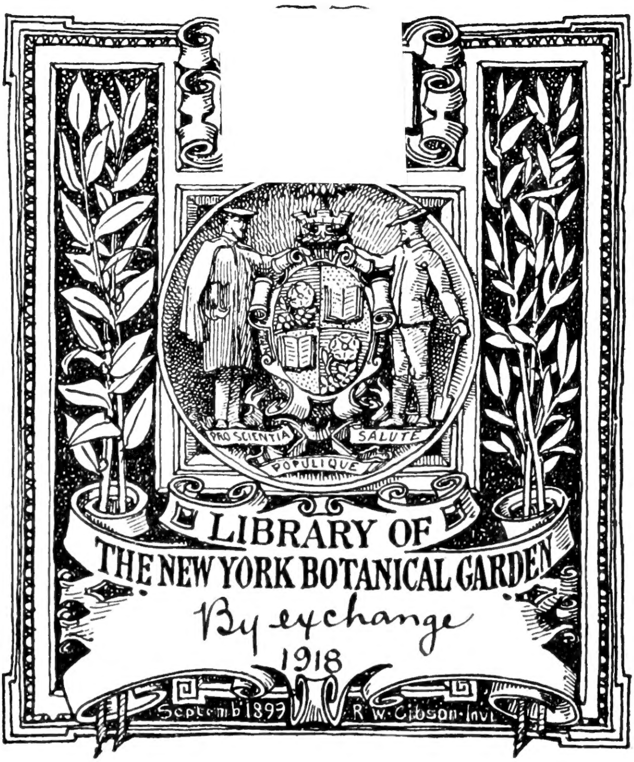
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PROCEEDINGS

OF THE

INDIANA ACADEMY OF SCIENCE

1916

PROCEEDINGS

OF THE

Indiana Academy of Science

1916

LEE F. BENNETT, Editor

FORT WAYNE PRINTING COMPANY
CONTRACTORS FOR STATE PRINTING AND BINDING
1917

CONTENTS

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 discussions 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 or active members.

Sec. 2. Any person engaged in any department of scientific work, or in 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 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 this 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.

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.

APPROPRIATION FOR 1916-1917.

The appropriation for the publication of the proceedings of the Academy during the years 1916 and 1917 was increased by the Legislature in the General Appropriation bill, approved March 8, 1915. That portion of the law fixing the amount of the appropriation for the Academy is herewith given in full.

For the Academy of Science: For the printing of the proceedings of the Indiana Academy of Science twelve hundred dollars: *Provided*, That any unexpended balance in 1916 shall be available for 1917 and that any unexpended balance in 1916 shall be available in 1917.

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, 1916-1917.

PRESIDENT,
W. J. MOENKHAUS.

VICE-PRESIDENT,
EDWIN MORRISON.

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.,
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.,
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, ORNITHOLOGY....................A. W. BUTLER.
ICHTHYOLOGY....................C. H. EIGENMANN.

COMMITTEES ACADEMY OF SCIENCE, 1916-1917.

Program.

F. M. Andrews, Bloomington.
Stanley Coulter, Lafayette.
H. L. Bruner, Indianapolis.

Nominations.

Will Scott, Bloomington.
J. H. Ransom, West Lafayette.
U. O. Cox, Terre Haute.

State Library.

W. S. Blatchley, Indianapolis.
A. L. Foley, Bloomington.
A. W. Butler, Indianapolis.

Biological Survey.

C. C. Deam, Bluffton.
H. W. Anderson, Crawfordsville.
George N. Hoffer, West Lafayette.
U. O. Cox, Terre Haute.
J. N. Nieuwland, Notre Dame.

Distribution of Proceedings.

H. E. Enders, West Lafayette.
John B. Dutcher, Bloomington.
A. W. Butler, State House, Indianapolis.
W. M. Blanchard, Greencastle.

Membership.

J. P. Naylor, Greencastle.
D. A. Rothrock, Bloomington.
L. J. Rettger, Terre Haute.

Auditing.

P. N. Evans, West Lafayette.
A. Hathaway, Terre Haute.

Restriction of Weeds and Diseases.

B. D. Myers, Bloomington.
J. N. Hurty, Indianapolis.
A. W. Butler, Indianapolis.
Stanley Coulter, Lafayette.
D. M. Mottier, Bloomington.

Academy to State.

R. W. McBride, Indianapolis.
Glenn Culbertson, Hanover.
H. E. Barnard, Indianapolis.
J. S. Wright, Indianapolis.
W. W. Woollen, Indianapolis.

Publication of Proceedings.

Lee F. Bennett, Editor, Valparaiso.
C. R. Dryer, Fort Wayne.
R. R. Ramsey, Bloomington.
R. R. Hyde, Terre Haute.
J. S. Wright, Indianapolis.

Advisory.

John S. Wright, Indianapolis.
Robt. W. McBride, Indianapolis.
Glenn Culbertson, Hanover.
Stanley Coulter, Lafayette.
Wilbur A. Cogshall, Bloomington.

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. Blatchley	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. M. Blanchard
1917–1918	W. J. Moenkhaus	Howard E. Enders	P. A. Tetrault	F. B. Wade	Wm. M. Blanchard

*Deceased.

MEMBERS.*

FELLOWS.

Anderson, H. W., Urbana, Ill 1912
Botany.

Andrews, F. M., 744 E. Third St., Bloomington 1911
Assistant Professor of Botany, Indiana University.
Botany.

Arthur, Joseph C., 915 Columbia St., Lafayette 1893
Professor of Vegetable Physiology and Pathology, Purdue Univ.
Botany.

Barnard, H. E. Room 20 State House, Indianapolis 1910
Chemist to Indiana State Board of Health.
Chemistry, Sanitary Science, Pure Foods.

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

Bennett, Lee F., 825 Laporte Ave., Valparaiso 1916
Professor of Geology and Zoology, Valparaiso University.
Geology, Zoology.

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

Bigney, Andrew J., Moores Hill, Ind 1897
Professor of Biology and Geology, Moores Hill College.
Biology, Geology.

Bitting, Katherine Golden, Washington, D. C. 1895
Miscroscopic Expert, Pure Food, National Canners Laboratory.
Botany.

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., Bloomington 1910
Graduate School, Indiana University.
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.

Burrage, Severance, Massachusetts Institute of Technology, Boston, Mass 1898
Bacteriology, Sanitary Science.

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.
Astromony.

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.

Davisson, Schuyler Colfax, Bloomington 1908
Professor of Mathematics, Indiana University.
Mathematics.

Deam, Charles C., Bluffton 1910
Druggist.
Botany.

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

Dutcher, J. B., Bloomington 1914
Assistant 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
Associate Professor of Zoology, Purdue University.
Zoology.

Evans, Percy Norton, West Lafayette 1901
Director of Chemical Laboratory, Purdue University.
Chemistry.

Foley, Arthur L., Bloomington 1897
Head of Department of Physics, Indiana University.
Physics.

Golden, M. J., West Lafayette 1899
Director of Laboratories of Practical Mechanics, Purdue University.
Mechanics.

Hathaway, Arthur S., 2206 N. Tenth St., Terre Haute 1895
Professor of Mathematics, Rose Polytechnic Institute.
Mathematics, Physics.

Hessler, Robert, Logansport 1899
Physician.
Biology.

Hoffer, George N., Littleton St., West Lafayette 1913
Associate Professor of Botany, Purdue University.

Hufford, Mason E., Bloomington 1916
Physics.

Hurty, J. N., Indianapolis 1910
Secretary, Indiana State Board of Health.
Sanitary Science, Vital Statistics, Eugenics.

Hyde, Roscoe Raymond, 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.

Lyons, Robert E., 630 E. Third St., Bloomington 1896
Head of Department of Chemistry, Indiana University.
Organic and Biological Chemistry.

McBeth, William A., 1905 N. Eighth St., Terre Haute 1904
Assistant Professor Geography, Indiana Normal School.
Geography, Geology, Scientific Agriculture.

McBride, Robert W., 1239 State Life Building, Indianapolis......... 1916
Lawyer.

Mees, C. L., Terre Haute.. 1894
President of Rose Polytechnic Institute.

Middleton, A. R., West Lafayette................................ 1908
Professor of Chemistry, Purdue University.
Chemistry.

Moenkhaus, William J., 501 Fess Ave., Bloomington............... 1901
Professor of Physiology, Indiana University.
Physiology.

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. N., The University, Notre Dame.................... 1914
Professor of Botany, Editor Midland Naturalist.
Systematic Botany, Plant Histology, Organic Chemistry.

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

Pohlman, Augustus G., 402 S. Grand Ave., 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., 323 University St., West Lafayette............ 1902
Professor of General Chemistry, Purdue University.
General Chemistry, Organic Chemistry, Teaching.

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.

Scott, Will, 731 Atwater St., 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.
Soil Survey, Botany.

Smith, Albert, University St., West Lafayette...................... 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 Bertran, 1039 W. Twenty-seventh St., Indianapolis..... 1914
Head of Chemistry Department, Shortridge High School.
Chemistry, Physics, Geology, and Mineralogy.

Waterman, Luther D., 226 Pratt St., Indianapolis.................. 1916
Physician.

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

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

Wright, John S., care Eli Lilly Co., Indianapolis................... 1894
Manager of Advertising Department, Eli Lilly Co.
Botany.

NON-RESIDENT MEMBERS AND FELLOWS.

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

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

Ashley, George H., Washington, D. C.

Bain, H. Foster, London, Eng.
Editor Mining Magazine.

Branner, John Casper, Stanford University, Calif.
Geology.

Brannon, Melvin A., President University of Idaho, Boise, Ida.
Professor of Botany.
Plant Breeding.
Campbell, D. H., Stanford University, Calif.
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........ 1938
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.
Fiske, W. A. Los Angeles, Cal., Methodist College.
Garrett, Chas W., Room 718 Pennsylvania Station, Pittsburgh, Pa.
Librarian, Pennyslvania Lines West of Pittsburgh.
Entomology, Sanitary Sciences.
Gilbert, Charles H., Stanford University, California.
Professor of Zoology, Stanford University.
Ichthyology.
Goss, William Freeman M., 61 Broadway, N. Y., 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 Univ.
Hygiene, Embryology, Eugenics, Animal Behavior.
Hay, Oliver Perry, U. S. National Museum, Washington, D. C.
Research Associate, Carnegie Institute of Washington.
Vetebrate Paleontology, especially that of the Pleistocene Epoch.
Hughes, Edward, Stockton, California.
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, Champaign, Ill.
    Professor of Zoology.
    Zoology.

KleinSmid von, R. B., President Univ. of Arizona, Tucson, Ariz.

Knipp, Charles T., 915 W. Nevada St., Urbana, Illinois.
    Assistant Professor of Physics, University of Illinois.
    Physics, Discharge of Electricity through Gases.

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

Marsters, V. F., Santiago, Chile, S. A., Fellow 1893
    Government Geologist.

McMullen, Lynn Banks, State Normal School, Valley City, North Dakota.
    Head Science Department and Vice Pres. State Normal School.
    Physics, Chemistry.

Mendenhall, Thomas Corwin, Ravenna, Ohio.
    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.

Purdue, Albert Homer, State Geological Survey, Nashville, Tenn.
    State Geologist of Tennessee.
    Geology.

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

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

Springer, Alfred, 312 East 2d St., Cincinnati, Ohio.
Chemist.
Chemistry.
Swain, Joseph, Swarthmore, Pa., Fellow 1898
President of Swarthmore College.
Science of Administration.
Waldo, Clarence A., care Washington University, St. Louis, Mo., Fellow. 1893
Thayer Professor Mathematics and Applied Mechanics, Washington University.
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.

ACTIVE MEMBERS.

Aldrich, John Merton, 316 S. Grant St., West Lafayette.
Federal Entomological Station.
Zoology, Entomology.
Allen, William Ray, 212 S. Washington St., Bloomington.
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Anatomy.
Baker, Walter M., Amboy.
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Mathematics and Physics.
Baker, William Franklin, Indianapolis, care Eli Lilly Co.
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Medicine, State School for Feeble Minded.
Blose, Joseph, Centerville.
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Breckinridge, James M., Crawfordsville.
Chemistry.
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Butler, Eugene, Richmond.
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Bybee, Halbert P., University Station, Austin, Texas.
Geology, University of Texas.

Canis, Edward N., R. F. D. No. 17, Clermont.
Officeman with William B. Burford.
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Farmer.
Ornithology and Mammals.

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Clark, George Lindenburg, Greencastle.
Chemistry, DePauw University.

Clark, Elbert Howard, Hiram, Ohio.
Mathematics.

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Crowell, Melvin E., Camborn, B. C.
Chemistry and Physics.
Cullison, Aline, Lyons.
Botany.
Damron, Oliver E., Valparaiso.
Mathematics, Valparaiso University.
Daniels, Lorenzo E., Rolling Prairie.
Retired Farmer.
Conchology.
Davis, A. B., Indianapolis.
With Eli Lilly and Company.
Chemistry.
Davis, D. W., Williamsburg, Va.
Biology, William and Mary College.
Davis, Ernest A., Notre Dame.
Chemistry.
Davis, Melvin K., 215 W. 12th St., Anderson.
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Physiography, Geography, Climatology.
Dean, John C., Indianapolis.
Astronomy.
Demaree, Juan B., State House, Indianapolis.
Deputy State Entomologist.
Botany.
Deppe, C. R., Franklin.
Dewey, Albert H., Portland, Oregon.
Department of Pharmacy, Northern Pacific College of Pharmacy.
Dietz, Harry F., Federal Horticultural Hall, Washington, D. C.
Entomology, Eugenics, Parasitology, Plant Pathology.
Doan, Martha, Richmond.
Professor of Chemistry, Earlham.
Dolan, Jos. P., Syracuse.
Donaghy, Fred, Ossian.
Botany.
Dostal, Bernard F., Philadelphia, Pa.
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Douglas, Benjamin W., Trevlac.
Fruit Culture.
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Zoology and Botany, Teachers College.
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Physician.
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Graduate Student, Physiology, Indiana University.
Physiology.
Edwards, Carlton, Earlham College, Richmond.
Ellis, Max Mapes, Boulder, Colo.
Instructor in Biology, University of Colorado.
Biology, Entomology.
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Merchant.
Botany, Ornithology.
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Instructor in High School.
Geology.
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Geology, Chemistry.
Fisher, Homer Glenn, Johns Hopkins Medical School, Baltimore, Md.
Student in Medicine.
Fisher, Martin L., Lafayette.
Professor of Crop Production, Purdue University.
Agriculture, Soils, and Crops, Birds, Botany.
Foresman, George Kedzie, Lafayette.
Instructor in Chemistry, Purdue University.

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Anatomy.
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Scientific Educational Department.
American Feed Manufacturers Association.
Chemistry, Nutrition.
Funk, Austin, 404 Spring St., Jeffersonville.
Physician.
Diseases of Eye, Ear, Nose and Throat.
Galloway, Jesse James, Columbia University, New York City.
Geology, Paeontology.
Garner, J. B., Mellon Institute, Pittsburgh, Pa.
Chemistry.
Gatch, Willis D., Indianapolis, Indiana University Medical School.
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Anatomy.
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Glenn, Earl R., Marshall and 24th St., Chicago, Ill.
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Earth Physics and Chemistry.
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Colorado State Normal School.
Biology.
Gottlieb, Frederic W., Morristown.
Care Museum of Natural History, Assistant Curator, Moores Hill College.
Archaeology, Ethnology.
Graybook, Irene, New Albany.
Botany.
Greene, Frank C., Tulsa, Okla.
Geology.
Grimes, Earl J., Russellville.
Botany, Soil Survey.
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Science of Law.
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Happ, William, South Bend.
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Zoology.
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Civil Engineering and Wood Preservation.
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Hennel, Cora, Bloomington.
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Physician.
Medicine, Surgery, X-Ray, Electro-Therapeutics.
Hinman, Jack J., Jr., State University, Iowa City, Ia.
Chemist, Dept. Public Health and Hygiene.
Chemistry.
Hoffman, George L., Philadelphia, Pa., care Milford Co.
Bacteriology.
Hoge, Mildred Kirkwood, Bloomington.
Instructor in Zoology, Indiana University.
Hole, Allen D., 615 National Road, Richmond.
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Geology.
Hostetler, W. F., South Bend.
Geography and Indiana History.
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Huber, Leonard L., Hanover.
Zoology.
Hird, Cloyd C., Crawfordsville.
Zoology.

Hutchinson, Emory, Norman Station, Ind.
Zoology.
Hutton, Joseph Gladden, Brookings, South Dakota.
Associate Professor of Agronomy, State College.
Agronomy, Geology.
Hyde, Carl Clayton, Bloomington.
Geology.
Hyslop, George, Ithaca, N. Y.
Cornell Medical School.
Ibison, Harry M., Marion.
Instructor in Science, Marion High School.
Iddings, Arthur, Hanover.
Geology.
Imel, Herbert, South Bend.
Zoology.
Inman, Ondess L., Bloomfield.
Botany
Irving, Thos. P., Notre Dame.
Physics.
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Botany, Agricultural Experiment Station.
Jackson, Thomas F., Tulsa, Okla.
Geology.
James, Glenn, West Lafayette.
Mathematics, Purdue University.
Johnson, A. G., Madison, Wisconsin.
Botany, University of Wisconsin.
Jones, William J., Jr., 231 Chauncey Avenue, West Lafayette.
State Chemist, Professor of Agriculture and Chemistry, Purdue Univ.
Chemistry, and general subject relating to Agriculture.
Jordan, Charles Bernard, West Lafayette.
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Chemistry.
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Physiology.
Kremers, H., New Haven, Ct.
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Liston, Jesse G., R. F. D. No. 2, Lewis.
High School Teacher.
Geology.

Logan, William N., 320 S. Fess Ave., Bloomington.
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Economic Geology.

Loomis, Nathaniel E., West Lafayette.
Assistant Professor of Chemistry, Purdue University.
Physical Chemistry.

Ludwig, C. A., city Y. M. C. A., Appleton, Wis.
Botany.

Ludy, L. V., 600 Russell St., West Lafayette.
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Experimental Engineering in Steam and Gas.

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U. S. Agricultural Experiment Station.
Plant Pathology and Mycology.

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Teacher in High School.
Physical Geography and Geology.

Malott, Clyde A., 316 East 2nd St., Bloomington.
Geology.

Mance, Grover C., Bloomington.

Markle, M. S., Richmond.
Earlham College.

Marshall, E. G., Carthage Ill.
Chemistry.

