outer zone of specimens of this genus it has been referred to the family Constellaridae.

Nicholsonella frondifera, n. sp. Plate VII, Figs. 6-7. The zoarium consists of wide flattened frond-like growths, 30 to 50 mm. wide, from the margin of which rise branches 15 to 20 mm. wide that frequently divide and anastomose. The thickness of the branches varies from 5 to 11 mm. The highest specimen seen measured 10 cm.

The surface is even and granulose. The zooecia of the mature zone are circular, completely separated by mesopores. Five to seven large, distinct, granular masses (cross-section of longitudinal tubuli in tangential sections) surround each zooecium.

The internal structure as seen from the longitudinal section is similar to *Nicholsonella pulchra* with the exception that diaphragms are more numerous in the mesopores of the mature region and the longitudinal tubuli are larger, fewer, and more clearly defined in *N. frondifera.*

The habit of growth in addition to the different internal characters separates *N. frondifera* from *N. pulchra*, its associated species.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Ridley limestone: Almaville; 2 m. W. of Lascasses; South side of Marshall Knob; 2½ m. NW. of Salem; Rutherford County, Tennessee.

Lebanon limestone: Big Springs, Rutherford County, Tennessee.

Holotype: 54043 U. S. Nat. Mus.

Paratypes: 244-3, 4, 5. Indiana University.

Family Halloporidae Bassler.

(Calloporidae Ulrich)

This family includes trepostomatous bryozoans with ramose, subfrondescent, massive or discoidal zoaria, having zooecial tubes that are thin-walled, attaining full size slowly, tabulated in the attenuated proximal end, and separated more or less completely by angular mesopores. Acanthopores are wanting.

Genus Hallopora Bassler. Genotype: Callopora elegantula Hall. Callopora Hall, Amer. Jour. Sci., ser. 2, vol. ii, 1851, p. 400; Pal. New York, 2, 1852, p. 144. Nicholson, Pal. Province, Ontario, 1874, p. 61; Geol. Mag., N.

S., 1, 1874, p. 13. Hall, 28th Ann. Rept. New York State Mus., 1879, p. 114. Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, pp. 154, 251. Foerste, Bull. Sci. Lab. Denison Univ., 2, 1887, p. 172. Hall and Simpson, Pal. New York, 6, 1887, p. 15. Miller, N. A. Geol. Pal., 1889, p. 295. Ulrich, Geol. Surv. Illinois, 8, 1890, pp. 372, 416; Geol. Minnesota, 1893, 3, p. 275; Zittel's Textb. Pal. (Engl. ed.), 1896, p. 275. Simpson, 14th Ann. Rept. State Geol. New York for 1894, 1897, p. 588. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, pp. 36, 186. Grabau, Bull. Buffalo Nat. Sci., 7, 1901, p. 167; Bull. New York State Mus., 9, 1901, p. 167. Cumings, 32d Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 741. Bassler, Bull. U. S. Geol. Surv., 292, 1906, pp. 40. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 139. Henning, Archiv. für Zoöl., 4, 1908, p. 48. Hallopora Bassler, Bull. U. S. Nat. Mus., 77, 1911, pp. 325-326; Zittel-Eastman Textb. Pal., 1913, p. 337.

Zoaria ramose and bushy and often anastomosing. The zooecia are thin-walled in the immature region, and attain full development slowly. Diaphragms are closely arranged in the tapering proximal portion of the zooecial tube, few or absent in the middle part, and few to numerous in the mature peripheral region. The apertures of the zooecia in the perfect state are closed by perforated ornamental covers which form diaphragms as the growth of the zooecial proceed. Acanthopores are absent.

Hallopora spissata n. sp. Plate VIII, Figs. 1-2. Zoarium consists of irregularly ramose, subcylindrical branches 5 to 10 mm. in diameter and from 1 to 2 cm. in length. The surface is smooth; maculae are absent. Zooecia are direct, angular, and thick-walled; 4 or 5 in 2 mm. Mesopores are entirely absent at the surface in completely matured specimens.

In the tangential sections the zooecia are polygonal and in contact with each other on all sides. In sections of the surface of the submature zone or in tangential sections of immature specimens the zooecia are subcircular, separated at some of the angles by intercellular spaces (mesopores). Where the walls of adjacent zooecia are in contact the boundary between them is marked by a well defined dark line.

The vertical sections show that few mesopores in which diaphragms are closely arranged are present at the bend from the immature to the mature region. They seldom reach the surface except in young specimens. In the axial region the narrow tapering zooecia which are scarcely wider than the mesopores are crowded with diaphragms. They are absent in the completely developed zooecial tubes of the submature portion and in some of the zooecia of the mature zone. From one to three diaphragms usually are present near the bend of the immature and mature portions. The peripheral zone is narrow, varying from ¾ to 1 mm. The walls thicken rapidly from the bend toward the surface, closing the mesopores and making the apertures subcircular.

Hallopora spissata differs from *H. splendens* in having a narrower mature zone, less number of diaphragms in the submature and mature portions of the zooecial tubes and much thicker walls at the periphery of mature specimens. The less number of diaphragms, thicker walls and more direct apertures distinguish this species from *H. ampla*.

Occurrence: Pierce limestone: Murfreesboro, Tennessee; Ward's Mill and Almaville, Rutherford County, Tennessee.

Holotype: Cat. 44519 U. S. Nat. Mus.

Paratypes: 238-22, 23, 24, 25; 244-8, 9, 18; 245-18. Indiana University.

Hallopora florencia n. sp. Plate VIII, Figs. 3-4. Zoarium forms subcylindrical branches, 1.5 to .3 mm. in diameter. The surface is smooth and without maculae.

The zooecia are oval, thin-walled, 7 to 8 in 2 mm. and usually in contact on two sides only.

Mesopores are numerous and crossed by close-set diaphragms.

In the axial region diaphragms are present in the zooecial tubes from the proximal ends to the beginning of the decided curvature in the early submature region, and average one tube diameter apart. In the remaining portion diaphragms are very few or absent and when present they occur near the periphery. This character is known to be persistent from the study of the numerous sections of separate localities and is considered worthy of the recognition accorded it here.

The zoarium of this species is similar in size to *H. dumalis*, but the diaphragms in *H. dumalis* occur throughout the zooecial tube.

Occurrence: Pierce limestone, 1¼ miles southwest of Florence, Rutherford County, Tennessee.

Holotype: 240: 13. Indiana University.

Family Trematoporidae Ulrich.

Zoaria ramose, incrusting or massive. The zooecial tubes in the axial region are thin-walled, and usually constricted where the diaphragms occur; wall thickened in the mature region; the divisional line of contact zooecia is conspicuous. Acanthopores are more or less abundant. Mesopores are usually numerous, of large size, and with apertures closed.

The beaded form of the zooecial tubes and mesopores formed by the constrictions of the walls when diaphragms occur, the crinulation of the walls in the axial region, and the general looseness and obscurity of the structure are characters quite unlike that of any other family of the integrated Trepostomata.

Genus Batostoma Ulrich. Genotype: Monticulipora (Heterotrypa) implication Nicholson. Bastosma Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 154. Foord, Contr. Micro-Pal. Cambro-Sil., 1883, p. 17. Miller, N. A. Geol. Pal., 1889, p. 294. Ulrich, Geol. Surv. Illinois, 8, 1890, pp. 379, 459; Geol. Minnesota, 3, 1893, p. 288; Zittel's Textb. Pal. (Engl. ed.), 1897, p. 275. Simpson, 14th Ann. Rept. State Geol. New York for 1894, 1897, p. 588. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 35. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 136. Cumings, 32d Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 740. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 272; Zittel-Eastman Textb. Pal., 1913, p. 338.

The zoarium is ramose, branching irregularly from an expanded base. The zooecial walls in the immature region are thin and irregularly flexuous.

In the mature region they are much thickened, ring-like, and seldom in contact. Diaphragms are few or wanting in the axial portion, but more abundant in the peripheral zone. Mesopores are numerous or few, of irregular shapes and sizes, and closed at the surface. Acanthopores are mostly large and abundant with a conspicuous lumen.

Batostoma libana (Safford). Plate VIII, Figs. 5-7. *Stenopora libana* Safford, Geol. Tenn. 1869, p. 285. This species was described by Safford as "like (S.) fibrosa, but with cell-tubes much larger." The following notes are based on specimens and photographs furnished by the U. S. Nat Mus. and sections of several specimens personally collected in Rutherford County, Tennessee.

The zoarium consists of smooth, strong, irregularly arranged branches, 8 to 12 mm. in diameter. Maculae are present, 7 to 8 in one sq. mm., distinguished by the larger size of the zooecia.

In tangential sections the zooecia appear angular, thin-walled, nearly everywhere in contact and 4 to 5 in 2 mm. A definite dark line separates the walls of adjacent zooecia. Mesopores are few, and those present have the appearance of young zooecia. Acanthopores are small, located at the junction angles, and less numerous than the zooecia.

In the longitudinal section the most striking features are the scarcity of diaphragms in the immature region, the narrow mature zone, and the acute angle of approach of the zooecia to the surface following a decided and short bend of the tubes from the immature to the mature region. Diaphragms are few in the peripheral zone, separated from one another by one-half to one tube diameter, and located near the abrupt bend of the zooecial tubes. They are rare or absent in the axial region.

The less number of mesopores, the smooth zoarium, and the acute angle of approach of the zooecial tubes to the surface following the short bend from the immature to the mature region distinguish this species from B. magnopora in which the tubes proceed towards the surface in a very gentle curve until they enter the peripheral region.

Occurrence: Lebanon limestone of Central Tennessee.

Holotype: 44693 U. S. Nat. Mus.

Paratypes: 247-2, 3, 4; 242-1. Indiana University.

Batostoma subcrassum n. sp. Plate IX, Figs. 1-3. Zoarium is ramose, subcylindrical or a little compressed, 5 to 10 mm. in the greater diameter. The surface is smooth with maculae (10 to 12 in one sq. mm.) distinguished by clusters of large zoecia about an apparently solid area which consists of mesopores, as shown in tangential sections.

The zoecia in the surface sections are subangular, thick-walled, in contact at nearly all sides and 4 to 5 in 2 mm. Mesopores are small, few, situated mostly at the angles of contact of the macular zoecia. Acanthopores are few, inconspicuous, and at the junction angles. The walls of contiguous zoecia are separated by a distinct dark line in perfectly preserved surfaces.

In the axial region at the proximal tapering ends of the young zoecia the walls are wavy, constricted at the diaphragms. In the completely developed zoecia of the axial region the diaphragms are from 2 to 5 tube-diameters apart with no constriction of the walls. The zoecia proceed forward in a broad curve and approach the surface at an acute angle. Diaphragms are more numerous in the mature zone than elsewhere, 2 to 3 in one tube-diameter with occasionally 1 or 2 incomplete ones in some of the zoecial tubes; the free portion is supported by the next diaphragm below. Mesopores are few, beaded, of irregular shapes and sizes, present in the submature and mature region.

Batostoma subcrassum is distinguished from *B. magnopora* in the singular approach of the zooecia to the surface, the thicker walls, more numerous diaphragms in the axial region and the absence of monticules.

Occurrence: This species is abundant in the Pierce limestone, one and three-fourths miles north of Eagleville, Rutherford County, Tenn.

Holotype: U. S. Nat. Mus.

Paratype: 242-7. Indiana University.

Batostoma dendroidea n. sp. Plate IX, Figs. 4-5. Zoarium has an even surface (spinulose in well preserved specimens), short branches, irregularly arranged, varying from 3 to 10 mm. in diameter, but in most specimens 5 to 8 mm. The numerous short branches give a knotty appearance to the zoarial mass.

The zoecia are angular, thick-walled, nearly everywhere in contact, and 7 to 8 in 2 mm. The apertures are subangular to circular. Mesopores are few, 1 to 2 among 10 zoecia. Acanthopores are numerous, 4 to 6 about each aperture, located at nearly all junction angles and occasionally between contiguous zoecia, inflecting the walls.

In the axial region the diaphragms are numerous in the attenuated end of the zoecial tubes and very few or absent in the zoecia that have attained full size. The tubes pass into the mature zone with a symmetrical curve and proceed to the surface nearly perpendicularly.

The mature zone is narrow, with 2 to 3 diaphragms crossing the zoecia in the distance of a single tube diameter. A few of the diaphragms are incomplete and coalesced with one another. The walls are greatly thickened, separated by a conspicuous median dark line. Acanthopores in the vertical section are distinct, many originating in the early mature region and do not reach the surface. In the mesopores, some of which develop into zoecia, five diaphragms occur in the distance of the diameter of a zoecial tube.

This species possesses several characters similar to *B. winchelli*, from which it can be distinguished by scarcity or lack of diaphragms in the full sized zoecia of the axial region.

Occurrence: Common in the Pierce limestone: Murfreesboro, Walter Hill, Wards Mill, Lascasses, Rutherford County, Tennessee.

Holotype: 44731 U. S. Nat. Mus.

Paratypes: 241—14, 15; 246—1. Indiana University.

Batostoma ramosa n. sp. Plate IX, Figs. 6-7. Zoarium is smooth, ramose, dividing every 10 mm. into subcylindrical solid branches, 4 to 6 mm. in diameter. Maculae of clusters of large zoecia are rather numerous, 6 in one-fourth of 1 sq. mm.

Zoecia are subangular, 8 to 8½ in 2 mm., contiguous on the sides only and separated at most angles by intercellular spaces (mesopores) of irregular shapes and sizes, in surficial sections of mature specimens. In tangential sections of the submature region or of young specimens the zoecia are angular and thin-walled; mesopores are few.

Acanthopores are distinct, located at the junction angles and between contact zoecia, occasionally inflecting the walls; 4 to 5 among 10 zoecia.

In the longitudinal section the zoecia of the axial region are thin-walled, crossed by diaphragms, few in number, and arranged in zones, convex upward, which probably bears a relation to periods of less rapid growth. The zoecial tubes turn outward in a slight curve to the initial portion of the thin mature region where the bending is short, angular and sufficient to permit the zoecia to approach the surface perpendicularly. The walls of the zoecia on the mature zone thicken slightly and are separated by a distinct median dark line. A single diaphragm (absent in some zoecia) is present near the turn of the zoecia from the submature to the mature zone.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: 44707 U. S. Nat. Mus.

Batostoma conferta n. sp. Plate X, Figs. 1-3. Zoarium consists of ramose subcylindrical solid stems 5 to 6 mm. in diameter. Maculae and monticules are absent. Acanthopores are large, sharply defined and irregularly distributed about the zoecia. Four to eight usually surround a single zoecium and inflect one or all of the walls of contiguous tubes.

In the tangential section the zoecia are thick-walled, polygonal, six to six and one-half in 2 mm., with an occasional mesopore. There is a distinct median dark line separating the walls. In the axial region the zoacial tubes are thin-walled. Diaphragms are rare or absent in immature region, but numerous in the late submature region and in the mature zone; 3 to 5 occur in the space of one tube diameter. Incomplete and coalesced diaphragms are rather abundant in each zoecial tube.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: 44736 U. S. Nat. Mus.

Paratype: 249-9. Indiana University.

Batostoma inutilis n. sp. Plate X, Figs. 4-5. Zoarium is smooth ramose dividing dichotomously every 6 to 8 mm. into compressed branches 4 to 5 mm. in greatest diameter.

Zoercia are polygonal to circular, 7½ to 8 in 2 mm. Mesopores are abundant in some parts of the mature zone, separating the zoecia completely, and in other area, they occupy the angular spaces only. The acanthopores are of medium size, distinct and few, one among ten zoecia. They occasionally inflect the zoecial walls.

In the axial region, the walls of the zoecia are thin and wavy. Mesopores are absent and diaphragms are very rare. The tubes proceed to the mature region in an undulating curve. A decided increase of curvature, the slight thickening of the walls, and the origination of an abundance of beaded mesopores mark the initial periphery zone. A few thin diaphragms occur in some of the zoecial tubes in the mature region and in others they are absent. A distinct median lamina separates the zoecial walls.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: 44708, U. S. Nat. Mus.

Genus Diplotrypa Nicholson. Genotype: Favosites petropolitanus Pander. Diplotrypa Nicholson, Pal. Tab. Corals, 1879, pp. 101, 155. Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 153. Foord, Contr. Micro-Pal. Cambro-Sil., 1883, p. 13. Roemer, Leth. geog., 1, Leth. Pal., 1883, p. 472. Miller, N. A., Geol. Pal., 1889, p. 187. Ulrich, Geol. Surv. Illinois, 8, 1890, pp. 378, 457. Rominger, Amer. Geol., 6, 1890, pp. 116-119. Ulrich, Geol. Minnesota, 3, 1893, p. 285; Zittel's Textb. Pal. (Engl. ed.), 1896, p. 275; also (not Ulrich) p. 104 (in part). Nickles and Bassler, Bull. U. S. Geol. Surv., 173, p. 36. Bassler, Bull. U. S. Geol. Surv., 292, 1906, p. 47; Zittel-Eastman Textb. Pal., 1913, p. 338; Bull. U. S. Nat. Mus., 77, 1911, pp. 312, 313. Callopora (not Hall) Dybouski, Du Chaetetiden d. Ostb. Silur.-Form., 1877, p. 106.

The zoarium of Diplotrypa is massive, or discoid and generally free, consisting of large prismatic zoecial tubes with thin walls. Mesopores are always present, but variable in number and size. Complete, horizontal diaphragms are present in both the zoecia and mesopores. Acanthopores are wanting.

Diplotrypa catenulata n. sp. Plate X, Figs. 6-7. Zoarium massive, discoid, 2½ to 4 cm. in diameter and ½ to 2½ cm. in thickness. The base is circular, covered with thin concentrically wrinkled epithelium. The zoecial apertures are large and polygonal: 4 to 4½ in 2 mm. Mesopores are few and of various shapes and sizes.

In the longitudinal section the tube-walls are thin and beautifully crenulated. The mesopores originate as catenated chambers, enlarging and developing into tubes similar to zoecia as they approach the periphery. The diaphragms of the zoecia are spaced from 2 to 4 tube diameters apart in the immature region and about one tube diameter apart in the mature zone. In the mesopores diaphragms are present at the constrictions.

The form of the zoarium, the large zoecia, crenulated walls and irregularly beaded mesopores are a group of characters that distinguish this species from any other species of the genus.

Holotype: 44658 U. S. Nat. Mus.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Genus Stromatotrypa Ulrich. Genotype: Stromatotrypa ovata Ulrich. Stromatotrypa Ulrich, Geol. Minnesota, 3, 1893, p. 301. Miller, N. A. Geol. Pal., 2d App., 1897, p. 758. Nickles and Bresler, Bull. U. S. Geol. Surv., 173, p. 35. Grabau and Shimer, N. A. Index Fossils, 1, p. 137.

Zoaria consist of laminated expansions growing upon foreign bodies, and of globuler masses in which the zoecial tubes radiate from a small base covered with epitheca. The zoecia have thin walls and are crossed by few diaphragms. Mesoposes are abundant in the basal portion, decreasing in size and numbers in the peripheral region of mature specimens. They are closely tabulated and bead-like. Acanthopores are present, having a distinct lucid center (lumen).

Stromatotrypa lamellata n. sp. Plate XI, Figs. 1-2. The zoarium consist of superimposed layers varying from 1 to 2 mm. in thickness. The base is covered with a wrinkled epitheca. The surfaee is even and without distinct maculae.

The zoecia are large, 4 to 5 in 2 mm., irregular in size and shape. When the mesopores separate the zoecia completely, they are oval or subcircular, and where the mesopores are few or absent the zoecial tubes are elongate polygons as seen in the tangential section.

From 3 to 7 acanthopores surround each zoecia and inflect the walls. They arise in the early mature zone, increase in size rapidly, and then taper gradually to their extremity which projects above the zoöidal cavity in perfectly preserved specimens.

The zooecial tubes are short and slightly inclined in the proximal region. The diaphragms are few, varying from .5 to 1 tube diameter apart. The mesopores are more numerous in the basal zone than in the mature portion and are crossed by relatively few and irregularly spaced diaphragms.

This species differs from the laminated form in the Black River of Minnesota in having less number of mesopores with fewer diaphragms; more angular zoecia and pronounced inflection of the zoecial walls by the well developed and relatively thick-walled acanthopores.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: 44718, U. S. Nat. Mus.

Stromatotrypa incrustans n. sp. Plate XI, Figs. 3-4. Zarium forms thin incrustations (from .5 to 1 mm. in thickness) upon foreign bodies. The surface is smooth and without maculae.

The zoecia are subangular, relatively thick-walled for the genus; 6 to 7 in 2 mm. Mesopores are few, occurring mostly at the junction angles of the zoecial tubes.

The acanthopores are about as numerous as the zoecia; of large size; thin dark wall, and a large central lucid area. They originate near the base of the zoarium and extend to the surface as well developed structures. In the zoecia there are three to four diaphragms. in the space of one tube diameter, and about twice that many in the mesopores.

The smaller size and thicker walls of the zoecia, the less numbers of mesopores and larger and fewer acanthopores separate this species from *Stromatotrypa lamellata* n. sp.

Occurrence: Pierce limestone, at ford 1¼ mile southeast of Blackman, Rutherford County, Tennessee.

Holotype: 245—14. Indiana University.

Stromatotrypa regularis n. sp. Plate XI, Figs. 5-6. The zoarium consists of thin layers upon foreign bodies, varying in thickness from .8 to 2 mm. The surface is even, and without monticules or maculae.

The zoecia are subpentagonal, thin-walled and completely separated by mesopores; 4 to 5 occur in 2 mm.

The mesopores are only slightly smaller than the zooecia, of more irregular shape, thinner walled and usually six-sided as seen in the tangential section. In the younger stages they are zooecial-like, with few or no diaphragms, becoming smaller in the mature region and crossed by 2 to 3 diaphragms in the distance of their own diameter. The smaller mesopores are distinctly beaded. The zooecia increase in size with age, and have few and irregularly spaced diaphragms; one to two in the primitive portion, and rare or absent in the peripheral zone. The acanthopores are large, thin-walled and have a well developed central lucid area. They occur at the angles of the zoecia and mesopores and are a little more numerous than the zoecia.

The characters of the tangential section separate this species from any described Stromatotrypa.

Occurrence: Pierce limestone, at the ford 1½ mile southeast of Blackman, Rutherford County, Tennessee.

Holotoype: 245-16. Indiana University.

ORDER CRYPTOSTOMATA VINE.

The definition of the order, as given by Ulrich in the English edition of Zittel's Textbook of Paleontology, and again repeated by Bassler in the Zittel-Eastman edition, published in 1913, is as follows:

"Primitive zooecium short, pyriform to oblong, quadrate or hexagonal, sometimes tubular, the aperture anterior. In the mature colony the aperture is concealed, occurring at the bottom of a tubular shaft ("vestibule"), which may be intersected by straight diaphragms or hemisepta, owing to the direct super-imposition of layers of polypides; vestibular shaft surrounded by vesicular tissue, or by a solid calcareous deposit; the external orifice rounded. Marsupia and avicularia wanting."

Family Ptilodictyonidae Ulrich.

Zoarium bifoliate, composed of two layers of zooecia, grown together back to back, forming leaf-like expansions, or compressed branching or inosculating stems, that are usually jointed, at least at the base; mesotheca without median tubuli; zooecia usually have hemisepta and semielliptical orifices; apertures usually ovate, surrounded by a sloping area or a distinct peristome; vestibules separated by thick walls.

Genus Graptodictya Ulrich. Genotype: Ptilodictya perelegans Ulrich. Graptodictya Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, pp. 151, 165. Miller, N. A. Geol. Pal., 1889, p. 307. Ulrich, Geol. Surv. Illinois, 8, 1890, p. 393. Procta, Syst. Sil. Centre Boheme, 8, pt. 1, 1894, p. 14. Simpson, 14th Ann. Rept. New York State Geol. for 1894, 1897, p. 541. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 46. Cumings, 32d Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 747. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 121.

The zoarium consists of a narrow, bifoliate, branching frond or cribrose forms, with a pointed base, articulating with a small basal expansion; apertures subcircular, surrounded by a peristome subpolygonal in outline; interspaces depressed, usually with one or two fine tortuous elevated lines.

Graptodictya fruticosa n. sp. Plate XII, Figs. 1-2. Zoarium consists of bifoliate branching frond, 1 to 1.5 mm. wide. The branches rise perpendicularly from the margins and are irregularly spaced from one another. On the type specimen the distance between the branches varies from .1 mm. to 1.5 mm. and portions of the zoarium can be selected in which 4 stipes spring from one margin and one from the opposite margin in the space of 5 mm. Some of the branches develop and bifurcate similar to the principal stipe and others form short lateral extensions 1 to 3 mm. in length. The bushy effect resulting from the irregular branching was observed in a number of specimens, with similar internal characters, and is here considered of specific value.

Sections show that the apertures are oval, arranged in longitudinal series and separated by two fine tortuous lines. Fine zooecia occur in 2 mm. within the series. At the bifurcation, the striated appearance is increased by the presence of narrower apertures; the serial arrangement is less definite, and the fine tortuous lines occasionally wind diagonally among the zooecia.