Mason, Preston Walter, West Lafayette.
Entomology, Purdue University and Experiment Station.

Mason, T. E., 226 S. Grant St., West Lafayette.
Instructor Mathematics, Purdue University.
Mathematics.

McBride, John F., 340 S. Ritter Ave., Indianapolis.
Chemistry.

McCartney, Fred J., Bloomington.
Philosophy.

McCulloch, T. S., Charlestown.

McEwan, Mrs. Eula Davis, Bloomington.

McGuire, Joseph, Notre Dame.
Chemistry.

McIndoo, N. E. 7225 Blair Road, Takoma Park, Washington, D. C.
U. S. Department of Agriculture, Bureau of Entomology.
Insect Physiology.
McKinley, Lester, Bloomington.
Graduate Student in Botany, Indiana University.
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Botanist for Eli Lilly Co.
Botany, Plant Breeding.
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Physics.
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Montgomery, Ethel, South Bend.
Physics.
Montgomery, Hugh T., South Bend.
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Science.
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O'Neal, Claude E., Delaware, Ohio.
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Botany.
Orahood, Harold, Kingman.
Geology.

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Phytopathology, Botany, Mycology, Bacteriology.
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Bacteriology, Fungi.
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Mammalogy.
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With Eli Lilly & Co.
Biology.
Silvey, Oscar W., College Station, Texas.
Physics, University of Texas.
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Biology, Bacteriology, Purdue University.
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Merchant.
Geology.
Thompson, Clem O., Salem.
Principal High School
Thornburn, A. D., Indianapolis, care Putnam-Myers Co.
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Chemistry.
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Tucker, Forest Glen, College Station, Pullman Washington.
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Chemistry, Botany.
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Warren, Don Cameron, Bloomington.
Zoology.

Weatherwax, Paul, Bloomington.
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Wheeler, Virges, Montmorenci.
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Wiancko, Alfred T., Lafayette.
Chief in Soils and Crops, Purdue University.
Agronomy.
Wiley, Ralph Benjamin, West Lafayette.
Hydraulic Engineering, Purdue University.
Williams, A. A., Valparaiso.
Mathematics, Valparaiso University.
Williams, Kenneth P., Bloomington.
Instruction Mathematics, Indiana University.
Mathematics, Astronomy.
Wilson, Charles E., Gainsville, Florida.
State Plant Board.
Zoology and Economic Entomology.
Wilson, Mrs. Etta L., 1044 Congress Ave., Indianapolis, Ind.
Botany and Zoology.
Wilson, Guy West, Carmel.
Mycology and Plant Pathology.
Wisner, Eber Hugh, Valparaiso.
Pharmacy, Valparaiso University.
Wissler, W. A., Cambridge City.
Chemistry.
Wood, Harry W., 117 Dewey Ave., Joliet, Ill.
Wootery, Ruth, Bloomington.
Wynn, Frank B., Indianapolis.
Professor of Pathology, Indiana University School of Medicine.
Yoeman, R. C., Lafayette.
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Young, Simon J., Valparaiso.
Physician.

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Mathematics.

Zufall, C. J., Pharmacognosy Laboratory, Bureau of Chemistry, Washington, D. C.
Pharmacognosy.

Fellows	78
Members, Active	273
Members, Non-resident	27
Total	378

Minutes of the Spring Meeting

OF THE

INDIANA ACADEMY OF SCIENCE.

JUNE 1, 2, AND 3, 1916.

A public meeting of the Indiana Academy of Science was held in the Auditorium of Valparaiso University on the evening of June 1st. The meeting was addressed by Dr. E. S. Riggs of the Field Columbian Museum of Chicago upon the subject: "The Story of the Horse." Total attendance twenty-four members of the Academy and about five hundred students, faculty and townspeople.

Friday June 2nd citizens of Valparaiso and members of the Faculty of Valparaiso University conducted the members of the academy on an automobile tour of northern Porter county. This afforded an opportunity to view the lakes, marshes, sand dunes and hills of the Valparaiso Moraine.

Luncheon was served by the university faculty on the shores of Lake Michigan. A business session was held after the luncheon.

BUSINESS SESSION—VALPARAISO.

Waverley Beach, Ind.,

June 2, 1916.

The meeting was called to order by the President, Andrew J. Bigney, after which the membership committee reported the following named persons for membership.

Homer Francis Black, Valparaiso, Teacher—Mathematics.

J. H. Cloud, Valparaiso, Teacher—Physics.

Oliver E. Damron, Valparaiso, Teacher—Mathematics and Zoology.

Earl Pinkerton, Valparaiso, Teacher—Zoology.

Earl Price, Valparaiso, Teacher—Agriculture.

S. A. Rifenburgh, Valparaiso, Teacher—Botany.

George D. Timmons, Valparaiso, Teacher—Chemistry.

A. A. Williams, Valparaiso, Teacher—Mathematics.

Eber Hugh Wisner, Valparaiso, Teacher—Pharmacy.

R. C. Yeoman, Valparaiso, Teacher—Engineering.

Simon J. Young, Valparaiso, Teacher and Physician.

C. A. Behrens, Purdue University, West Lafayette—Bacteriology.

J. F. Barnhill, Indiana University School of Medicine, Indianapolis—Professor of Surgery.

George L. Bond, Indiana University School of Medicine, Indianapolis—Professor of Medicine.

J. R. Eastman, Indiana University School of Medicine, Indianapolis,—Professor of Surgery.

Murray Hadley, Indiana University School of Medicine, Indianapolis—Professor of Surgery.

B. B. Turner, Indiana University School of Medicine, Indianapolis—Professor of Pharmacology.

Upon motion duly passed they were elected to membership.

On motion of Mr. Dryer, the following committee was appointed on memorial on the death of Doctor Dennis: Stanley Coulter, chairman, Amos Butler, Charles R. Dryer.

On motion of E. R. Cummings the matter of recommending the national adoption of the Centigrade Scale was referred to the Executive Committee for consideration at the December Meeting.

On motion of J. W. Beede, a special committee was appointed to prepare resolutions to recommend the preservation of Dune Park and to co-operate with the Chicago Geographical Society and the Chicago Prairie Club. The President appointed the following committee: Lee F. Bennett, chairman, Dr. Stoltz, Charles R. Dryer.

On motion of Mr. Beede the President appointed the Secretary, and Messrs. McBeth and Cummings as a committee to prepare resolutions which are to be read at the banquet.

Dr. J. A. Aldrich spoke on a scientific project which is now under way of formation and which is given the support of the Entomological Society of America (Membership 550). At present there seems no ready means of publishing the works of an increasing number of workers. It is the plan of a number of workers to establish the Thomas Say Foundation in recognition of the fine work of Thomas Say an Indiana worker. The plan is to interest men of means in the matter and urge them to endow a foundation which may have Indiana as its center and thus bring worthy recognition upon one of its workers. The plan was favorably endorsed at the December Meeting in 1915.

Adjournment.

Andrew J. Bigney, President.
Howard E. Enders, Secretary.

Upon return from the automobile tour the members of the Academy and others were guests of the University at the banquet at 6:30 p. m. in Altruria Hall.

President Bigney called the meeting to order and in an appropriate manner voiced the appreciation of the members of the Academy of the courtesies extended by Valparaiso University. He then called for the report of the Committee on Resolutions.

Resolved, That the visiting members of the Indiana Academy of Science hereby express their gratitude for the hospitality extended by the Officers and Faculty of Valparaiso University, for the bountiful noon luncheon served by the ladies on the shore of Lake Michigan, and for the transportation and entertainment furnished by citizens of the town.

BE IT FURTHER RESOLVED, That the Academy especially acknowledge the kindly interest and splendid hospitality of President Brown and Mr. Kinsey.

Dr. Charles Dryer then spoke on "The Geological Formations Visited During the Day."

Mr. W. E. Pinney gave "Greetings from the Citizens of Valparaiso to the Indiana Academy of Science."

Professor Bennett of the University, and Chairman of the Local Committee spoke for the Program Committee.

Dr. Riggs of the Field Columbian Museum, Chicago, spoke of his own personal enjoyment of the day.

Vice-President Kinsey on "Appreciation of the Presence of the Indiana Academy of Science as Guests."

(Attendance at the banquet about one hundred persons, including twenty-four members of the Academy.)

Adjournment.

ANDREW J. BIGNEY, President.
HOWARD E. ENDERS, Secretary.

On Saturday morning, June 3rd, fifteen members visited the steel mills at Gary.

The following named members attended the Spring Meeting.

J. M. Aldrich	W. F. Baker
J. H. Clark	J. W. Beede
E. R. Clarke	L. F. Bennett
J. H. Cloud	A. J. Bigney
E. R. Cummings	A. A. Bourke
Chas. C. Deam	Homer F. Black
Chas. R. Dryer	S. A. Rifenburgh
Howard E. Enders	G. D. Timmons
Irene Graybrook	M. L. Weems
Wm. A. McBeth	A. A. Williams
Earl Pinkerton	Simon J. Young
Earl Price	Ray C. Yeoman

MINUTES OF THE EXECUTIVE COMMITTEE

Claypool Hotel,
Indianapolis, Ind., December 7, 1916.

The executive committee of the Indiana Academy of Science met in the Moorish Room of the Claypool and was called to order at 7:30 p. m., by the President, Andrew J. Bigney. The following members were present: Andrew J. Bigney, Stanley Coulter, Amos Butler, Wm. M. Blanchard, W. A. Cogshall, W. S. Blatchley, C. C. Deam, J. P. Naylor, R. W. McBride, H. L. Bruner, D. M. Mottier, A. L. Foley, C. H. Eigenmann, and Howard E. Enders.

The minutes of the executive committee of 1915 were read and approved. The reports of the standing committees were then taken up. *Program Committee*—Stanley Coulter, chairman, reported that the committee has by invitation arranged for the consideration of "A Century of Science in Indiana," as the theme of the general program in celebration of the first hundred years of scientific work in the State. The program as arranged bears fifty-eight papers to which three additional titles were added on motion of the chairman.

On motion Professor James Troop of Lafayette is asked to prepare a memorial on Dr. F. N. Webster, for publication in the 1916 Proceedings. On motion there shall be two sections for the consideration of papers: Section 1 shall include Bacteriology, Botany and Zoology; and Section 2 shall include Geology and Geography, Chemistry, Physics, Mathematics and Engineering.

On motion the out-of-State speakers on the general program shall be guests of the Academy at the Dinner.

The report of the program committee was received and passed.

The treasurer, Wm. M. Blanchard reported as follows:

December 1, 1915 to December 2, 1916.

Balance from 1915	$327.00
Dues collected	247.00
Total	$574.00
Expenditures to December 2, 1916	196.49
Balance	$377.51

Upon motion duly passed the report was received and turned over to the Auditing Committee.

Committee on State Library.—W. S. Blatchley, Chairman, reported that the State Librarian has not done any binding of either domestic or foreign publications because of the irregular receipt of foreign works during the war. All bound books are cataloged and properly shelved. The report was received.

Biological Survey.—C. C. Deam, Chairman, read a summary of bibliography of the work on animals and plants of Indiana. Much work has been done on vertebrates and the higher plants but much remains untouched, particularly on the lower animals and the lower plants. The work thus far done has devolved upon persons who have been busy with other pursuits. After a discussion of the report it was proposed that a resolution be prepared to recommend that the scientific bureaus of the State be manned by persons of recognized scientific attainment, and that the Indiana Academy of Science endeavor to use its influence to this end.

On motion, C. H. Eigenmann, Stanley Coulter and W. R. Blatchley are hereby asked to present such resolution at the general session.

Distribution of Proceedings.—Howard E. Enders, Chairman, reported delay and difficulties in printing that will delay the appearance of the Proceedings a month or more.

Membership Committee—No report.

The failure of persons to pay their initiation fee and dues upon their election to membership was discussed.

On motion the Secretary is authorized to prepare a form to be sent to new members informing them of their election and that their names will be enrolled upon the payment of the initiation fee and dues.

Auditing Committee—J. P. Naylor, Chairman, reports the correctness of the Treasurer's report.

Restriction of Weeds and Diseases—Stanley Coulter and D. M. Mottier, members, reported informally that no work had been done.

Relation of the Academy to the State—R. W. McBride, chairman, reported informally.

Publication of Proceedings.—No report.

On motion the following members are recommended as Fellows: Luther D. Waterman, Retired Physician, Scientist, Indianapolis; Judge R. W. McBride, Indianapolis; Lee F. Bennett, Professor of Zoology, Valparaiso University; Mason E. Hufford, Department of Physics, Indiana University; Fernandus Payne, Associate Professor of Zoology, Indiana University.

The Spring Meeting of the Academy was discussed and the following places were suggested: by D. M. Mottier, Turkey Run; by W. S. Blatchley, Spencer; and by Stanley Coulter, Purdue University and the dedication of its new biological building. The matter is referred to the new Program Committee with power to act.

Dr. Henry Bruner spoke upon the matter of the establishment of an *Academy Foundation* for furthering research among its members and affording a ready means of publishing valued papers for which the American journals now seem overcrowded. Possibly such Foundation would stimulate persons to provide portions of legacies towards this cause.

The matter was discussed favorably by Mr. Wright who suggested that patrons of the Academy and charitably inclined persons might be appealed to.

On motion the following *Committee on Academy Foundation* is to report to the executive committee next year: John S. Wright, Henry L. Bruner, Judge Robert W. McBride.

Motions from the Spring Meeting were considered:

(a) Memorial on the death of Dr. Dennis;

(b) Adoption of the Centigrade Scale;

(c) Special committee on Preservation of the Sand Dunes.

(a) Memorial on the death of Dr. Dennis has been provided for on the general program;

(b) On motion the Indiana Academy of Science endorses the general adoption of the Centigrade Scale in the United States.

(c) A letter from Professor Lee F. Bennett, chairman of the special committee, was read in which he reported very favorably upon a movement now inaugurated to make the Dune Park a National Park.

Adjournment.

ANDREW J. BIGNEY, President.
HOWARD E. ENDERS, Secretary.

GENERAL SESSION—Assembly Room, 9:15 a. m., December 8.

The meeting was called to order by Andrew J. Bigney, President. The minutes of the executive committee were read and approved.

On motion duly passed the five persons who were recommended by the executive committee were elected Fellows of the Indiana Academy of Science.

The following resolution was presented by the Chairman, C. H. Eigenmann of the Resolution Committee:

Resolved, That a permanent Advisory Council, or Committee of Five, be appointed; second, that the Academy express its conviction that appointive officers of the scientific Bureaus of the State should be persons of recognized scientific attainments; and third, that the newly elected Governor be informed of the existence of the committee and of its readiness to help if the governor finds it desirable to call for co-operation.

The following Committee of Five, or Advisory Council, was named: John S. Wright, chairman; Robert W. McBride, Glenn Culbertson, Stanley Coulter and Wilbur A. Cogshall.

The regular program was then taken up, as follows: David Worth Dennis—An Appreciation, by Allen D. Hole; John Pierce Durbin John—An Appreciation, by Wm. M. Blanchard.

On motion, the Academy expressed its unanimous appreciation of the excellent papers of Professors Hole and Blanchard.

After the reading of the papers by Professor Lindley and Mr. Blatchley, the meeting adjourned.

AFTERNOON SESSION, 1:30 P. M.

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

Floyd E. Beghtel, 204 E. 3rd St., Bloomington, Teacher.

Alfred L. Bushey, West Lafayette, Instructor in Agriculture.

Forrest F. Craig, 527 E. 6th St., Bloomington, Student.

Aline Cullison, Lyons, Student.

Tobias Dantzig, Bloomington, Instructor in Mathematics.

Juan B. Demaree, Room 130 State House, Indianapolis. Botanist.

Martha Doan, Earlham College, Richmond. Professor of Chemistry.

William F. Epple, 234 Pierce St., West Lafayette. Dairy Chemist.

Arthur H. Estabrook, 219 E. 17th St., Indianapolis. Geneticist.

Francis Albert Federer, care of Eli Lilly Co., Indianapolis. Botanist.

Harry T. Folger, 727 Atwater Ave., Bloomington. Student.

Albert H. Froemming, 727 Atwater, Bloomington. Student.

Francis C. Guthrie, Bloomington. Student.

Hazel Hansford, 710 S. Fess Avenue, Bloomington. Student.

John E. Hemmer, Bloomington. Student.

H. V. Houseman, 902 W. Main St., Crawfordsville, Instructor in Chemistry.

Howard Leigh, 307 N. 7th St., Richmond. Student.

Jesse G. Liston, Lewis. Teacher.

Wm. N. Logan, 320 S. Fess Ave., Bloomington. Associate Professor of Geology.

Nathaniel E. Loomis, 127 Waldron St., West Lafayette. Assistant Professor of Chemistry.

Lester McKinley, Bloomington. Student.

Edward G. Mahin, 27 Russell St., West Lafayette. Professor Analytic Chemistry.

E. B. Mains, 427 Wood St., West Lafayette. Assistant Botanist, Experiment Station.

Burton J. Malott, 2206 Calhoun St., Ft. Wayne. Teacher.

Charles E. Montgomery, 213 University St., West Lafayette. Instructor.

Bruse V. Moore, 810 S. Fess Avenue, Bloomington. Psychology Assistant.

Harry A. Noyes, 705 Russell St., West Lafayette. Bacteriologist.

Aute Richards, Crawfordsville. Professor of Zoology.

Katharine Riley, 56 Whittier Place, Indianapolis. Student.

William R. M. Scott, 114 Marstellar St., West Lafayette. Botany Assistant.

William H. Sheak, Ijamsville. Lecturer on Birds and Mammals.

Philip Spong, 3873 E. Washington St., Indianapolis. Student.

Emma Louise Tevis, 122 W. 18th St., Indianapolis. Student.

Elliott R. Tibbets, 2445 N. Penna. St., Indianapolis. Printer.

Frank B. Wynn, Hume-Mansur Building, Indianapolis. Professor of Pathology.

On motion they were duly elected to membership.

C. H. Eigenmann reported informally upon the Pan-American Scientific Congress which he attended at Washington, D. C., last year during the holiday season as delegate from the Indiana Academy of Science.

He also reported that the Biological Survey of the Lake Maxinkuckee Region, undertaken under the direction of Doctor Evermann, has not been published. The work is voluminous and there is a wish to publish it as a whole rather than to subdivide it. Thus far there has been difficulty in providing for its publication.

The regular program was then taken up. Paper numbered 33 was read in the general session after which the Academy separated into two sections as follows: Section 1—Bacteriology, Botany and Zoology, presided over by President Andrew J. Bigney, Howard E. Enders, Secretary; Section 2—Chemistry, Engineering, Geology and Geography, Mathematics, and Physics, presided over by W. A. Cogshall, chairman, and Edwin Morrison, Secretary.

The sectional meeting adjourned at 5:30 for the Academy Dinner at 6:15, at which President Bigney gave the address on "The Advancement of Scientific Thought During the Century."

Seventy-two members and guests attended the dinner.

Evening Session, 8:00 p. m.

The Academy and a representative gathering met in the Assembly Room to hear the papers by Doctor Harvey Wiley, George S. Bliss and Barton W. Evermann.

Saturday, December 9, 10:00 a. m.

Business.

The report of the Nominating Committee was as follows:

President—W. J. Moenkhaus, Bloomington.

Vice-President—Edwin Morrison, Richmond;

Secretary—Howard E. Enders, West Lafayette.

Assistant Secretary—Philip A. Tetrault, West Lafayette;

Press Secretary—F. B. Wade, Shortridge H. S., Indianapolis.

Treasurer—Wm. M. Blanchard, Greencastle;

Editor of Proceedings—Lee F. Bennett, Valparaiso.

In the name of Indiana University Professor Eigenmann invited the Academy to hold its next Fall Meeting at Bloomington.

On motion, duly passed, it was the sense of the Academy that it accept the invitation, and referred the matter to the Executive Committee for consideration.

It was moved and passed that the Program Committee shall print in the program the names and addresses of persons who present papers at the meetings of the Academy.

On motion, the Advisory Committee is requested to introduce itself to the governor by way of advising greater dispatch in the publication of the Proceedings.

General Program.

The general program was then taken up. After the paper by Lee F. Bennett the following resolution was adopted:

Whereas, There is an attempt to establish a National Park in the Sand Dune area of Northern Indiana, and

WHEREAS, This is a movement which should be highly commended because such a Park would supply the need for a place for recreation for millions of people who can not afford to visit other similar places of interest in the United States, and

WHEREAS, This Dune Region should be preserved because of its position on the Shore of Lake Michigan and because of its great natural history value, and

WHEREAS, There is need for immediate action on the part of Congress because it will soon be too late to obtain land for such purposes on account of its value as sites for manufacturing plants.

THEREFORE BE IT RESOLVED, that we, the members of the Indiana Academy of Science do respectfully and earnestly ask the Senators and Congressmen from Indiana, the Governor and all of the members of the legislature of Indiana to vote for and to help in every other possible way this movement to establish a National Park within the Sand Dune area of Northern Indiana.

Adjournment to sections to complete the reading of papers.

General adjournment.

ANDREW J. BIGNEY, President.
HOWARD E. ENDERS, Secretary.

REPORT BIOLOGICAL COMMITTEE INDIANA ACADEMY SCIENCE 1916.

Mr. President:

Your committee on biological survey submits the following report.

It is believed that the importance of a biological survey of Indiana is not underestimated, but that it has been sadly neglected. Certain forms of animal life are rapidly disappearing in Indiana, and, in fact, some have already disappeared. The higher forms of plant life of the State are threatened by the ax, plow and grazing; and some forms, no doubt, are already extinct. The acquatic forms of plant life as well as animal life are having a struggle against drainage and poisoning by sewage contamination.

It is believed the real importance of the work to be done can be best realized by briefly giving what has been done, and calling attention to the groups that have not been worked.

Of the work done on the fauna of Indiana, I will give the titles in chronological order with the name of the author and the date and place of publication.

The Batrachians and Reptiles of Indiana by O. P. Hay; published in the Ind. Geol. Rept. Vol. 17: 409-610:1892. Subsequent papers by Blatchley have added much to the preceding paper.

The Lampreys and Fishes of Indiana by O. P. Hay; published in the Ind. Geol. Rept. Vol. 19: 146-296:1894. Considerable work has since been done on this subject by several authors, especially on the ecological and economic lines.

The Crawfishes of Indiana by W. P. Hay in the Ind. Geol. Rept. Vol. 20:

475-507:1896. Since this publication E. B. Williamson has described a new species from Wells County.

The Caves of Indiana and their Fauna by W. S. Blatchley in the Ind. Geol. Rept. Vol. 21:122-212:1897.

The Birds of Indiana by Amos W. Butler in the Ind. Geol. Rept. Vol. 22: 515-1187:1898. This is one of the most complete works ever done on the fauna of the State, yet some additional information has been added.

The Mollusca of Indiana by R. E. Call in the Ind. Geol. Rept. Vol. 24: 235-531:1899. Many additions to the preceding paper have been made by Daniels and Blatchley.

The Dragonflies of Indiana by E. B. Williamson in the Ind. Geol. Rept. Vol. 24: 229-333: 1899. A list of the species now known to occur in the State, numbering 125, is presented by Mr. Williamson at this meeting.

A catalogue of the Butterflies known to occur in Indiana by W. S. Blatchley in the Ind. Geol. Rept. Vol. 17:365-408:1892. He lists 108 species and says Edwards credits 23 more species whose range includes Indiana.

The Orthoptera of Indiana by W. S. Blatchley in the Ind. Geol. Rept. Vol. 27:123-471:1903. This is an exhaustive and creditable work, characteristic of Mr. Blatchley.

The Insect Galls of Indiana by M. T. Cook in the Ind. Geol. Rept. Vol. 29:801-867:1905. Several additional papers have been published by the same author, and Prof. Cook promised to present a paper at this meeting which would bring the knowledge of the gall insects of Indiana up to date.

A preliminary list of the Arachnida of Indiana by Nathan Banks in the Ind. Geol. Rept. Vol. 31:715-747:1907.

On the Coleoptera known to occur in Indiana by W. S. Blatchley, published as Bulletin No. 1 of the Ind. Geologial Survey, consisting of 1,386 pages, in 1910. This is one of the most scientific and comprehensive works done by any author in the U. S. on this subject, and does great honor both to the author and to the State. This Bulletin did not include the snout-beetles which have been separately treated by Mr. Blatchley and Mr. Lang.

The Mammals of Indiana by Walter L. Hahn in the Ind. Geol. Rept. Vol. 33: 417-654:1909. This is an accurate and painstaking piece of work.

The Coccidae or Scale insects of Indiana by Dietz and Morrison. Published in the Rept. State Entomologist No. 8:195-321:1916. This is a late and accurate piece of work.

It will be noted that the greater part of the survey work done has been on the Vertebrata, the larger and conspicuous forms; and that much yet remains to be done on the invertebrata.

Of the survey of the insect life of the State, the greater part remains yet to be done. Of the Hemiptera, only the Coccidae have been studied. Of the Lepidoptera, the Moths, the larger and more difficult group and the one of the greatest economic importance are yet to be studied. Nothing has been published on the Diptera or Hymenoptera, both large and important groups of insects.

On the flora of Indiana, papers are few that treat of all of the species of a group that occur throughout the State. The latest and most complete papers follow in chronological sequence.

The Flowering Plants and Ferns of Indiana by Stanley Coulter in the Ind. Geol. Rept. Vol. 24:553:1002:1899. This was a most excellent work; and we are promised that this work will be brought up to date by the same author at this meeting.

Revised list of Indiana plant Rusts by J. C. Arthur in Proc. Ind. Acad. Sci. 1903. This group of so much economic importance has been much studied, and, yet, much remains to be done. We are promised that the knowledge of this group will be brought up to date at this meeting.

Preliminary list of the Hymenomycetes or Mushrooms of Indiana by Donnald Reddick in the Ind. Geol. Rept. Vol. 32:1193-1252:1908.

Indiana Fungi by J. M. Van Hook in the Proc. Ind. Acad. Sci. 1910 and 1911.

The Trees of Indiana by C. C. Deam in Ind. Forestry Rept. 1911.

It will be noted that there is yet much to be done on the plant life of the State. On the lowest forms only fragmentary papers have appeared. The work on the fungi is far from complete. Practically nothing has been published on the lichens of the State; little on the Characea; nothing on the Hepaticae; only local lists on the mosses; and much yet remains to be done on the higher forms of plant life.

A review of the work done on the flora and fauna of the State shows that it is chiefly of a systematic nature. Life histories; life zones; and the ecological and economic features of the biological survey have been treated in a fragmentary way in isolated papers, and in only a few instances have attempts been made to bring together the systematic, ecological and economic knowledge of a group in one paper. Then, too, if I mistake not, there is little work in progress to accomplish the ends desired.

Admitting that there is much to be done, who is to do it? Any one familiar with the work knows that it should be done by some one with more than a rudimentary knowledge of the subject, if reliable results are to be obtained. Then too, much time and money are necessary.

There are several ways by which results may be obtained; and some of them will be briefly stated, because your committee believes that some action should be taken at this meeting to further the work on the biological survey.

First: The work might be done by some philanthropic individual. Instances of this kind, however, are rare exceptions. The advance of science has been in specialization and today a subject of any magnitude means collaboration; consequently one person is not able to do it all.

Second: The professors in charge of the departments of biology in our colleges and universities might so arrange the work of their departments as to accomplish more than they have. They might encourage more students to specialize on local or state problems. The assignments to students need not be difficult, and problems of local interest might be worked up, or those in which the time required is beyond the reach of the professor himself.

Third: Our legislature might be prevailed upon to have the work done under a special grant by the legislature. The possibility of aid from this source is very remote.

Fourth· The work to be done by some State department. Today Indiana has a State department of Geology and Natural History. This department has already published the greater part of the biological work done in Indiana. We have a State department of Entomology. We have a State department of Forestry; and a State department of Fish and Game. If you will investigate what other states are doing, you will find these same state departments doing the biological work. What are our state departments doing along the line of biological survey? You know that in order to get the maximum service from these offices, that they must be filled by scientific men. Scientific men, too, can be obtained as cheaply as politicians. Not one of the State Entomologists has been a member of the Ind. Acad. Sci. Only one of the three State Foresters has been a member; and not a single one of the Fish and Game wardens since Phillip Kirsch, who let it be known, was a scientific man. We do not contend that one could not be a worthy scientific man and be the head of one of the state departments named and not be a member of the Ind. Acad. Sci. but it surely would be extremely poor business for such a head to stand aloof from the body of men in Indiana with whom he would and should co-operate.

Mr. President: It is not necessary to go into detail. To us it appears clear that the most feasible plan for the greater works of the biological survey is to have the work done by our various state departments. To accomplish this it will be necessary for the members of the Academy to see to it that the State departments referred to are filled with men of scientific ability and with men who are willing to do something along this line. At present these State departments do not have the financial means to do much, and we must lend our aid in securing special appropriations for these departments to undertake special work. It should be borne in mind that our State Geologist at the last session of the legislature asked an additional appropriation to extend his work and his request was denied. There should be concerted action between the Academy and the State departments, and the several members must accept it as a duty to explain the situation to his representative and senator. Our case is a most worthy one, and positive results will follow active endeavor. Our committee recommends that a resolution be passed at this meeting, which will set forth the great need of further work on the biological survey, and show why it should be done by the State departments, and that this resolution include the appointment of a committee which shall at an appropriate time present the matter to the Governor elect.

Program of the Thirty-Second Annual Meeting of the

INDIANA ACADEMY OF SCIENCE

Claypool Hotel—Indianapolis

Friday and Saturday

December 8 and 9, 1916.

Officers

Andrew J. Bigney, President.
Amos W. Butler, Vice-President.
Howard E. Enders, Secretary.
E. B. Williamson, Assistant Secretary.
William M. Blanchard, Treasurer.
Frank B. Wade, Press Secretary.
Harry E. Barnard, Editor.

Program Committee.

Stanley Coulter L. F. Bennett Severance Burrage

General Program

Thursday.

Meeting of the Executive Committee . . . . 7:30 p. m.

Friday.

Business Session . . . . 9:15 a. m.
General Session . . . . 10:00 a. m.
Sectional Meetings . . . . 1:30 p. m.
Informal Dinner. (Claypool) . . . . 6:00 p. m.
General Session . . . . 8:00 p. m.

Saturday.

General Session . . . . 9:00 a. m.
Sectional Meetings . . . . 10:00 a. m.

The Presidential Address.

The address of the retiring President, Andrew J. Bigney, will be delivered at the informal dinner.

A Century of Science in Indiana.

As this is the Centennial year of Indiana, the Program Committee selected the above theme for the general session and the papers are presented by the writers at the invitation of the committee.

General Meetings.

Friday, 10:00 a. m.

David Worth Dennis—An Appreciation.................... Allen D. Hole
John Price Durbin John—An Appreciation............ Wm. M. Blanchard
Francis Marion Webster—An Appreciation.................. James Troop
Mental Hygiene in Indiana—Retrospect and Prospect........ E. H. Lindley
A Century of Geology in Indiana...................... W. S. Blatchley

Friday, 8:00 p. m.

The Early History of Chemistry in Indiana.................. H. W. Wiley
Indiana's Feeble-Minded—What is Being Done and What Should be done (Illustr.).. George S. Bliss
A Century of Zoology in Indiana..................... B. W. Evermann

Saturday, 9:00 a. m.

A History of Public Health Work in Indiana............... John N. Hurty
A Century of Botany in Indiana...................... John M. Coulter
The Sand-Dunes of Indiana as a National Park (Illustr.)..... L. F. Bennett

Sectional Meetings.

Friday, 1:30 p. m., and Saturday, 10:00 a. m.

Bacteriology.

1. An Improved Medium for the Cultivation of Trypanosoma Brucei, 20 min.. C. A. Behrens
2. Technic for Bacteriological Examination of Soils, 12 min. .... H. A. Noyes and Edwin Voight
3. Acute Poliomyelitis, 20 min........................ C. A. Behrens
4. Cultivation of Trypanosomes in Vivo, 10 min....... H. C. Travelbee

Botany.

5. Plants New to Indiana VII, 7 min.................... C. C. Dean
6. The Effect of Centrifugal Force in Plants, 10 min...... F. M. Andrews
7. The Trees of White County with some Relation to those of the State, 15 min................................ L. H. Heimlich
8. Supplementary List of the Rusts of Indiana, 10 min..... H. S. Jackson
9. An Aecium on Red Clover—Trifolium pratense, 5 min.... G. N. Hoffer

10. Parasitic Fungi Attacking Forest Trees and Shrubs (By Title) .... G. N. Hoffer
11. Additions to the List of Plant Diseases of Economic Importance in Indiana, 5 min .... Geo. A. Osner
12. An Elementary Discussion of Economic Growth of White Oak (By Title) .... B. N. Prenetice
13. Relation Between Nitrogen Compounds and Plant Growth in Winona Lake, 20 min .... Thurman B. Rice
14. A Variation in Plantago lanceolata, 5 min .... Paul Weatherwax
15. Fascination in Oenothera biennis, 5 min .... Paul Weatherwax
16. Weed Seeds in the Soil, 10 min .... F. J. Pipal
17. Experiments with Hydrogen Peroxide in Preventing Grain Smut, 5 min .... F. J. Pipal
18. Rusts of Hamilton and Marion Counties, Indiana II... Guy W. Wilson
19. Deterioration in Asparagus, 10 min .... Katherine G. Bitting
20. Our Present Knowledge of the Indiana Flora, 10 min. .... Stanley Coulter.
20A. Peculiarity of Branching in Cladophora, 5 min. (Lantern) .... Mildred Nothnagel

CHEMISTRY.

21. The Ethyl-sulphuric Acid Reaction, 10 min .... P. N. Evans
22. E. M. F. Measurements of the System H_2 Pt — 0.1 N (HCl + KCl) — Hg_2 Cl_2 — Hg, 10 min .... N. A. Loomis
23. Chemistry in Indiana. (By title), 20 min .... J. H. Ransom
24. Determination of Sulphur in Iron Pyrites, 5 min... Wm. M. Blanchard
35. Rate of Humification of Green Manures, 10 min .... R. H. Carr
26. Indiana Soils Containing Excess Soluble Salts, 10 min..... S. D. Conner
26A. The Effect of Certain Dissolved Salts upon the Cohesion of Water, 10 min. (Lantern) .... Edwin Morrison
26B. The Preparation of CO_2-free Volumetric Solution of Acids and Alkalies, 10 min .... Wm. F. Epple

ENGINEERING.

27. Pressure on Objects in a Moving Current of Air (Illustr.), 15 min. .... Albert Smith

GEOLOGY AND GEOGRAPHY.

28. Some Topographic Features of the Wabash Valley in Carroll County, 10 min .... F. J. Breeze
29. Diversion of Drainage from Indian Creek to Burnett Creek, Tippecanoe County, 5 min .... F. J. Breeze
30. Notes on the Hardness of Kunzite stellite, 10 min .... F. B. Wade

Mathematics.

Physics.

Zoology.

50. The Ants of Indiana (By Title)......................M. W. Wheeler
51. Bird Censuses, 5 min...............................M. L. Fisher
52. The Time Birds Get Up in the Morning, 5 min..........M. L. Fisher
53. Multiple Allelomorphs and Multiple Factors in Heredity, 10 min..R. R. Hyde
53A. The Turtles and Batrachians of the Lake Maxinkuckee Region, 20 min..........Barton Warren Evermann and H. Walton Clark
53B. Chief Moses Day—Day-byway-waindung..........Albert B. Reagan

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On account of the many centennial papers which have taken much of the space in the present publication, a few papers have been left unpublished. Should the authors desire these papers may be re-entered in the next year's program and printed in the next year's Proceedings.

The paper "Our Present Knowledge of the Indiana Flora" by Stanley Coulter has been withheld by the request of the author. This paper considers some 500 species not included in the present state catalogue. It will be published in the next year's Proceedings.

EDITOR

10. Pipal, F. J. Ind. Acad. Sci. Proc. 1915.

Address of the President.

A Century of Progress in Scientific Thought.

Andrew J. Bigney.

The Centennial thought is uppermost in the minds of the people of the great commonwealth of Indiana. In every hamlet and village, in every town and city, the history of our beloved state has been represented on canvas and on the streets, in parks, in church, auditorium, and hall. The praises of Indiana have been sung by bard, and proclaimed by the minister and statesman, by the children and the teacher until the entire state is filled with thoughts of the wonderful progress and the marvelous resources and possibilities of this commonwealth.

It has seemed to me to be eminently fitting, in this centennial year, that the address of this hour should be devoted to a resume of scientific thought during the past century covering the period of the statehood of Indiana No state has a corner on scientific thought. It is the work of the world, hence national boundaries vanish when we consider such thoughts.