The primitive tubes are thin-walled and lie upon the median laminae from the proximal end to the hemiseptum, where the outward turn is short and sufficient to permit the tube to approach the surface perpendicularly.

Diaphragms, mesopores and median tubuli are wanting.

The hemisepta is short, blunt, and projects directly towards the mesotheca.

The form of the zoarium distinguishes this species from others of the genus.

Occurrence: Pierce limestone, Walter Hill, Rutherford County, Tennessee.

Holotype: 237-12. Indiana University.

Graptodictya dendroidea n. sp. Plate XII, Figs. 3-4. The zoarium forms a narrow bifoliate frond, 1.5 to 2 mm. wide. The first, 10 to 15 mm. above the articulated base, is an unbranched stipe above which dichotomous branching occurs every 2.5 to 3 mm.

The zooecia are oval, arranged in longitudinal rows, 8 to 9 in 2 mm. Two fine lines separate the rows in the middle of the lateral surface, but near the border where the long axes of the apertures are obliquely directed the tortuous lines pass between the apertures in the series. The walls of the zooecia in *G. fruticosa* are thinner, the apertures larger and the longitudinal rows (14 to 14.5 in 2 mm.) more closely crowded than in *G. dendroidea* (13 to 13.5 in 2 mm.).

The form of the zoarium of *G dendroidea* is characteristically different from all other described species.

Occurrence: Pierce limestone; Walter Hill, Rutherford County, Tennessee.

Holotype: 237—13, 14. Indiana University.

Family, Rhinidictyonidae Ulrich.

Genotype: Rhinidictya nicholsoni Ulrich. Stictopora (part) Hall, Pal. New York, 1, 1847, p. 73. Ulrich, Geol. Surv. Illinois, 8, 1890, p. 388.

Rhinidictya Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 152. Hall and Simpson, Pal. New York, 6, 1887, p. 20. Miller, N. A. Geol. Pal., 1889, p. 320. Ulrich, Geol. Minnesota, 3, 1893, p. 124. Procta, Syst. Sil. Centre Boheme, 8 pt. 1, 1894, p. 15. Ulrich, Zittel's Textb. Pal. (Engl. ed.), 1896, p. 279. Simpson, 14th Ann. Rept. State Geol. New York for 1894, 1897, p. 605. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 48. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 158. Cumings, 32d Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 755. Bassler, Bull. U. S. Nat. Mus., 77, 1911, pp. 131, 132; Zittel-Eastman Textb. Pal., 1913, p. 345.

Zoarium bifoliate, continuous or jointed, consisting of compressed branches or leaf-like expansions; occasionally trifoliate; zooecia subgraduate, arranged longitudinally; orifices and apertures elliptical or subcircular, sometimes a little truncated posteriorly; median tubuli between the median laminae and between the longitudinal rows of zooecia; mesopores wanting, but vesicular tissue often developed; inferior and superior hemiseptum sometimes present. The family has been redefined to include the new genus Hemidictya which has both inferior and superior hemiseptum.

Genus Rhinidictya Ulrich. Genotype: Rhinidictya nicholsoni Ulrich. Stictopora (part) Hall, Pal. New York, 1, 1847, p. 73. Ulrich, Geol. Surv. Illinois, 8, 1890, p. 388.

Rhinidictya Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 152. Hall and Simpson, Pal. New York, 6, 1887, p. 20. Miller, N. A. Geol. Pal., 1889, p. 320. Ulrich, Geol. Minnesota, 3, 1893, p. 124. Procta, Syst. Sil. Centre Boheme, 8, pt. 1, 1894, p. 15. Ulrich, Zittel's Textb. Pal. (Engl. ed.), 1896, p. 279. Simpson, 14th Ann. Rept. State Geol. New York for 1894, 1897, p. 605. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 48. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 158. Cumings, 32d Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 755. Bassler, Bull. U. S. Nat. Mus., 77, 1911, pp. 131, 132; Zittel-Eastman Textb. Pal., 1913, p. 345.

"Zoaria composed of narrow, compressed, dichotomously divided branches, with the margins sharp, straight and essentially parallel; attached to foreign bodies by a continuous expanded base. Zooecial apertures subcircular or elliptical, arranged alternately in longitudinal series between slightly elevated, straight or flexuous ridges, carrying a crowded row of small, blunt spines. Space immediately surrounding apertures sloping up to summits of ridges." (Ulrich.)

Rhinidictya tabulata n. sp. Plate XII, Figs. 5-6. Zoarium consists of bifoliated branching form, the branches rising from the margins; the type specimen is 3 mm. wide, .8 to 1.7 mm. in thickness midway between the margins. The surface is even with an occasional subsolid area, formed by the thickening of the zooecial interspaces of mature specimens. The margins are thin, celluliferous, approximately parallel, except near the bifurcations.

The zooecia are elliptical. In the central portion of the lateral surface they are arranged in longitudinal and diagonal rows (7 to 11 in the type specimen), with the longer diameters of the apertures parallel to the margins. Between the longitudinal series and the edges of the branch occur short, less definite series, each consisting of 4 or 5 zooecia that extend upward and outward. The longer diameters of these zooecia are parallel to the longitudinal series of apertures in the proximate branches rising from the corresponding margin.

Close set, wavy rows of tubuli are present upon the crest of the ridge separating the series of zooecia, and in a few cases a single one is found between the zooecia within the series. In the subsolid areas their distribution shows much less systematic arrangement.

The longitudinal section shows clearly the bifoliate character of the zoarium and the presence of median tubuli. The primitive zooecial tube is .3 mm. long, lies inclined upon the median lamina, extends upward, increases in size with age and ends abruptly by a short turn into the long (.7 to .8 mm.) vestibule. No superior septum is developed. From one to four diaphragms cross some of the vestibular tubes. The intercellular space in the vestibule zone consists of solid tissue except in a few cases near the junction of the vestibule and the primitive zooecia, where diaphragm-like structures occur.

This species resembles *Rhinidictya mutabilis* in many of its characters, but differs in the presence of diaphragms in the vestibular tubes.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: (98) U. S. Nat. Mus.

Rhinidictya salemensis n. sp. Plate XIII, Figs. 4-5. The zoarium consists of bifoliate branches 2 mm. thick and from 5 to 10 mm. wide. The surface is even with small, solid, unequally distributed maculae, composed of compact sclerenchyma and radiating rows of vertical tubuli.

The zoocial apertures are small, oval, and separated from one another by walls that are greater than twice the short diameter of the opening in thickness and traversed by a single row or an irregular band of vertical tubuli. The zooecia are not arranged in definite longitudinal series as in many Rhinidictya; 7 to 8 occur in 2 mm.

Median tubuli are shown in the longitudinal section. The zooecial tubes lie along the median laminae for only .1 to .2 mm. and then turn outward with a short bend and proceed nearly direct to the periphery. The interspaces in the vestibular zone are filled with solid tissue traversed with numerous tubuli. No diaphragms occur in the zoocial tubes.

Occurrence: Ridley limestone, 2½ miles northwest of Salem, Rutherford County, Tennessee.

Holotype: 245-7. Indiana University.

Rhinidictya lebanonensis n. sp. Plate XIII, Figs. 6-7. The zoarium branches dichotomously. The branches are small, 2 to 2.2 mm. wide and .5 mm. thick. The margins are celluliferous; the zooecia in the rows nearest the margin are more widely spaced than in the other series. Nine to ten rows of zooecia are present on the lateral surfaces.

The zooecia are oval; 7 in 2 mm. measured along the rows. Each longitudinal series is separated by a wavy line of close-set tubuli.

In the longitudinal section the median laminae are distinct, and in a portion of the section the median tabuli are shown. The primitive zooecia lie along the median laminae, terminating at the entrance of the vestibule where the posterior wall extends forward and constricts the aperture by forming a superior hemiseptum. Beyond the septum the tube lies along the posterior wall of the upper primitive zooecia for a distance of about .2 mm. It then turns sufficiently to permit the zooecia to open perpendicularly at the surface. The tube in the vestibular zone is constricted notably by the thickening of the walls.

This species resembles *R. fidelis* and *R. minima* in having a well developed superior hemiseptum. It can be distinguished from *R. fidelis* by the smaller zoarium, the decided construction of the zooecial tubes in the vestibule and the direct apertures.

The zoarium of *R. minima* is smaller and has less number of rows of zooecia than *R. lebanonensis*.

Occurrence: Lebanon limestone, ½ mile south of Milesford, Rutherford County, Tennessee.

Holotype: 247-9. Indiana University.

Genus Pachydictya Ulrich. Genotype: Pachydictya robusta Ulrich. Pachydictya Ulrich, Jour., Cincinnati Soc. Nat. Hist., 5, 1882, p. 152. Foerste, Bull. Sci. Lab. Denison Univ., 2, 1887, p. 152. Miller, N. A. Geol. Pal., 1889, p. 313. Ulrich, Geol. Surv. Illinois, 8, 1890, pp. 390, 522; Geol. Minnesota, 3, 1893, p. 145. Procta, Syst. Sil. Centre Boheme, 8, pt. 1, 1894, p. 15. Simpson, 14th Ann. Rept. State Geol. New York for 1894, 1897, p. 530. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 48. Hennig, Archiv. fur Zool., K Sven. Vet.-ckad. Stockhalm, 2, No. 10, 1905, p. 25. Bassler, Bull. U. S. Geol. Surv., 292, 1906, p. 57. Graban and Shimer, N. A. Index Fossils, 1, 1907, p. 159. Cumings, 32d Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 751. Bassler, Bull. U. S. Nat. Mus., 77, 1911, pp. 137, 138.

The zooecial apertures of Pachydictya are oval and have well developed, ring-like walls; no hemisepta. The character distinguishes the genus from any other of the family Rhinidictyonidae.

Pachydictya senilis n. sp. Plate XIII, Figs. 1-3. Zoarium is ramose, branches vary from 1 to 1.2 mm. in thickness and 6 to 10 mm. in width. The margin is non-poriferous and variable in width, ranging from .2 to .6 mm. Maculae of mesopores and raised clusters of zooecia occur irregularly distributed over the surface.

The zooecia are oval or circular, with well developed peristome, arranged in indefinite longitudinal series; and separated by irregular rows of minute vertical tubuli in the peripheral zone. Deeper tangential sections show an increased number and larger mesopores which in some places separate the zooecia.

The vertical section shows median tubuli traversing the median laminae longitudinally. The zooecial tubes are recumbent only a very short distance, then turn outward and approach the surface almost direct. Two to six diaphragms cross the tubes in the vestibular zone.

The mesopores are crowded with diaphragms in their earlier part, but closed at the surface by the thickened walls of the zooecial tubes.

Pachydictya robusta is closely allied to this species, but the larger zoarium, and large zooecia of *P. robusta* serves to differentiate it.

Occurrence: Pierce limestone, Murfreesboro, Tennessee.

Holotype: 55140 U. S. Nat. Mus.

Genus Trigonodictya Ulrich. Genotype: Pachydictya conciliatrix Ulrich. Tigonodictya Ulrich. Geol. Minnesota, 3. 1893. p. 160. Nickles and Bassler,* Bull. U. S. Geol. Surv., 173, 1900. p. 49.

"Zoarium of triangular branches, constructed upon the plan of Prismopora, but with zooecia and all minute details of structure as in Pachydictya."

Trigonodictya irregularis n. sp. Plate XIII, Figs. The zoarium consists of irregular, triangular branches with unequal poriferous faces. The edges are noncelluliferous.

The zooecial apertures are oval, 7 to 8 in 2 mm. counted diagonally. The peristome, the structure of the interzooecial spaces, and the arrangement of the zooecia, show great similarity to *Pachydictya foliata* Ulrich.

Straight and coalesced diaphragms occur in the zooecial tubes, varying in number from one to eight.

The small tubuli, present in the interspaces of *Trigonodictya conciliatrix* and the longitudinal arrangement of the zooecia, serve to distinguish it from this species.

Occurrence: Lebanon limestone; 2 miles southwest of Christiana, Rutherford County, Tennessee.

Holotype: 245-11. Indiana University.

New Genus Hemidictya. Zoarium bifoliate fronds or irregularly ramose forms with nonporiferous margins; surface with maculae; zooecia with thin walls, elliptical or subcircular; vestibule nearly direct, walls thicken and form peristomes; diaphragms appear in some of the vestibular tubes: inferior and superior hemiseptum present; spaces between the vestibule traversed by one or more series of minute tubuli. The presence of a peristome shows the close relation of this genus to Pachydictya, from which it is distinguished by the occurrence of hemisepta.

Genotype: Hemidictya lebanonensis, n. sp.

Hemidictya lebanonensis n. sp. Plate XIV, Figs. 1-3. Zoarium consists of thin fronds, 5 to 10 mm. across and one mm. thick, from the edge of which rise several compressed short branches 2.5 to 3 mm. wide and .3 to .5 mm. thick. The margin is conspicuously non-poriferous in the angle of bifurcation, where it is .5 mm. wide in the type specimen, and becomes narrower rapidly farther along the branch.

The surface is even, upon which is distributed small subsolid macules,

*Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 49.

2 to 3 mm. apart in which the vestibular are greatly thickened and the zooecia less numerous than in the intermacular area.

The zooecia are arranged into more or less definite longitudinal rows (13 to 14 in 2 mm.) separated by one or more rows of minute tubuli. The apertures at the surface are mostly elliptical (6 to 7 in 2 mm. measured longitudinally) with the longer diameter parallel to the direction of the series. In the maculae and near the non-poriferous margin the apertures are rounded.

The cross-section shows a single row of median tubuli traversing the median laminae lengthwise.

The zooecia in the primitive area lie inclined upward along the median laminae to the inferior hemiseptum. After passing the septa the zooecial tube turns abruptly outward, enters the vestibular area and proceeds almost directly to the surface. An occasional diaphragm, either straight or curved, occurs in some of the zooecia.

Occurrence: Lebanon limestone; Big Springs, Rutherford County, Tennessee.

Holotype: 248—25. Indiana University.

Family Stictoporellidae, Nickles and Bassler.

This family differs from Ptylodictyonidae mainly in that the zoarium is not articulated, but grows upward from, and is continuous with, a spreading base.

Genus Stictoporella Ulrich. Genotype: Stictoporella interstincta Ulrich.

Stictoporella Ulrich, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, pp. 152, 169. Miller, N. A. Geol. Pal., 1889, p. 325. Ulrich, Geol. Surv. Illinois, 8, 1890, p. 394; Geol. Minnesota, 3, 1893, p. 179. Pocta, Syst. Sil. Centre Boheme, 8, pt. 1, 1894, p. 14. Ulrich, Zittel's Textb. Pal. (Engl. ed.), 1896, p. 279. Simpson, 14th Ann. Rept. State Geol. New York for 1894, 1997, p. 535. Nickles and Bassler, Bull. U. S. Geol. Surv., 173, 1900, p. 46. Grabau and Shimer, N. A. Index Fossils, 1, 1907, p. 157. Cumings, 32d Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 756. Bassler, Bull. U. S. Nat. Mus., 77, 1911, p. 127; Zittel-Eastman Textb. Pal., 1913, p. 345.

Micropora Eichwald (not Gray, 1848), Bull. Soc. Nat. Moscow, No. 4, 1855, p. 457; Lethaea Rossica, 1, 1860, p. 393.

Zoarium, branching, cribose, or leaflike, from an expanded base. Zooecia with primitive portion tubular, usually long, generally without hemisepta, the inferior one only occasionally present. Apertures at the bottom of a wide, sloping vestibule. Thick-walled mesopores, with true diaphragms wanting occur between the apertures and line the margin of the zoarium.

Stictoporella cribrilina n. sp. Plate XIV, Figs. 4-7. Zoarium consists of a cribrose, bifoliate expansion from an extended base. The anastomosing branches average .7 mm. in thickness and .5 to 1 mm. in width. The fenestrules are small oval openings .75 to 1.5 mm. in greatest diameter and irregularly distributed.

Zoecial apertures are small, separated completely by mesopores, and occur in diagonal and longitudinal rows; 10 zoecia in 2 mm. diagonally and 7 in 2 mm. longitudinally. The vestibular walls of the zooecia and mesopores are distinctly granular along the contact, forming an encircling dark band. The orifices of the zooecia lie at the base of sloping vestibules which are composed of homogenous tissue forming a ring about the opening.

As shown in the longitudinal section the zooecial tubes are thin-walled in the primitive region and lie prostrate upward on the median lamina, then turning outward, opening into the vestibules acutely. The walls of the vestibules terminate almost perpendicularly at the periphery. A single diaphragm crosses many of the zooecial tubes usually shortly preceding the turn from the reclining position towards the vestibule.

The mesopores are short, rising in the late primitive zone. True diaphragms are absent, but in some thick irregularly arranged tabulae occur.

This species differs from *Stictoporella cribrosa*, in having smaller fenestrules, a granular band surrounding the apertures of the mesopores and zooecia, more numerous mesopores and diaphragms crossing the zooecia. The zoaria of the other species is so different from *S. cribilina* that no other differentiating characters are necessary.

Occurrence: Pierce limestone, Murfreesboro, Tennessee, and 1 mile north of McFadden Ford, Rutherford County, Tennessee.

Holotype: 56162 U. S. Nat. Mus.

Paratype: 238, 20, 21; 242-13. Indiana University.

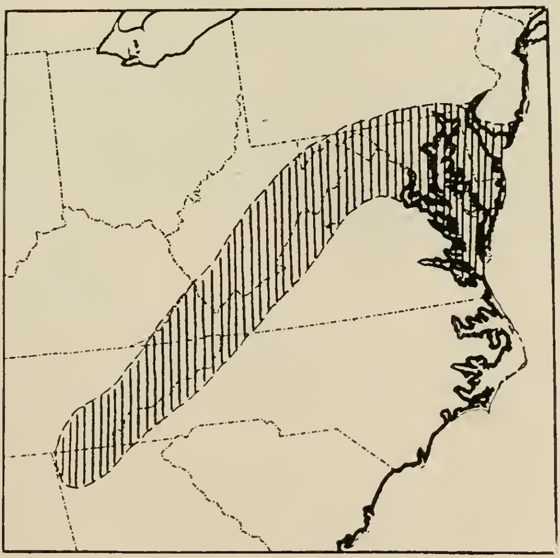

FIG. 1.

Fig. 1.—A portion of the eastern part of the United States showing the probable boundary of the Early Stones River (Mosheim) Sea.

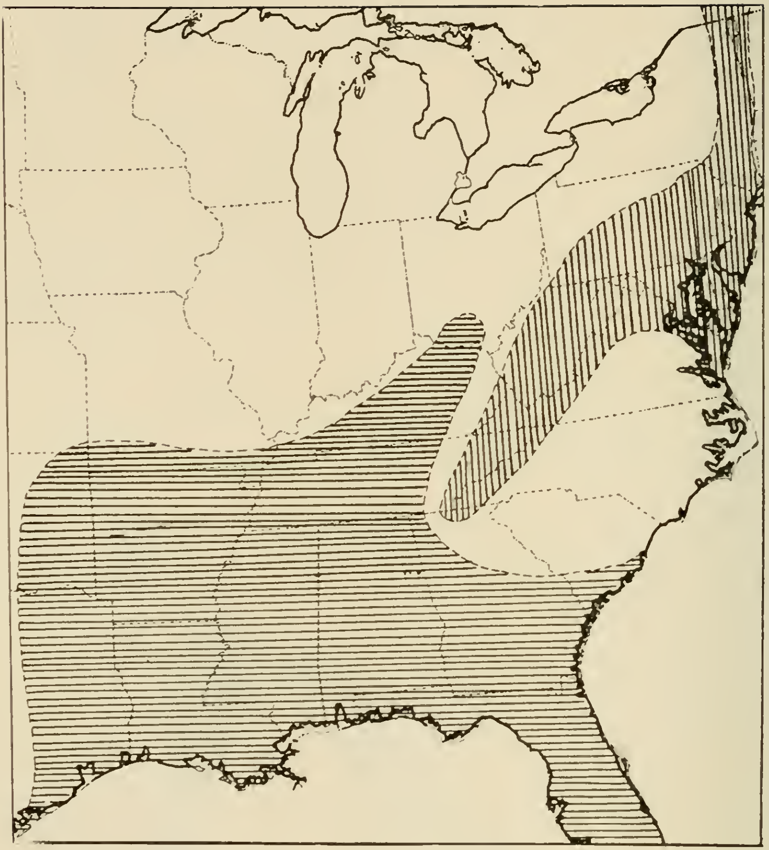

FIG. 2.

Fig. 2.—Map showing the extent of the Gulf of Mexico Embayment (horizontal-lined area) during Middle Stones River time and the Appalachian-Champlain sea (vertical-lined area).

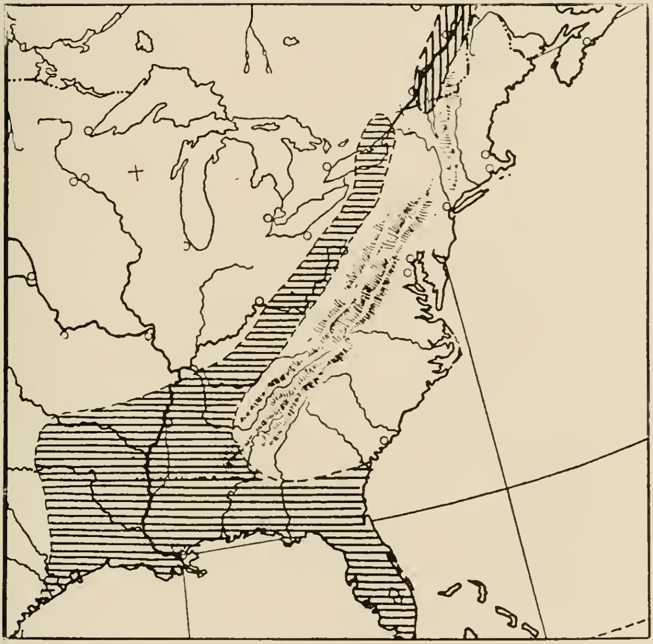

FIG. 3.

Fig. 3.—Map of eastern North America showing the greatest extent of the Gulf of Mexican embayment (Lebanon-Pamelia time) and the probable restricted conditions of the Appalachian and Champlain troughs.

RANGE AND DISTRIBUTION OF THE BRYOZOAN SPECIES OF THE CENTRAL BASIN OF TENNESSEE

TABLE 2. SHOWING RANGE AND DISTRIBUTION OF STONES RIVER BRYOZOA.

(aa — very abundant, a — abundant, c — common r — rare, cf — compare to species of horizon.

SPECIES	Central Tennessee				Upper Valley of Mississippi		Ontario Canada	New York	Russia	Other Horizons
	Murfreesboro	Pierce	Ridley	Lebanon	Black River	Richmond	Chazy	Chazy	Middle Ordovician	
Cyclostomata										
Anolotchia explanata, new species		c	c							
Ceramoporella grandis, new species		c		c						
Ceramoporella ingenua, new species		c								
Coeloclema consimile, new species		c								
Coeloclema inflatum, new species		c								
Coeloclema pierceanum, new species		c								
Corynotrypa delicatula (James)		c		c	c	c			c	
Corynotrypa tennesseensis Bassler		c		c						
Mitoclema cinctosum Ulrich			c							High Bridge ls., Kentucky.
Trepostomata										
Batostoma conferta, new species		c								
Batostoma dendroidea, new species		c								
Batostoma inutilis, new species		c								
Batostoma libana (Safford, name only)				c						
Batostoma ramosa, new species		c								
Batostoma suberasum, new species		c						c		
Constellaria lamellosa, new species		c	r							
Dekayella ridleyana, new species			c							
Dianulites cf. petropolitanus			c						cf.	Middle Ordovician of Upper Valley of Mississippi; Ontario.
Diplotrypa catenulata, new species		c								
Hallopora florencia, new species		a								
Hallopora spissata, new species		aa	a							
Hemiphragma irrasum (Ulrich)		a	c		a					
Heterotrypa patera, new species		r								
Heterotrypa stonensis, new species		r								

Mesotrypa crustulata, new species		c								
Mesotrypa dubia, new species		c								
Monticulipora compacta, new species		c								
Monticulipora discula, new species		c	c	c						
Monticulipora intersita, new species		c								
Nicholsonella frondifera, new species	a	aa	a	a				c		
Nicholsonella pulchra Ulrich	a	a		a						
Orbignyella multitabulata, new species		c								
Orbignyekla nodosa, new species				aa						
Orbignyella sublamellosa Ulrich and Bassler		c	c							
Stromatotrypa incrustans, new species		c								
Stromatotrypa lamellata, new species		c	r	c				c		
Stromatotrypa regularis, new species		c								
Cryptostomata										
Arthroclema stratum Ulrich				c	c					
Chasmatopora sublaxa (Ulrich)		c	a	c	c		c			
Escharopora angularis Ulrich		c			c					
Escharopora briareus (Ulrich)				c						Highbridge Is. Kentucky
Escharopora confluens Ulrich		c			c					
Escharopora libana (Safford)				c						
Escharopora ramosa (Ulrich)				c						
Escharopora subereeta (Ulrich)			r		c		r			
Graptodictya dendroidea, new species		c								
Graptodictya fruticosa, new species		c								
Helopora spiniformis (Ulrich)		c	r	c						
Hemidictya lebanonensis, new species				r						
Bachdictya cf. fimbriata		r			cf.					
Pachydictya cf. foliata		c	c	c	cf.					
Pachydictya senilis, new species		c								
Rhinidictya basalis (Ulrich)				c						
Rhinidictya lebanonensis, new species				c						
Rhinidictya nashvillensis (Miller)		c	c							
Rhinidictya, tabulata, new species		c	c	c						
Rhinidictya trentonensis (Ulrich)				c	c					
Setoporella cribrilina, new species		c	r							
Trigonidictya irregularis, new species				r						

TABLE 3. SHOWING THE RANGE AND DISTRIBUTION OF OTHER SPECIES FROM THE STONES RIVER OF CENTRAL TENNESEE

Abbreviations: M = Murfreesboro, P = Pierce, R = Ridley, L = Lebanon, BR = Black River, SR = Stones River, C = Chazy, Pa = Pamelia, Ri = Richmond, T = Trenton, X = present

SPECIES	Central Tennessee					Kentucky		E. Tennessee	Virginia	Maryland	Pennsylvania	New York			New Jersey	Canada			Baffin Land	Upper Mississippi Valley		
	M	P	R	L	BR	SR	BR	SR	SR	SR	SR	C	Pa	BR	BR	C	BR	RI	BR	BR	T	Ri
Camarella varians Billings			X					X				X				X						
Camarotoechia orientalis (Billings)				X								X				X						
Ceraurinus scofieldi (Clarke)				X										X						X		
Cleiocrinus tessellatus (Troost)				X																		
Columnaria alveolata Goldfuss	X	X	X	X	X		X							X			X			X	X	
Ctenobolbina subcrassa Ulrich			X			X																
Ctenodonta gibberula Salter	X																					
Cyclonema praeciptum Ulrich	X																					
Cyrtoceras? stonense Safford	X																					
Cyrtospira tortillis Ulrich	X																					
Dinorthis deflecta (Conrad)	X	X	X	X	X		X													X		
Drepanella ampla Ulrich			X			X																
Drepanella elongata Ulrich				X		X																
Drepanella macra Ulrich				X																		
Eccyliomphalus contiguus Ulrich	X	X	X	X																		
Ectomaria prisca extenuata Ulrich	X																					
Eotomaria canalifera Ulrich	X																					
Eotomaria labiosa Ulrich	X																					
Eurychilina aequalis Ulrich			X			X																
Eurychilina subradiata Ulrich		X		X										X						X		
Fletcheria incerta (Billings)				X												X						
Gonioceras anceps Hall			X											X						X		
Gonioceras occidentale Hall	X																			X		
Hebertella bellarugosa (Conrad)		X	X				X					X							X	X		
Hebertella borealis (Billings)				X				X				X				X						
Helicotoma declivis Ulrich	X																					
Helicotoma subquadrata Ulrich	X																					

Helicotoma tennesseensis U. and S.	X																					
Hudsonaster narrawayi (Hudson)				X												X				X		
Leperditia fabulites (Conrad)	X	X	X	X									X				X			X		
Liospira abrupta U. and S.	X					X														X		
Liospira americana (Billings)	X	X	X	X	X								X					X			X	
Liospira convexa U. and S.			X																			
Liospira dicipiens Ulrich	X																					
Liospira progne (Billings)	X	X	X	X	X								X									
Liospira subconcava Ulrich	X																					
Lophospira bicincta (Hall)	X	X	X	X			X						X									X
Lophospira centralis Ulrich	X																					
Lophospira perangulata (Hall)	X										X											
Lophospira procera Ulrich	X																					
Lophospira (?) trochonemoides Ulrich	X																					
Maclurites magnus Lesueur	X	X	X	X				X	X	X	X	X	X									
Maclurites nitidus Ulrich and Scofield	X																			X		
Modiolopsis (?) consimilis Ulrich	X																					
Ophiletina sublaxa depressa U. and S.	X																					
Orthis tricenaria Conrad	X	X	X	X	X		X						X				X			X		
Palaeocrinus sulcatus Safford		X																				
Phragmolites grandis (Ulrich)				X																		
Pianodema stonensis (Safford)		X																				
Pianodema subaequata (Conrad)	X	X	X	X			X						X		X		X			X	X	
Plectoceras bondi (Safford)	X																					
Primitiella limbata Ulrich				X																X		
Protorhyncha ridleyana (Safford)		X	X																			
Pterotheca saffordi (Hall)				X																		
Pterygometopus troosti (Safford)	X	X	X	X									X									
Rafinesquina incrassata (Hall)		X	X	X				X				X										
Raphistomina modesta Ulrich	X																					
Salterella billingsi Safford	X																					
Scenidium anthonense Sardeson				X											X					X		
Schmidtella subrotunda Ulrich				X																X		
Solenopora compacta (Billings)				X										X						X		
Streptelasma (?) parasiticum Ulrich				X																X		
Stromatocerium rugosum Hall			X		X		X										X			X		
Strophomena incuravta (Shephard)	X	X	X	X									X				X			X		
Tetradium syringoporoides Ulrich		X	X	X				X	X	X	X		X									
Tetronota bidorsata (Hall)	X	X	X	X																X		
Tetranota sexcarinata U. and S.				X																	X	
Trochonema bellulum Ulrich	X																					
Trochonema eccentricum Ulrich				X													X					
Trochonema umbilicatum latum Ulrich				X																		
Whiteavesia saffordi (Ulrich)	X																					
Zittelella varians (Billings)	X		X					X								X						
Zygospira saffordi Winchell and Schuchert		X	X	X																		

PLATE I

Ceramoporella ingenus Ulrich and Bassler.
1. Vertical section x 20.
2. A portion of the surface x 10.
3. Tangential section x 20.
Pierce limestone, Murfreesboro, Tenn.

Ceramoporella grandis Ulrich and Bassler.
4 and 5. Tangential sections x 20, showing the proiminent lunaria'
6. A portion of the surface x 10.
Pierce limestone, Murfreesboro, Tenn.

PLATE I.

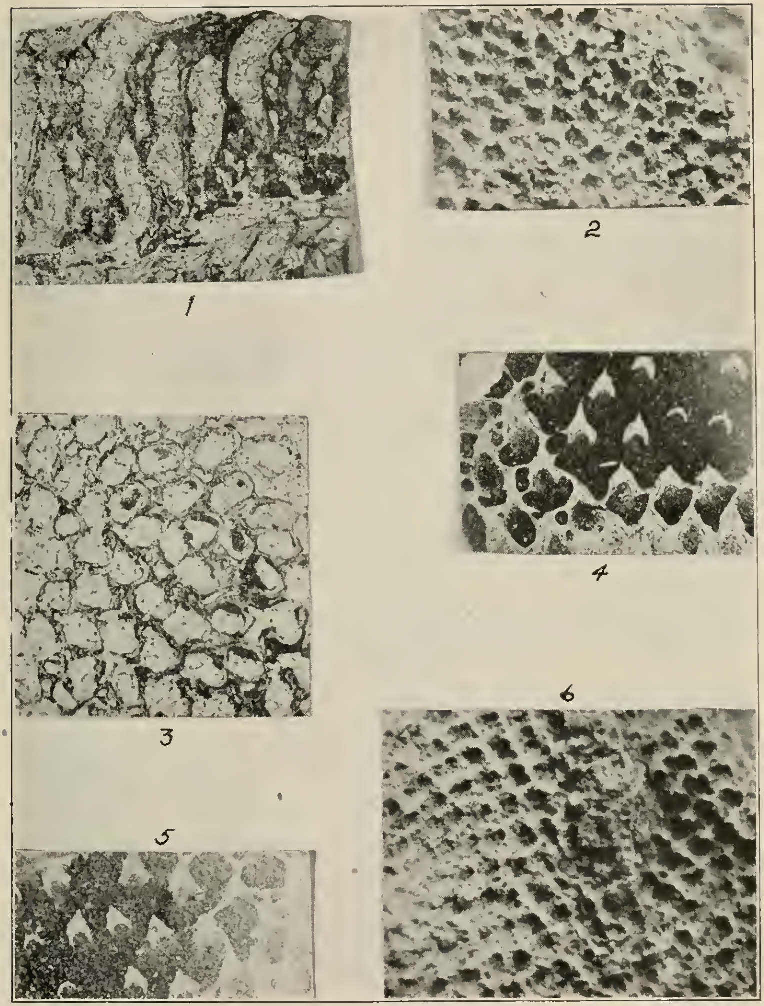

PLATE II

Coeloclema pierceanum n. sp.

1. Tangential section x 18, showing the circular shaped lunaria.
2. Longitudinal section x 18, showing the irregular opening within the stem
   Pierce limestone, Walter Hill, Rutherford Co., Tenn.

Coeloclema inflatum n. sp.

3. Cross-section x 18, showing the hollow stem.
4. Longitudinal section x 18.
5. Tangential section x 18, showing the lunaria with inflated, outward curved ends.
   Pierce limestone, Florence, Rutherford Co., Tenn.

Coeloclema consimile n. sp.

6. Longitudinal section x 18, showing the long zooecocial tubes.
7. Tangential section x 18, showing crescent shape lunarium.
   Pierce limestone. Lascassas, Rutherford Co., Tenn.

PLATE II.

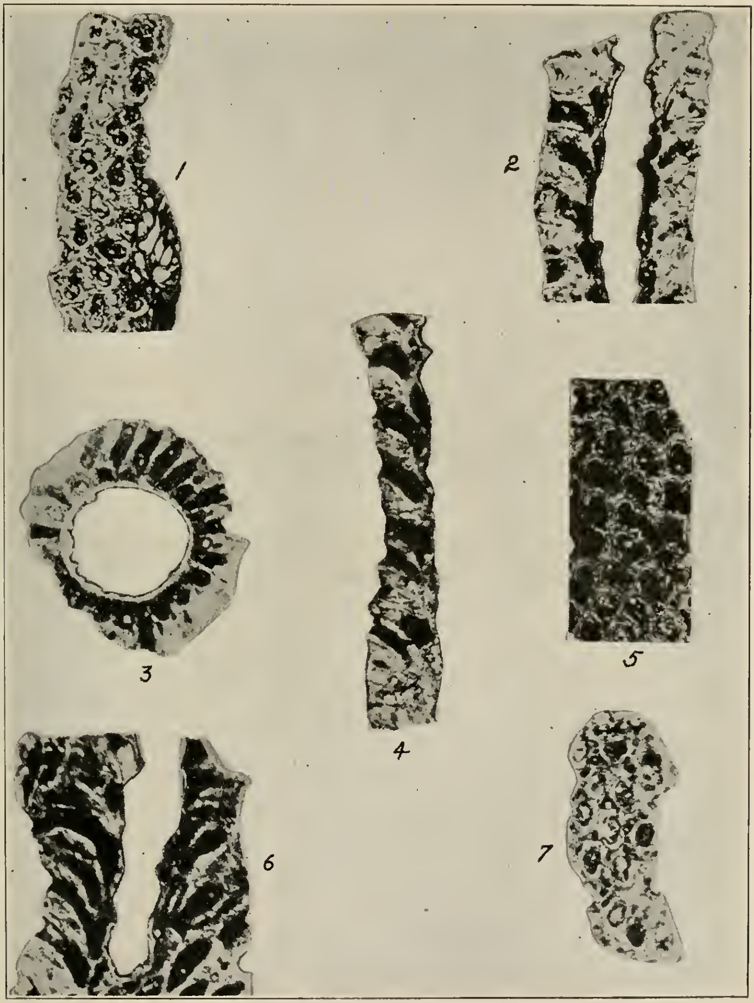

PLATE III

Anolotichia explanata n. sp.

1. Longitudinal section x 20, showing superposed layers.
2, 3, and 4. Tangential sections x 20.
Pierce and Ridley limestones, Murfreesboro and Sulphur Springs, Rutherford Co., Tenn.

Trigonidictya irregularis, n. sp.

5. Cross-section x 18, showing the three divisions of the laminae.
6. Longitudinal section x 18.
Lebanon Limestone, Christiana, Tenn.
(See Plate XIII)

PLATE III.

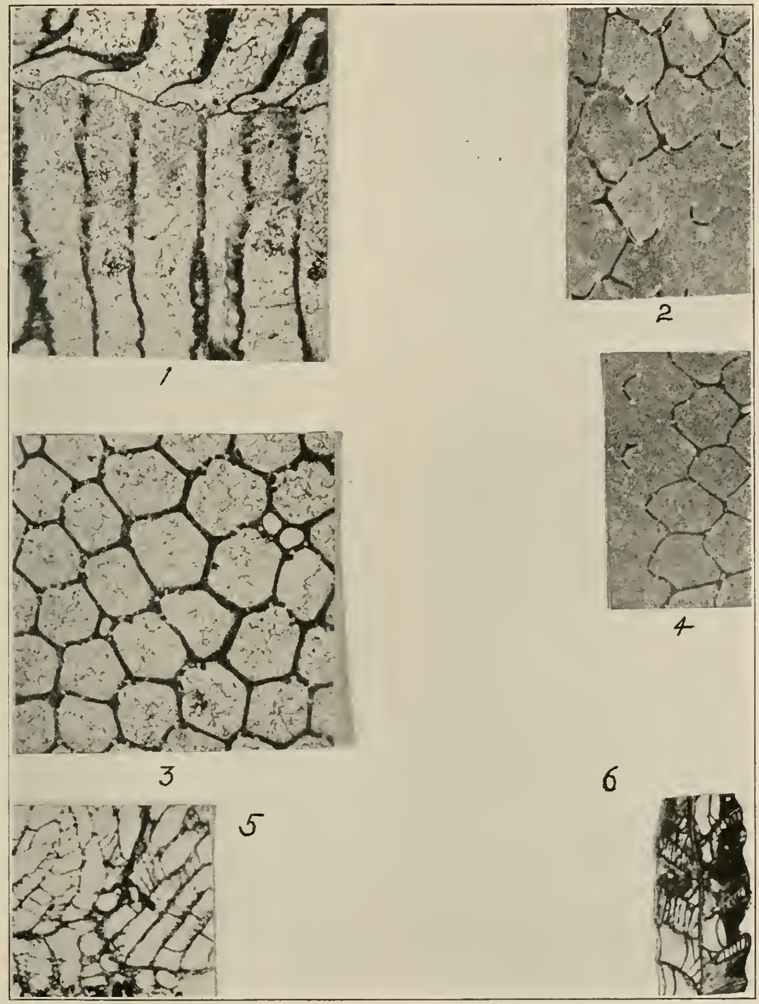

PLATE IV

Monticulipora intersita Ulrich and Bassler.

1. Tangential section x 20.
2. Longitudinal section x 20.
   Pierce limestone. Murfreesboro, Tenn.

Monticulipora discula Ulrich and Bassler.

3. Tangential section x 20.
4. Longitudinal section x 20.
   Pierce limestone. Murfreesboro, Tenn.

Monticulioora compacta Ulrich and Bassler.

5. Tangential section x 20.
6. Longitudinal section x 20.
   Pierce limestone. Murfreesboro, Tenn.

PATE IV.

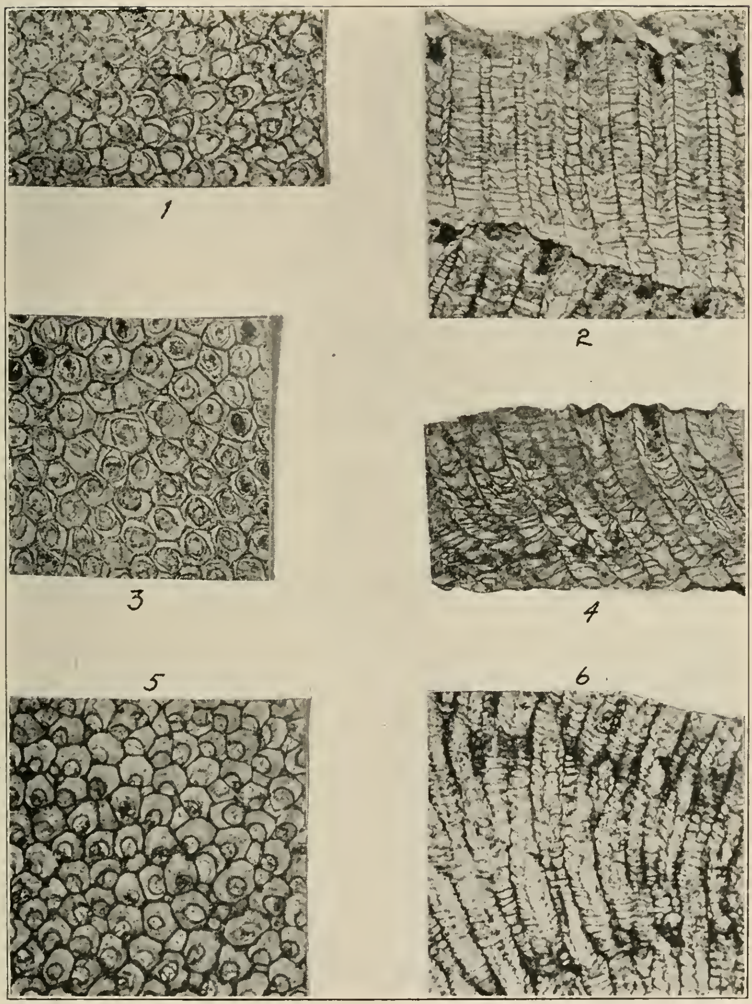

PLATE V

Orbignyella nodosa n. sp.

1. Tangential section x 18.
2. Longitudinal section x 18.

Lebanon limestone. Big Springs, Rutherford Co., Tenn.

Orbignyella multitabulata n. sp.

3. Longitudinal section x 18.
4. Tangential section x 18.

Pierce limestone. Almaville, Tenn.

Mesotrypa crustulata n. sp.

5. Tangential section x 20.
6. Longitudinal section x 20.

Pierce limestone. Murfreesboro, Tenn.

PLATE V.

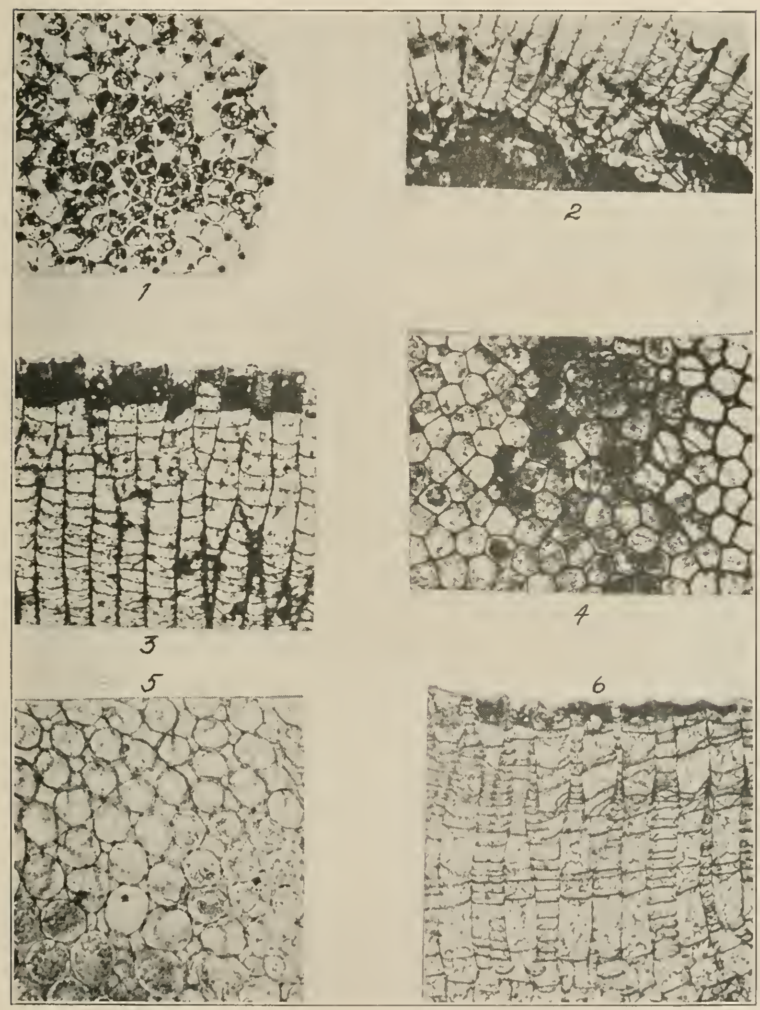

PLATE VI

Mesotrypa dubia n. sp.

1. Tangential section x 20.
2. Longitudinal section x 20.
   Pierce limestone. Murfreesboro, Tenn.

Dekayella ridleyana n. sp.

3. Longitudinal section x 18.
4. Tangential section x 18.
   Ridley limestone. Salem, Tenn.

Heterotrypa patera n. sp.

5. Longitudinal section x 18.
6. Tangential section x 18.
   Pierce limestone. Stokes Gannon Ford, 2 miles northwest of Murfreesboro, Tenn.

PLATE IV.

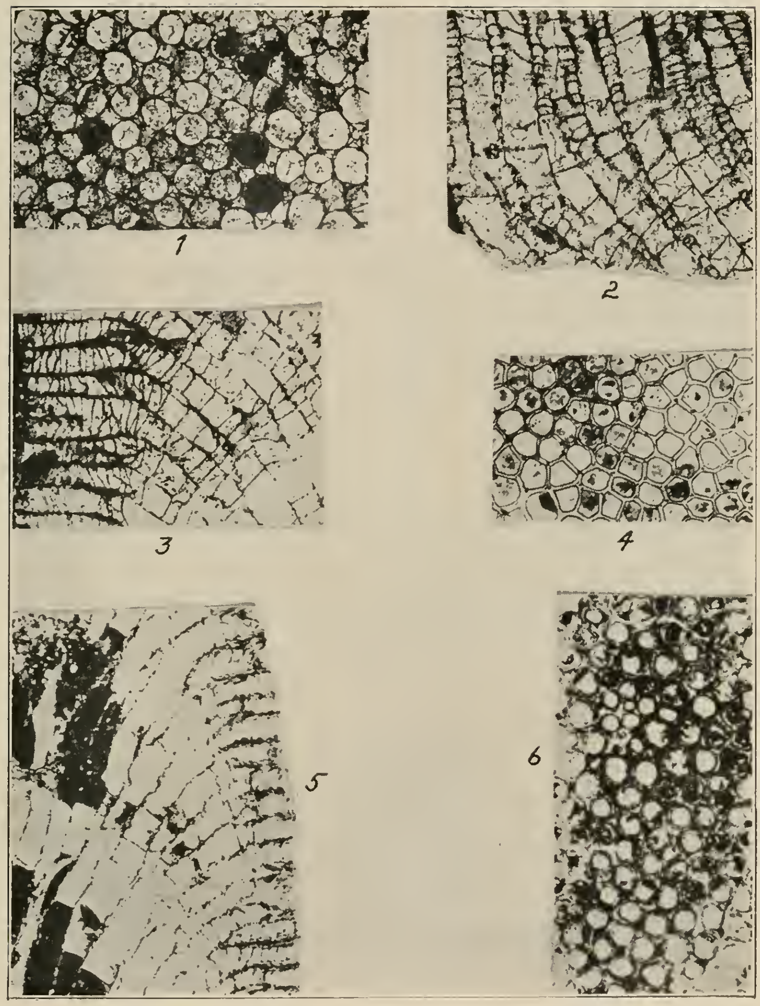

PLATE VII

Heterotrypa stonensis n. sp.

1. Longitudinal section x 18.
2. Tangential section x 18.
   Pierce limestone. Stokes Gannon Ford, 2 miles northwest of Murfreesboro, Tenn.

Constellaria lamelosa n. sp.

3 and 4. Tangential sections x 20.
5. Longitudinal section x 20.
   Pierce limestone. Murfreesboro, Tenn.; Lascassas, Tenn.

Nicholsonella frondifera n. sp.

6. Longitudinal section x 20.
7. Tangential section x 20.
   Pierce, Ridley and Lebanon limestone. Murfreesboro, Atmanville, Marshall Knob, Salem, Rutherford Co., Tenn.

PLATE VII.