In order to most fully appreciate this century of progress in scientific thought, it is necessary to take ourselves back one hundred years to 1816 when our state was born, and look about us so that we may view our subject from the best standpoint. The Battle of Waterloo had just been fought. The conquered hero had been banished to the Island of St. Helena. George III was still living. It was three years before the birth of Queen Victoria. Abraham Lincoln was a lad of eight years. James Monroe was President of the United States. There were only nineteen states in the Union. The territory west of the Missippi was practically unknown. It was sixteen years before the first railway, thirty-one years before the electric telegraph, sixty-one years before the telephone and ninety-one years before the wireless telegraph. No steamship had crossed the Atlantic. No airship had been thought of.

The world was truly in the pioneer stage of scientific thought. Little by little new thoughts began to dawn upon the minds of some who began to express themselves in a public way and occasionally in the way of some invention like the railway or electric telegraph so that the people began to see that there was a real value in such thought. The public was very slow to appreciate the intrusion of modern inventions and even the inventors themselves were very cautious. It is interesting to note how careful the early railroad companies were concerning their trains. One time-card read as follows: "The ——— Railroad Company will run a train daily leaving ——— station at 10 a. m. provided it does not rain."

Within my own memory, when the mowing machine was first introduced, the men who had been mowing the grass with the scythe, feeling that their work was gone, arose in some places as one man against this intrusion and demolished this new machine. The same was true with the introduction of the self-binder to replace the cradle, also the replacing of the horse street cars in the cities with the cable and electric cars. The resistance to modern scientific thought has been powerful not only in the orient, but also in our own country. To overcome that resistance has required tact and great perseverance. Like all reforms the greatest gain has been made by teaching these new things to the youth in the public schools, colleges and universities.

Even in the schools the progress has been slow, at least until recent years. Dr. J. P. D. John said he taught Chemistry in Moores Hill College in 1875 and did not perform a single experiment, and he was one of the most advanced teachers of that day. Who today would think of teaching in that way?

I think it is generally conceded that the greatest stimulus to scientific thought in this century was the injection into the thinking world of Darwin's Origin of Species in 1859. Not that everybody accepts his views but it has served as a stimulus to thinking men, and has caused them to direct their efforts in a way that has resulted in the most rapid development of scientific thought in the history of the world. Man must know how to learn new truths. It has required the centuries past to teach him the experimental method of investigation.

Another event likewise has had a tremendous influence on scientific thought, and this was the first marine laboratory established on the island of Penikese in Buzzards Bay in the summer of 1873 by the greatest naturalist of his time, Louis Agassiz. This Summer School gave the greatest impetus to the correct method of teaching the biological sciences and in an indirect way to the other natural sciences. The students, fifty in number, were largely teachers from the eastern states. Agassiz's purpose was to train these fifty teachers in the right methods of work. They would carry into their schools his views of scientific teaching. Then each of these schools would become a center in its time to help others, until the influence toward real work in science would extend throughout the educational system. This purpose has been realized in a remarkable degree. Among the men who were in this school were David Starr Jordan, William K. Brooks, Charles O. Whitman and Charles S. Minot. Dr. Jordan is known throughout the world not only as a great scientist but also as a most inspiring teacher. The students of Indiana University and Leland Stanford University know how to sing his praises. Only three years after this Summer School closed, Dr. Brooks began his career at the Johns Hopkins University, this being the first year of that great University. Every student of the school from 1876 to the day of his death in 1908 felt the influence of his life and teaching. Dr. Whitman had a similar but not such a long career at Chicago University as a center of influence, and Dr. Minot at Harvard. Who can measure the scientific influence that has gone out from these four men at Leland Stanford, Johns Hopkins, Chicago and Harvard. The stamp of the method and spirit of Louis Agassiz is upon every one of them and upon their followers.

When the methods of Darwin and Agassiz became throughly established in the schools, the progress of scientific thought became rapid. Every line of science felt the impress of this method of study. The response was quick and certain. To show what progress has really been made it will be necessary to consider some of the leading subjects.

I. Astronomy.

At the beginning of the century under consideration the greatest activity was in Germany. There was not an observatory in the southern hemisphere, neither were there any in the United States. Sir William Herschel was just closing his remarkable career as an astronomer. He made for himself the first large telescopes and with them searched the heavens so thoroughly and with such keen vision that a new and clearer conception of the stellar universe was given to the world. Herschel with LaPlace laid such a foundation for astronomical observation and research that the future study went forward with rapid strides. Uranus had been discovered in 1781 and the asteroids were being discovered. Before very much more could be done it was necessary to establish observatories, in order that greater accuracy might be secured.

In 1821, the first one in the Southern Hemisphere was established at Parramatta in New South Wales. In 1829 one was built at Cape of Good Hope, in 1868 one at Cordova in Spain and the Harvard Observatory in 1881 at Arequipa in Peru for studying the spectra of the southern stars. It seems that the American Observatories began with the Cincinnati Observatory under Professor Mitchell about 1845. Since then numerous and well equipped observatories have been established in the leading centers of Europe, such as Potsdam, Kensington, Paris, Berlin and Greenwich, and in the United States at Washington, the Lick, Yerkes, Mt. Wilson and Harvard. The United States at present holds about the position that Germany did at the beginning of the century.

In 1816 no refracting telescopes with the object glass larger than six inches had ever been made. Herschel had, however, made a reflecting telescope with a mirror four feet in diameter as early as 1801.

In 1824 Fraunhofer made an object glass 9.9 inches for the Dorpat Observatory in Russia. This was regarded as a "giant." In 1833, one fifteen inches in diameter was made for the Pulkowa Observatory in Russia and about 1843 one was supplied to Harvard College. In 1865, Thomas Cooke of York, England, completed one twenty-five inches in diameter, then Alvan Clarke of Cambridge, U. S. commenced one twenty-six inches in diameter for the Washington observatory, and in 1877 one thirty-six inches for the Lick Observatory and in 1892 one forty inches for the Yerkes Observatory.

The branch of Astronomy that was practically unknown at the beginning of the century—that of spectrum analysis—has during the century assumed the most far-reaching proportions. The discovery in 1814 of the many dark lines in the light of the sun and also in the stars marked the beginning of spectroscopic astronomy.

The chemistry of the sun began to be known and now thirty-nine of the elements found on the earth have been found in the sun. Helium was found in the sun before it was discovered on the earth. Exhaustive studies of the spectra of the stars, nebulae and comets have been made, so that we know much about the composition of the various heavenly bodies. With the spectroscope, the approach or the recession of a star can be determined together with the velocity of the same.

Another method of astronomical study that has become exceedingly valuable is that of celestial photography. It must be borne in mind that the art of photography was not known until 1830 when Niepce and Daguerre founded this art. Its marvelous development is well known. The astronomer soon recognized how this art might be made use of in celestial study. The first celestial ob ect to be photographed was the moon in 1840 by Dr. J. W. Draper, and the sun in 1845 by Foucault and Fizeau. The first photograph of a star was that of Vega in 1850 at Harvard. The total eclipse of the sun of 1860 was photographed. The first photograph of the spectrum of a star was made in 1872 by Henry Draper. Long exposures have become an important feature, the time occasionally reaching forty hours. Time will not permit me to more than mention the great advances made in cataloguing the stars, finding out the distances of the heavenly bodies, determining much concerning stellar evolution as a result of spectroscopic investigation, and the science of thermo-dynamics, the discovery of some close relationship between the solar and terrestrial weather, and the really marvelous achievements in the realm of higher mathematics by such men as Adams, LeVerrier, and Newcomb.

II. Chemistry.

A century ago, our knowledge of Chemistry was indeed very primitive. The studies in this line were shrouded with the mysterious and hence were lost in the thoughts of alchemy. The beginning of real Chemistry, however, had been made. Oxygen, hydrogen, and chlorine had been discovered. The bleaching power of chlorine had been demonstrated and applied in the manufacture of cloth. A few of the organic compounds such as lactic, citric, malic, oxalic, and gallic acids had been discovered. Most of this work had been done by Scheele. Then came the work of the founder of modern chemistry, that of Lavoisier. His greatest work, probably was the overthrow of the phlogiston theory, which paved the way for the true conception of combustion. With this settled there was a chance for the development of true chemical relations.

In 1807, a most important discovery was made by Sir Humphrey Davy. He applied his galvanic battery to the decomposition of caustic soda and caustic potash. This lead to decomposing calcium chloride and other related compounds, and finally to the preparation of the metal aluminum by Wohler in 1827 from certain compounds of potassium and clay. Davy also proved that oxygen is not a necessary constituent of an acid, but that hydrogen is. A number of theories and laws soon followed. Dalton established the laws of definite and multiple proportions and the atomic theory. Gay-Lussac's law of combining gases and Avogadro's law were important discoveries.

The work of Berzelius followed in determining the atomic weights which developed most of our analytic methods. He closed his work in 1848.

The law of specific heat was discovered by Dulong and Petit in 1819. The work of these men lead to a much clearer knowledge of the molecule and the atom with its electrons and the nature and composition of gases, together with the powers of combination. In organic chemistry especially the study of the structure of chemical compounds has resulted in great progress in the industrial world, for it was discovered that new compounds could be made by uniting the elements composing them, such as urea, uric acid, caffeine, alizarine, indigo and some alkaloids. This method of building compounds has led to the manufacture of gun-cotton, dynamite, and similar explosives, the development of the candle industry, to the improvement of tanning and brewing and the preparation of gases and oils and many other lines of industry.

The periodic system or the arrangement of the elements according to their atomic weights is one of the greatest generalizations of the century. This has been developed by Newland beginning in 1864, and Meyer, followed by Mendeleef in 1869 and others continuing the study.

Thus chemical thought has continually advanced through the century and the result has been the marvelous application to almost everything: agriculture, manufacturing, mining, in the home, in business, in medicines and in the arts.

III. Physics.

The advances made in physics are as surprising as in other lines of scientific thought. The century opened with conceptions that could not stand the test of modern methods of thinking and experimenting.

For instance, the caloric theory of heat that held that heat was a subtile fluid had just been exploded by Count Rumford who showed that heat is the result of molecular motion. Newton's corpuscular theory of light was still generally accepted. Even in the eighth edition of the encyclopedia Brittannica published in 1856, heat was defined as a material agent of a peculiar nature, highly attenuated.

Fourier demonstrated the laws of conduction by mathematical as well as by physical research which also covers electrical conduction and this is the real basis of Ohm's Law.

Another experimenter of great renown was Regnault. His most noted work was in improving the thermometer and determining the laws of the expansion of gases, vapor pressure, specific heat of water, and the elastic force of steam. These studies led to one of the most important accomplishments of the century, the liquefaction of all gases. This was first done in 1877 by Pictet and Cailetet when they reduced oxygen, nitrogen, hydrogen and air to the liquid state.

Carnot created the science of thermo-dynamics or the dynamics of heat. Lord Kelvin and others were contributors to this science.

The mechanical theory of heat naturally led to the doctrine of the conservation of energy. This doctrine was first stated by Robert Mayer, a German physician in 1842, but the heat equivalent of mechanical energy was first determined by Joule in 1847 and further proved by Lord Kelvin, Helmholtz and Tyndall.

The establishment of the undulatory or wave theory of light is one of the great achievements of the century. This was due to Thomas Young, an Englishman, and Fresnel, a Frenchman. As a result of this conception, other discoveries followed, such as spectrum analysis, polarization of light and the determination of the velocity of light.

The most marvelous achievements of the century in physics have been in electricity and magnetism. We are tracing the scientific thought and not primarily the application to the needs of man.

Just before the opening of the century the discovery of the Galvanic battery by Galvani and Volta made possible the future developments. The next discovery was by the Danish physicist Oersted which showed the close relationship of electricty and magnetism. The electro-magnet was the result. This paved the way for the electric telegraph which Joseph Henry first made in 1832 but was made practical by Morse in 1844.

The conversion of electricity into mechanical energy was made possible by Oersted, Arago, Ampere, Sturgeon and Henry. This gave rise to motors. Another discovery was necessary; how to convert mechanical energy into electricity. This was accomplished by Michael Faraday. This gave us the dynamo, but it was nearly half a century before it came into practical use. In 1831, Faraday also discovered the principle of induction. This greatly improved the telegraph and made possible the telephone. To Graham Bell is due the honor of having made the first telephone for practical use.

The past twenty-five years has been marked by continuous and persistent research and many new discoveries are being made. Maxwell's theory of electric waves and its verification in 1888 by the German physicist Hertz laid the foundation for the wireless telegraph of Marconi in 1907.

The wonderful experiments of Sir William Crookes in passing an electric current through a high vacuum and experiments in radiant matter were preliminary to the discovery of the X-rays by Roentgen of Germany in 1895. The radio-activity of matter now is attracting much attention. Research continues in the most perfectly equipped laboratories that man can devise and the world is confidently expecting the report of other great discoveries in electricity.

Many physicists have been studying acoustics and the laws of harmony have been revealed. The photographing of sound waves has been accomplished by Prof. Foley and others. The invention of the phonograph by Edison was the result of the study of the principles of acoustics.

Other physicists have been interested in finding the nature of matter itself.

IV. Geology.

Geology is a young science. Many facts have been described since the dawn of history. Many volumes had been written on the subject, but it was not a science as that term is understood today. It is really a present century science. Not until the last century had nearly closed had any one thought of the earth as having been evolved through the ages. The most learned thought the earth had been formed instantly about 6,000 years ago. It, however, dawned upon James Hutton near the close of the last century that the earth really had had a history. How to read and interpret this history was the next question to settle. Some inductive method needed to be found. The basis was laid by Hutton as early as 1795 but Charles Lyell in 1830 clearly set forth the method. He showed that the earth structures had been formed by the processes now in operation. With this method it was easy to explain most of the varied formations.

About the beginning of the century, two fundamental geological truths were outlined. One, that of stratigraphy, by William Smith in 1815, and the other palaeontology by Cuvier in 1808. With such foundations, they were now ready to make some progress in interpreting the history of the earth.

The advances made in the geological interpretation of the history of the earth during the present century may be conveniently considered under three divisions, viz, catastrophism, uniformitarianism and evolutionism.

In the early part of the century, the dominant thought was that the great changes in the earth as an inorganic body and in the organic part were due to great catastrophes in which the ocean bottom would rise and cause the waters to flood the lands thus destroying all life. Things would then quiet down, new organisms would be created by special act of God and a new geological regime would be started. The catastrophe was supposed to be supernatural and the quiet period natural. Species of animals and plants were regarded as immutable. When these ran their courses they were destroyed and new ones formed.

Lyell opposed this view and insisted that the processes now in operation must be considered in action in the same way in the past and that there was thus a uniform and gradual advance from the earliest times to the present geological conditions. This was the doctrine of uniformitarianism.

A new thought, however, was in process of formation which was destined to attract much attention and arouse the thinkers of the world and that was the theory of evolution.

Darwin's Origin of Species set the world in a whirl of thought. For half a century this thought has been advanced by one school of thinkers and hotly contested by another. Battle after battle has been waged and compromise after compromise has been made, and now at the close of the century has this thought come to be recognized as of inestimable value in the interpretation of the great book of nature.

James Dana took up this new thought and made use of it in his geological studies. He thought of the development of the earth as a unit. Geology was not simply a record of geological events but a study of causes and effects—a real philosophic study. Under his skillful research and thinking Geology was rapidly organized into a real science. Explanation of the origin of ocean basins and continents, the mountains and valleys, the stratified and unstratified rocks, the water and the heat, the great variety of organic forms and the origin of the earth, now could be more satisfactorily interpreted. The age of the earth, the mineral resources, and their uses to man, the evolution of the various forms of life, and the origin of man have received the most thorough attention on the part of the greatest geological thinkers of the world.

V. Biology.

The last line of scientific thought that will engage our attention is biological. This is the most important for it deals with life problems and these concern us most acutely. This science was also born in this century. While many facts were known concerning plants and animals yet the principles underlying the life of these organisms was little understood.

The first valuable work of the century was in the realm of embryology. The greatest work was done by VonBaer. He began his investigations in 1819 after reading the works of Pander. After many years of study he established the truth of the three germ layers, and the development of the various tissues and organs from these layers. This gave a new direction to the study of embryology. Balfour, Huxley, Remak, Hertwig, and others continued these studies and brought the subject to its present stage. In these investigations a new line of thought has been evolved, that of cell-lineage. Boveri, Conklin, Wilson, Whitman, Lillie, and others have shown that there are certain areas in the protoplasm of the egg that give rise to definite parts of the adult animal.

The next great truth to be discovered was that set forth in the cell theory, that all plants and animals are made of cells. In 1665, Robert Hooke of England observed the cellular structure of cork and spoke of the little boxes composing it, but he did not realize the full purpose and nature of these. It was left to the present century to fully establish and announce this theory to the world. This honor belongs to Schleiden and Schwann principally to the latter and was made known in 1838. In 1835 Dujardin had seen living matter in the lower animals and called it sarcode. Schleiden had seen it and called it gum. In 1846, Hugo von Mohl observed a jelly-like substance in plants and called it protoplasma. It soon dawned upon the scientists that the sarcode of the animals and the protoplasma of plants were one and the same thing. In 1861, Max Schultze fully set forth the protoplasmic doctrine. With this new thought the modern conception of the cell theory would include four things—the cell as a unit of structure, the cell as a unit of physiological activity, the cell as embracing all hereditary qualities within its substance, and the cell in the historical development of the organism.

The study of the cell is the great field of the biologist. Staining the protoplasm began in 1868. The centrosome was discovered in 1876, and the chromosomes in 1883. The chromosomes are now regarded as the structural parts which carry the hereditary characteristics. Another problem came up for settlement and that was the origin of the living things. From the earliest times it had been considered that living things were generated spontaneously. In 1836, Franz Schultze performed the first experiments to overthrow the theory of spontaneous generation. The death blow to this theory was given by Pasteur in 1864 and Tyndall in 1876. It was clearly demonstrated that all life must come from previously existing life.

The next great advance in biologic thought was the discovery of the germtheory of disease. As early as 1687 when Leeuwenhoek discovered bacteria, some medical men suggested that contagious diseases were due to microscopic organisms that passed from the sick to the well. This suggestion was soon dropped and was not revived until 1837 when the Italian Bassi demonstrated that the diseases of silkworms were due to the transmission of minute particles from the sick to the healthy. Upon these experiments Henle in 1840 announced the germ-theory of disease. Experimental proof was not found until 1877 when Pasteur and Koch showed that splenic fever of cattle was caused by anthrax germs.

In 1867, Sir Joseph Lister added another important discovery that of the use of antiseptics in surgery. Carbolic acid was first used. This has revolutionized surgery.