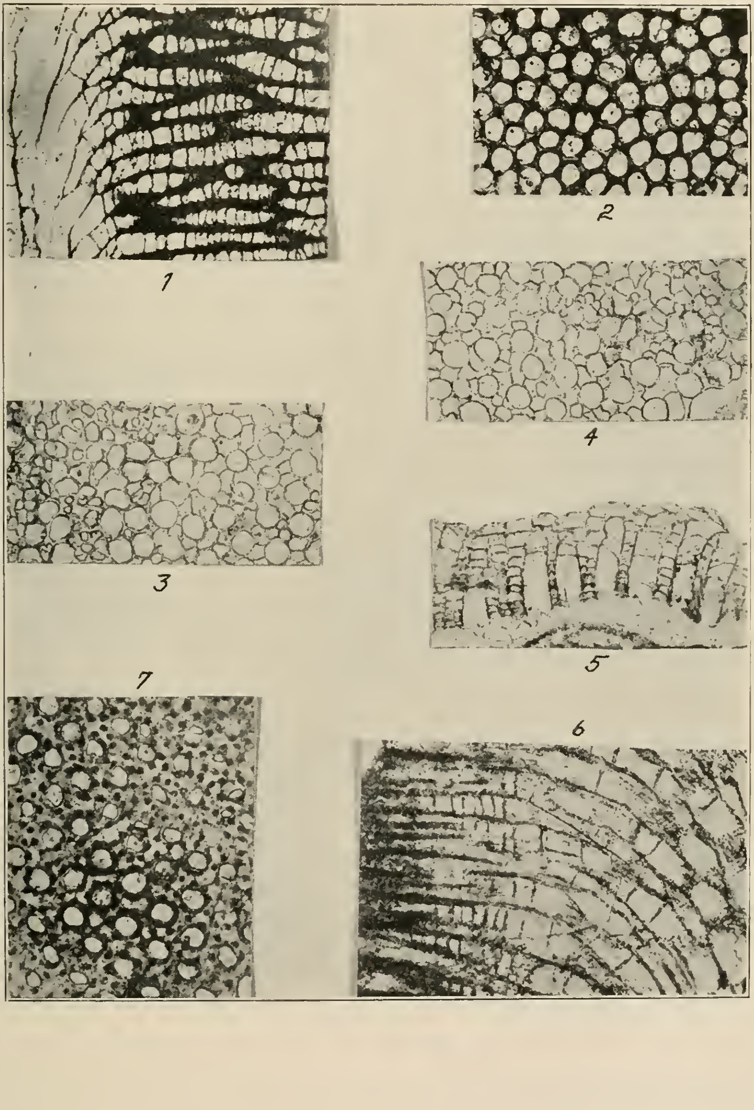

PLATE VIII

Hallopora spissata n. sp.

1. Longitudinal section x 20.
2. Tangential section x 20.
Pierce limestone. Murfreesboro, Ward's Mill, Almaville, Tenn.

Hallopora florencia n. sp.

3. Longitudinal section x 18.
4. Tangential section x 18.
Pierce limestone. Florence, Tenn.

Batostoma libana (Safford).

5. Portion of zoarium, natural size.
6. Longitudinal section x 20.
7. Tangential section x 20.
Lebanon limestone, of Central Tennessee.

PLATE VIII.

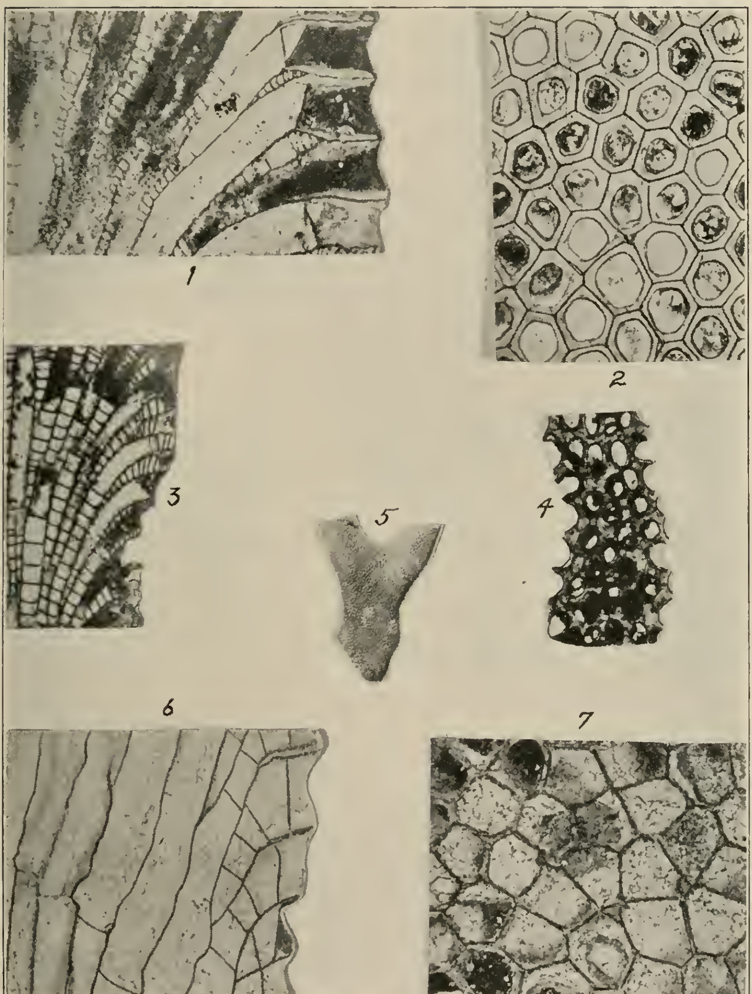

PLATE IX

Batostoma suberassum n. sp.

1. Longitudinal section x 20.
2. Tangential section x 20.
3. A portion of zoarium, natural size.
   Pierce limestone. Murfreesboro and Eagleville, Tenn.

Batostoma dendroidea n. sp.

4. Tangential section x 18.
5. Longitudinal section x 18.
   Pierce limestone. Murfreesboro, Walter Hill, Wards Mills, and Lascassas, Tenn.

Batostoma ramosa n. sp.

6. Longitudinal section x 20.
7. Tangential section x 20.
   Pierce limestone. Murfreesboro, Tenn.

PLATE IX.

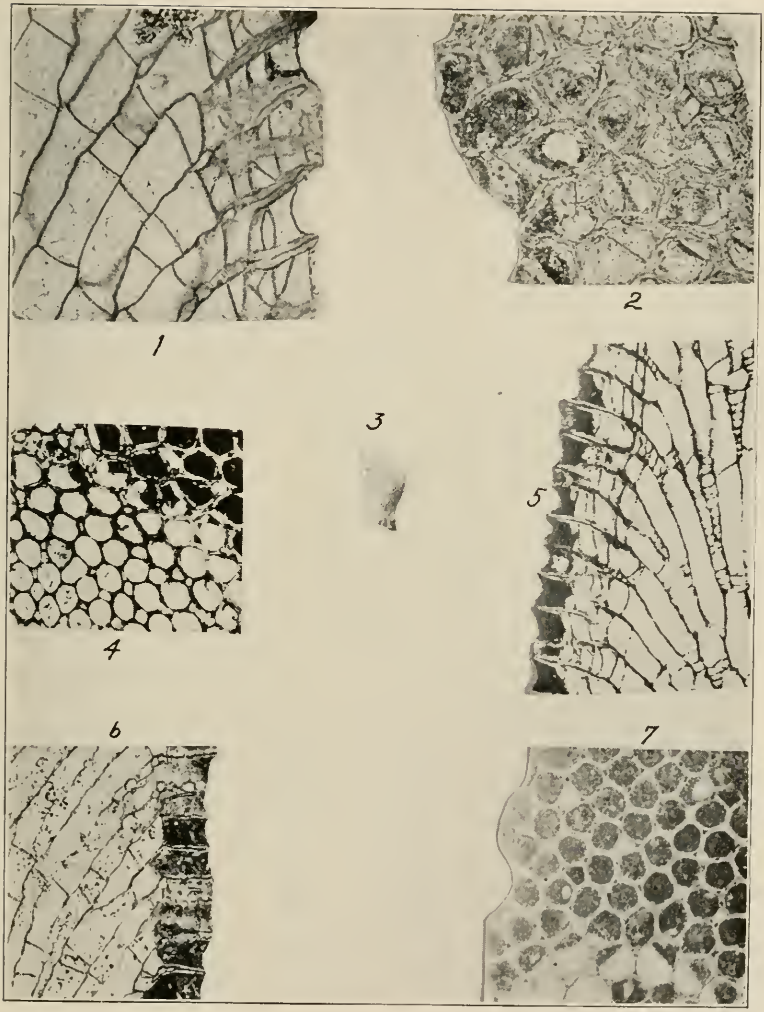

PLATE X

Batostoma conferta n. sp.

1 and 3. Longitudinal section x 18.
2. Tangential section x 18.
Pierce limestone. Murfreesboro, Tenn.

Batostoma inutilis n. sp.

4. Longitudinal section x 18.
5. Tangential section x 18.
Pierce limestone. Murfreesboro, Tenn.

Diplotrypa catenulata n. sp.

6. Longitudinal section x 20.
7. Tangential section x 20.
Pierce limestone. Murfreesboro, Tenn.

PLATE X.

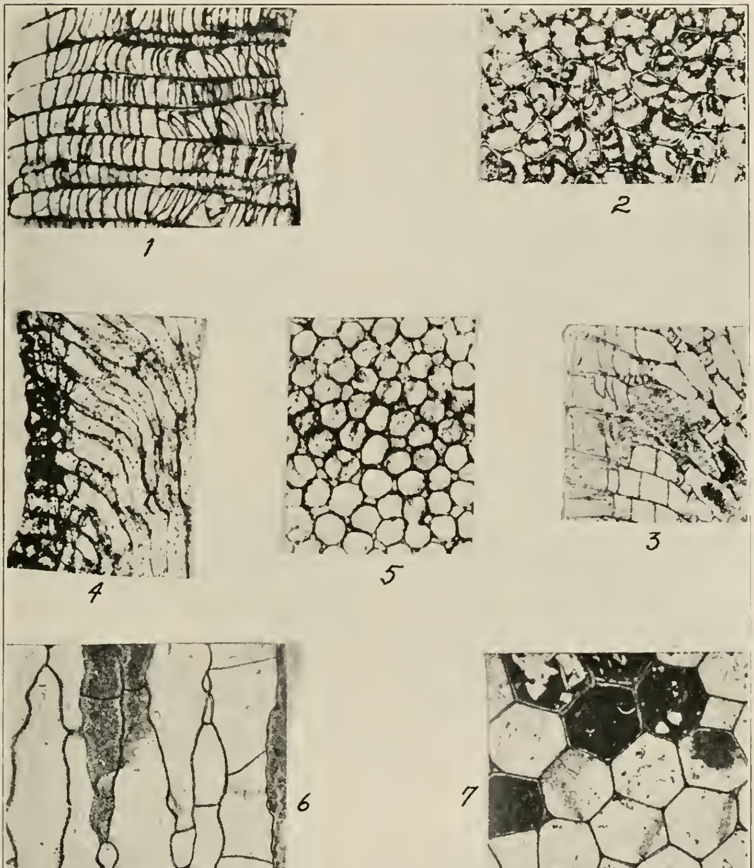

PLATE XI

Stromatotrypa lamellata n. sp.

1. Vertical section x 20, showing supposed layers.
2. Tangential section x 20.

   Pierce limestone. Murfreesboro, Tenn.

Stromatotrypa incrustans n. sp.

3. Vertical section x 18.
4. Tangential section x 18.

   Pierce limestone. Blackman, Tenn.

Stromatotrypa regularis n. sp.

5. Tangential section x 18, showing pentagonal-like zooecia.
6. Longitudinal section x 18.

   Pierce limestone. Blackman, Tenn.

PLATE XI.

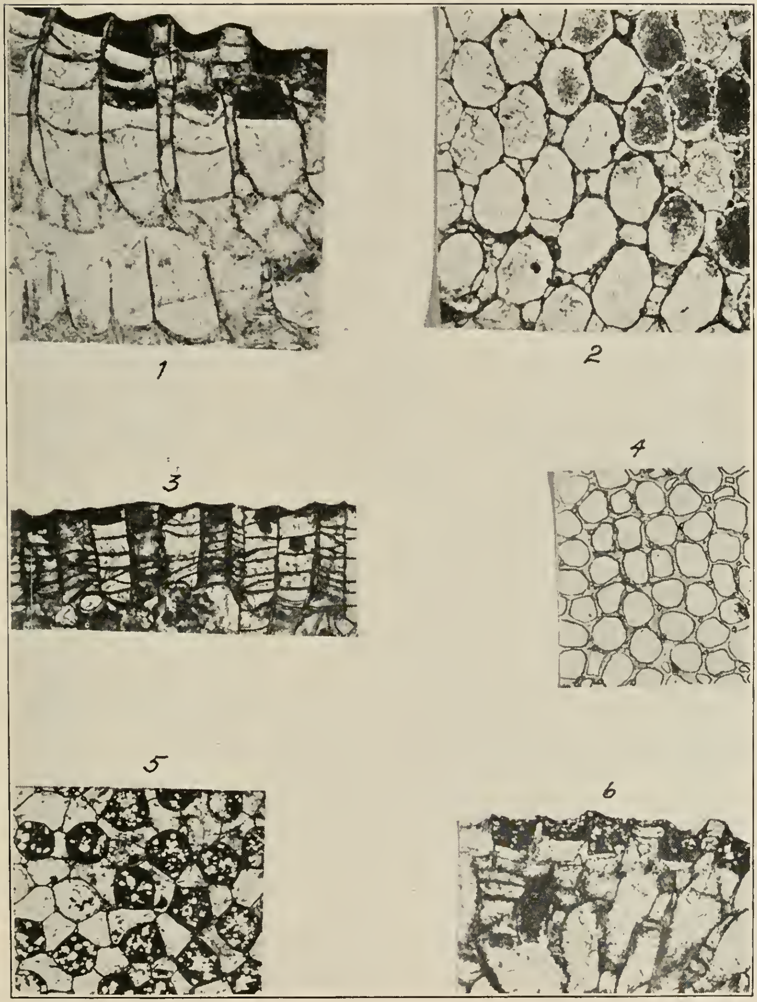

PLATE XII

Graptodictya fruiticosa n. sp.

1. Longitudinal section x 18.
2. Tangential section x 18.
   Pierce limestone. Walter Hill, Tenn.

Graptodictya dendroidea n. sp.

3. Tangential section x 18.
4. Longitudinal section x 18.
   Pierce limestone. Walter Hill, Tenn.

Rhinidictya tabulata n. sp.

5. Longitudinal section x 20.
6. Tangential section x 18.
   Pierce limestone. Murfreesboro, Tenn.

PLATE XII.

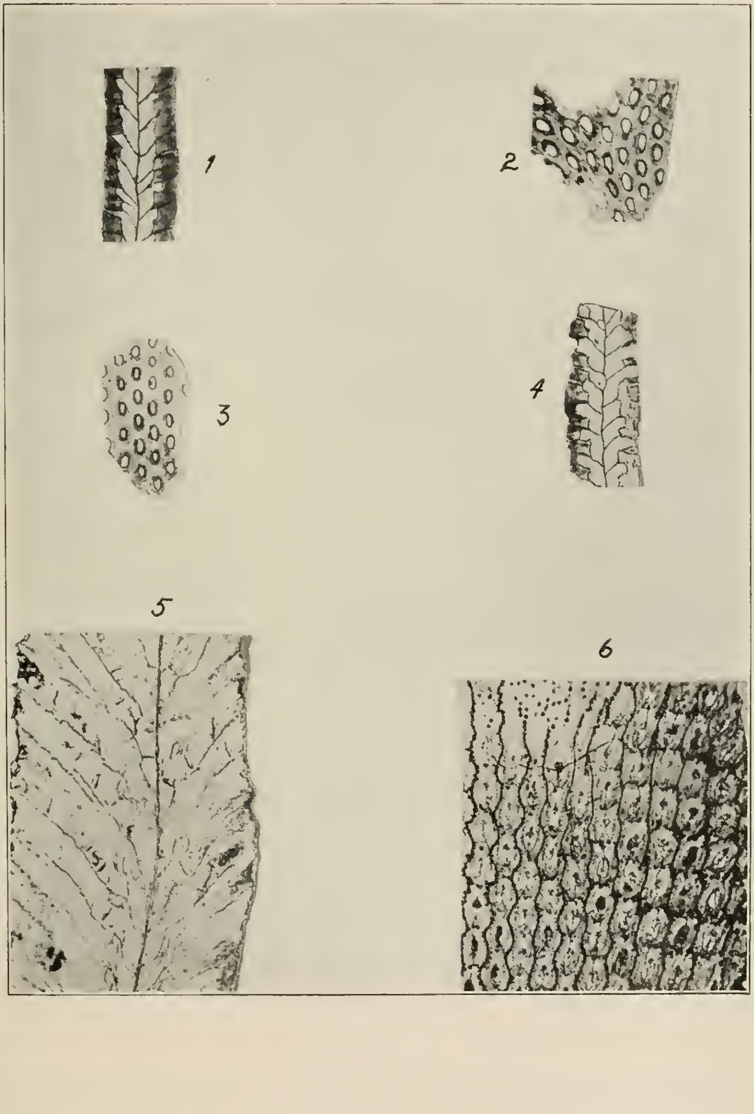

PLATE XIII

Pachydictya senilis n. sp.

1. Tangential section x 20.
2. Tangential section x 20, near the surface, showing tubuli.
3. Longitudinal section x 20.
   Pierce limestone. Murfreesboro, Tenn.

Rhinidictya salemensis n. sp.

4. Longitudinal section x 18.
5. Tangential section x 18.
   Ridley limestone. Salem, Tenn.

Rhinidictya lebanonensis n. sp.

6. Longitudinal section x 18, showing superior septum.
7. Tangential section x 18.
   Lebanon limestone. Miles Ford, Rutherford Co., Tenn.

Trigonidictya irregularis n. sp.

8. Longitudinal section x 18.
9. Tangential section x 18.
   Lebanon limestone. Christiana, Tenn.
   (See Plate III)

PLATE XIII.

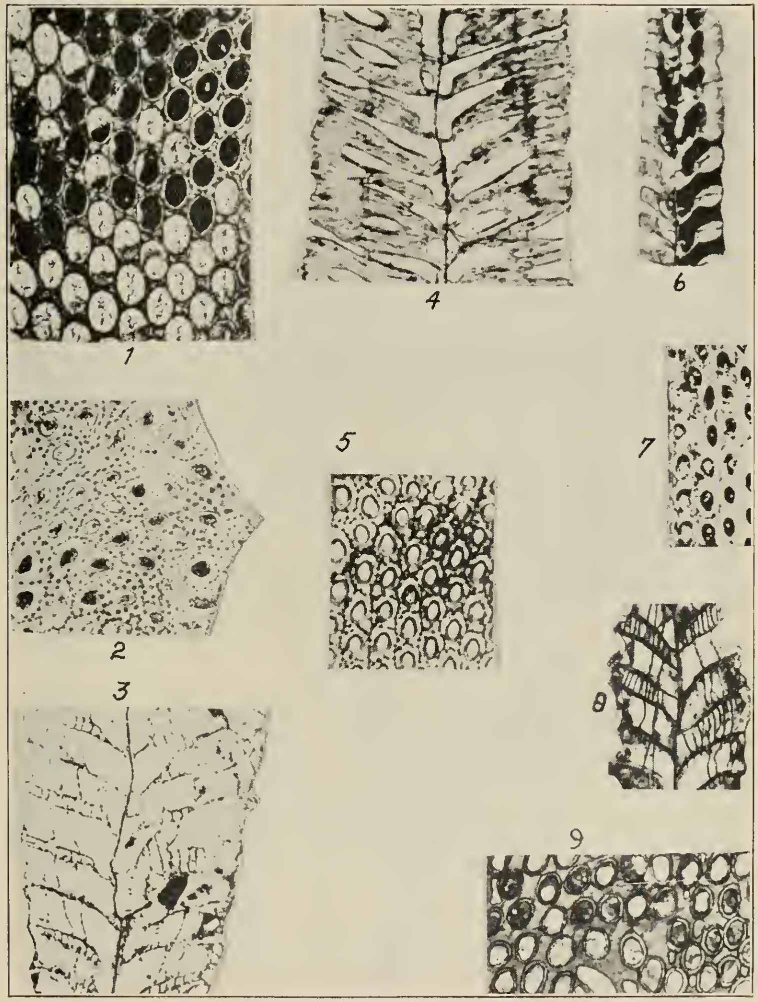

PLATE XIV

Hemidictya lebanonensis n. sp.

1. Cross-section x 18, showing median tubuli.
2. Tangential section x 18.
3. Longitudinal section x 18.
   Lebanon limestone. Big Springs. Rutherford Co., Tenn.

Stictoporella cribilina n. sp.

4. Tangential section x 20.
5. Longitudinal section x 20.
6. Portion of the surface x 10.
7. Photograph of a slab from the Pierce limestone showing a portion of a zoarium.
   Pierce limestone. Murfreesboro and McFadden Ford, Rutherford Co., Tenn.

PLATE XIV.

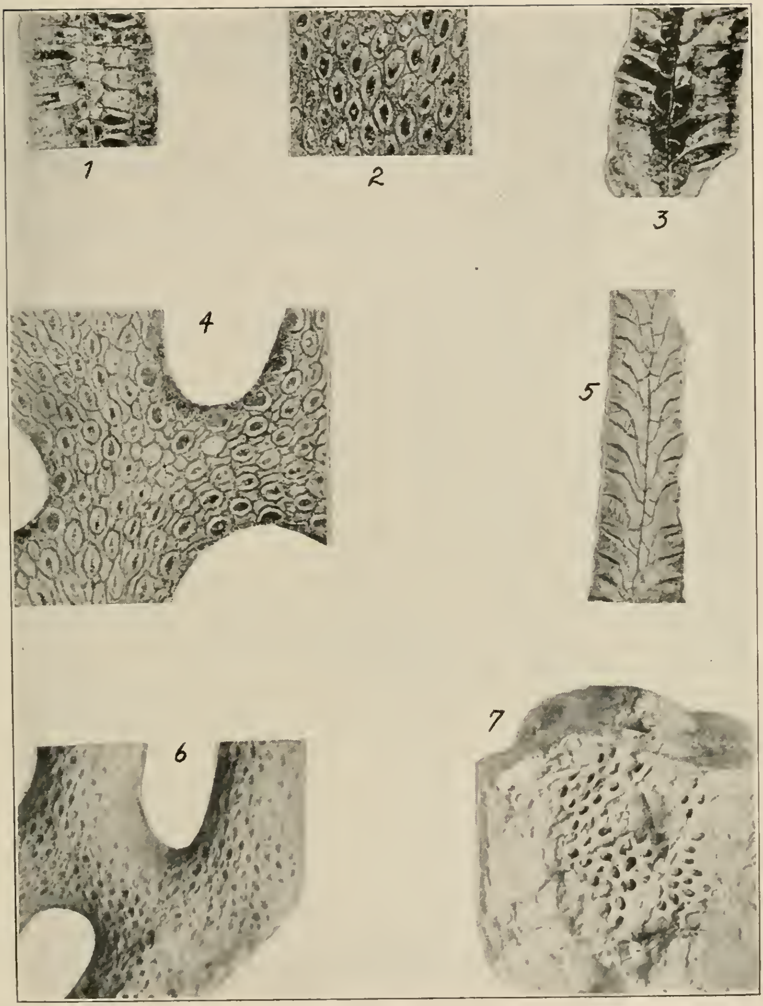

TABLE 1. CORRELATION TABLE OF THE STONES RIVER DEPOSITS OF NORTH AMERICA

		Gulf of Mexico Embayment							Appalachian and Champlain Trough				
	Group	Central Basin Tennessee	Alabama	Oklahoma	Kentucky	Central Pennsylvania and Central New York	Bellefont Pennsylvania	Eastern Canada	Eastern Tennessee	Western Virginia	West Virginia and Maryland	South Central Pennsylvania	Eastern New York and Western Vermont
Lower Chazyan	Stones River Group	Lebanon ls.	Stones River ls.	Simpson formation	Camp Nelson ls. / Base not exposed / High Bridge ls.	Pamelia ls.	Lebanon ls.	Rideau SS.		Stones River ls.	Stones River ls.	Pamelia ls.	
						?			?			?	?
		Ridley ls.					Ridley ls.		Lenoir ls.			Stones River ls.	Crown Point ls.
		Pierce ls.	Attala Cong.				?						Day Point ls. ?
		Murfreesboro ls.							?				
		Base not exposed					?		absent				
									?	?	?		
			?	?					Mosheim			?	

A SYNOPSIS OF THE SUBSPECIES OF ELECTRON PLATYRHYNCHUM (LEADBEATER).

BY

HARRY C. OBERHOLSER.

An incidental investigation of the typical form of *Electron*[1] *platyrhynchum* led to the discovery of an apparently new subspecies of this group. For better elucidation of its relationships the following synopsis of all the subspecies of *Electron platyrhynchum* may be useful. The names of colors used in this paper are from Mr. Ridgway's "Color Standards and Color Nomenclature." For the privilege of consulting material pertinent to the present study, the writer is indebted to the authorities of the United States National Museum.

ELECTRON PLATYRHYNCHUM PLATYRHYNCHUM (Leadbeater).

[*Momotus*] *Platyrhynchus* LEADBEATER, Trans. Linn. Soc. Lond., XVI, pt. 1, 1829, p. 92 ("Brazil"; errore pro western Ecuador).

Chars. subsp.—Size large; subterminal portion of middle tail-feathers without barbs; upper parts rather dark; lower parts tinged with bluish.

Description.—Pileum and cervix between chestnut and Sanford's brown; back between parrot green and grass green, shading into meadow green on the upper tail-coverts; tail prussian green, the edges of the feathers less bluish, their tips black; wings deep chaetura drab, the outer part of the upper surface of the quills meadow green, their edges less bluish, the outermost quills more bluish (near wall green); upper wing-coverts rather yellowish grass green; sides of head and of neck of the same color as the crown; chin between meadow green and grass green; throat and jugulum of the same shade as the crown, but paler; remaining lower parts meadow green, in places inclining to grass green; crissum darker; under wing-coverts drab, much washed outwardly with the green of the upper wing-coverts.

Measurements.—Wing, 121.5—130 mm.; tail, 188—223; exposed culmen, 36; tarsus, 20; middle toe without claw, 14.5.

Type locality.—Western Ecuador.[2]

Geographic distribution.—Western Ecuador and western Colombia.

Remarks:—Dr. E. Hartert has already shown[3] that the type of *Momotus platyrhynchus* Leadbeater, though supposedly from Brazil, is really from Ecuador, as is plain from its large size and uncut central rectrices. As a matter of fact, the Brazilian bird is much nearer *Electron platyrhynchum pyrrholaemum*, as hereinafter shown.

[1]For the use of this generic name in place of *Prionornis*, *cf.* Ridgway, Bull. U. S. Nat. Mus., No. 50, VI, 1914, p. 470.
[2]Here definitely designated.
[3]Novit. Zool., V., 1898, pp. 497-498.

ELECTRON PLATYRHYNCHUM SUBOLES Nelson.

Electron platyrhynchus suboles NELSON, Smithson. Misc. Coll., Vol. 60, No. 3, September 27, 1912, p. 5 ("Cana (at 2.000 feet altitude), eastern Panama").

Chars. subsp.—Similar to *Electron platyrhynchum platyrhynchum*, but much smaller; pileum paler and duller; and chin more distinctly greenish.

Measurements.—Male (type): wing, 117 mm.: tail, 177[1]; exposed culmen, 42; tarsus, 18; middle toe without claw, 13.5.

Type locality.—*Cana* (altitude 2.000 feet) Darien, eastern Panama.

Geographic distribution.—Eastern Panama.

Remarks.—This form has a rather limited distribution in eastern Panama, and extends possibly to at least the lower Atrato Valley in northwestern Colombia, although birds from the upper part of this valley are *Electron platyrhynchum platyrhynchum*.

ELECTRON PLATYRHYNCHUM MINOR (Hartert).

Prionirhynchus platyrhynchus minor HARTERT, Novit. Zool., V. No. 4, December 31, 1898, p. 498 ("Panama").

Chars. subsp.—Similar to *Electron platyrhynchum suboles*, but bill relatively shorter and broader: green of upper parts duller, more olivaceous; and under parts less bluish.

Measurements.—Male: wing, 110—118 (average, 112.8) mm.; tail, 155—192 (171); exposed culmen, 35—40 (38.1); tarsus, 17—18.5 (17.8); middle toe without claw, 13—15.5 (15.1).

Female: wing, 106—116 (average, 110.9) mm.; tail, 151.5—186.5 (168.6); exposed culmen, 34—39 (36.5); tarsus, 16.5—18 (17.2); middle toe without claw, 13—15 (13.9).

Type locality.—Panama.

Geographic distribution.—Central America, east to Canal Zone in Panama, and west through Costa Rica to eastern Nicaragua.

ELECTRON PLATYRHYNCHUM ORIENTICOLA, subsp. nov.

Chars. subsp.—Similar to *Electron platyrhynchum platyrhynchum* from western Ecuador, but smaller; subterminal portions of middle rectrices entire; upper parts paler; the back and wings more yellowish; lower surface lighter, and posteriorly much less bluish (more yellowish or greenish).

Description.—Type, adult female, No. 177,039, United States National Museum; Hyutaniha, just below the falls of the Purus River, Brazil, March 16, 1901; J. B. Steere. Pileum and cervix amber brown, verging toward Sanford's brown; back deep yellowish oil green, its lower part cerro green; upper tail-coverts between grass green and meadow green; tail prussian

[1] By mistake given as 188 mm. by Ridgway, Bull. U. S. Nat. Mus., No. 50, VI, 1914, p. 474.
[2] From Ridgway, Bull. U. S. Nat. Mus., No. 50, VI, 1914, pp. 472-473.

green, the edges of the feathers less bluish, their tips black; wings deep chaetura drab, the edges of the upper surface of the feathers bay green, those of the primaries more bluish, the lesser coverts wholly cerro green; chin between biscay green and light bice green; sides of the neck like the crown; throat, jugulum, and upper breast of the same color, but lighter; remainder of the lower parts biscay green, anteriorly varying to bluish light bice green; crissum similar, but darker and duller; lining of wing light cinnamon, the edges of the wing mixed with bluish green; "eyes black."

Measurements.—Type: wing, 106.5 mm.; tail, 179; exposed culmen, 31.5; tarsus, 16.2; middle toe without claw, 13.

Type locality.—Hyutaniha, just below the falls of the Purus River, northwestern Brazil.

Geographic distribution.—Northwestern Brazil, east to the Madeira River; west probably to eastern Ecuador; and north probably to central southern Colombia.

Remarks.—This new race is most closely allied to *Electron platyrhynchum pyrrholaemum*, with which it agrees in the condition of its middle tail-feathers, but from which it differs in its paler head, more yellowish back and upper surfaces of wings, and lighter, as well as posteriorly more yellowish or greenish (less bluish), lower surface. The bird recorded by Dr. C. E. Hellmayr from Humaytha on the Madeira River[1] belongs, of course, to this form. No specimens from eastern Ecuador have been examined, but the bird from this region is, without much doubt, referable here. The example from Florencia, central southern Columbia, which Dr. F. M. Chapman indicated as belonging to *Electron platyrhynchum pyrrholaemum*[2], is apparently very close to this new subspecies, if, indeed not identical.

ELECTRON PLATYRHYNCHUM PYRRHOLAEMUM (Berlepsch and Stolzmann).

P[rionirhynchus]. p[latyrhynchus]. pyrrholaemus BERLEPSCH and STOLZMANN, Proc. Zool. Soc. Lond., 1902, II, pt. 1, October, 1902, p. 35, in text ("La Merced, Borgoña", [central Peru]).

Electron platyrhynchum medianum TODD, Proc. Biol. Soc. Wash., XXVI, August 8, 1913, p. 174 ("Rio Turutu, Provence del Sara, Bolivia").

Chars. subsp.—Similar to *Electron platyrhynchum orienticola*, but pileum darker, back and upper surface of wing less yellowish, and inferior surface darker, more bluish.

Measurements.—Wing, 114—117 mm.; tail, 188—190; exposed culmen, 34—37; tarsus, 14—18; middle toe without claw, 16.

Type locality.—La Merced, central Peru.[3]

Geographic distribution.—Peru and Bolivia.

[1]Novit. Zool., XIV, No. 2, November 1, 1907, p. 403.
[2]Bull. Amer. Mus. Nat. Hist., XXXVII, 1917, p. 269.
[3]So given by Dr. C. E. Hellmayr, Novit. Zool., XIV, 1907, p. 403.

Remarks.—This race is apparently confined to Peru and Bolivia, since birds of this species from Brazil, Colombia, and probably eastern Ecuador, belong to other forms. The absence of racquets on the middle rectrices is evidently only a subspecific character, as this occurs sometimes in other races which normally have well-defined racquets.

The Bolivian bird has been described as a new race, *Electron platyrhynchum medianum*[1], which is similar to *Electron platyrhynchum pyrrholaemum*, but is supposed to have the chin spot more bluish, the posterior under parts and exposed surfaces of remiges somewhat less bluish, and the rufescent areas of chest slightly darker and duller. These differences are apparently individual, an opinion in which Mr. Todd himself now concurs.

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[1]*Electron platyrhynchum medianum* TODD, Proc. Biol. Soc. Wash., XXVI, August 8, 1913, p. 174 ("Rio Turutu, Provence del Sara, Bolivia").

OBSERVATIONS ON THE FOOD OF CLADOCERA.

BY THE LATE

Homer G. Fisher.

During the winter of 1913-1914 I became interested in the feeding of two species of cladocera (Daphnia pulex and Simocephalus vetulus) which were being reared in the laboratory of Dr. A. M. Manta at the Station for Experimental Evolution of the Carnegie Institution of Washington. It was a part of my duty to collect food for them and hence the food was often examined microscopically, but by this method I was unable to determine just what elements of the mixture were being used as food by the daphnids.

At the suggestion of Dr. Banta, I then tried to examine the contents of the alimentary tracts of some of the daphnids, but I was still unable at that time to arrive at any definite conclusion as to what constituted their food. The only organized material that I was able to make out was a very minute organism that I supposed to be a bacterium. These observations were extended during the following year at the Zoological Laboratory of Indiana University and during the following summer at the Indiana University Biological Station. At the Biological Station a third form, Daphnia hyalina, was studied.

The method has been to examine the alimentary tracts as soon after feeding as possible to determine what had been ingested. At the University Laboratory the daphnid was always rinsed in tap water, placed on a clean slide, and crushed with a clean cover slip. In this manner most of the material of the alimentary canal was expelled and made available for observation. At the Biological Station the same method was used except that the animal was allowed to swim in distilled water a few minutes before it was put on the slide. Additional studies were made by making smears of the alimentary tract and staining. The stain used was in every case Flemming's triple stain. The following species and numbers were examined; at the Station for Experimental Evolution about 15 individuals, at the University Laboratory 18 Daphnia pulex and 14 Simocephalus vetulus, and at the Biological Station 64 Daphnia pulex, 17 Simocephalus vetulus, and 3 Daphnia hyalina. They were all parthenogenetic females.

At the Station for Experimental Evolution the daphnids were all obtained from laboratory jars. At the University they were obtained from Hill Pond, and at the Biological Station they were collected from Eagle (Winona) lake and from Cherry creek near its mouth. At the lake all of the Daphnia were obtained with a plankton pump from near the center of the lake at a depth of 4-8 meters. The Simocephalus were collected with a silk sampling net from the creek and from the edge of the lake among the aquatic plants. The material was examined as soon after collection as was practicable.

The only organized material found in the intestine of any of the species was a minute pear shaped flagellate, the systematic position of which has not been determined. There may be two or more species of the flagellates but they are so minute that it is not possible at present for me to determine this. That they are flagellates can only be made out with an oil immersion lens. In many of the specimens the intestine was gorged with the flagellates and in no case have I ever found them absent. In living material the typical flagellate movement can be discerned.

The possibility has been suggested that the observed phenomena was only a Brownian movement, but upon staining enough organization can be made out to show clearly that the animal is a flagellate. Some individuals can be seen dividing. The unformity of the shape of the individuals also shows them to be living organisms, as it is not likely that powdered particles in suspension would be of a uniform pear shape. As a further evidence that the bodies were alive I ran some Flemming's fixing solution under the cover glass and as soon as it reached the animal they immediately ceased all movement.

It was also suggested that these might only be parasitic in the intestine of the daphnid, but it was observed that they were found almost exclusively in the anterior end of the intestine. However, the material from the anal end of the intestine showed a few, but it seems that even these might have been forced to their position by the movement of the water around the body of the daphnid at the time it was crushed.

I also strained a large quantity of lake water through a silk net and then filtered it through filter paper. Upon examination this filtrae was found to contain the same flagellates. This demonstrated that they were living in the same water with the daphnids.

Since no other organized material was found in the intestine of the three species of cladocera and since their occurrence is constant, it seems reasonable to conclude that they form the food of the animal. While the number of individuals is not large, I believe that the times and conditions of collection of material are diverse enough to mean more than a much larger number of individuals collected at the same place during a single season.

[1]Mr. Homer Glenn Fisher died in Oct., 1917. He had hoped to be able to extend these studies before publishing. He had submitted this preliminary summary which is published with no substantial change.—Will Scott.

THE FLOOD MYTH OF THE CHIPPEWAS.

BY

Albert B. Reagan.

Manabush is the erator god of the Chippewa Indians. Soon after his birth his parents were both killed by a clan of sealions. After their death he lived with his grandmother till he became of age. He then decided to go out and avenge the death of his parents. The sea monsters who had killed his parents lived on an island. This was first surrounded by water for a short distance. Then for a space of about a mile and a half there was a circular band-area of floating pitch-like ice across which a canoe could not venture without certainly getting stuck in the pitch and consequently being captured. But notwithstanding this apparently unsurmountable difficulty, Manabush was determined.

He told his grandmother his plans. She listened attentively to their narration, then sadly advised him not to undertake the hazardous task, though she wished to see the annihilation of the destructive sea beasts. In concluding she said. "It is no use for you to fight with the sealions of that island. Your canoe will get stuck in the pitch. Then the beasts will come out and devour you." But he was the more determined. He made a large canoe and covered it with tallow so it would float and go through the pitch. After it was completed, he made a strong bow and prepared plenty of arrows. He then launched his canoe and told his grandmother to go ahead of him with another canoe in a zigzag way up the channel a little distance at the start. (This custom of having the women proceed a war party for a little way when starting on a war expedition was long afterwards followed by the Chippewas in starting on the war path against the Sioux.) Then when everything was ready, he started out on his war enterprise.

After considerable labor in paddling and pushing his canoe through and over the pitch-like ice, he landed safely on the island in the night where he stayed till the break of day. Then at dawn he gave the warwhoop and ran for the house of the king, or chief sea monster. Upon hearing the warwhoop, the king jumped from his bed and got his bows and arrows; and the two powerful beings started to fight according as they were gifted by their superior givers. The battle was terrible. They fought continuously for two days without killing each other. Then they rested on their arms with the contest a draw.

But Manabush had advisers at hand. On the evening following the second day's battle, Batter, a bird of the blue jay family, accosted him and said: "You can not kill King Sealion by shooting him in the body, as his heart and vital parts are not there as in most beings." Then after a short pause, he continued: "I will tell you where they are if you will promise to give me some of the meat from his dead carcass."

With open mouth and wide eyes, Manabush listened to Batter's statement and advice till he had closed, then replied: "My brother, if you will tell me where King Sealion's heart is I will give you the meat you ask and make you king of the Blue Jays and all meat birds."

"In truth," spoke up Batter as he flew to a limb over Manabush so as to be heard more easily without talking loud enough to be heard by any one else, "this monster's heart is in his little toe. Aim for that next time you go to battle with him and you will succeed."

The morning of the third day Manabush again gave the warwhoop. Immediately King Sealion came out with his full equipment for battle. The fight was on. Manabush aimed for the little toe of his adversary. The arrow struck squarely and penetrated the vital regions. King Sealion keeled over and died there and then, seeing him fall, Manabush ran to him, took out his big knife and scalped him. He then sailed across the surf to where he had left his grandmother, singing his song of victory as he went, as the Indians have since sung when returning from a battle field.

When his grandmother heard him coming singing the victory song, she started out to meet him in her canoe. Meeting him, she took the scalp and went on ahead of him to shore. Landing, she called the village neighbors and all commenced to have the war dance around the scalp in the middle of the dance hall, as it has since been the custom of the Indians to dance the war dance down through the ages. Thus they danced till they had completed the orgie, after which they smoked the pipe of peace.

This dance lasted four days. Then Manabush bade his grandmother goodbye and started west over the earth in quest of other "hurtful" beasts. After four days of journeying he met four wolves, one of which was a chief. These accompanied him for four days in his passing westward. As he thus journeyed with them, he noticed every evening when they camped for the night that they would pile sticks in a heap and King Wolf would jump over the pile four times, after which the wood would catch fire without the aid of a fire-starter. By watching them, he also learned the art. On they traveled. As they thus journeyed, young wolves followed along behind and chased down the moose and deer and killed them as needed. Then they would dress and cook some and all would eat to their satisfaction. So all had a pleasurable time.

After journeying four days with the wolf pack, he chose for his companion one of the young wolves whom he called his nephew. Leaving the rest behind, he then traveled on in his western travels. The evening of the first day after they had parted company with the other wolves they came upon the track of a moose which it was decided his nephew should chase on the following morning. That night Manabush had an unfavorable dream. The next morning as a consequence of the forboding evil foreshadowed in it, he cautioned his comrade to be careful. "The dream was about chasing this moose," he said. "It was a bad dream about you in this chase." He continued: "In chasing this moose you are to track, whenever you come to a little stream always cut a tree down and walk across it. Don't jump over the stream. Be careful."

As per arrangement, the nephew started out on the chase, Manabush following his tracks. Soon he came to a little stream over which he fell a tree as he had been instructed. He then crossed it safely. After a while he came to another very small stream which he thought he would jump, as it seemed too small to take time to cut a tree down on which to cross. Furthermore, he could see the moose only just a little farther on, staggering with fatigue, and, by crossing immediately, he could soon overtake it. He could even taste fresh meat, he imagined, the moose being so sure his. As he jumped, the stream instantly swelled its dimensions to a raging torrent and swept him away with it. It had been caused to become a large river by the great Snake God who lived near a sand point that projected into the lake a little way off from the outlet of the river. This snake god's home was on an island just beyond the sand point. Here he lived in company with many other snakes and other animals that live in the water. Here they had their lodges, as did the bear family. These snakes and beasts were the great evil enemies of our race. Here to this island the wolf was taken prisoner. There he was killed and skinned and his hide was used to cover the door-way of the principal lodge of the place where the greater part of the snakes went in and out in their strollings about.

Following along behind, Manabush tracked his nephew to this second stream, now a big river, and found that his tracks ended there. At once he knew he had disobeyed his orders of the morning when he had told him to cut a tree across every stream he came to. He had cut one tree down and had crossed the stream there safely. Now he had disobeyed orders and had tried to jump the stream, but was taken by the current. And the stream getting larger and swifter as it passed out toward the lake, took him out with it to the residence of King Snake. There this snake and his companions had killed him and took his hide for a door-cover for the snakes' passage-way. Finding that the tracks ended at the stream-crossing and that he had undoubtedly been swept out into the lake, Manabush started down its winding course, hoping against hope that he might find him stranded and yet alive, or might be lucky enough to find his body, if dead. He had luck in obtaining desired information, but not his comrade's body.

As he neared the stream's mouth, he saw a bird looking down into the water. He slipped slowly up to it and made a grab for its head. Unluckily, however, he just missed his hold and ruffed up the feathers on the back of its head and neck. The bird was Kingfisher. The top bunch of feathers on his head Manabush made by this stroke, by grabbing him by the head and slipping his hold. Escaping, the bird flew away a short distance and lit. Then looking back and seeing Manabush, he said: "I would have told you where your nephew has gone had you not grabbed me as you did." Manabush, however, was equal to the occasion, for he knew the weak points in the make-up of the lives of all living things. So he said to him: "Come over and tell me and I will make you a pretty bird." In consequence of this promise, he flew near and told him that his nephew had been killed by King Snake who lived near the sand point. He told him further that the snakes and bears and other water beasts come out on the sand point to sun themselves about noon each nice day and the King Snake would be the last one to come on shore. Manabush thanked him for the information and then "fixed him up" and made him a pretty bird by rubbing his breast with white clay and painting his body black-blue.

Having completed his talking with Kingfisher, he started for the sand point mentioned, after he had made a strong bow and had prepared bull-rush tops for arrows. When he got near the sand beach he said to himself: "I will be a tree-stub". And on reaching the place he turned into a stub of a poplar tree. Then after while as the sun ascended the heavens, the snakes came out to sun themselves on the sand as they were wont to do. The white bears came last, followed by King Snake. The others had noticed nothing; but King Snake at once noticed the tree-stub. "What is it?" he asked. On scanning it further, he exclaimed: "I believe that is Manabush standing there!" He then turned to one of the chief snakes and said: "Go to yonder stub. Climb it. Then coil around it and squeeze it hard." This snake chief did as he was bidden. He coiled himself around it and squeezed; but Manabush never moved. After this snake had tried his crushing powers for a considerable time, he gave it up and went back to where King Snake was, saying: "That can't be Manabush." King Snake, however, was not satisfied. He turned to a white bear and commanded him, also, to examine the supposed stub, saying: "You go and climb on that stub to its very top. Then climb down so as to scratch it as you descend." The bear did as he was told. Manabush nearly yelled, but never moved. Going back to his master, the bear said: "That can't be Manabush." Being satisfied, King Snake immediately came ashore and stretched himself on the sand in the sun.

After all the reptiles were fast asleep, Manabush turned to be a man again. He then took out his bow and arrows and went near King Snake and shot him in the body, but without injuring him in the least. He then remembered what Kingfisher had told him, that to injure King Snake he must shoot his shadow. So with the second shot he aimed at the beast's shadow, and instantly the reptile stretched out and gasped in awful pain. Seeing this, Manabush started back to get a few logs together to make a raft, for Kingfisher had told him that if he wounded King Snake, he would flood the world to the top of the trees in revenge. Then the water would go down again. But if he killed him, he would destroy the whole world in a mighty flood. The waters had already begun to rise. So he got on the raft he had succeeded in making and floated about as he watched the water rise until the trees all disappeared. Then the water went down again.

After it had got dry on the earth again, he went back to tell Chief Wolf what had happened. After narrating this to the wolf tribe, he went back to the lake where he had had the encounter with King Snake; he knew by the world's not being destroyed utterly that this snake had only been wounded. Consequently, he had it in his mind to make sure of his killing him, be the consequences what they would.

As he was walking along the shore of the lake on his return, he heard something rattling. Looking ahead, he saw a large frog-like, old lady of the bad-witch type jumping along. She had a rattle which she used in doctoring the sick. She also had a pack of basswood on her back.

"Helloo, grandma," he shouted to her. "Where are you going?"

"I am going to King Snake's house to doctor him," answered the frog-lady.

"Why, what is the matter with King Snake, grandma?"

"One great god, Manabush, shot King Snake for revenge."

"Grandma, teach me your medicine," broke in Manabush. "I will pay you."

Tempted with the promised pay, the old medicine-frog-lady told him all about her doctoring and medicine songs. Then after he had learned all she could impart, he killed her and, skinning her, put the skin on himself. He then took the rattle and the pack of basswood bark and started for the village where King Snake lived. On the way he stopped where the old frog-lady had lived. There he made himself much at home and waited an invitation to doctor. The evening following his arrival, a messenger came to him saying: "Grandma, you are again requested to come and doctor King Snake."

"All right," answered Manabush.

Then imitating the old frog-lady, he started to finish his killing of King Snake. Moreover, realizing the dire results that would follow, he got a lot of trees together for a raft, as he journeyed toward that snake's house. Getting everything in readiness, he entered that reptile's yard. As he entered the door he noticed his nephew's skin hanging as a curtain to the doorway. The sight of it made him feel so badly that he almost cried. He entered the house, they, of course, supposing him to be the old-medicine-frog-lady. They had him enter the room where King Snake lay very weak and sick. On entering, he took his rattles and started to sing the medicine songs he had learned from the aged frog-lady. As he sung, he crawled nearer and nearer to King Snake's side. As he did so, he saw that the arrow he had shot at the previous time was still imbeded in the flesh with the broken end still sticking out. He waited. At the opportune moment he pushed the arrow completely in and instantly killed King Snake. He then immediately fled from the house, singing to cover his tracks and to prevent suspicion.

He knew the consequence of his act and made with all speed for his raft, and none too soon, for while he was still running the water reached knee deep in depth. The raft also began to float away just as he got on it. Soon then the whole world was submerged. In this catastrophe the animals commenced to swim around trying to get somewhere where they would be safe from the raging waters. Some succeeded in getting onto the raft; others hung to it. For four days they were floating as if it were in the middle of a great ocean; there was no land to be seen anywhere. The whole land surface of the earth had been swallowed up.

Manabush had forgotten to get a handful of dirt from mother earth before getting aboard his raft. So on this fourth day of tempestuous waters he called a council, saying: "We must do something. We can not stay here on this raft for all time. We must get some dirt."

In accordance with the decision of the council, Manabush chose Beaver, Otter, Loon, and Muskrat as divers to try their hands in getting some earth from the bottom of the deep to start land again. Beaver went down first, but died before he reached the bottom of the waters. Otter dove likewise, but died and floated lifeless over the water. Then Loon went down but returned without anything. He had seen the bottom of the surging waters, but had lost his life just as he was nearing the green, carpeted land and trees. When he floated near the raft dead on his return, Manabush seized him. He then brought him back to life by blowing his breath in his face. Muskrat then started in his diving. For four days nothing was seen of him. Then he floated again on the water near the raft, dead and all doubled up. Manabush pulled him on board the raft and blowed breath into him again. Then he went to examining him to see what he had found. In his hands (front paws) he found a little dirt and sand, also some in his feet and mouth. A leaf and some seed were also found. Having obtained the coveted gifts of earth, he dried them in his hands and caused them to increase till he had a handful. The act of recreation of the world was then at hand.

Being all ready for the work before him, Manabush held his filled hand of dirt, sand, and seed up on a level with his face with palm up. At once he began to blow his breath strongly over the lump and blew particles off it around the raft. In this way he formed an island. Immediately, then, the animals left the raft and began to roam on the land surface; but he kept on blowing the particles from his hand out farther and farther, thus extending the land area. He kept up this blowing till the "land could be seen out of sight." He then sent a raven to fly around the land and see how big it was. This bird was gone four days, then returned. So Manabush said: "That's too small." He then blowed more and more. He then sent a dove to see how large the land surface had grown. This bird found it so large that it never came back. So Manabush was satisfied that the world was big enough. He then threw down the chunks of substance he still had in his hands and these are the mountains of the world. He then replanted the earth with moses, trees, herbs, and grasses, after which he departed for his home.