In 1859, as already stated, Darwin's Origin of Species started on its mission. New interest in evolution was now kindled. Gregor Mendel, in 1866 and 1867 announced a great truth—the purity of germ-cells. This, however, attracted little attention on account of Darwin's new thoughts about organic evolution. The truth of Mendel was re-discovered in 1900 by the botanist DeVries and others. The names of Galton, Weissmann, Castle and Davenport must be added as important in developing Mendelism as a theory of heredity. The doctrine of evolution is too extensive to review in a brief paper. In its establishment as a scientific truth four names should be honored by being mentioned—those of Lamarck, Darwin, Wallace and

Weismann. A host of others have done much by way of demonstration and interpretation.

In developing scientific thought so much depends upon the method. The experimental method of investigation of the truths of biology as used today is worthy of special mention. In the further use of this method, we may expect much in the fields of heredity and evolution, changes in the environment of organisms, studies in fertilization, and on animal behavior.

If the discovery of these truths meant simply intellectual achievements, I am sure they would not impress the world very much, but most of them have a practical application for the benefit of mankind. Man must more and more be considered the most important creature.

He can and must be developed as a symmetrical being. Through biological study, disease is being checked, lives are being spared, eugenics is playing a part in the evolution of the race, temperance and sanitation are being placed on a sure foundation, and even peace ethics and religion can be advanced in their beneficial influence upon the race.

In conclusion, may I pay a word of tribute to the scientists of the world who, quietly in laboratory and library, unassuming for the most part, not anxious to have their names heralded abroad but diligent in their search for truth and when found to gladly and unselfishly give the benefits to the world usually "without money and without price," sometimes to an ungrateful world, but usually due honor comes in time. I am also glad to record that the scientific men and women of Indiana and especially of the Indiana Academy of Science have contributed no small part in the advancement of the scientific thought of the world.

The mission of science may be expressed in the words of the sacred writer: "Man bindeth the floods from overflowing and the thing that is hid bringeth he forth to light."

David Worth Dennis—An Appreciation.

Allen D. Hole

In attempting to find the way in which to express somewhat clearly and somewhat adequately the estimate which I am sure all of us have, who knew David Worth Dennis, it has seemed to be necessary to turn for help to many different sources; and so first of all, I ask leave to quote a few sentences from two men who stand among those who have the keen sight to see the unseen, and the souls sensitive to the calls of truth which come perhaps to us all, but are understood from a great distance by but the few. Such sentences as these have seemed to help more than anything else to make the kind of atmosphere in which alone men like Professor Dennis can be truly understood, truly estimated.

It is Walt Whitman who says: "Surely whoever speaks to me in the right voice, him or her I shall follow; as the water follows the moon, silently, with fluid steps, anywhere around the globe."

And again such words as these penned by Professor Hiram Corson: "Inspiring power must come from an author's or teacher's *being*, and not from his brain.

"Being is teaching; the highest, the only quickening mode of teaching; the only mode which secures that unconscious following of a superior spirit by an inferior spirit, of a kindled soul by an unkindled soul."

And again Professor Corson, in speaking of the value in the teaching of literature of one who unites a fullness of intellectual and spiritual vitality, says:

"The inspiring power of personality is quite as much needed in scientific training. Many are the men still living in whom the great naturalist, Professor Louis Agassiz continues to live, in this world, and they are far superior as naturalists by reason of what he elicited from them of the 'What Is.' He thus brought them into a deeply sympathetic relationship with the animal kingdom—a relationship which is the condition of sagacious insight."

A number of those present here today were in attendance at the banquet in this building a little more than seven years ago. It was, you remember, the twenty-fifth anniversary of the organization of the Indiana Academy of Science. You will also remember that Professor Dennis was on that evening at his best as he discharged with gracefulness and exceptional ability the duties of toastmaster. Dr. Foley, the President of the Academy for that year, used words in introducing Professor Dennis as presiding officer at the banquet, which deserve repetition here today, for they sum up with remarkable accuracy the character of the man to whom we today do honor. Dr. Foley said:

"There is no man in Indiana who has had more influence upon the teachers of the state, upon the schools of the state; there is no man who has been closer to the hearts of his pupils. There is no man who has had more to do with the development of science in Indiana than has Professor David W. Dennis."

It will be difficult for us here today to pay a higher tribute than is contained in these words which we rejoice to know were said in the presence of him who so well deserved the praise they express. Professor Dennis had the qualities which might have made of him a leader in scientific research; he enjoys, indeed, a reputation as a scientist of which anyone might well be proud; but the main part of the extraordinary energy with which he was endowed went into the work of inspiring young men and women; in speaking "in the right voice" to those whom he met, and so securing "that unconscious following" from among his students, because, like Agassiz he "elicited from them of the 'What Is.' "

Great is he who discovers a new truth and gives it to the world; but greater is he who discovers a young man to himself and sends this enkindled soul into the world of personalities which are groping almost blindly for, they know not what.

At a time like this, when we are facing a future bristling with problems which cause us to feel that we must summon to our aid all the best minds of the world, and yet in the face of so great needs we are reminded afresh that we must go forward without the leadership and the inspiration of one and another upon whom we have learned to look as being able to show the way to victory against even the most desperate odds, the sense of loss sustained may perhaps unfit us for making a true estimate of the character and abilities of those who have left us. As a corrective to our vision it may therefore be well to apply some principles of judgment which have been thought through in times of less emotional stress; if with such guidance we find out instinctive feelings supported we may be assured that we can both freely express what we feel and also mark out a true path of life for those who are seeking for guidance in the experiences of the past.

Such well considered principles are, fortunately for us in this instance, ready in the work of another distinguished member of the Indiana Academy of Science who responded to a toast at the banquet to which reference has already been made. Dr. David Starr Jordan, introduced by Professor Dennis and with Darwin as a text, developed for his hearers in his own clear and forcible way the following outline of the conditions necessary to the making of a great man of science; briefly stated the conditions are these:

1. Heredity.
2. Being "brought right up against nature."
3. "Walking with a Henslow"; that is, with "a man with enthusiasm."

I suppose that if a corrective is to be applied to our judgment of our friends, no better standard can be found than this suggested by Dr. Jordan.

And I suppose also that to a man such as Professor Dennis was, the use of such a standard, suggested by such a man as Dr. Jordan, would give the highest possible satisfaction and meet with the very fullest possible approval.

As to heredity, David Worth Dennis could trace his ancestry to representatives of English families who formed part of the company that reached New England on the Mayflower; ancestors from whom also are descended the Greenleafs and farther down the line, the poet John Greenleaf Whittier, himself; by another line the Bachilers to Daniel Webster; and by still another through the Gardners to David Worth, the maternal grandfather of David Worth Dennis. Generations of Puritan and Quaker ancestors, men and women from whom have come statesmen and literary and professional men, this is the kind of stock from which men of strength of character and of insight come.

The scientist, the enthusiastic apostle of disease prevention, and the determined seeker for the best ways to accomplish desired ends, are foreshadowed in the following incidents in the lives of his ancestors, taken from many similar ones which might be chosen:

1. His maternal grandfather, living in North Carolina, being much grieved over the death in infancy of two of his children on account, as he believed, of lack of proper medical attention, determined that he would prepare himself to be a physician. He accordingly supplied himself with the best medical books he could secure, and after having studied them carefully, drove to Philadelphia, attended lectures, received instruction from leading physicians of the city, and then returned to North Carolina where he practiced medicine for the remainder of his life with great success.

2. His mother mystified him as a little child by going at times in the morning to a certain building which stood in the yard, remaining for a short time inside, then reappearing in different dress to go away for awhile, at times for a few hours, at times for all day. Returning, she would first go to the building in the yard, and finally would come to the house in which they lived wearing her customary clothing. As a child he was warned never to go into this building in the yard, and it was not until years afterward that he learned that his mother in that way was giving assistance in cases of contagious diseases in the neighborhood, protecting her own family meantime by the best means known to her.

It is little wonder that in the fight against small-pox, typhoid fever and tuberculosis, Professor Dennis was to be found enlisted as an enthusiastic leader, always urging fearlessly the adoption of the methods approved by the latest results of scientific investigation.

And he was from his boyhood "brought right up against nature." The earlier contact with nature was incidental to the life on the farm in Wayne County, Indiana, where he was born. The later contact with nature was a continuous experience of his own choosing. He has himself said that Whittier's "Snowbound" is almost a literal description of his own boyhood experiences in winter time. The program for one day with snows less deep then in New England was about as follows: Up at 4:30 a. m. in a room without fire; faces washed out of doors; breakfast by candle-light or lamp light; milking or preparing wood for fires, then to district school a mile away. In the evening, after supper, study for an hour; apples, cider, nuts; "speaking pieces" from the lower steps of the stairway; game of blind man's buff; prayers; to bed at nine o'clock. Such experiences have the making of sterling character in them provided they come to such as have the heredity, the oversight, and the companionship to make use of them. Professor Dennis had all these three, and his close contact with nature begun thus with the beginning of his life, was never broken. On the contrary, though in later life he of necessity spent much time in the cities, and in the school-room, he found companionship with nature wherever he might be. His class rooms were with him laboratories, his city home was surrounded with trees and birds; a visit to Panama, to Europe or to Arizona, meant out door life in large measure, and mountain climbing wherever mountains could be found.

And he, too, "walked with Henslow." No one, probably, can tell how many different names would, all told, have to be used in place of "Henslow" if the names of all the men of enthusiasm were to be recounted with whom Professor Dennis walked as a companion. Wherever he went he was drawn to men of insight, of initiative, of great ideas. One can hardly make a mistake, however, if one should name an early college teacher as among the first and greatest to kindle this easily kindled soul. He has, I am sure, in the presence of many here paid tribute to Joseph Moore and borne testimony to the inspiring, stimulating influence which came to him as he took up at Earlham College the studies which opened for him the way to his life work as a teacher. Through Joseph Moore, David Worth Dennis became an intellectual and a spiritual descendant of the great Louis Agassiz. Professor Moore had received from Agassiz that quickening of which Professor Corson spoke in the quotation already given; he had been introduced to that sympathetic relationship with not only the animal kingdom but with all created things, inanimate as well as animate, until he felt that even the specimens of rock by the roadside are sacred because they are so really the work of God. Professor Dennis could and did receive from Professor Moore in large measure this prophetic spirit, this reverence for truth which came from the great personality of Agassiz. And this touch of enthusiasm and inspiration and revelation came to add its perfecting, vivifying influence to the power of heredity and to the effect of a life which was open to the voices of nature, making thus complete the conditions for the production of the truly great man who lived among us so long, giving to us all so freely of the richness which he was constantly able to draw from the daily experiences of life.

As in the case of all men whose greatest power is found in their ability to stimulate, to quicken, and to inspire, great difficulty is encountered when an attempt is made to interpret Professor Dennis to those who never knew him.

His power came from his whole personality, therefore his words when reported by another lose a part—rather lack a part of the whole message which they originally carried. And yet it is worth while for ourselves and worth while for others to recall some of his characteristic sayings.

In recalling the different modes of travel now as compared with those generally used in his boyhood, and noting especially the wonderful reduction in the amount of time now required to travel from one place to another, he once said:

"The real question is not how soon we can arrive, but what we are worth when we do arrive."

From his recollections of his childhood, two incidents show how the child was in his case "father to the man" in at least two particulars, that is, in his love for the study of nature, and in the necessity he felt of thinking for himself. Speaking of his winter experiences as a boy, he says, "I have passed many a happy hour tracing Jack Frost's steps on the window panes and studying out his landscape designs." And as having a double bearing on the great questions of human destiny, on the one hand, and on insight into human nature on the other, note this record of impressions made upon him as a child; he says:

"Many sermons (of that day) landed most of the human race in a lake of fire; but I did not believe it; for they (the speakers and others), talked and laughed at the close of the service."

Another incident in his childhood greatly impressed him, a time when his sister wanted a feather for her hat, and being refused, wept for two days and nights about it. Professor Dennis, looking back as a mature man upon the incident, with fine loyalty for his home, and with discriminating judgment concerning the issues which were at stake, commends his father and mother for their refusal to change their decision which had been announced; but with equally fine judgment and insight into the great problems which children have to meet without at the time knowing that they are problems at all, he says on behalf of his sister:

"She ought to have had the feather. A normal racial desire ought not to be suppressed any more than a tadpole's tail. The bigger the tail, the better it can swim; it will be absorbed later, and turned into legs; the bigger the tail, the bigger the legs."

The secret of his power over his pupils cannot be stated in a single word, or a single phrase, but the following sentence, which he penned throws interesting light on the question. He says:

"My boys and girls hang like a magnet over every page I read. I cannot conceive of a pleasure unshared or unsharable."

As indicating how his logical faculty and his ambition worked together to make him an efficient instrument in service, note this:

"Soon after bicycles came into general use I heard a certain make recommended as being 'as good as a Columbia;' I did not rest satisfied until I had a Columbia. The same method of making choices had guided me earlier in my life. I had been in attendance at Spiceland Academy for one term. I heard that Spiceland Academy was 'as good as Earlham College;' as soon thereafter as possible I entered Earlham College. When there I chose largely the classics; they were difficult, but I noticed that the best students were in those classes. That was enough for me."

As to other work and experiences while at college he says: "I took all the sciences that were offered. I found that science awakened interest; classics awakened my mind."

His faith in the conclusions reached by scientific research is indicated by the following prediction which he records, after having spoken of Mendel's discoveries embodied in the well-known Mendel's law. This is his prediction:

"By 1950 we shall be on the way to health, sanity and happiness because his law, (Mendel's) will have taught us how to breed these things into the human race."

If the task I have were primarily biographical in its nature I should be under obligation to report many facts which under the circumstances, need not be recorded. It is, to be sure, of interest to us to know that he was born just as the last century was being half completed; and it would be of even greater interests to us here to know the different stages by which he secured his education, the positions of trust and honor which he held, the number and titles of his published works, and such like data which make up a record from one standpoint of his life's achievements. These matters, however, important though they are, I must leave for some one else to care for, to be presented in another way. I have merely attempted to say that we loved him, that we now do honor to his memory, and to show some of the reasons for his being a man whose influence has gone out so widely in such a beneficent way.

One other phase of his life's work should be mentioned, his distinctly religious work. He was throughout his life a member of the Friends Church, and for years a minister in that denomination. His religious work was not, however, so far as he was concerned, separated from the other activities of his life. He was accustomed to say that he could never draw the line between teaching and preaching. "Those who hear my lectures," he once said, "tell me that I am preaching; and some of those who listen to my sermons say that I have been lecturing; and I suppose they are both right." One of his associates in the work of teaching and preaching has said this of him and his work:

"Many who were anxious and fearful concerning the innovation of scientific truth and theory upon the old established order of things, have been comforted and reassured by his interpretation of modern thought and ancient beliefs. He had been all his life a diligent reader of the Bible and at the same time an enthusiastic student and observer of nature. That he could solve all difficulties that arose between the old and the new, he did not imagine or claim; but he did one thing of inestimable worth—he maintained with earnestness and reverence his full faith and confidence in spiritual reality while giving himself with tremendous enthusiasm to scientific pursuits; and he demonstrated in his own life the possibility of being a devout follower of Christ and at the same time accepting without any fears or reservation the best results of modern scientific investigation and thought."

The Indiana Academy of Science today honors the memory and recalls the helpful associations of him who was a charter member of the organization, a fellow once its president, and to the end of his life a devoted and inspiring comrade in scientific pursuits.

A much larger group made up of his students and associates in many different fields of endeavor, also acknowledge with gratitude the debt they owe to David Worth Dennis, the scholar, the fearless investigator, the genial companion, the stimulating teacher, the inspiring leader, a servant of God and a helper to his brother man.

David Worth Dennis—An Appreciation.

Alden H. Hadley.

Read at the Annual Meeting of the Indiana Audubon Society, May 10 and 11, 1917. Printed by the request of the Academy of Science.

When the message came telling me that Dr. Dennis had passed away there came over me an unspeakable feeling of sadness, a sense of personal loss that nothing in this world would assuage or repair. Only two or three weeks before those of us who had attended our State Audubon Society meeting at Rushville had been privileged to hear him in one of his characteristic bird talks, which he gave with all his old-time ardor and enthusiasm, before a splendid gathering in the high school building. In the afternoon I had said goodbye, little dreaming that I should see him no more on earth. I had known for a good while that his life was hanging by a slender thread; how slender none of us knew nor dared even guess. Yet during all these days he had gone on cheerfully and undauntedly, giving and taking the best there was in life. And is it not beautifully fitting my friends, that the final summons, which was the beginning of the end, should have come while he was out under the open sky, in God's great Out of Doors, watching the migrant birds, which he loved so well to do.

I said a moment ago that my first feeling, on learning of the death of the man we all loved so well, was one of great sadness and loss, but as the hours passed by there gradually came over me a feeling of a different sort; an almost overwhelming sense of the unspeakable greatness of human life at its best; for as I went back in my mind over the life of David Worth Dennis, so much of it as I myself had known for almost a quarter of a century, a great feeling of exultation came over me and I felt like shouting a loud trumpet note of victory, for *his* was pre-iminently the triumphant life.

In attempting to write just a few words in appreciation of Dr. Dennis, no one can realize more than I the difficulty of the task. It is hard to speak worthily and yet with restraint of such a man. His days and his years were so rich and so full and he touched life at so many points. I have tried hard to picture to myself in some sort of way the influence of that life as a whole and the more I have tried the more has my mind been baffled in the attempt. Pascal has defined the universe as a sphere whose centre is everywhere and circumference nowhere, and it has occurred to me that in the truest and deepest sense, and without exaggeration, some such definition as this is applicable to the life of Dr. Dennis, in fact to the life of any great loving, throbbing personality that in its journey through the world attempts to "mold things just a little nearer to the heart's desire."

The thought has often come to me that there are few relationships in life that offer richer opportunities for reward and that open up such far-reaching vistas into the future as that which exists between teacher and student. So I say that when I think of the half century that Dr. Dennis devoted to teaching and of the hundred and thousands of men and women, now scattered over the length and breadth of our land, who have come under the inspiring influence of his great personality, my mind fails utterly to grasp the infinite possibilities for good that flow from such a life.