He now lives in the home of the Dawn and is the great king of all spirits.

GLACIAL DEPOSITS IN PINE RIVER VALLEY, COLORADO.

BY

ALBERT B. REAGAN.

The table-flats at Florida, east of Durango, Colorado, on the Denver & Rio Grande Railway and eastward across Pine river to beyond Spring creek at Laboca on that railroad—in fact, the whole area from the bluff-mesas west of Durango to the bluff-mesas beyond Spring creek to the eastward in a curve running to the northeast of Durango and bending far to the southward and southeastward, is covered heavily with glacial drift, except where the country rocks project above it in points, ridges, and buttes in many places. The mesas southwest of Ignacio are also covered with glacial boulders and other glacial material. How much farther the glacier extended is not known to the writer.

A little northeast of Durango in the Animus valley there are heavy morainic deposits, associated with extensive outwash deposits. The same phenomenon appears on the Florida, above and in the vicinity of the station of the same name. At Oxford the outwash material, loess, etc. is ten feet deep, superimposed on a bed of boulders often from ten to twenty feet in depth. West of Ignacio the outwash material butts up against the mesas, being often twenty feet thick in the valleys. At Ignacio and at the Southern Ute Boarding School a mile to the northward, the outwash and upper till loess and adobe clay is from five to ten feet deep back from the mesa's edge of the first bench. Immediately underneath this are from five to twenty-five feet of boulders underlain in places by lower till. At Laboca only outwash material was seen, there often forty feet thick, as is shown in the valley cuts of the present washes.

Three miles north of the present Indian school on Pine river, the stream has cut completely through the debris, which here shows no lower till, but twenty-five feet of boulders on which are superimposed outwash till and loess. The bench west of the boarding school, to which a part of the school land extends, is one hundred feet above Pine river in elevation, but at no place in the slopes from the river to its crest is the original rock shown. On top of the bench are five feet of adobe, beneath which are twenty-five feet of boulders, and under this till to an unknown thickness. At Bayfield, ten miles north of Ignacio, the outwash material is of immense thickness, overlying boulders; while to the southeast of that city over a small ridge of jutting, original country rock buttes, is a pocket of glacial deposits of a similar nature. Also from Bayfield northward on Pine river for many miles, outwash material is very conspicuous. The valley fillings seem to be composed wholly of it.

The glaciers that made these deposits seem to have had two or more centers. The glacier in the vicinity of Durango appears to have come down the Animus river channel. The rest of the glaciers seem to have had their origin in the lake country above the junction of Vallecieto creek and Pine river in the high peaks of the San Juan range. Pushing downward from the heights, they appear to have collected in a basin in the Vallecieto district of the upper Pine, now a magnificent valley from a mile to several miles wide and several miles in length, blocked in by mountains and ridges which rise one thousand feet above the valley floor. Here the glacier pushed southward, spreading out both eastward and westward into a huge fan as it reached the valley flats, even crawling over the lower ridges of the foothills and beginning to spread extensively before reaching the latitude of Bayfield. The writer can not say whether the Spring Creek glacier was a branch of the Pine River glacier, or came from another glacier center in the same mountains. This much is sure, at Laboca they formed a continuous ice sheet and the outwash materials coalesced. Extensive glacial debris was also noticed about Pagosa Springs fifty miles east of Bayfield.

As the boulders overlie the mesas south of Ignacio, it would seem that they were carried there when the glacier was higher and more extensive than when it deposited the great boulder deposits in the lower benches at Oxford, northeast of Durango, at Ignacio, and in the lower valley of the river near the latter place. Whether two glacial stages are here represented could not be determined with the data obtained.

Since glacial times the river and its confluents have cut entirely through the drift at most places all the way to bed rock and have also widened out a very considerable inner-valley flood plain.

PROBABLE EOCENE GLACIAL DEPOSITS IN THE FORT APACHE REGION, ARIZONA.*

BY

ALBERT B. REAGAN.

When the writer wrote his article on the Fort Apache Region, Arizona, much uncemented gravel and boulders was found capping the mesas and underlying the lava flows. These deposits he placed in the Tertiary and Quaternary. In his section on Canyon creek, Arizona, from the source of that stream to its confluence with Salt river, he gives 125 feet of coarse, uncemented gravel, of gneiss and quartzite boulders, capping the clastic rocks. Gilbert's section at the crossing of Canyon creek also gives 20 feet, coarse uncemented gravel of quartzite and gneiss boulders.** Some of the writer's other sections in that region are here copied in whole or in part to show the existence of this material in various parts of the reservations, as follows***:

Section in Seven Mile Hill canyon, five miles southeast of Fort Apache, Arizona.

		Feet
1.	Basalt	200
2.	Volcanic ashes	10
3.	Strata of mostly unlithified sand and clays	40
4.	Shale, light colored, sandy	4
5.	Conglomerate rock, the cement being volcanic ash. The pebbles and cobble stones of this series being quartzite, granite, andesyte, rhyplyte, limestone of the Palaeozoic era, etc., (no cobblestones or pebbles of the basaltic type were found in this conglomerate).	60
6.	Strata of partly lithified coarse grained, reddish to light brown sandstone, composed of angular and rounded grains of granite, rhyolyte, etc. In this series the rhyolyte-trachyte particles predominate.	200
7.	Red gypsiferous shales with sandstone and limestone of the Carboniferous age ....600 to	1100
		1614

Section along East wall of Cherry Creek Canyon, Arizona, seven miles north of Salt River, near Mr. James Hinton's house.

		Feet
1.	Light to dark brown rhyolyte	30
2.	Conglomerate rock	80
3.	Tufa conglomerate and agglomerate	20

*For references on this region the reader is referred to the following: Gilbert, G. K., and Marvin, A. R., U. S. Geogr. Sur. west of the 100th Meredian, Vol. iii, and special references as follows: Gilbert, pp. 163, 164, 165, 526-528; Marvine, pp. 221-223.

Loew, Oscar, *ibid.*, pp. 587, 642.

Reagan, Albert B., Geology of the Fort Apache Region in Arizona, Am. Geologist, Nov., 1903, pp. 265-308, 2 maps, 1 plate.

**Gilbert, *ibid.* p. 164; Reagan, loc. cit., p. 270.

***Reagan, *ibid.* pp. 270-275.

4.	Light gray sandstone	10
5.	Rhyolyte	30
6.	Gray sandstone and conglomerate	100
7.	Fine grained, gray to brown sandstone, composed of ground up Archean and Palaeozoic rocks, granite, rhyolites, diabases, etc.	40
	Total—apparently all Tertiary	210

Section South of White river, three miles west of Fort Apache.

		Feet
1.	Basalt	200
2.	Unlithified volcanic ashes	10
3.	Loose strata of slightly lithified clays and sands	40
4.	Carboniferous, red gypsiferous shales with sand stone and limestone ....600 to	1000
		1250

Generalized Section on the Government trail from Ellison's to Canyon creek.

		Feet
1.	Adobe	8
2.	Loose cobble stones and pebbles	1
3.	Yellow clay interstratified with loose sand	4
4.	Cobble stone stratum	1
5.	Light yellow to pink, lithified, stratified rock, composed of fine grains of Archean and Tonto rocks	10
6.	Dark brown, partly lithified sandstone	1
7.	Yellow to brown and pink, cross-beded sandstone	10
8.	Conglomerate series	20
9.	Porphyry, gneiss and granite rocks (intrusive)	100
10.	Tonto sandstone and shales (Cambrian)	500
11.	Archean (?) hornblende biotite granite, olivine diabase and hornblende diorite	500
	Total	1155

Section on Carrixo Creek (after Gilbert).*

		Feet
1.	Coarse gravel composed of vitreous sandstone, quartzite, and gneiss boulders	50
2-7.	Clastic rocks	1370
	Total	1420

*Gilbert, *loc. cit*; Reagan, *ibid.*, p. 274.

Section North from near Camp Apache (Fort Apache) (after Gilbert)).**

		Feet
1.	Basalt and basalt gravel	70
2.	Pale pink slightly coherent, massive sand and gravel resting unconformably on No. 3	520
3-6.	Clastic rocks	1670
	Total	2260

It is quite possible from the data at hand that the deposits have accumulated in Seven-mile Hill section and in the Salt River and Hinton regions and in many other places in the area, covered by this paper throughout the Tertiary and may have begun even earlier. A part of the series which the writer had originally designated "Tertiary", principally in the sections mentioned above, begins with a consolidated, coarse conglomerate stratum, beneath which are strata of partly lithified sands, clays and gravels reaching a thickness of nearly a thousand feet in thickness in some places. The formation is found, for the most part, in the ancient canyons of the region. Conformably on the formation above designated "Tertiary", in this paper and in my original report on the region, are hundreds of feet of unconsolidated gravels and clays and occasionally volcanic ashes. This series covered the entire region, excepting possibly the Ellison dome, so that the lava flows which closed the Quaternary, flowed over a plain. Since then much has been removed so that now it is patchy, except where it is protected by superimposed lava. It now fills the valleys of the Pinal and Apache mountain districts; the volcanic and plutonic rocks projecting above it as peaks and mountains. The middle Cherry creek valley and the Tonto basin, as well as the Ellison flat, are covered with it. It covers the Mogollon mesa together with its southern prolongations, including the Cibicu divide, to a thickness of from five hundred to a thousand feet in many places. It is the surface rock of much of the Kelley butte country, and extends beneath the lava of the Nantan Plateau as far as visited.

At the time the writer studied the region, he believed that these deposits were due to a stage of ponding, as a result of differential uplift and lava flows, since he found no glacial striae; but since his study of the glaciation in the San Juan mountains in Colorado and the Deep Creek region, Utah, he has been compelled to change his views and conclude that the deposits in question are of glacial origin and probably in part due to laking, as a result of glaciation and volcanic disturbances. This view is also born out by the fact that the Cibicu divide and the Mogollon mesa, which are both heavily covered with this drift, are higher than the surrounding country and show no evidence of a laking stage.

The deposits, clays, sands, gravels, and boulders of schist, quartzite, gneiss, carboniferous rocks, vitreous Tonto sandstone, diorite, trachyte, rhyolite, and Archean rocks, indicate different development centers for the

**Gilbert, *ibid.*, p. 165.

glaciers that swept over the region. The materials of the Seven-Mile Hill deposits and those beneath the lava flows of the Nantan plateau indicate that the glaciers came from the White Mountains to the eastward. This is also indicated by the dip of the clays and sands. But the deposits of the Cibicu divide indicate by their composition that they came from the west and northwest (and possibly from the southwest), as do also the Hinton and Salt river deposits the latter being composed of quartzites, gneiss, vitreous Tonto sandstone, Archean and Palaeozoic rocks, and biotite granite, all of which are exposed in the upper Canyon creek region, the Ellison dome and the Tonto basin, and south of Salt river along the western face of the Plateau. It is also quite probable that some of the debris came from the mountains to the northward.

From the inadequate data at hand it would seem that at least the deposits below the partly consolidated conglomerate series are Tertiary, extending to the early Tertiary, as Gilbert, Marvin, and the writer concluded when examining the region, and that the remainder are Quaternary, as was also then concluded. This being the case, as the facts at hand seem to indicate, we would, therefore, have had glaciation here in the early Tertiary, probably in the Eocene period, repeated again in the Quaternary. Laking in consequence of blocking lava flows and faulting probably played their parts as did also the subsequent development of drainage, which is, in part, inverted and, in part, diverted.

The finding of glacial material forming the opening series of the Eocene in many parts of the world brings again to the fore with emphasis the fact that glacial epochs have occurred at the beginning (or the close) of each great era of geologic time. This raises the question again, Why do geologic eras close? Is there not a cosmic cause? And as the writer has suggested in previous publications,* may not these changes both in climate and in the readjusting and rebuilding of the earth's crust be due to results brought about by our solar system having reached one or the other terminus of the great elipse around which it is whirling with its company of planets, meteors, planetoids, secondary planets, and comets, much as our extreme yearly seasons are caused by similar positions of the earth with reference to the path it travels around the sun and to the inclination of its axis.

*Regan, Albert B., The Glacial Epoch, Trans. Acad. Sci. of Kansas, Vol. XXVI, 1913, pp. 70-83; Sunspot, Vol. 1, No. 11, January, 1916, pp. 13-30.

SOME NOTES ON THE ESTIMATION OF CHROMIUM AS CHROMIC OXIDE.

BY

WM. M. BLANCHARD AND PAULINE NORRIS.

Schirm (Chem.-Ztg., *33*, 877) states that chromium can be determined gravimetrically by precipitation from a chromic salt by ammonium nitrite solution and igniting the precipitate with the filter in a Rose crucible.

Schoeller and Schrauth (Chem.-Ztg., *33*, 1237) state that accurate gravimetric determinations of chromium may be made by precipitation from a boiling, dilute solution of the chromic salt by the addition of one cc. of aniline and boiling for five minutes. The precipitate is filtered, washed, and ignited.

Hanus and Lukas (8th. Intern. Congr. Appl. Chem., I, 209-12) state that chromic hydroxide can be precipitated quantitatively from neutral or alkaline solutions containing chromates by hydrazine hydrate and some of its derivatives.

Rothaug (Z. anorg. Chem., *84*, 165-89) states that a long series of estimations made by precipitating chromium hydroxide by means of ammonium hydroxide, ammonium sulphide, the iodide-iodate method, and by hydroxylamine, gave results running high from 0.17% to 1.60%, the error being due to the formation of chromic chromate during the ignition.

These statements are interesting compared with the assertions of Fresenius (Quant. Chem. Analysis, 6th. Ger. Edition, Cohn's Eng. Translation, page 281) that when chromium is precipitated in glass vessels, the results are high owing to contamination with silica; if the precipitation is carried out in porcelain vessels, the results are much more satisfactory, and if platinum vessels are used, the results are quite accurate.

With a view to verifying the statements of Fresenius or those of Rothaug, the following experiments were made: The purest obtainable potassium dichromate was carefully recrystallized and the chromium estimated by evaporating to dryness solutions to which were added ethyl alcohol and hydrochloric acid, redissolving, and precipitating the chromium from boiling dilute solutions with ammonium hydroxide. After washing, the precipitate was ignited with the filter, heated over a Meeker burner and afterwards with blast lamp, cooled and weighed. 0.1500 gram of the dichromate was taken each time; this quantity should give 0.0775 gram chromic oxide.

Five determinations in beakers of the best American glass gave 0.0791, 0.0797, 0.0791, 0.0794, 0.0795.

Five determinations with precipitation in a large porcelain casserole gave 0.0794, 0.0790, 0.0796, 0.0798, 0.0794.

Five determinations with precipitation in a large platinum dish gave 0.0798, 0.0797, 0.0791, 0.0792, 0.0794.

Three determinations with glass beakers, the precipitate being dissolved and reprecipitate, gave 0.0796, 0.0790, 0.0789.

One determination with precipitate ignited in a Rose crucible gave 0.0799.

Two blank determinations gave no precipitates.

From these results it would appear that the estimation of chromium by precipitation as chromium hydroxide and ignition in the ordinary way is not reliable and that the error is independent of the composition of the vessel in which the precipitation is effected.

SOME SPECIAL PHYSIOGRAPHIC FEATURES OF THE KNOBSTONE CUESTA REGION OF SOUTHERN INDIANA: AN EXAMPLE OF EXPLANATORY PHYSIOGRAPHY.

By

Clyde A. Malott

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SOME SPECIAL PHYSIOGRAPHIC FEATURES OF THE KNOBSTONE CUESTA REGION OF SOUTHERN INDIANA: AN EXAMPLE OF EXPLANATORY PHYSIOGRAPHY.

BY

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INTRODUCTION AND STATEMENT OF PROBLEM.

Physiography is a study which deals largely with the development of land forms. It attempts to explain the landscape by the action of certain processes on earth materials under particular conditions, and is perhaps less descriptive than it is explanatory. Probably no other phase of physiography presents so many problems as the results of the action of running water on the many kinds of rock material under various geologic and topographic conditions. The intricacies of drainage development and adjustment, traced by means of topographic forms, often present a history by no means simple.

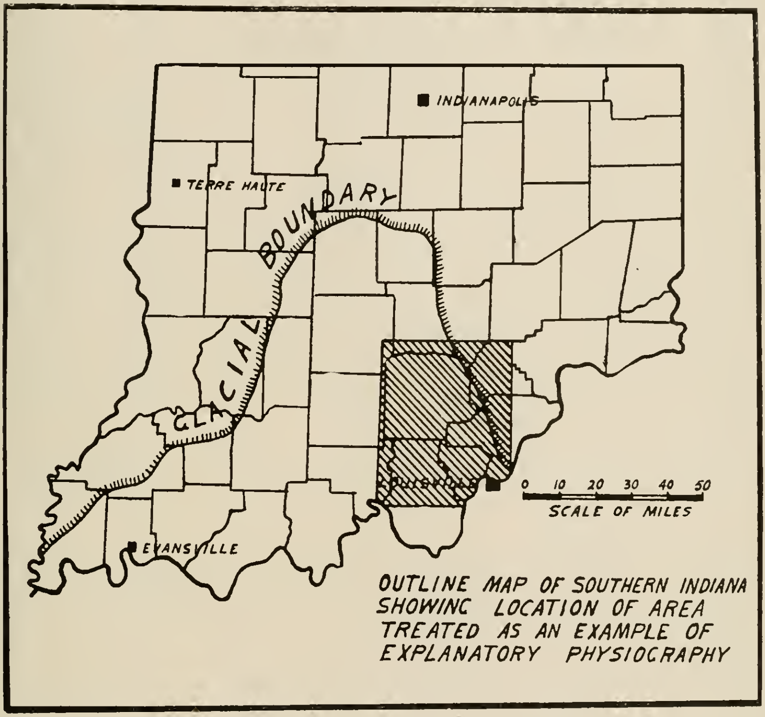
The more intricate and complex an individual history, the more fascinating it is to the student of physiography.

Problems pertaining to drainage are by no means few in southern Indiana. The division of the Illinois glacial lobe, or rather the projection of two lobes into southern Indiana, left a large triangular area of about 5,000 square miles in extent, untouched by the ice. Where the pre-glacial streams came against the eastern margin of the western lobe there was much derangement of the pre-existing drainage, especially the smaller streams. But it is in the unglaciated area that stream development and adjustment have gone on unhampered. It is here that we find some of the finest examples of adaptation of the drainage direction to the geologic structure and the topographic conditions. The details of drainage development involve intricate cases of underground drainage with diversion of the waters from original surface streams to other streams by subterranean piracy. Such a condition would result only in a special limestone region where both geologic and topographic conditions are favorable. But the subject matter of this paper is a presentation of the broader features which permit certain stream adjustments to take place rather than a consideration of the full details of drainage phenomena and topographic form. A part of the subject matter, however, is concerned with the general considerations of a rather odd case of stream gradient and also with the details of a notable case of stream piracy, but the cases are presented as illustrative of stream adjustments to the geologic and topographic conditions which characterize the particular region here chosen.

The area from the Muscatatook River along the southern boundary of Jackson County to the Ohio River on the south presents a number of rather striking physiographic features. The chief one of these is the southern and best developed portion of the Knobstone escarpment, the most prominent relief feature in Indiana. The area embraces western Scott, western Clark, Washington, Floyd, and Harrison counties. This is the area shown by the general map accompanying this paper. It is essentially the Knobstone cuesta and contiguous territory near the eastern margin of the unglaciated portion of southern Indiana. The topographic map is a bit of detail within the larger area shown by the general map. The area is chosen here to illustrate the importance of geologic structure in the development of topographic forms, and also to present one or two illustrations of adaptation of drainage to geologic structure and topographic condition. The special factors concerned in these phases of physiography will be presented in some detail.

DEFINITION OF GEOLOGIC STRUCTURE AND TOPOGRAPHIC CONDITION.

Frequent mention is made in this paper of geologic structure and topographic condition. There is no intention of using these terms in any other than the ordinary sense, yet it is well to give an exact statement of the meanings of the terms as used in the present discussion. The definition here given of geologic structure as a physiographic term is intended to be applied to a plains region. Under the term geologic structure are included the types of regional rock and the lithologic succession, as well as the inclination of the strata. Essentially this is the descriptive stratigraphy and the regional dip of the rock. It is lithology and structure. A physiographic paper need have no more of this phase of geology given than is necessary to show the responsibility of the inclination of the strata, the type of rock, and the relationship of the rock layers as conditioning factors in the devel-



OUTLINE MAP OF SOUTHERN INDIANA SHOWINC LOCATION OF AREA TREATED AS AN EXAMPLE OF EXPLANATORY PHYSIOCRAPHY

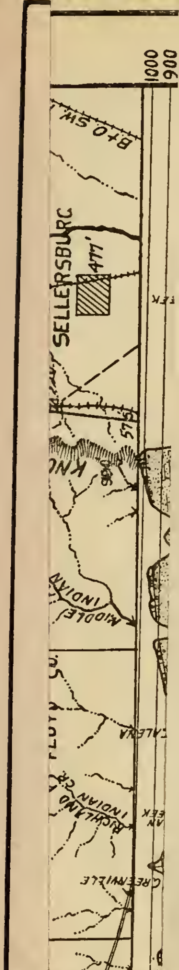
opment of topographic forms. It is the intention of the writer in this paper, however, to show specifically that the topographic forms present in the stages of youth and maturity are dependent very largely upon lithology and structure.

Topographic condition is the state of a region with respect to the form, size, and relationship of the relief features. The simplest topographic condition is that of a level plain. The coastal plain is an example. The topographic condition becomes more complex as relief or difference in elevation from place to place is produced by the physiographic processes, chief of which is running water. Essentially, topographic condition is expressed generally by stating the stage of topographic development in terms of the erosion cycle. But to say that a region is in youth, maturity, or old age is usually insufficient, since most regions with any but the softest rocks have more than one erosion cycle represented. If the region is limited in area, its topographic condition may be signified by the statement of the particular stage represented in the erosion cycle. But the terms youth, maturity, and old age are really only first glance terms when applied to any region of considerable areal extent. It will be seen that the form, size and relationships of the relief features are largely dependent upon rock structure and the denudational agency which actively produced them. The broader details included under the term topographic condition (details embraced in the statement of the stage of the erosion cycle, but never specifically stated) are such as the local base level, the elevation of areas above base level, the size of the streams, proximity to major streams, presence of major and minor divides or watersheds, and the regional topographic forms present which are dependent upon the type of rock and which may involve special physiographic processes. The meaning of the last mentioned detail of topographic condition may be clarified by an illustration. A region of limestone rock whose surface is well above the potential base level and in which subterranean drainage is well developed, is characterized by specific topographic forms. The outcrop of the Mitchell limestone, the so-called Mitchell plain with its disappearing streams and its sink-hole topography, illustrates the condition. Solution by descending meteoric waters concentrated along the joints and bedding planes of the limestone rock largely gave rise to the particular topographic forms present, and these forms are dependent upon the type of rock.

GEOLOGIC STRUCTURE OF THE KNOBSTONE CUESTA REGION.

General Stratigraphy.