May I crave your pardon for just a bit of personal reminiscence? As a boy there early dawned in my mind an ardent love for the many things in the great world of Nature about me, and there grew apace the intense and eager desire to learn to know something about all these various forms and the laws of their being. Just about this time some one informed me that there was a man in a college over in Eastern Indiana who could no doubt tell me all the things I most wished to know. At last the time came for me to go. I little dreamed of the things that were in store for me there. Under the patient guiding hand of this teacher we learned to see and to know many things that had hitherto been a sealed book to us. Through the wonderful eye of the microscope we saw something of the mysterious processes of life unfolding itself, and we were constantly taught to look back through the dim vistas of the past in order to try to understand, as best we could, something of what the history of that life had been on the earth. Not only were the beauties and the wonders of many of the forms in Nature's organic kingdom revealed to us, but in the chemical laboratory as well, under his guiding hand, we saw again something of the marvels of the so called inorganic world. There, for the first time, was made known to us something of the strange powers of chemical affinity, the wonderful attractions and repulsions of matter. And here, too, we were led to see that all was law and that nothing in nature comes about by chance. And, moreover, we learned to see that even in Nature's inorganic kingdom there are marvels past finding out, and above all we came to regard this clayey bulk of earth upon which we dwell, not as so much senseless dirt, inert and lifeless, but rightly understood, teeming with boundless life and full of unlimited potentialities. Indeed the deepest lesson that sank into our lives as we came from the class-room of Professor Dennis was that God is not an absentee God but an ever-present God working in his world, and that in the truest imaginable sense each day is a day of creation. With ardor and enthusiasm and a deep and abiding reverence were we taught these things, and not wholly by the spoken word of lecture but as often by the beautiful law of indirection.

Now the work of the scientist is essentially analytic. It is to dissect and to tear part; yet all too frequently is it the case that science teachers leave their world all disarticulate and torn to bits which is calculated to have a rather chilling and depressing effect upon the student. Dr. Dennis was above all a scientist. The scientific habit of mind was his constant charateristic. He was past master in the art of scientific analysis; yet he never left us chilled and depressed or stranded and helpless, for the world that he had torn to bits under his skilled touch became again orbed into one beautiful harmonious whole. Herein, no doubt, lay much of his power as a great science teacher. Not that he ever strained a point to make his presentation of the subject in hand popular or entertaining, not that at all. For pseudo-science he had the utmost contempt, and for the so-called nature-faking, and for many of the popular contemporary nature-study books, which he considered full of misrepresentations and inaccuracies, he had also the liveliest criticism. Dr. Jordan had given us a fine picture of Agassiz at Penikese; of the intimate and beautiful relationship that came to exist between the great teacher and the little group of devoted seekers after truth that there gathered about him. I have thought that it is wholly within the bounds of truth to say that something of this same fine spirit and this same enthusiasm that existed at Penikese, came to be the permanent atmosphere that enveloped the class-room in the little Eastern Indiana College where for so many years Dr. Dennis carried on his life work. At any rate I can conceive of no finer relationships than those which there existed between our great teacher and the young men and women who from year to year came into his class-room. It was indeed a memorable event in my own life when some kind fate decreed that I should find my way into his laboratories. On that day, now almost a quarter of a century gone by, I humbly sat at his feet and learned some of the profoundest lessons that have ever come into my life. And in all the years that have since come and gone, years that ripened into a friendship that was too deep and fine for words, I have always felt that he was my teacher and I have never ceased to sit at his feet and learn. I can do no less than bring to you this feeble tribute to his memory today.

Thus far I have spoken primarily of David Worth Dennis as teacher and in this connection I might say that a few years ago one of Indiana's best known and most efficient college presidents remarked that he regarded Dr. Dennis as the most versatile teacher in our state. And this leads me to say a word in regard to his versatility. I have often thought that he missed greatness as a mere scientist by sheer reason of this versatility. He had not the temper or habit of mind that could for long content itself in one narrow field of endeavor. However he had the highest regard for the scientific specialist, for he realized deeply that it is only in this way that the sum total of human knowledge is increased. However, his own restless spirit was interested in the whole vast kingdom of nature. Now it was micro-photography or bacteriology that claimed his attention. Again it was botany or paleontology. Not alone in the realm of science did he have a wide range of interests, but in the world of literature and art were his sympathies and appreciations very broad and deep. I recall in the old college days, when compulsory attendance at morning chapel service was the rule, how invariably there was full attendance when it was learned that Dr. Dennis was going to speak. I furthermore recall on what a wide range of subjects he spoke to us. Perhaps just fresh from a lecture on comparative osteology or embryology he would entertain and instruct us with a talk on Dante or Venetian architecture.

I spoke awhile ago of his power of keen scientific analysis as being one of his greatest assets as a successful teacher. I neglected to add that in addition to this power his success was due in great measure to an intimate knowledge of the subject in hand, to his boundless love and enthusiasm, which same sentiments he inspired in his students, also to his unstudied, inimitable manner of presentation. I have often found myself wondering whether or not he ever consciously followed any of the laws of pedagogy, his whole method was so naive and artless. It is utterly impossible to convey to any one who has never been privileged to be in his class-room any adequate portrayal of the man as the great teacher that he was. Combined with the qualities above mentioned he possessed an inimitable sense of humor that was constantstantly playing just beneath the surface of his warm and genial nature. Not only on his own students did he make a powerful and lasting impression but also on the members of the teaching profession at large. One of Indiana's best known teachers has said that Dr. Dennis has probably influenced the teachers of our state more than any other man.

As an exponent of educational theory he was very advanced and progressive, but he was always constructive and never unduly iconoclastic. He felt that we had better keep our house awhile, even though it be poor and insufficient until we found ourselves adequately equipped to replace it with a better one.

I would not in any wise be doing justice to the memory of David Worth Dennis if I did not touch briefly, though, however, inadequately, upon another aspect of his life and character. I think it was Professor Caird who once remarked that "the human soul is a wonderful instrument for the world to play upon." In this figure of Professor Caird there is opened up a vast field of thought and suggestion. It is indeed infinitely important just how the spirit of man reacts as it comes in contact with the strange forces that environ it. The author above quoted has also defined a man's religion as his "summed-up attitude toward the universe." Now Dr. Dennis was profoundly interested in the great problems of science and religion which are ultimately the great problems of being and destiny. Not that he ever wasted any time in useless speculation, he had no inclination for that. He came into the world just about the middle of the last century, at the period when the whole thought of the world was being transformed, and almost the entire structure of human knowledge was being torn down and builded anew. For the nineteenth century will go down in history as the age of the triumph of the evolutionary concept. His young mind early caught the vision which had come to the great Darwin.

"A fire-mist and a planet
A crystal and a cell
A jelly-fish and a saurian
And a cave where the cavemen dwell,
Then a sense of law and beauty
And a face turned from the clod,
Some call it Evolution
And others call it God."

Fearlessly, yet reverently, he championed the cause of the new knowledge, for he felt deeply, as did the late Professor Drummond, that the idea of evolution had come into the world just in time to save it from despair. It mattered not to him that some of the teachings of this new knowledge seemed to run counter to certain old and time-honored notions held elsewhere. He felt in his inmost being that all truth is one and comes from God, and then and always he followed fearlessly and without misgiving wherever truth seemed to lead.

Now some of the finest spirits of our time have been chilled and depressed by the great discoveries of modern science, for it has seemed to them to accentuate that sense of disproportion between man and the mere vastness of the material universe. To them man has seemed to have been left orphaned and alone in a world without purpose or design. Professor Dennis accepted the conclusions of modern science without reservation, yet with a deep and abiding faith that there is a kind heart beating through the scheme of things. He could exclaim with Tennyson "All's love, yet all's law." And again with Carlyle "the universe is not dead and demoniacal, a charnel house full of spectres, but God-like and my father's."

Those of us who came upon the scene at a somewhat later time have little conception of how hotly the battle raged in those days, now long gone by, nor can we adequately conceive of what courage it required to champion the cause of evolution, especially in those ultra-conservative communities that held steadfsatly to the old traditional thought.

I said a moment ago that Dr. Dennis was not a specialist in any particular branch of science but that he was interested in the entire kingdom of nature. He "saw life steadily and saw it whole." So in his early years he caught a vision of another kingdom, the one which the simple Galilean peasant came to establish in the lives and hearts of men. Those of us who knew him best can testify that few men have embodied more fully in their lives the spirit of the gentle Nazarene. It has never been my privilege to know any one who in his thinking had so completely gotten rid of that old and often times arbitrary distinction between things sacred and things secular. To him the whole of life and its activities was bathed with a sacred and transfiguring significance.

I must say just a word about his spirit of magnanimity, his generosity, for his whole life was one of service. It was characteristic of the man that he never lost interest in his students, even though they were long gone out from his classes, and there are large numbers of men and women throughout the length and breadth of our land now filling positions of trust and importance, who owe such situations to his kindly interest and spirit of helpfulness. This same spirit found expression in many other channels. He was intensely interested in the efforts of science to alleviate human suffering and in its heroic fight against disease. Consequently in his lectures we heard much about Louis Pasteur and others of that group of men who have done so much to lessen the sum total of human misery. Just prior to his death he was actively engaged in an anti-tuberculosis movement in his own community, and he was not only championing this cause by spoken word but by financial support.

I have said little or nothing in regard to the formal or official relationships he bore to various organizations and institutions. This no doubt has been done or will be done elsewhere, for it has been my sole purpose to endeavor to give you a personal appreciation of the man as I knew him. I know he took great interest and delight in the welfare and work of our Indiana Audubon Society of which he had been an officer ever since its organization in 1898. He was president of the society in 1912–13. And now my friends I bring you just one other glimpse of the man whom we are remembering today.

One April day, not long ago, there came to my notice a common enough little incident or rather a simple little drama that went straight to the heart of nature and of life. In an upland field a man was plowing, and following him were a lad of four and a maid of seven. It was one of those glorious spring days when all nature seemed to be springing into newness of life. A soft haze lay on the horizon. From out the near-by woods came the intermittent calls and rapping of wood-peckers and the songs of blue-bird and robins. And up from some neighboring ponds and swales came the musical piping of the hylas. A brown thrush was singing in a haw-thicket. To the boy and the girl just released for this spring-time holiday all nature seemed to be flinging out her eternal challenge and invitation. All the wistful wonder of the world seemed mirrored in their eager ecstatic faces. Now it was a wild-flower with which they came swiftly running to their father, now a great swelling, showy, opening bud of the horse-chestnut, now a curious pebble or a quill dropped from a flicker's wing. All these simple elemental things brought them a joy and a delight that knew no bounds. Now here I thought is the secret of perennial youth to keep untarnished this child-like wonder and delight in these common elemental things of earth. I speak without exaggeration when I say that more than any one I have ever known David Worth Dennis has kept alive, all through the years, this keen and simple and almost childlike love and wonder for the common every day things of God's great Out of Doors. A bird-song, a wild-flower, a rare fern found in some deep shady glen, a common algae of the brook; all these things moved him to strange delight. Often has he told me that the robin or the blue-bird or the oriole that came and sang in his dooryard this spring had just as fresh an interest, stirred in him just as deep a joy as those which had sung in his boyhood days. In the woods he was a rare companion, and as I pen these lines there come thronging back a host of happy memories of many golden days spent in the woods of May and June. His visits were always looked forward to with eager anticipation and are among the most cherished memories of our lives. I think he knew that the latch-string always hung out at "Pinehurst Farm;" and his simple tastes, his utter freedom from conventionality, his fine sociability and his entertaining talk made him a thrice welcome guest. It mattered not that his coming was unexpectedly announced by a long distance call or a hasty line—neither did it matter that the corn-planter must stand idle for a day or two, for some wonderful things were happening in the woods of the hill-country which very urgently demanded our presence there.

When Robert Louis Stevenson died in Samoa, Bliss Carman, in an impassioned threnody, said of him:

"He was not born for age, Ah no,
For everlasting youth is his!
Part of the lyric of the Earth
With spring and leaf and blade he is."

David Dennis was "part of the lyric of the Earth." He had the spirit of undying youth. Life for him never lost its zest.

It was on a singularly beautiful morning in May when we met in the chapel of the college, where so many of the best years of his life had been spent, to pay a little tribute of love and respect to his memory. Out on the campus the vireos and orioles were singing. The president arose and after reading to us that great Pauline oration in the 13th chapter of 1st Corinthians said: "On this the most beautiful day of the year I have read to you one of the most beautiful pieces of literature ever written, and we have come to pay a simple tribute of love to the memory of one of the most beautiful lives that has ever been lived." What more could one say than that? Only, again, just let us say of him those words which Emerson spoke of Thoreau—"Wherever there is truth, wherever there is beauty, wherever there is virtue, he will find a home."

John Price Durbin John—An Appreciation.

Wm. M. Blanchard.

On the seventh of August of the present year passed to his reward John Price Durbin John. Were it for no other reason that that he was a charter member and an early president of our Indiana Academy of Science, it would be appropriate for us to pay tribute to his memory. There are other reasons, however, why it is befitting that we make this meeting an occasion for expressing our appreciation of the life and labors of this great man. During the present year the people of Indiana are observing in various ways the one hundredth anniversary of the admission of the state to the Union and they are recalling to the younger generation the various forces and factors that have contributed largely to our wonderful development. Indeed, the keynote of the present meeting of the Academy is Indiana's Centenary and much effort has been made to have this meeting mirror our State's growth along material and intellectual lines. Now the most conspeiuous factor in a State's development is her men and few men have exerted a deeper influence on the educational and spiritual forces of our commonwealth than John P. D. John. And Dr. John was distinctively an Indiana man for all of his home life was spent in three college towns of the State: Brookville, Moores Hill, and Greencastle; and this remarkable fact is worthy of publication, while he was not a college graduate he had the unique distinction of becoming a professor in and president of the college in each of these towns. As a matter of record a brief biographical sketch will be in order.

Dr. John was born in Brookville November 25, 1843. He became a teacher in the public schools at seventeen and at twenty was elected Professor of Mathematics in Brookville College, an institution of some prominence a half century ago. He became President of the college in 1869, serving in this capacity for three years. In 1872 he became Professor of Mathematics in Moores Hill College and four years later was elected President. In 1882 he was elected Professor of Mathematics in DePauw University and in 1889 became its president. The same year he was elected President of the Indiana Academy of Science and the following year was chosen President of the Indiana College Association. He resigned the presidency of DePauw in 1895 and from that time until the year of his death he was a conspicuous figure on the lecture platform.

Dr. John's chief service to his State was in the fields of religion and education, and it was not to his own State alone that he rendered such conspicuous service for his uplifting influence was felt not only by thousands of people in Indiana but by multitudes in practically every state in the Union.

As a teacher he is said to have been original and inspiring. Dr. H. A. Gobin, a life long friend, has said of him, "His students always regarded him as thoroughly competent in every subject that he taught and it is evident that his interest in their welfare led them to regard him as a personal friend of greatest value. He was independent and thorough going in all of his investigations. He was a master of Mathematics, Astronomy, and Philosophy and these great subjects were made to contribute to his interpretation of the Scriptures and the emphasis and beauty with which he presented the doctrines of the Christian Religion."

After a service of nine years in Moores Hill College he resigned and went to Europe, partly for the benefits of foreign travel, partly to study at close hand the educational institutions and methods of the old world. It was soon after his return that he was elected to a professorship in DePauw. During the years immediately following, he not only maintained his mastery over his specific subject of Mathematics but he became thoroughly familiar with those educational problems and possessed himself of those educational ideals that prepared him for such efficient service later as President of the University. In his inaugural address as President, delivered on June 19, 1890, he pointed the way towards a lofty goal towards which he endeavored to direct his trustees and lead his faculty. His aim was to build up a real University, backed by his church, but non-sectarian in character, broad in its sympathies, allowing great intellectual and religious freedom to student and teacher. While not detracting from the value and importance of the classical studies of Mathematics and the Ancient languages, he warmly advocated equal facilities for the study and teaching of Philosophy, Science and History. With him a cardinal doctrine was that the value of a subject depends not so much upon the subject itself as upon the method by which the subject was handled. He maintained that where rightly taught, Botany, Geology and Chemistry are as efficient a means of culture as an equal amount of Latin, Greek or Mathematics. He took the ground that the training value of any course resides chiefly in the process rather than in the subject itself and insisted that while a limited amount of mathematical, linguistic, scientific, and philosophical study should be required of all students, on the other hand, each student should be left to spend the larger part of his time in whatever department he found the most interest and from which he expected to derive his chief culture. In his own epigrammatic way of expressing it, he believed in "freedom in the pupil, freedom in the teacher, and freedom in the subject," freedom, however, "not unrestrained, but unconstrained."

Dr. John cherished great hopes of building up a conspicuous university in the heart of Indiana. At that time, DePauw was believed to be on the eve of receiving an addition of two million dollars to its endowment and prospects of expanding libraries, well equipped laboratories, and commodious dormitories were rosy indeed. In building up a great university Dr. John believed that first emphasis should be placed on the proper equipment of the college of liberal arts as the center from which might radiate the various professional schools. He stood for thoroughness, a few subjects taught by live instructors, a few departments with thorough equipment, a small curriculum with sound methods, and he opposed everything that savored of the superficial. His first plea was for men—thoroughly live, enthusiastic, inspiring men, quite convinced that where a great teacher labors in library or laboratory there will students be gathered together. And he would not be content with teaching men, they must be producing men, men seeking after truth, investigators, ever pushing back the boundaries of the known. Regarding the relation between the college of liberal arts and the professional school he took an advanced position and advocated the introduction into the former as a part of the undergraduate course whatever subjects in the professional school were largely academic, in order that a man might shorten to a reasonable degree the time required for preparation for his chosen profession.

In the fall of 1889 Dr. John delivered the presidential address before the Indiana Academy of Science, his subject being "Religion and the Law of Continuity." Upon the evidence of certain breaks in the foundation of inductive Science—the Law of Continuity, Continuity of matter, Continuity of phenomena, Continuity of law, he proceded to construct an argument to show that the Christian religion is at least not unscientific. His own summary will serve to illustrate the logical processes of his mind. "There are in the history of the Universe, some apparent breaches of the principle of continuity. Other apparent breaches of the principle are, therefore, equally possible. As Science demands some apparent failures of the law, any other system may equally demand failures without thereby becoming unscientific. Whether such a system be really unscientific or not is a question of fact and not necessarily of how it stands related to our conception of the law of continuity. The Christian religion, like Science, is not to be judged by its apparent strain upon this law for no finite mind completely knows the law; but, like science, it is to be judged by the ends it proposes and the means by which it seeks to achieve them."

In December 1891, in his presidential address before the Indiana College Association he spoke on "The College in the New Education," pointing out that the difference between the old and the new education lay chiefly in *method*. He took the ground that time is an important element in the attainment of culture and that continuity of effort along a single line is more efficient than an equal total amount of separate efforts along numerous lines, and that this particular line must be left largely to the student's choice. It is still a source of instruction and inspiration to read this address.