The general geologic structure and topographic condition of the area here under discussion are shown on the general map. The map shows the Knobstone cuesta south of the Muscatatuck River. The general lithologic succession of rocks is shown by the geologic cross-section inserted in the map in proper position. This section extends from just north of Jeffersonville west to Marengo. Something like 100 feet of New Albany shale overlie the Devonian limestones which outcrop mainly east of the mapped area, and are present in the region mainly below drainage level. Succeeding the Devonian New Albany shale comes the Knobstone group of sandy blue-gray shales and muddy sandstones, the latter coming into prominence towards the top. The Knobstone group has a thickness of approximately 500 feet. The Knobstone and succeding formations discussed in this paper belong to the Mississippian period. The Harrodsburg, Salem and Mitchell limestones follow in order. The Harrodsburg limestone is rather silicious, and is usually more crystalline than the other limestones. It consists of thin to massive layers characteristically unevenly bedded, having a total thickness of about 90 feet. The Salem limestone is quite massive, and is typically a calcareous freestone. In the region under discussion it has



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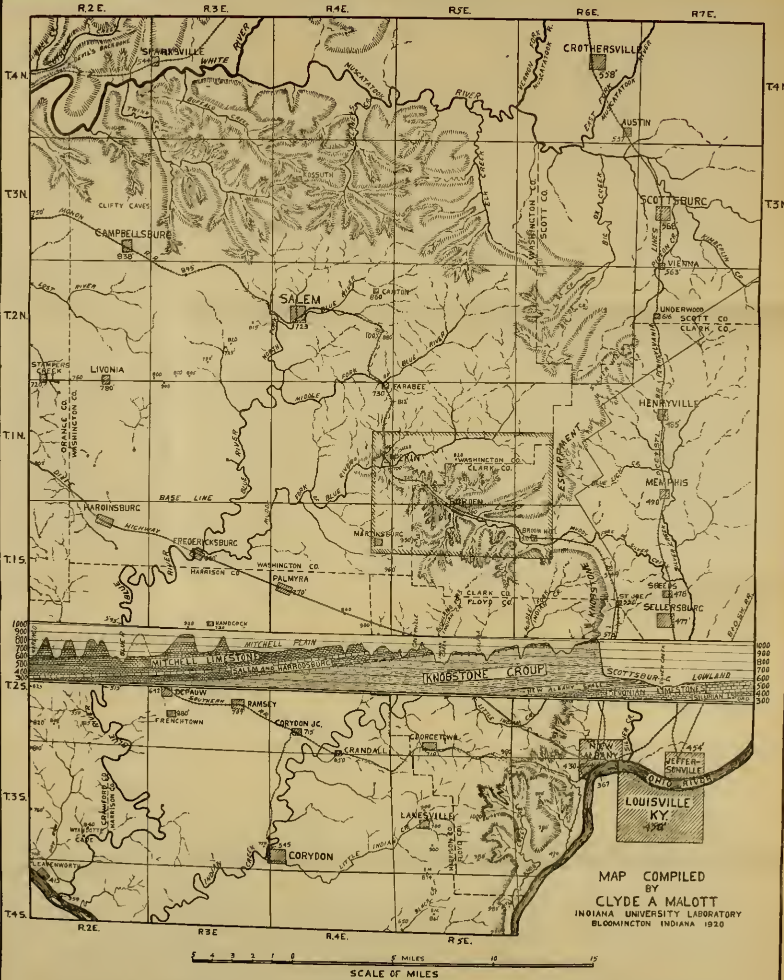

GENERAL MAP OF THE KNOBSTONE CUESTA REGION SHOWING THE GEOLOGIC STRUCTURE AND TOPOGRAPHIC CONDITION

an average thickness of perhaps less than 40 feet. The Mitchell limestone is a group of limestones totaling some 350 feet in thickness in the region. It consists of about 220 feet of St. Louis limestone at the bottom, about 90 feet of Fredonia Oölite (representing the St. Genievieve), and about 40 feet of Gasper Oölite (distinctly of Chester age) at the top. The Mitchell limestone, though composed of several geologic units, is really a great lithologic unit of compact, thin-bedded, highly jointed limestone layers with occasional thin bands of shale and impure limestone horizons. The limestone in places contains considerable chert. Near the top of the St. Louis chert is quite conspicuous and bears numerous colonies of the coral *Lithostrotion canadense.* The uppermost strata outcropping in the region are the clastic members of the Chester series above the Mitchell limestone. The sandstones and shales, however, contain one or more members of limestone. The total thickness in the region is approximately 200 feet.

Regional Dip.

The above lithologic series dip to the west or probably a little south of west at the north of the area, at the rate of about 30 feet to the mile. Local dips may be much more or less than this amount, due to anticlinal or terrace flexures, such as the geologic cross-section shows. This regional dip causes each lithological unit to outcrop along its strike extending almost north and south. The lowest unit outcrops farthest east and the others follow in order to the west. No particular unit has an areal outcrop proportional in width to its thickness with respect to any other unit. This is because of the difference in resistance of the units and the topographic condition. The topographic condition of the area occasionally allows a thinner unit to occupy a wide area while a thicker unit may have a relatively narrow outcrop.

Areal Outcrop of Lithologic Units.

For the details of the areal outcrop of the above geologic or lithologic units, reference must be made to a geologic map. It may be stated here parenthetically that the writer is firmly convinced that no detailed physiographic study of the driftless area of southern Indiana can be adequately made without the aid of detailed lithologic knowledge of the region. This is essentially a geologic study, and its expression is found in the geologic map and the stratigraphic column. A general idea of the representative outcrop may be gained by reference to the geologic and topographic cross-section on the general map. This map also shows the position of Knobstone escarpment by means of hachure lines, following Newsom's map.[1] This escarpment is composed of the Knobstone strata. The lowland area to the east consists of both the lower softer portion of the Knobstone strata and the unresistant New Albany shale. At the south the Mississippian limestone belt begins at the very top of the escarpment and extends westward. In the middle portion of the area only the Harrodsburg limestone extends as far east as the

[1]J. F. Newsom, A Geologic and Topographic Section Across Southern Indiana. 26th Annual Report, Ind. Dept. of Geol. and Natural Res. 1901.

top of the escarpment. Farther north we have a true cuesta formed of the Knobstone, as the vale or back-slope is composed of the upper part of the Knobstone rock and this back-slope has a dip comparable to that of the strata of which it is composed. At the extreme north this cuesta is much dissected and destroyed by the short streams flowing north into the Muscatatuck River. Probably more than half of the mapped area has the Mitchell limestone as the surface rock. The great thickness of this limestone and the development of subterranean drainage have allowed a plain of considerable width to extend along the strike of the outcrop. This plain in places attains a width of 25 miles. To the west of the Mitchell limestone area and mainly at the south, the Mitchell limestone is partially covered by the clastic Chester members. The Chester in the area overlying the Mitchell limestone is mainly in the form of ridges and outliers..

The lower geologic units extend farther west along the east and west streams than their general upland outcrop, and often extend along the streams into the general outcrop region of the succeeding units. Thus, along Muddy Fork of Blue River the Knobstone strata extend several miles west of Pekin, whereas in the upland area adjacent the succeeding limestones form the surface rocks.

TOPOGRAPHIC CONDITION OF THE KNOBSTONE CUESTA REGION.

Factors Involved in the Development of Topographic Condition.

The explanation of the topographic condition of a region brings in an inventory of the responsible active and conditioning factors. The active factors are simply the physiographic processes, viz., weathering and erosion. The conditioning factors consist of both material and time elements. The material elements are the various lithologic units exposed to the physiographic processes. The expression "time elements" as used here needs brief explanation. The physiographic development of any region involves certain changes in the lay of the land with respect to the sea. These changes may be due to regional elevation or depression, or warping and tilting. These things may take place in the region itself or in an adjacent region which is intimately related to it. Thus, a slight regional depression or a tilting in the lower Mississippi valley would allow the sea to come much nearer the southern Indiana region, and certain important changes in stream regimen would result. In addition to land movements, glaciation has been an important factor in the physiographic development of many regions. Climatic changes may give rise to important changes in stream regimen, and should be included here. Regional elevation, regional depression, warping and tilting, glaciation, and climatic changes are influential conditioning factors, and are here called time factors, since they are occurrences which may belong to any period of time without regard to any other factors concerned in topographic development.

A full explanation of the topographic condition of a region may involve all of the above factors. A detailed physiographic analysis of the area here under discussion would certainly involve all of them. A full discussion of them is not intended here. Such would call for a detailed topographic map of the entire region. The topographic condition is very inadequately presented on the general map. The elevations given here and there, the presence and position of the Knobstone escarpment, the drainage lines, and the inserted geologic and topographic cross-section show the main elements. Where some considerable detail is given, a topographic map has been prepared. This small bit of the larger area is presented in detail to reveal a particular condition. The explanation of the present topographic condition of the area emphasizes lithology, since the lithologic units largely control the topography. The time factors or elements will be little more than mentioned, except where the explanation offered is one which has never been brought to the attention of physiographers previous to this presentation.

Influence of Lithology.

The New Albany black shale and the sandy shale and muddy sandstones of the Knobstone group belong to the class of non-resistant rocks. They weather very rapidly by alternate freezing and thawing. The fragments given up by the freezing and thawing method of weathering are readily carried away by the streams of running water. These rocks also are easily corroded by running water. Streams even of small size in these rocks have reached grade close up to their sources. As a result of this, streams heading in a region where these rocks are relatively high above local base level have a very precipitous descent at their very headwaters, but soon take on a relatively flattened gradient within a short distance from their over-steepened heads. The upper part of the knobstone, however, consists of a relatively large amount of massive impure sandstone. It is much more resistant than the lower Knobstone rocks. Only very locally, however, does this upper portion resist weathering sufficiently to stand as vertical cliffs. It may be said that the great thickness of Knobstone rocks with the corresponding rather wide areal outcrop does not result in the formation of cliffs. But the outcrop consists of quite steep slopes, often attaining 30 degrees or more from the horizontal.[2]

The Harrodsburg limestone immediately over-lying the Knobstone is much more resistant to mechanical denudation, and the interstream spaces are often gently rolling tracts. Where the streams have cut through the Harrodsburg capping of the Knobstone, tongue-like upland tracts are bordered by the steep slopes leading abruptly to the Knobstone valleys. The limestone is soluble in meteoric waters and since it is bedded and jointed, sink-holes are quite common. The Knobstone-Harrodsburg contact is consequently a spring horizon of some importance. The Harrodsburg is

[2]For weathering and erosion of Knobstone rocks, see the following references: J. F. Newsom, A Geologic and Topographic Section Across Southern Indiana, 26th Annual Report, Ind. Dept. of Geol. and Natural Res. 1901, pp. 265-273. G. H. Ashley, Geology of the Lower Carboniferous Area of Southern Indiana, Ind. Dept. of Geol. and Natural Res. 1902, pp. 54-58. E. R. Cummings, The Geological Conditions of Municipal Water Supply in the Driftless Area of Southern Indiana, Proceedings of the Ind. Acad. of Science, 1911, p. 114-124.

frequently the regional rock back from the Knobstone escarpment for miles, and forms an excellent example of a structural plain. Newsom[3] makes it clear that the Harrodsburg has been stripped by erosion from the underlying Knobstone to the north of the area under discussion, and that this removal has permitted in later times the more rapid dissection of this portion of the area.

The Salem limestone where typically developed is a calcareous freestone. It is very massive and unbedded, and is not a well-jointed limestone. These structural characteristics prevent it from having many sink-holes formed in it directly. Topographically it is characterized by long gentle slopes and fairly broad valleys. It is somewhat less resistant to denudational agents than the underlying Harrodsburg, but frequently the topography of one merges into that of the other rather indistinctly.

The Mitchell limestone is fairly resistant to mechanical denudational agents. It is structurally characterized by its great number of thin beds of very close and compact nature and its highly jointed condition. These structural characteristics combined with its position above the base level of the region of its outcrop have been responsible for a wide area of subterranean drainage whose perfection of development is probably not excelled anywhere. It is pitted with numerous sink-holes of all sizes and combinations. Only the larger streams in this limestone belt are surface streams. The outcrop of this limestone belt almost everywhere possesses a typical karst topography. Its presence as a fairly resistant stone mechanically and its disposition to drink up the waters which fall upon it by subterranean drainage have caused to come into existence a wide structural plain which has a westward dip somewhat less than the dip of the strata which make up the lithologic unit. A structural plain of this kind is expected to have an inclination less than the dip of the rocks where their thickness is considerable and their resistance not extraordinary. The removal of the overlying material took place rather progressively from the east to the west. The eastern portion was exposed first and is therefore older. While the western part was still protected by overlying strata, the eastern portion was being reduced. The presence of outliers of the overlying clastic Chester several miles to the east of the general Chester scarp is indicative of the method of the formation of the Mitchell plain.[4]

The clastic Chester members over-lying the Mitchell limestone are made up of unresistant shales and rather resistant sandstones with one or more intercalated limestones. Sandstones predominate in the region here mapped. The limestones are inconstant. The Chester of the region is found rather

[3]Loc. Cit., p. 268.

[4]Probably no clearer presentation of the principles underlying the development of sinkholes and underground drainage has been written than the article by J. W. Beede entitled, "The Cycle of Subterranean Drainage as Illustrated in the Bloomington, Indiana, Quadrangle". Proceedings of the Indiana Academy of Science for 1910, pp. 89-111. This article is a classic of its kind. Beede regards the Mitchell plain (which he names such) as a peneplain. This idea is not emphasized by the writer, yet some evidence appears to show that the Mitchell plain part coincides with local peneplains, representing one or more halts in regional uplift, but as a whole it is probably structural. See pp. 24-26. "The 'American Bottoms' region of Eastern Greene County, Indiana—A Type Unit in Southern Indiana Physiography", C. A. Malott, Indiana Univ. Studies No. 40, March 1919.

as outliers on the Mitchell. As indicated above, the Mitchell has been revealed by the stripping away of the over-lying clastic Chester materials by mechanical denudation. Outliers occur as much as ten miles east of the much dissected Chester scarp. The cross-section on the general map shows the topographic position and nature of the outliers. They are often ridge-like on the interstream tracts.

Influence of Physiographic Development.

Further explanation of the present topographic condition of the area may be gained from the interpretation of the topographic forms present in the region itself and in the adjacent regions. It appears that sometime about the middle of the Tertiary the entire region was reduced to a peneplain, all parts having been reduced to their respective base-levels.[5] The region was then rejuvenated by uplift. Dissection of the uplifted peneplain followed. Dissection was fairly complete near the major streams, and in the regions of soft rocks local areas were reduced to base-level. These locally reduced plains indicate that the uplift amounted to something like 175 feet. The region was again rejuvenated and dissection was renewed or continued. The Tertiary uplifted peneplain is now represented by remnants which are as much as 300 to 500 feet above the present base-level.

The New Albany shale and the lower part of the Knobstone areas were reduced to a lowland in contrast to the region to the west of the Knobstone escarpment. The lowland plain consists of an undulating strip of country varying from slightly above 400 feet in the lowlands adjacent the Ohio River to something like 600 feet in the low divide between Silver Creek and the tributaries of the Muscatatuck River. Since there are a large number of hills and rather flat interstream tracts at an elevation of 500 feet or more at the south and coming up to 600 feet near the above mentioned divide farther to the north, it has been stated that a base-level plain or local peneplain was formed at that level.[6] The writer concurs in the belief in a base-leveled plain of local area, and believes that its further development at the south was terminated by rejuvenation. The rejuvenation, however, was not necessarily brought about by uplift, as stated by Butts. The dissection of the plain was just as likely brought about by drainage changes made near the beginning of the Pleistocene. The present Ohio River is a large stream made up of a number of former drainage basins which were more or less individually destroyed or deranged by combination into a large major stream approximately skirting the outer limits of glacial advance. This drainage derangement took place largely near the beginning and during the earlier part of the Pleistocene. A very much

[5]For the physiographic development of southern Indiana and associated regions see the following: C. A. Malott, the "American Bottoms Region of Eastern Greene County, Indiana—A Type Unit in Southern Indiana Physiography, Ind. Univ. Studies No. 40, 1919, pp. 3-4, 21-36. Chas. Butts, Geology of Jefferson County, Kentucky, Kentucky Geological Survey, 1915, pp. 201-203. It may be stated here that valley filling is not a problem of the region considered in this paper. Such valley filling as occurs may be definitely referred to outwash and valley-train material from the Illinoian and Wisconsin glacial borders.

[6]Chas. Butts, Geology of Jefferson County, Ky., Ky. Geological Survey, 1915, pp. 201-203.

smaller stream than the present Ohio occupied this territory near Louisville. It was able to reduce the area of the soft rocks nearly to base-level, but it had a much steeper gradient in its graded condition than the much larger present Ohio. When the present Ohio invaded the basin of the much smaller pre-glacial stream the local peneplain was STATICALLY REJUVENATED, due to the sinking of the larger stream into the plain on account of its ability to reach a much lower gradient in its graded condition. It may be further noted that the region of the Muscatatuck River to the north still possesses such a local base-leveled plain as existed in the New Albany locality. It is inferred that the stream which the present Ohio dispossessed was somewhat near the size of the Muscatatuck or the White river. These streams possess a gradient in their graded condition of slightly less than one foot to the mile, while the Ohio below New Albany has a gradient slightly less than three inches per mile. It would appear that such a change in gradient initiated by the invading Ohio would allow a trenching of something like 90 feet.[7] This corresponds to the amount of the trenching of the local peneplain in the vicinity of New Albany.

Thus the region of soft rocks, the region occupied by the New Albany shale and the lower part of the Knobstone group, has been greatly reduced as a whole. In this region no remnant of the uplifted Tertiary peneplain is preserved. It is low compared to the region on the west where considerable tracts of the uplifted Tertiary peneplain remain at an elevation of 900 to 1000 feet above sea level. The broad valley of the Muscatatuck on the north is at an elevation of 525 to 550 feet. The Ohio on the south has a narrow alluvial plain of about 430 feet in elevation. Low water is 60 feet lower. Silver creek flowing directly to the Ohio along the strike of the outcrop of the non-resistant lower Knobstone shales and the New Albany shale has reduced much of its drainage area to a low plain. The Muscatatuck and its tributaries in the same soft rocks have developed a notably wide plain. The continuous lowland developed in these soft rocks has been designated the Eastern Lowland by Newsom.[8] It will here be referred to as the Scottsburg Lowland, from its typical development in the vicinity of Scottsburg in Scott County.

Immediately to the west of this lowland comes the Knobstone escarpment, which from a distant view loses its ragged, dissected aspect, and appears wall-like to the observer. It rises abruptly 300 to 500 feet above the lowland. The short streams which descend the escarpment against the dip of the rock have cut down to a fairly low gradient, almost back to their very sources. Back of the escarpment the streams often head at the very crest and flow west and south down the long back-slope of the cuesta. These streams have a relatively long distance to go before reaching the Ohio,

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[7]This figure is derived by taking the difference between the gradients of the Ohio and its assumed predecessor from New Albany to Cannelton, a distance of approximately 120 miles. In the latitude of Cannelton valley filling begins to be rather conspicuous, and nullifies any difference in the gradients of the former and the present stream, assuming that the valley filling of southwestern Indiana and associated regions belongs to the Pleistocene. (See C. A. Malott, The "American Bottoms Region", Ind. Univ. Studies, No. 40, 1919, pp. 26-34.)

[8]J. F. Newsom, A Geological Section Across Southern Indiana from Hanover to Vincennes, Proceedings of the Indiana Academy of Science, 1897, p. 251.

and consequently must have a much lower average gradient. These latter streams flow over fairly resistant rock. They are rather peculiar in that they possess gradients about equal in all portions of their courses. The gradient of Blue River will be discussed in some detail below.

The general topography of the back-slope portion of the cuesta is largely dependent upon the rock in which it is developed. These regional features dependent upon the rock have already been briefly described. For some miles back from the escarpment crest, the interstream tracts reach up to the preserved portions of the uplifted Tertiary peneplain. The main streams have broadly trenched this uplifted plain, and are from 100 to 250 feet lower. The interstream areas are somewhat beveled toward the main streams, and fairly gentle slopes are the rule. Even in the Knobstone rocks (these are the rocks on which the slopes are developed for several miles back from the scarp), the valley slopes are fairly gentle. The exception is along the line of Muddy Fork of Silver Creek, which is a special exception, and will be discussed below. Where the regional rock is composed of the Harrodsburg and Salem limestones, the slopes are long and gentle, and a late maturity type of topography is generally prevalent. This sort of topography is excellently shown on the detailed topographic map in the vicinity of Martinsburg.

Farther west, in the region of the outcrop of the Mitchell limestone, the topography has the appearance of an uplifted sinkhole plain, which it probably is in part. This plain has a westward slope of about 20 feet to the mile. The uplift following the development of the Tertiary peneplain permitted removal of waste material down to about the top of the St. Louis limestone horizon. Drainage upon this rock is typically subterranean. But it is probable that a portion of this plain is of base-level origin, as it in part corresponds to locally developed plains elsewhere about 175 to 200 feet below the older and higher peneplain. Further uplift of the region permitted the trenching of the plain by the main streams. Blue River and Indian Creek receive few surface tributaries in their intrenched condition in the sinkhole plain, or Mitchell plain. Lost River in its headwater area flows over this broad fairly level plain in a valley scarcely below the plain itself. Farther west this stream sinks into the limestone and is lost to view for some 10 miles. From the place where it sinks to where it appears again at the surface it makes a descent of about 125 feet. The old surface channel is present. There is little doubt but that uplift was a factor in bringing about this subterranean condition. Distinct evidence is at hand showing that this subterranean space of Lost River has been progressively made longer and longer, and it is probable that sinks will continue to develop in the stream farther up than the present sink with a resultant abandonment of the present one.

Approximately one-half of the Mitchell limestone area above the general ground-water table is partly covered by clastic Chester strata. The Chester occurs as ridges and isolated hills which rise high above the flat spaces of the Mitchell limestone areas. These hills reach approximately to the elevation of the uplifted Tertiary peneplain, attaining heights of

900 feet or more. The region of their occurrence is quite rugged. Blue River from the vicinity of Fredericksburg to the Ohio River is intrenched deeply in the Mitchell limestone group, and the adjacent hills are developed in the clastic Chester Series. The tributary streams upon approaching Blue River become subterranean. The intrenched condition of the main stream is responsible for this condition of the tributaries. The streams are surface streams in the clastic rocks of the Chester Series, but on coming down to the limestone below, the water disappears in the enlarged joints. The development of these streamless tributary valleys has been progressive. As the tributaries have grown and cut downward, they have progressively reached the limestone. The water then has developed a sink near the margin of the uncovered limestone. Later, when more of the limestone became exposed by the removal of the clastic material, a new sink would appear farther upstream, and the old one would be abandoned. In this way, too, the flat valleys in the Mitchell limestone have been developed. Probably much of the Mitchell plain itself has been developed in this manner.

THE PECULIAR GRADIENT OF BLUE RIVER.

Blue River with its several head streams each beginning at the crest of the escarpment, offers an excellent example of the southwestwardly flowing streams. The several sources of Blue River are well above 900 feet above sea level on the remnantal portion of the Tertiary peneplain at the crest of the escarpment. The three main branches are down to 715 feet at Salem, 730 feet at Farabee, and 700 feet at Pekin, respectively. From these places to the Ohio River the fall is a little better than five feet to the mile. This gradient is continued practically to the very Ohio itself. This condition is rather unusual. Normally a stream is well graded in its lower course, and possesses a much lower gradient in this portion of its course. Blue River is not in a graded condition in its lower reaches, nor does it have a lower gradient in its lower reaches than it has much farther up stream. It is in a graded condition, however, in its middle portion, as for instance, Muddy Fork in the vicinity of Pekin. Here, in one of the three branches of Blue River, the gradient is as low as in the many times larger lower portion of the stream. Ashley noted this peculiarity of Blue River, and offered rejuvenation by uplift or tilting as an explanation.[9]

There are three different explanations which may be offered in interpretation of this rather unusual gradient of Blue River and other similar streams of the region. First, the condition may be the result of the difference in the hardness of the rock in different reaches of the stream. In the region of Pekin, Muddy Fork of Blue River is at grade in a wide valley which it has developed in Knobstone strata. The Salem and Farabee forks are in a similar condition where they are developed in the Knobstone. Farther down in the course the stream is intrenched in the mechanically

[9]G. H. Ashley, Geology of the Lower Carboniferous Area of Southern Indiana, 27th Annual Report, Indiana Department of Geology and Natural Resources, 1902, pp. 58-61.

resistant Mitchell limestone with its capping of Chester sandstones. The hard rock below has acted as a barrier permitting the stream to reach a graded condition where it passes over the non-resistant strata, while in the hard rocks time enough has not yet elapsed to permit a graded condition to come into existence. Second, the condition may be the result of rejuvenation by uplift, as explained by Ashley. Under this explanation the effects of the rejuvenation have not yet been transferred to the middle and upper reaches of the stream, and these upper reaches still possess the old graded condition while the lower reaches are steepened as a result of rejuvenation. The third explanation offered is the same as that given above as an explanation of the partial or local peneplain stretching north from New Albany. Under this explanation rejuvenation took place on account of a major drainage line, the present Ohio River, taking the place of a small pre-glacial stream.

It is likely that the peculiar gradient of Blue River is a combination of the three conditions offered in explanation. The effect of rejuvenation by uplift would ordinarily be transferred gradually up stream. The hardness of the rock of the lower reaches of the stream has much delayed the transference of the rejuvenated condition of the stream gradient, permitting the retention of the graded condition in the mechanically unresistant rocks above. The later rejuvenation caused by the replacing of the minor local stream by an important major stream since the beginning of the Pleistocene has given an additional steepness of gradient to the lowest reaches of the stream. The transference of this steepened gradient beyond the lowest part of the stream has not yet taken place, because of insufficient time since the last change in stream regimen. It is not thought that subterranean drainage of much of the tributary space should influence the gradient of Blue River, unless it can be shown that much water which formerly went into it is now diverted to another stream by an underground channel. Blue River probably receives as much of this sort of drainage as it loses. Should considerable tributary space, however, have its waters diverted much farther down stream than these waters formerly entered, there would be some change in the gradient locally. It may be mentioned further that the graded condition of Muddy Fork of Blue River may have been partly brought about by the loss of a large tributary in the vicinity of Pekin by surface piracy.

A NOTABLE CASE OF SUCCESSIVE STREAM PIRACY.

The Development of Muddy Fork of Silver Creek.

The factors as above outlined in the topographic development of the Knobstone cuesta region have permitted considerable areas of the old uplifted Tertiary peneplain to exist near the crest of the escarpment. But such a topographic condition as exists in the region of the escarpment with the present drainage systems is rather unstable. There is such an unequal amount of work being done by the set of streams that flow from the scarp eastward and northward and the set of streams which flow westward and southward, that the divide is being shifted down the dip of the rock westward and southward. This condition of instability of the position of the crest of the escarpment has been continued from the past. From early topographic maturity until the beginning of old age is a period of drainage adjustment. When adjustment has been completed, old age of the stream system has already begun. In the region in question stream adjustment began a long time ago, but the adjustment is far from complete.

Since the short, steep-headed streams coming down from the Knobstone escarpment have a decided advantage over the back-slope streams, they have a tendency to develop their drainage area by headward erosion into the territory drained by the back-slope streams. The headwaters of the backslope streams may be expected to be captured by the eastward and northward flowing streams. Search along the escarpment shows that this drainage adjustment as a whole has not taken place, but in a number of places appears imminent. There is one place, however, where such piracy has notably taken place. This is along the line of Muddy Fork of Silver Creek, from near Pekin in southeastern Washington County to near Broom Hill in Clark County. Here, much reversal of drainage has already taken place, and a great break occurs in the escarpment along the line of this stream. Newsom[10] repeatedly calls attention to this rather unusual opening in the Knobstone escarpment. His maps show a beautiful example of barbed drainage pattern and the broad col at Pekin where the formerly westwardly flowing stream entered Muddy Fork of Blue River But it does not appear that Newsom realized the significance of these tell-tale features. Ashley[11] calls attention to the area and the causes of the condition in the following words: "- the soft and easily eroded nature of the Knobstone has allowed the erosion to proceed more rapidly so that the gorge has in many cases sunk its bottom down to drainage level, and the point of rapid descent has advanced from the mouth to the headwaters on account of the shortness of the stream. Indeed, in many cases it is evident that, due to their shortness, these northward and eastward flowing streams are cutting down the divides at the expense of the streams flowing the other way. A good illustration of this 'river stealing', as it is called, is seen about Borden. The valley in which Borden lies originally drained to the northwest, the divide being nearly as far east as Broom Hill. But the Muddy Fork of Silver Creek, having cut down its side of the divide faster than the stream draining to the northwest, has captured all the drainage about Borden and it is only a question of time when it will extend up so far as to tap the Mutton (Muddy) Fork of Blue River at Pekin and divert all the drainage above that point to Silver Creek".

The topographic map accompanying this paper shows the topographic conditions of a small area in the region of Pekin and Borden. This somewhat restricted region offers details of much interest in the drainage

[10] J. F. Newsom, Geologic and Topographic Section Across Southern Indiana, 26th Ann. Rept. Ind. Dept. Geol. & Natural Resources, 1901.

[11] Geology of the Lower Carboniferous Area of Southern Indiana, 27th Annual Report of the Dept. of Geology and Natural Resources, 1902, p. 61.

adjustment of the region. It lies between five and ten miles back from the general scarp. Muddy Fork of Blue River flows west-southwest past Pekin, and as a graded stream is entirely in the Knobstone rocks. Muddy Fork of Silver Creek flows southeast, and is characterized by a barbed drainage pattern. This drainage is almost wholly in the Knobstone rocks. Only the long, tongue-like, inter-stream tracts 800 feet or more in elevation are capped by the Harrodsburg. The slopes are steep and wooded, and are quite characteristic of Knobstone topography where it is in a much dissected condition due to minor stream development. The uplands between Pekin and Martinsburg have a typical surface expression of the overlying Harrodsburg. The inter-stream tract east of Martinsburg reaches an elevation of about 950 feet, and is expressive of a remnant of the uplifted Tertiary peneplain, being capped by Tertiary gravels and sand.

The valley of Muddy Fork of Blue River at Pekin has an elevation of 700 feet, and seems to be in a graded condition. In the next fifteen miles the valley descends 100 feet, being approximately at an elevation of 600 feet at Fredericksburg. Drainage from approximately forty square miles flows past Pekin. Muddy Fork of Silver Creek heads in a number of steep ravines a short distance southeast of Pekin. These ravines are sharply trenched below the general level of the upland. Starting from an elevation of 730 feet in a broad, valley-like sag, a mere gravel and silt terrace above Blue River valley at Old Pekin, marking the lowest part of the divide between the two stream systems, one may make a rapid descent into Muddy Fork of Silver Creek. A descent of 100 feet is attained in the first mile, and within one and one-half miles the elevation is down to 600 feet. This is the elevation of Blue River fifteen miles below Pekin. At Borden the valley of Muddy Fork of Silver Creek is down to an elevation of 560 feet. The stream here has developed a fairly wide, flat valley and is in a graded condition.

The barbed drainage pattern of Muddy Fork of Silver Creek is a result of stream piracy. The parent stream of the present Muddy Fork of Silver Creek was a small stream flowing down the eastern face of the Knobstone scarp very similar to numerous others of the present time. Back-slope streams of the cuesta flowed westward from the crest of the escarpment. The position of the parent stream of Muddy Fork of Silver Creek does not appear to have been more favorably located for its development of headward erosion than many streams of the present along the escarpment. But for some reason it has succeeded in capturing practically the entire stream system of a large tributary that formerly flowed northwest and emptied into Blue River at Pekin. It would appear that after having once broken through the divide near the crest of the escarpment further capture of the lower tributaries followed in relatively quick succession.

The drainage direction of the tributaries of Muddy Fork of Silver Creek coming in from the south between Borden and Broom Hill suggest that a single stream flowed to the northwest one time through sections 13, 12 and into section 1, and that this unit of drainage has been broken up by the successive capture of parts of it by different branches of the invading Muddy Fork. Fairly distinct sags in the ridges between the small separate systems strengthen this suggestion. If such a drainage adjustment ever took place, it has been so long ago that only these slight evidences of it remain. Such an adjustment would be possible, and if it did actually take place, it is probable the only case of its kind described.

The first stream which still retains direct evidence of having once drained into the Blue River system is Dry Fork Branch. This stream now empties into Muddy Fork of Silver Creek, about a mile below Borden. It is the first of the series of barbed tributaries. In succession the tributaries of the old northwest drainage line were annexed to the Silver Creek system. A number of these, especially those coming in from the north, are decidedly barbed. The latest ones to be taken in were those in sections 29 and 32, between Pekin and Borden. Evidence of this successive capture of the tributaries of the northwest extending stream is not found alone in the barbed drainage pattern. The gradation plain formed by the northwesterly flowing stream has not been entirely destroyed. To the northwest of Borden, just above the town, is preserved the oldest recognized portion of the old gradation plain. Quite a large remnant is preserved here, and it still retains the silts and gravels of the old stream bed. This remnant is shown beautifully on the topographic map. Fig. 1 shows its even line as quite a distinct feature where it has been cut into by the reversed drainage. The elevation of this ancient valley remnant is about 755 feet, whereas the present reversed valley floor is 575 feet in elevation. This means that the drainage change permitted the old gradation plain to be trenched at this place something like 180 feet. At the mouth of Dry Fork Branch the en-

Fig. 1.—View of the even surface (sky line) of a remnant of the old gradation plain of the former northwestwardly flowing stream just west of Borden. View taken from the south side of the present reversed valley. The present reversed stream is entrenched at this place 180 feet below the old gradation plain. The gradation plain remnant here has preserved upon it old gravels and silts similar to those shown in Fig. 5.

trenchment is not less than 200 feet. Remnants of the gradation plain are perfectly preserved on both sides of the present intrenched valley to the northwest of Borden. The remnants are more extensive farther up the stream where the piracy occurred at successively later periods. Finally the whole of the old valley is seen for a stretch of about three-fourths mile in section 30 stretching southeast from old Pekin. Old Pekin is built on the Blue River margin of it. (See Figure 2, 3, and 4.) This portion of the old valley is more than one-half mile wide, as wide as the present valley of the Muddy Fork of Blue River. It was made by a stream comparable in size to this Fork of Blue River. It drained an area of approximately 35 square miles while that of Muddy Fork of Blue River drains approximately 40 square miles.

The few tributaries of the old drainage course yet remaining are shallow streams. The largest one comes in from the south. It is not discernably below the old valley flat in the northeast one-quarter of section 31, (See Fig. 4). On approaching Blue River it is trenched broadly into the old alluvial deposits, and enters Blue River accordantly. The small tributaries from the north have scarcely been able to transport their load across the old valley flat, and have the appearance of having slightly aggraded the old valley flat where they debouch upon it.

Fig. 2.—View of the old valley where it joins the valley of the Muddy Fork of Blue River near Pekin. View taken from the road on the hill in the northern half of Sec. 31. Old Pekin in the distance.

The divide between the present streams on the old valley flat southeast of Old Pekin is only 30 feet above the valley of Blue River. The old valley-flat projects above the valley or Blue River as a terrace. It appears that Blue River has cut its valley down something like 30 feet since the stream adjustment has taken place, but such is probably not the case. It is evident

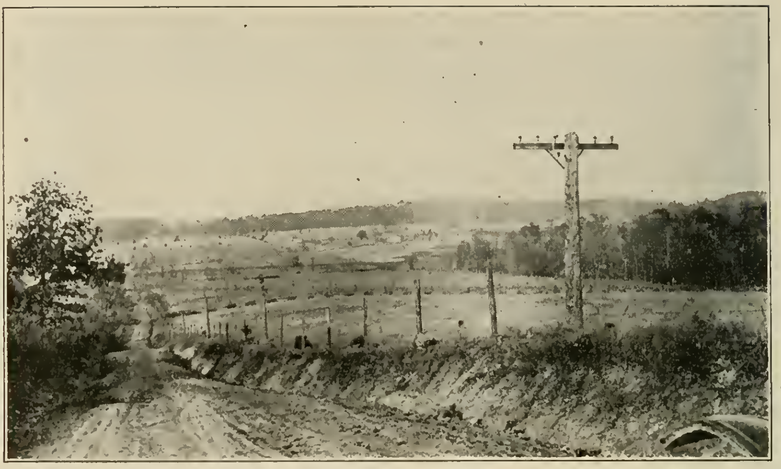

Fig. 3.—View taken from the same place as in Fig. 2, but looking more directly across the old col which formerly was occupied by a stream draining an area of 35 square miles in extent. This old abandoned valley is filled 30 feet or more with ancient alluvium, and stands 30 feet or more above Blue River valley.

Fig. 4.—View taken from the hill in N. E. quarter of Sec. 31, looking east up the old graded valley. The trees in the distance mark a deeply intrenched drainage line belonging to the Muddy Fork of Silver Creek. The newly diverted drainage is rapidly destroying the old graded valley plain.

that the old valley-flat is composed of alluvium to a considerable depth, probably as much or more than the entire 30 feet of its projection above Blue River valley. (See Fig. 5). This alluvium composed of gravels and silts over the old bed rock floor is much deeper than a normal stream of its size should have possessed. With the beheading of this ancient drainage in the earlier stages of successive piracy the drainage remaining would not be able to retain as low a gradient as the previous larger more vigorous drainage. The result would be aggradation of the valley. If this is a correct interpretation, the fact that the present valley of Blue River is 30 feet below the old valley flat is not altogether a result of erosion downward of its bed since the stream adjustments have been made. Again this aggradation of the lower part of the valley will aid in explaining the exceptionally low gradient of the old northwestwardly flowing stream as determined by the relative elevations of the remnants of the gradation plain. At Borden it is 755 feet and in the preserved lower portions it is 730 feet where it is lowest. This would be a gradient of less than five feet to the mile.

The Potential Future of Muddy Fork of Silver Creek.

When one realizes that the larger part of Muddy Fork of Silver Creek has been made at the expense of the Blue River drainage system, and that

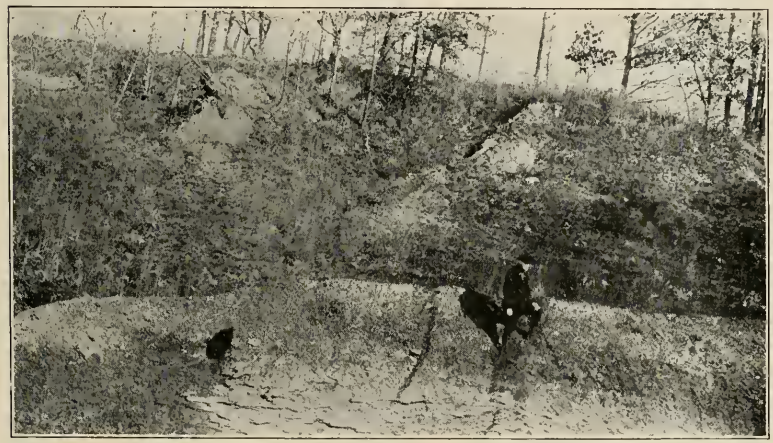

Fig. 5.—View showing gravel and silt overlying the bed-rock floor of the old abandoned valley southeast of Pekin. Monon R. R. cut in the southwest corner of Sec. 29, about 2 miles southeast of Pekin.

the last annexation was relatively recent, one must inquire whether the drainage adjustments are yet complete. It needs little more than casual observation to note that the piracy is far from complete in the Pekin-Borden region. The tiny stream shown on the topographic map in the southeast corner of section 30 was really the latest accession. This was a mere wash leading to the northwest before the Monon Railroad was built through the old col. The cut necessary for a more gradual descent into the Silver Creek system allowed the wash to send its waters into the

Silver Creek system. The small wash from the north now sends its water into both systems. The rapid headward erosion of the new system will soon cause all of it to be deflected to the southeast. Likewise, the remaining tributaries of the old system must be taken over into the new system. Muddy Fork of Blue River would normally remain at its present elevation for a long period. In the meantime, the new system will invade farther and farther to the northwest, and in a short time, geologically speaking, Muddy Fork of Blue River itself will be taken over into the Silver Creek system. The headward erosion of the invading system will be relatively rapid, since it has mainly alluvium to work upon in order to capture Blue River. One might go still further in anticipation of this successive piracy. The invading system will extend itself in the direction of the present flow of Muddy Fork of Blue River and capture tributary after tributary of the present stream, just as it has done in the past after capturing Dry Fork Branch of the old system. By following the line of a graded stream in this manner, the successive stream piracy must be relatively rapid. Such successive stream piracy will continue as long as the stream gradient in the reversed direction is more favorable for headward erosion than the normal present direction. Whenever these stream gradients reach a balanced condition the adjustment is complete and the drainage systems have arrived at the beginning of the old age condition.

Development of Special Bed-Rock Terraces.

Another result of the above described stream adjustments must be mentioned in this paper. The barbed tributaries of Muddy Fork of Silver Creek have been adjusting themselves to a direction of flow in accord with that of the main stream where they enter it. They have a tendency to adjust themselves in such a manner that the junction of the main stream and the tributary form an acute angle pointing in the down stream direction. Practically all of the barbed tributaries have been and are making this adjustment. Those on the north of the main stream have much more perceptibly oriented themselves in the down stream direction than those on the south. This is because the dip of the rock favors a migration of the main stream against the south bluff, especially in the non-graded portion of the valley. This has resulted in a shortening of the tributaries from the mouth and the consequent nullification of their orientation in the downstream direction of the mainstream. While this direction adjustment of the barbed tributaries has been taking place, the valleys have also been deepened by down cutting. The combination of this direction adjustment at the mouth of the tributaries and the down cutting has permitted bed-rock benches or terraces to come into existence on the upstream side near the mouths of the tributaries. (See Fig. 6.) Some of the tributaries have more than the one set of terraces. They range in height from 10 to 25 feet above the present valley flat or above one another. It is probable that new accession of drainage due to capture above has had something to do with the development of these bed-rock terraces, since the resulting more vigor-

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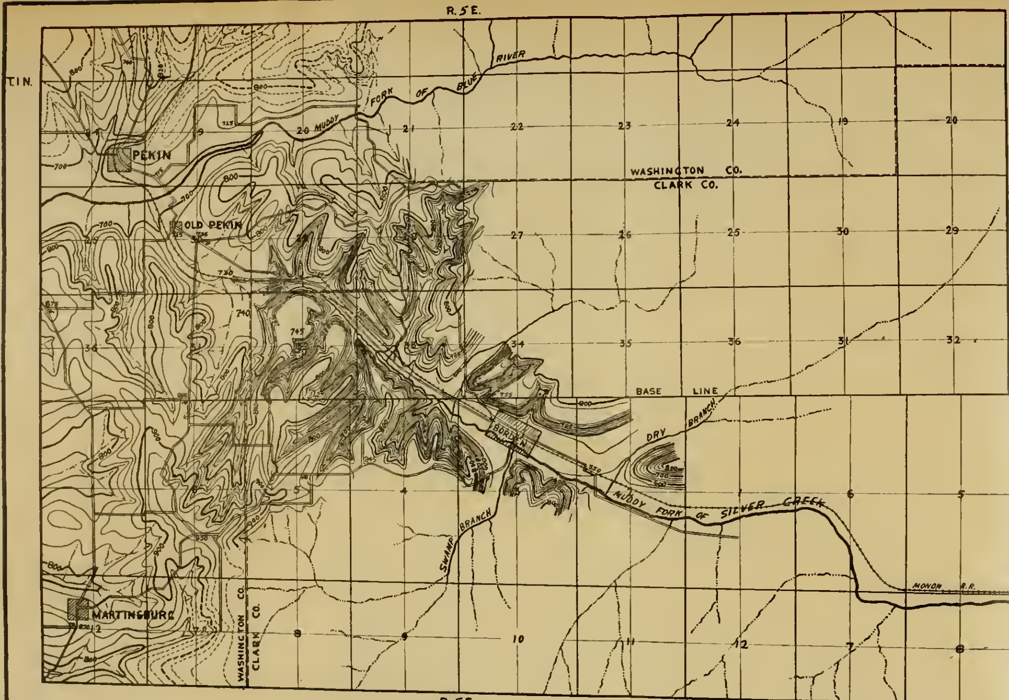

TOPOGRAPHIC MAP OF PEKIN-BORDEN REGION, WASHINGTON AND CLARK COUNTIES, INDIANA

SHOWING A NOTABLE CASE OF STREAM PIRACY, WHERE BY REVERSAL OF THE DRAINAGE A NEW CYCLE OF EROSION IS INTRENCHED WITHIN AN OLDER ONE. NOTE THE IMMINENCE OF THE DIVERSION OF MUDDY FORK OF BLUE RIVER AT OLD PEKIN.

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SCALE OF MILES

CLYDE A. MALOTT
INDIANA UNIVERSITY
1919

ous stream would permit a lowering of the gradient where previous to drainage accession the valley had become somewhat broadened in a comparatively graded condition. But in any case the adjustment of the barbed tributaries in the down stream direction of the main stream is the responsible factor determining the position of the terraces. These terraces have an origin unlike any others that have come under the observation of the writer. So far as he is aware such terraces have never been described before.

It may be mentioned here that the case of piracy here described is one of the same type as that of the famous Kaaterskill Creek of the eastern face of the Catskill mountains, New York.[12] The topographic conditions are essentially the same except for magnitude. Kaaterskill Creek has taken over about 12 square miles of the head-water drainage of Schoharie Creek, the back-slope stream of the Catskill mountains cuesta. On the same cuesta an adjacent scarp-stream, Plaaterskill Creek, has added some 5

Fig. 6.—Bed-rock terrace northwest of the mouth of the barbed stream one-half mile northwest of Borden. This terrace is an example of those being formed where the barbed streams come into the main stream. They are due to an adjustment of the barbed tributaries to the present reversed drainage line as downward erosion is taking place. These terraces have an origin unlike any others known to the writer.

square miles to its drainage by successive piracy. Farther south, Sawkill Creek has stolen some 10 square miles from a westward flowing stream, but this case is not a case of successive piracy. It was perhaps largely brought about by glacial action. It will be re-called that Muddy Fork of Silver Creek has added something like 35 square miles to its drainage by successive piracy.

[12]For a brief description of this piracy see: N. H. Darton, Bull. Geol. Soc. Amer., Vol. VII, 1896, pp. 505-507. Also, R. D. Salisbury and W. W. Atwood, U. S. Geol. Surv., Prof. Paper, 60, 1908, pp. 49-50.

SUMMARY AND CONCLUSION.

This paper conforms to the principle that physiography is explanatory rather than a mass of descriptive matter. The map, especially the topographic map, takes the place largely of the descriptive matter. The purpose of the paper is to show specifically the responsibility of the geological structure in the development of topographic form, especially in a regional way, and also to show the importance of the combined geologic structure and topographic condition in drainage adjustment. It deals with the knobstone cuesta region lying between the Muscatatuck and Ohio Rivers near the eastern margin of the driftless area of southern Indiana. The details defining, describing, and explaining the geologic structure and topographic condition take up a relatively large proportion of the paper. Details are given showing how the particular lihtologic units with their regional westward dip are important conditioning factors in giving rise to topographic forms, and that the topographic condition in the stages of youth and maturity are lagely dependent upon lithology and structure. Other conditioning factors scarcely less important are the so-called time factors, such as regional elevation and depression, warping and tilting, glaciation, and climatic changes. Active factors, weathering and erosion, are given no detail, but their activity is tacitly assumed and occasionally referred to directly. The development of the Scottsburg Lowland, or the Eastern Lowland of Newsom, is given an explanation somewhat different from any heretofore advanced. A local peneplain after having been normally developed is subjected to further erosion by a peculiar sort of rejuvenation brought about by glaciation. The Ohio River has been formed from a number of smaller streams which were near the margin of the glacial ice at its farthest advance. This stream dispossessed a minor stream in the vicinity of New Albany, and on account of its ability to reach a much lower gradient than the smaller stream, intrenched itself in the local peneplain developed in the area of soft rocks. Tributary streams have since partially destroyed the local peneplain rejuvenated in this manner. Such a rejuvenation is here called *static rejuvenation.*

The peculiarity of the streams flowing east and north from the Knobstone escarpment is described. Blue River is discussed in some detail, since it is representative of all the streams on the back-slope of the cuesta. Its peculiar, fairly uniform gradient demands explanation. It is shown that such a gradient is the result of a complex set of conditions, in which lithology, uplift, and static rejuvenation play their part.

Finally the details of the piracy of Muddy Fork of Silver Creek are given. It is shown that this piracy is a direct result of the geologic and topographic condition along the Knobstone escarpment. This piracy is not an instance of a single case, but consists of successive piracy wherein a large number of tributaries belonging to a single streau system are annexed to the drainage system of an invading stream. It is noted that the conditions are highly favorable for the piracy to continue, and that eventually the larger part of Muddy Fork of Blue River will be taken over by Muddy Fork of Silver Creek. Such piracy will continue until a balanced condition of the gradients of the two stream systems is reached. Such a condition will mark the beginnings of old age of the stream systems, when stream adjustments are practically complete. It is further noted that in the adjustment of the barbed tributaries to the reversed drainage, an unusual set of bed-rock terraces is being made where the barbed tributaries join the main stream. These terraces are due to conditions unlike any which have elsewhere come under the observation of the writer.

The special features in this paper to which the attention of physiographers is directed are as follows: definition of the terms "geologic structure" and "topographic condition" as physiographic terms; a grouping of the physiographic factors under two heads, active factors and conditioning factors; a division of the conditioning factors into the so-called "material" and "time elements", with definitions and illustrations of the new terms used; a declaration of the importance of geologic structure (lithology and structure) in the development of regional topographic forms in the stages of youth and maturity;[13] an extension of the use of the term "rejuvenation" in which the term "static rejuvenation" is proposed, and along with the term a regional example of it offered. These are phases of physiography which the writer attempts to make pertinent or which he wishes to present initially. Finally contributions to regional physiography are made in the treatment of a particular region as a whole and parts of it in detail.

The viewpoint of this paper is pre-eminently that of explanation of physiographic phenomena. A region is selected and discussed purposely for the presentation of this sort of physiographic treatment. The common physiographic forms and processes are given little space. It is held that the topographic map contributes such data as size, shape, and relationship of topographic forms, and that the text need not be filled with a mass of rather unnecessary and burdensome detail. The text should be concerned primarily with the general conditions which permit of the development of the particular array of topographic forms, and should be focused especially on the unusual forms and unusual relationships. When these latter things are considered the text may have in it then such additional descriptive matter as may be necessary in the explanation of the forms or relationships. Such a program is attempted in the presentation of the material in this paper. Attention is first centered upon the factors which have controlled the topographic development. Then follows a presentation of the unusual features with sufficient detail to show what the features are and why they exist.

[13]This idea is by no means new, but it appears to the writer that too little emphasis has been placed upon it in physiographic papers. English physiographers are more appreciative in this respect than their American neighbors. "These forms (land forms) never occur scattered haphazard over a region, but always in an orderly subordination depending on their mode of origin. . . . . The geological structure and the mineral composition of the rocks are often the chief causes determining the character of the land forms of a region. Thus the scenery of a limestone country depends on the solubility and permeability of the rocks, leading to the typical Karst-formations of caverns, swallow-holes and underground stream courses, with the contingent phenomena of dry valleys and natural bridges. A sandy beach or desert owes its character to the mobility of its constituent sand grains, which are readily drifted and piled up in the form of dunes. A region where volcanic activity has lead to the embedding of dikes or bosses of hard rock amongst softer strata produces a plain broken by abrupt and isolated eminences." Hugh Robert Mill, Encyclopaedia Britannica, Vol. XI, Eleventh Edition, P. 633.

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