Dr. John was well aware of the increasing demands made upon the college or university in the call for more subjects, a broader, more extensive curriculum, and the greater demands made upon the teacher by the newer method, the lecture method. He saw as clearly as anyone the need of greatly increased financial resources and the necessity of providing professors with competent assistants. In advocating the lecture method in college teaching, he refused to surrender in the least the vital principle of personal contact between teacher and student. Furthermore, he would hold each instructor under obligation to keep abreast of the tide in his own subject, intimately acquainted with the progress of research in his chosen field, not merely from year to year, but from month to month. There must be no laggards on his faculty. Each professor must be a specialist and each professor must be adequately supplied with tools for his work. To fill a college position a man must have done graduate work in the larger institutions equipped for highly specialized research and he must have become a master in some particular sphere of intellectual activity. I commend to your attention the words in which he summarized this address: "The three essentials of a great modern college are able instrucors, liberal equipment, and wide differentiation of work; able men who can inspire ambitious youth by mere contact; large equipment that every subject may be comprehensively taught, and broad differentiation that every instructor may be an authority in the department for which he stands." On the roll of his faculty are found the names of Oliver P. Jenkins, now at Leland Stanford, Clarence A. Waldo, now at Washington University, and Lucien M. Underwood, late Professor of Botany in Columbia University. Men who knew Dr. John well have expressed the opinion that if he could have received the financial support upon which he had counted when accepting the presidency of DePauw, his achievement at Greencastle might have been comparable with that of President Harper at Chicago.

It was an occasion of great regret to faculty, students and alumni when, in 1895, he resigned the presidency of the University, a position which he had filled for only six years but with conspicuous success. During the brief period of his administration he placed the institution upon a higher plane and started its development long new lines. In building a university he placed the chief emphasis upon the college of liberal arts. During these years he was a great inspiration to faculty and students and his uplifting influence was felt upon the educational work of the entire state.

If Dr. John's withdrawal from this particular position gave rise to the fear that he was lost to the educational forces of the country, his rapidly increasing prominence on the public platform soon demonstrated that he had merely widened the sphere of his influence and the field of his labors. His services were in great demand and it is said that at one time he had the greatest number of engagements ever booked by a single lecturer. And it is a high tribute to his eloquence, his personal magnetism, and the forceful presentation of his arguments that for almost a quarter of a century he traveled up and down this country addressing large assemblies on such themes as "Signs of God in the World," "The Worth of a Man," "The Overlap of Science and Religion," " The Sublimity of a Great Conviction" and never for once felt the need of a joke, a harrowing story, or a stereoptican to assist him in commanding the attention of his audience. The lecture that first brought him into prominence was that entitled "Did Man make God or did God make Man?" prepared in reply to the great agnostic orator, Robert J. Ingersoll, who had coined the expression "An honest god is the noblest work of man."

In the preparation of this lecture was illustrated one of Doctor John's characteristic traits—his love of truth and fair play. In order that he might not misrepresent Mr. Ingersoll, he sent to him that part of his manuscript in which the teachings of the agnostic had been set forth and asked whether they had been fairly stated. Upon receiving an affirmative reply he proceeded to expose the fallacy of his position and the result of his effort was the production of a lecture that was applauded from one end of the country to the other.

One who was intimately acquainted with Dr. John and who followed his career closely has written as follows of this period of his life: "He had an unusual voice for public speaking. With splendid modulation, a rich, deep tone, and epigrammatic literary style, he proved a master of assemblies. He sought not to be popular, but intellectually entertaining. His marvelous memory, combined with almost limitless power for sustained thought, dominated by a strong imagination and mathematical accuracy, accompanied by originality, both in thought and expression, gave him a unique place on the lecture platform." (Editor Western Christian Advocate.)

Personally, Dr. John was a very lovable man, warm hearted and generous. While his life was spent in a religious and intellectual atmosphere and while he was a man of very positive religious convictions, he was of a tolerant spirit, ever eager to lead others into what he had found to be "paths of righteousness and peace," yet never given to denunciatory methods of bringing other men to his way of thinking. That he owed much to the ideal home life with which he was blessed is mirrored forth in the dedicatory lines in one of the volumes of published addresses:

To
My Wife
Whose Devotion to Principle
Loyalty to Conviction
and
Courage in Duty
Have been my Inspiration;
Whose Gentle Womanhood
and
Tender Motherhood
Have Hallowed Our Happy Home.

Francis Marion Webster.

James Troop.

It is always a pleasure to add one's testimony to what naturally comes spontaneously, as it were, from his many friends, when a good man is called upon to lay down his implements, and leave his active life here, and pass over to the great beyond. And so, as one who has been more or less intimately acquainted with Professor Webster for the past third of a century; in fact, during the larger portion of his active, public life, I wish to add a word of appreciation to, as well as to reiterate what has already been said by others.

The following facts have been furnished me by Mrs. Webster, his widow, from an article written by Dr. L. O. Howard and printed in the Proceedings of the Entomological Society of Washington. In that we learn that Professor Webster was born at Lebanon, New Hampshire, August 2, 1849. He was the son of J. S. and Betty A. (Riddle) Webster. He married Maria A. Potter of Sanwich, Illinois, August 21, 1870. He was Assistant State Entomologist of Illinois from 1882 to 1884; Special Agent of the U. S. Department of Agriculture from 1884 to 1891; Entomologist of the Ohio Agricultural Experiment Station from 1891 to 1902; an assistant on the Biological Survey of Illinois during 1903 and 1904; after which he was appointed to a position in the Bureau of Entomology, U. S. Department of Agriculture, in charge of Cereal and Forage Crop Insect Investigations. While located at Lafayette, Indiana, 1884-1891, he was Consulting Entomologist of the Indiana Experiment Station during the last three years. He was sent on a mission to the Melbourne, Australia, International Exposition by the U. S. Departments of State and Agriculture in 1888, visiting other portions of Australia, Tasmania, and New Zealand, returning in 1889. He was engaged during part of the years 1886-1890 in the solution of the problem of the suppression of the buffalo gnat in the valley of the lower Mississippi River. He was a fellow of the American Association for the Advancement of Science and of the Indiana Academy of Science, the American Association of Economic Entomologists, the Entomological Society of America, and the Entomological Society of Washington. He was a member of the Biological Society of Washington, the National Geographic Society, the American Society of Naturalists, and the Geological Society of Iowa. He was an honorary member of the Entomological Society of Ontario and a corresponding member of the Cambridge Entomological Club and the New York Entomological Society.

It will be seen at once that in order to keep up a membership in good standing and to maintain an active part in the studies and investigations of all of these various organizations, it required a very active and busy brain, and this is just what Webster possessed to an eminent degree.

The writer had just come to Purdue University in the fall of 1884, only a few weeks before Webster appeared on the scene, and both being interested in practically the same kind of work, a very close friendship sprang up between them, which continued until his death from pneumonia at Columbus, Ohio, in January, 1916, while attended a meeting of the American Association for the Advancement of Science. It has been said that he was Professor of Economic Entomology in Purdue University from 1885-1888. This is a mistake. Professor Webster never did any teaching while located at Purdue University; in fact, he often remarked to the writer that no amount of money could induce him to take charge of classes in the class-room. This was not his forte. It is somewhat rare at the present time to find a great investigator and a great teacher in the same person. The investigator must find out the facts, often by long and patient "watchful waiting," before the teacher can impart them to the younger generation in such a way as to make them helpful to the world. Webster was an investigator, a close observer and thinker along the lines of natural history, but he did not wish to be confined to the walls of a class-room. His activities could only be limited by the broad fields of Nature. And it is well that it was so. Forty years ago, when Webster first came on the scene, there was great need of careful investigators. The science of Entomology was comparatively new (it is not old yet), and but very little real practical scientific information had been published. Teachers were groping in the dark for facts which they did not possess, and many of the so-called facts of those days have since had to be revised, and in this work Webster had an active part. His first published articles began to appear about 1874, and, although not a college graduate, many of his papers since that time would do credit to the best trained minds of his day. He was strong on using the daily and weekly newspapers for his publications, because (1) so much of the so-called information given out by these periodicals was so unreliable and unsatisfactory that he wished to correct that evil as much as possible; and (2) he saw in them a quick and cheap method of getting this information out to the people. But he came to be an authority among the scientific men of this and other countries. Many of his articles have been published in the best scientific journals of the world. His address as President of the Association of Economic Entomologists, in 1897, entitled "The Present and Future of Applied Entomology in America," is spoken of by Dr. L. O. Howard, as one of the best things he ever wrote. While his work was not confined to any one class of insects, his best and perhaps most useful work has been along the lines of Cereal and Forage Crop Insect investigations. The farming interests of the United States owe much to the life work of F. M. Webster. "He died at the end of a long and useful career, actively in the harness, but with a most useful life work accomplished, with his children grown up and practically established in life, and after all it was a good way to die."

Mental Hygiene: Retrospect and Prospect.

E. H. Lindley.

Hippocrates—Fifth Century B. C.

"Men ought to know that from nothing else but the brain come joy, despondency and lamentation * * * and by the same organ we become mad and delirious, and fears and terrors assail us, some by night and some by day; and dreams and untimely wanderings, and cares that are not suitable and ignorance of present circumstances, desuetude, and unskilfulness. All these things we endure from the brain when it is not healthy * * * ."

Mental Hygiene as the science and art of securing healthy mindedness, and of combating mental unsoundness, came slow and late. It is a development of the latter half of the 19th century. It emerged as one fruition of the development of physiology, pathology and psychology. Feuchtensleben's classic study; Braid's studies of hypnotism; Bernheim's suggestive therapeutics; Charcot and Janet's studies of hysteria; Beard's masterly study of neurasthenia; Weir Mitchell's rest cure; DuBois's psychic treatment of nervous disorders; Freud and Jung's conception of insanity and of psychoneuroses, and their method of psycho-analysis; the recent elaboration of the work cure for the insane and nervous; the elaboration of conceptions of the unconscious and sub-conscious psychic states and split of personalities in relation to disease, made by Binet, Prince and Sibis; the fuller differentiation of organic from functional disorders; all these culminating in a veritable arsenal of methods of psychognosis, and psychotherapy; such are a few of the landmarks which suggest the meteoric rise of mental hygiene. The whole structure rests on a more adequate view of the inter-action of mind and body, and on a new emphasis on mental states in the causation of disease. More properly they reflect the distinctively modern view of the terrific unity of body and mind, and the knowledge that mind and body, like Siamese twins, share each other's fortunes. Not only does somatic disorder tend to produce mental disorder, but mental conflicts and stresses interfere with the normal functioning of the body. This doctrine of the reciprocal relations replacing the older view of one-sided causation, has revolutionized our whole conception of disease of every human sort. The mental state of the patient always required treatment along with the physical.

Such, in brief, is the significance of mental hygiene. The quickening influence of this movement on research and teaching in medicine, and pedagogy, and social service, and the administration of charities, no less than in the administration of criminal law, give new hope for a conquest of human misery.

But my theme is historical. The history of mental hygiene in Indiana is as brief as the short and simple annals of the poor. Yet it is a most creditable history, and reflects not only the enlightened spirit of the times, but the influence of extraordinary leadership.

In our earlier history as a state, the chief problems involving mental hygiene, centered about the care and treatment of the insane, and to some extent, of the delinquent. The history of mental hygiene in our state is therefore chiefly institutional. What is Indiana's record in this regard? The last century opened with the minds of men yet enthralled by the demonological view of insanity. Insanity was a possession of the individual by an alien and malignant spirit. This was accompanied by confinement in dungeons, and horrible mistreatment of the unfortunates. Yet in France, Pinel, and in England, Tuke, have long proclaimed the conception that insanity is a disease of the brain and that right medical treatment is always imperative, and in some cases curative. In the early twenties, European alienists began to make extravagant claims as to the proportion of the insane who could be cured by humane and scientific methods. Responsive to this new conception and with fine enthusiasm, the legislature of 1827 made provision for a hospital for the insane. The first hospital was a log cabin called the crazy house, but it is important to note that the idea was to treat the insane as sick, and not as criminal. Dorothea Dix in an address to the Assembly in 1844 aroused the legislators to renewed concern for the insane. And as a result, the first real hospital for the insane was completed in 1848. It provided for both curables and incurables. Later, many incurables were returned to counties where they languished in jail, a serious retrogression. This practice was discontinued, however, in 1883.

In 1883, the legislature created three new hospitals to be located at Logansport, Richmond, and Evansville. The construction of each was abreast of the best thought of the times, including, in the case of Richmond a modified cottage plan of domicile, a plan which has met with high favor, and which is more fully developed in the new hospital at Madison.

A few years ago the Central Hospital for the Insane, thanks to the wisdom of Superintendent George F. Edenharter, erected a pathological building to provide for research and teaching. This marks an important advance.

But in spite of wise leadership and supervision, our state hospitals for the insane are so over-crowded that they cannot fully realize their functions as hospitals for the cure of the insane. It is to be hoped that larger resources and more room may soon be available.

2. As to the feeble-minded, our state has proceeded slowly but wisely. The School for Feeble-Minded at Fort Wayne opened in 1890, represented the culmination of a long period of care of the feeble-minded in other institutions. The recognition that feeble-mindedness is incurable, now led to a lower age of commitment from eighteen to sixteen years, and retention indefinitely. The law of 1901, creating a department for adult females from sixteen to forty-five years, was an important protection to society, and was designed to prevent mentally irresponsible women from transmitting a taint to increasing posterity.

The development of occupational activities, the provision of farm colonies, and the education of children in adjustment to their proper mental level, are some of the achievements of the State School at Fort Wayne.

3. The recognition that epilepsy is hereditary led to the founding of the epileptic village at Newcastle, where outdoor life and suitable occupation is provided in the most approved way for those whom the state has decreed shall not reproduce their kind.

4. The public recognition of the need of reformatory treatment of criminals, crystallized in 1897 into a provision for the transformation of the southern prison into the Indiana Reformatory, carrying with it the indeterminate sentence and parole, and later the suspended sentence, as well as a program of mental examination and of right education. This is a brilliant chapter in the history of our state.

5. About 1905, sterilization to prevent hereditary criminality and feeblemindedness was practiced with the consent of the inmates. The law was to apply to incurable idiots and incorrigible criminals. In 1909 the practice was discontinued on legal grounds, at the request of the Governor. But the law, held by many to be one of the most beneficient, still exists on our statute books.

In many of these measures, Indiana has been in advance of most states and has won deserved recognition.

6. There is not time to recount the achievements for sound morality and mentality, of the benign control of youth by the state through the establishment of a board of children's guardians, based on the rights of a child to a decent life, defended even against an unworthy parent. In this class falls also the provision for juvenile courts. These wise provisions are designed to protect plastic childhood from adverse environments which render impossible a normal mental and moral development.

7. Not less important is the recognition of the claims of mental hygiene by our educational institutions. The Indiana University School of Medicine was one of the first in the west to provide extensive courses in mental pathology and psychiatry. It seeks to train physicians competent to deal with the psychic factor in disease, to diagnose mental diseases as well as physical, to provide prompt treatment for incipient and acute insanity, to give wise counsel concerning heredity in relation to nervous and mental disorder and to convert the public to the view that insanity is a disease, not a crime.

The establishment by the University Medical School of a most efficient department of social service has rendered aid in reducing for many patients the stresses of adverse environment as well as providing for the re-education of many victims of bad mental habits.

For many years Indiana University has provided courses in mental pathology and the principles of psychotherapy, designed to train laymen to mastery of their own mental lives and to furnish leadership in the state-wide campaign against mental disorder.

Several institutions of higher learning in our state, are maintaining courses in orthogenics, training men and women in the diagnosis and treatment of backward and feeble-minded children.

This sifting of the school population and the provision of special training for abnormal children, is made possible by the genius of Alfred Binet. The Binet-Simon standard test for mental age, as revised by Goddard, Yerkes, and now presented in its best form by a Hoosier, Dr. L. M. Terman of Stanford University, supplies an efficient instrument for the detection of mental defects.

This makes possible a grading of school children by mental age rather than by chronological. It enables employers also to sift the industrial population and promises a new classification of vocations with reference to mental level. The feeble-minded cannot advance beyond their level. They cannot therefore win or retain promotion in tasks beyond their capacity. These standard tests should tend to bring the right job to the right man, thus increasing industrial efficiency, and replacing discontent and worry and other depressing mental states, with confidence and happiness and good-will.

8. Two years ago Governor Ralston appointed a commission to study the problem of the mentally defective and insane. The report of that commission reveals the existence of more than thirty thousand defective and insane persons in Indiana. The number is increasing and the cost of proper care mounts to millions. Out of the work of the commission, grew the Indiana Society for Mental Hygiene, as a member of the American Society for Mental Hygiene.

This society is to work for the conservation of mental health; for the prevention of mental disease and mental deficiency; and for the improvement, the care and treatment of those suffering from nervous or mental deficiency. It seeks to survey conditions in Indiana, to make known the causes of insanity, and to bring to the people knowledge of the means of prevention. It hopes, through public opinion and legal enactment to prevent in time the reproduction of the unfit, and to encourage the adequate provision for early treatment of the mentally sick. When it is known that the chief causes of insanity and feeble-mindedness are heredity, alcohol, syphilis, and head injuries, it is plain that society can and must control these causes through measures of prevention. For in the words of a recent writer, "at the present rate, while we are doubling our population, we are quadrupling our feeble-minded, and multiplying by three our insane. So that within three hundred and fifty years, the crazy people will break out and put us in." To meet these grave emergencies, the Governor's commission makes the following recommendations, which have been adopted by the Indiana Society of Mental Hygiene, as its program of immediate work.

FROM THE REPORT OF THE COMMITTEE ON MENTAL DEFECTIVES.

Conclusions.

1. The solving of the problem of the mental defective is vital to the state in the development of its social life.

2. One per cent. *at least*, of the general population, is mentally defective, i. e. either epileptic, insane or feeble-minded.

3. Nine thousand, four hundred and eight-four (9,484) *mental defectives*, or thirty-five one-hundredths of one per cent., of the total population, are now on public support.

4. a. There are 1,300 epileptics in the state needing institutional care as epileptics, 1,000 in the community at large or in institutions not suited to their care, and 305 in the Indiana Village for Epileptics.

b. The problem of the care of the insane in Indiana has been carefully worked out in the past fifty years, until now eighty-five per cent. of the insane in the state are cared for in state institutions.

c. The actual problem of the care of the feeble-minded is greater, inasmuch as it appears that the state at present is caring for but 1,350 or twenty per cent. of the estimated number who need care.

5. Mental defectiveness is a large factor in the cause of crime, delinquency, pauperism, inefficiency and many other social ills.

6. Further study of the cause and prevention of mental defectiveness is imperative.

Recommendations.

The Epileptic.

1. Additional provision for the care of women at the Village for Epileptics.

2. The enlargement of the Village for Epileptics to 1,200 capacity, and provision for larger medical facilities at that Village.

The Insane.

1. Indiana should at once provide additional institutional accommodations for one thousand patients now in need of hospital care.

Provision should, therefore, be made for the care of these one thousand patients, now in need of but not receiving institutional care. *First, by providing psychopathic departments at each of the existing hospitals, for intensive hospital treatment for the acute insane; second, by the erection of additional buildings at each of the existing hospitals as the plans of the several hospitals permit such expansion, and third, by the purchase of land for farm colonies and the* erection of inexpensive buildings thereon in connection with these institutions where such colonies can be satisfactorily maintained.

If after the above provisions have been made, there is still need of further hospital extension, we would recommend that the question be left to a committee appointed for that purpose.

2. There should, also, be provided at the Robert W. Long Hospital a psychiotric department, for observation and treatment of incipient mental cases.

3. At other general hospitals throughout the state detention wards should be established for observation and detention pending commitment and admission to the state hospitals. We feel that no person suffering from mental disease should be placed in jail.

4. The development of means for occupational therapy for patients.

5. A law providing for voluntary admission to state hospitals, thus taking care of incipient cases at a time when recovery is more hopeful.

The Feeble-Minded.

1. The enlargement of the School for Feeble-Minded Youth at Fort Wayne by a colony in the southern part of the state, on not less than 1,000 acres of land, with inexpensive buildings.

2. An additional law providing for commitment of patients to the School for Feeble-Minded Youth, the same as to the Village for Epileptics.

3. That in the event of increase in the facilities for the care of the feeble-minded, there be a law providing for the committal of adult feeble-minded males similar to the law now existing for the commitment of adult feeble-minded females.

General.

1. *There should be mental as well as physical examination of school children. Wherever it is possible, separate schools or separate rooms should be established.*

2. *We regard as highly important, and strongly recommend, the enactment of a law providing for a commission, with sufficient funds, to study the entire question of the mental defectives in this state.*

I confidently believe that these aims will appeal to the members of the Indiana Academy, and that all will join with us in this necessary effort to reduce mental unsoundness, and thus to contribute to the happiness and efficiency of all our people.

A Century of Geology in Indiana.

W. S. Blatchley.

A wise man once said that the Good Lord made the Geology of Indiana simple so that it could be easily understood by the State Geologists elected by the people. Whether the Almighty had that idea in mind, when the geological formations now constituting the area comprising the State were laid down, is and always will be a matter of conjecture. Suffice it to say, that according to the best knowledge obtainable, those formations were deposited in the order and manner set forth by the writer in another paper presented to this Academy in 1903.*

Prior to 1837 there is but little record of work done toward utilizing the mineral resources or determining the geology of Indiana. It is known that as early as 1804 the location of outcrops of coal was noted and marked on the land survey maps of the State, and in 1811 a small mine had been opened at Fulton, Perry County, from which it is said Robert Fulton obtained a supply of fuel for the first steamboat descending the Ohio River.

In 1817, William McClure, who afterward came to New Harmony with Robert Dale Owen, published a work "Observations on the Geology of the United States of America, etc." in which was a colored geological map of the Eastern United States. This shows Indiana in one color, the entire area of the State being included under what he called the "secondary" or area of stratified rocks. Indiana is not mentioned in the text of this work.

First Accounts of Wyandotte Cave.

In 1819, appeared the first published account of any cave in the United States, that of Wyandotte Cave, of Crawford County. It appeared in Wm. McMurtrie's "Sketches of Louisville and its Environs", under the heading, "The Mammoth Cave of Indiana." The cave at that time was owned by one Dr. Benjamin Adams who had preempted the land on which it is situated for the purpose of making saltpetre. McMurtrie says: "At what precise period it was first discovered must be left to tradition and wild conjecture to determine, but it is evident, from circumstances hereafter to be mentioned, that many ages must have elapsed, since that terrible convulsion of the earth, which has, in some places, rent asunder the solid rock for a hundred feet together. Although its existence was generally ascertained in 1798, it is only since the year 1814 that we have any account of it that can be relied on." He states on the next page, however, that Gen. Wm. H. Harrison visited the

*"The Indiana of Nature; Its Evolution," Presidential address by W. S. Blatchley, delivered December 28, 1903.

cave in 1806. "This gentleman informed Dr. Adams that there were at that time, enormous lumps of some saline matter scattered over the floor, individual pieces of which, he was persuaded, would have weighed from one to 200 pounds. The whole of this crystalized body must have been an impure sulphate of magnesia, which is still found there, though in small crystals, and only on the sides and in the interstices of the rock, which is owing to all the larger ones having been removed, several wagon loads of which were taken to Frankfort and other places."

McMurtrie's brief description is of the old cave only, the new portion not having been discovered until 1850. He says that the earth in the old passage "contains about five pounds of the nitrate of lime or magnesia, to the bushel, and is composed of decaying animal and vegetable matter, principally of bats' dung, which may be seen hanging in tufts on every rock." From the wording one does not know whether he meant that the bats or the dung clung to the rocks, but probably the former." "Continuing on the main route for some distance further" says McMurtrie, "the eye is involuntarily attracted by immense pebbles, weighing from one to five hundred tons, which lie precisely in the middle of it. I say pebbles, because, although they are composed of carbonate of lime, they are as completely rounded as any fragment of a primitive rock that can be produced in a water course." Some one must have needed these "rounded pebbles" and removed them from the cave, as I have never seen any signs of them. Continuing, he says: "The first serious impediment that presents itself consists in the ceiling or roof of the gallery descending so low as to touch the floor, leaving a small arched opening, through which, whoever wishes to penetrate further, must crawl and scuffle, not on his hands and knees, for that is impossible from the shallowness of the arch, but, literally speaking, on his belly. This spot has been styled by the guide, and not inaptly, the bat's burial place, the soil on which you creep, to the depth of a foot, being composed entirely of their remains."

After reaching the large room at the end of the old cave which he calls the "Chamber of Fountains," and descanting upon the wonders of what is now known as the Pillar of the Constitution, McMurtrie says: "I think that I may safely assert that the cave bears along with it most unequivocal proof of its having originated in an earthquake, which has split the rock, and opened a passage for a superincumbent body of water that has rushed in and filled a part, if not the whole of the cavity."

In Vol. I, "Transactions and Collections of the American Antiquarian Society," published in 1820, is an Appendix entitled "Account of a Great and very Extraordinary Cave in Indiana, in a letter from the owner to a gentleman in Frankfort, Kentucky." This letter was written by Dr. Adams, February 27, 1818, to John H. Farnham of Frankfort, but was not published till 1820, or one year after McMurtrie's work above cited. In transmitting it, Farnham said: "To the chymist and natural philosopher, the Indiana cave presents a most interesting theatre of experience and speculation;

and I congratulate the public that it is in the possession and ownership of a gentleman of the enlarged and liberal mind of Dr. Adams." The letter of Adams set forth but more briefly the same facts as given in McMurtrie's account. He called the column at the end of the old route the "Pillar", states that it is about one and one fourth miles from the entrance and, as did also McMurtrie, that it is composed of "satin-spar." The main idea of Dr. Adams in this letter seems to have been the advertising of the salts of the cave. He called it his "Epsom Salts Cave," and stated that the "first in importance was the sulphate of magnesia or epsom salts, which abounds throughout this cave in almost its whole extent and which I believe has no parallel in the history of that article. The quality of the salt in the cave is inferior to none and when it takes its proper stand in regular and domestic practice must be of national utility. Every competent judge must pronounce it inexhaustible. The worst earth that has been tried will yield four pounds of salt to the bushel, and the best from 20 to 25 pounds. The next production is the nitrate of lime or saltpetre earth. There are vast quantities of this earth and equal in strength to any that I have ever seen. There are also large quantities of nitrate of allumina or nitrate of argil, etc." Dr. Adams carried on the business of leaching these salts between 1812 and 1820 on an extensive scale, and as late as 1905 remains of his old wooden hoppers and troughs were to be seen in the vicinity of the mouth of Wyandotte.

In 1823 the legislature passed "an act concerning saltpetre caves and for other purposes." The preamble to the act recited that "it has been represented to this General Assembly that great loss has been sustained by the owners of stock, cattle and horses, from the use of substance extracted from saltpetre caves, epsom salt caves and others of different kinds, in consequence of the same having been left unenclosed by the owners or occupiers thereof, for remedy whereof, etc." The act provided that the owner of any such cave who should allow it to remain unenclosed and exposed to the stock of the neighborhood, should be liable to a fine of $10 for every day it was left so exposed, and also liable in damages for stock injured. This act continued in force many years and was embodied in the Revised Statutes of 1843.

In Flint's "Geography of the Mississippi Valley," published in 1833, there is also a brief account of Wyandotte under the name of "Epsom Salts Cave," but it was evidently compiled from the two articles above quoted.

Survey for Canal to Connect Waters of Lake Michigan and Wabash River.

In April, 1829 Howard Stansbury, a civil engineer in the employ of the United States, was instructed "to ascertain the practicability of uniting by a canal the waters of Lake Michigan with the Wabash River." With a party of assistants he spent two seasons, those of 1829 and 1830, in the field. From his report, dated October 17, 1831, I have taken a few facts of general geological interest since they show some of the conditions existing in Northern Indiana nearly 90 years ago. He was ordered to examine and compare the two routes described as follows:

1.—"The first, starting from Lake Michigan, would ascend the valley of the St. Joseph River (of the lake) to leave it at a convenient point near to the Kankakee River; then it would cross to this stream to descend its valley down to the mouth of Yellow River; thence up the same to a point from which a cross canal could be run to Tippecanoe River. From hence the route descends this stream, and then the Wabash, to the head of steamboat navigation.

2.—"The other would ascend the valley of the St. Joseph River (of the lake) up to one of its head branches; from thence to the fork formed by the St. Joseph of the Maumee and St. Mary's rivers, then from that point through the valley of Little River, to the Wabash River, as far down as the head of steamboat navigation."

The first of these routes he designated in his report as the "Southern route," stated that most of the territory through which it passed was included within the Indian boundary lines, had never been explored and that none of the lands belonging to the Government had been surveyed. He says that along the greater parts of both routes there was a great scarcity of stone, and that all locks, dams, aqueducts, etc., would have to be constructed of wood. The St. Joseph River near South Bend was gauged at a very low stage on July 25, 1829, and found to have a flow of 1,395 cubic feet per second.

The soil of the wet prairies near the Kankakee, "after penetrating the turf with which they are covered, is found to consist of quicksand and soft mud, in most instances of great fluidity and considerable depth. Embankments will be required to pass the canal over them, the earth for which, consisting of a mixture of sand, clay, and pretty coarse gravel, is generally convenient."

While surveying the line from Yellow River to the Tippecanoe, a distance of nine and two-thirds miles, he learned from the Indians that upon the summit of the water shed between these streams was a large lake which they called Mek-sin-kuk-keek and which it was stated would supply all the water that was needed for that section of the canal. He therefore ran lines from Yellow River to the lake, found that the route was practicable but that the lake lay ten miles to the left of the direct course and would require some deep cuts. He states that "this route was therefore abandoned for the more direct one on which we found that another lake lay immediately in our way which although not as large as the former, was nevertheless fully capable, together with Yellow River, to furnish the needed supply of water. This route is termed the "Devil Lake Route" from the name of the lake on its summit, which was found to contain 7,313,883 square yards." This so called "Devil Lake" of the Stansbury report is now the well known "Bass Lake," a noted resort for Chicago and Indianapolis citizens during the summer months. It is interesting to note also that what is now known as Monon Creek, a tributary of the Tippecanoe and from which the town and railway of the same name derived their names, was, in the Stansbury Report, called the Motimonon River.

The total length of the southern route as surveyed by Stansbury from the mouth of the St. Joseph at Lake Michigan to the mouth of the Tippecanoe where the canal would connect with the Wabash was found to be 157.7 miles; the ascent and descent 127 and 171 feet, respectively; the number of locks required, 37 and the estimate of the total cost, $1,895,904.

In surveying the proposed "Northern Route" Stansbury found that the most feasible connection between the St. Joseph of Lake Michigan and the St. Joseph of the Maumee was by way of Pigeon River, a large branch of the former. This stream he found had its source in a cluster of lakes, in one of which, Fish Creek, a tributary of the other St. Joseph, also had its rise.

The following paragraph from the Stansbury report regarding the summit level between the two streams, located in what is now Steuben County, is of especial interest in this connection:

"The country around the summit level, abounds in small lakes, from an half to two miles in length, either connected together in chains, or separate and alone, without any apparent inlet or outlet. They consist of the purest spring water, are full of the finest fish, and are of immense depth (in one of them, the bottom, as I have been informed, was sought in vain with a line of 250 yards). The soil of the surrounding country is a mixture of sand, clay and gravel, indicating a bed of clay. Their supply from beneath being constant, they do not appear to be affected by the drought of summer, but where there are outlets, these are considerably swollen by the melting of the snows and ice on their banks, in the spring."

You will note that Stansbury did not sound the lake himself, but was informed that it was more than 750 feet in depth. The truth is that, like the lengths of the caves of Southern Indiana, the depths of the Northern Indiana lakes are greatly exaggerated by the surrounding inhabitants. According to their story many of them are "bottomless," or have deep holes in which it is "impossible to find bottom." Their attempts at sounding were probably made with an ordinary fishing line or the butt end of a cane pole. No one of the local residents who has such beliefs has ever brought up a Chinaman's queue on his fish hook or a new species of fish from the central regions of the earth. The fact is that the deepest water in any lake of the State, and the writer has sounded them all, is 121 feet in Tippecanoe Lake, Kosciusko County.

Stansbury found that the length of the proposed canal by the northern route from Lake Michigan to Fort Wayne, where it was proposed to connect it with the Wabash and Erie canal, would be 177.11 miles, its descent 553 feet, the number of locks required 69 and the estimated cost $1,860,468. He states that the southern or Kankakee—Tippecanoe River route "is shorter by more than twenty miles. It will require but 36 instead of 69 locks, thereby occasioning a great saving of time in the transportation of all articles of trade; and, lastly and principally, it enjoys the paramount advantage of commanding an unfailing and ample supply of water on the summit. For these reasons the preference has, without hesitation, been given to the southern route."

He ends his interesting report with the following paragraph: "The prosecution of this extensive survey, by subjecting to minute inspection a very interesting portion of our country, has tended entirely to confirm the view in which the examination has its origin. It has conducted the brigade through a region abounding in every natural advantage, fertile in soil, presenting great facilities of communication, and lying immediately adjunct, on one side, to a stream which will soon be rendered navigable throughout its length, and covered with the bustle of an active trade; and, on the other, to a great arm of our Mediterranean waters, stretching itself into the very heart of a rich and, soon to be, a populous country; and furnishing, for the naval defense of our internal frontier, a safe and convenient harbor, easily fortified, and affording every possible advantage for a naval depot. The means of uniting the two, have now been sufficiently developed to render it certain that that valuable improvement may be effected at a small comparative expenditure of money and labor; and a path has been fully opened for the enterprise of a young, but rapidly advancing State."

The Era of Internal Improvements.

Between 1830 and 1835 there was a great awakening of the public road spirit in the United States. The era of "Internal Improvements" was on, and canals, railways and improved roads were projected, either on paper or in reality in many of the States. The people of Indiana caught the fever, and in 1835 the Legislature authorized the surveys of six important routes, as follows:

1. A route for a railroad or turnpike road from Madison via Indianapolis, Danville and Crawfordsville to Lafayette.
2. A route for a railroad or turnpike road from Crawfordsville via Greencastle, Bloomington, Bedford and Salem, to New Albany.
3. A route for a railroad from Evansville via Princeton to Vincennes.
4. A route for a railroad from Vincennes to Terre Haute.
5. A route for a macadamized turnpike road from New Albany via Greenville, Fredericksburgh, Paoli, Mount Pleasant and Washington to Vincennes.
6. The completion of the surveys and estimates on the Lawrenceburgh and Indianapolis railway.

Noah Noble was then Governor of Indiana, and, at his request, made to the United States Topographical Bureau, for an engineer of ability to take charge of the surveys, Howard Stansbury, the U. S. Assistant Civil Engineer who had made the survey for the Lake Michigan-Wabash River Canal, was detailed for the service. The reports of Mr. Stansbury and his several assistants, dated December 17, 1835, were published in the House Documentary Journal for 1835 and 1836, and are very full and exceedingly interesting, containing many notes on the local outcrops of stone and surface topography of the regions traversed. For example, the assistant in charge of the Madison-Indianapolis Railway survey describes the country in the vicinity of Flat Rock Creek in the following glowing terms:

"In this rich and fertile country, which abounds with noble specimens of stately white oak, the valleys of water courses are bounded by ranges of sand and gravel hills running in parallelism with the streams, the bottom lands of which in some instances, expand to a width of two or three miles, and possess a soil, exuberant in a high degree, being nowhere infested with rocks or stones, and exhibit proofs of the greatest fecundity in the rankness of their vegetable products, while the beautiful area between them is a uniform plain, having no rise perceptible to the eye, and admirably adapted for the reception of a railway."

Edward Watts, the assistant engineer in charge of Route 2, which proposed either a railroad or a turnpike road from Crawfordsville to New Albany, turned down the railroad end of it in the following brief paragraph:

"By reference to the maps you will discover that a railroad, in order to pass through the points prescribed by law, necessarily passes over undulating country, crossing water courses nearly at right angles, thereby occasioning ascents and descents entirely inadmissible upon a railway, which could only be removed by long, deep cuts and heavy embankments, the cost of which would be so enormous as to render any idea of the construction of the work out of the question."

Though rejected as impracticable by Mr. Watts, the railway between New Albany and Crawfordsville was begun by private capital in 1847, completed to Lafayette in 1854 and afterward to Michigan City, thus connecting Lake Michigan and the Ohio River. It is now a part of the main line of the C. I. & L. (Monon) Railway, extending from Chicago to Louisville, Kentucky.

The first two railways planned and completed within the State were thus north and south lines having their southern terminals on the Ohio River, which was then the main artery of commerce for all the states along its borders. These roads were constructed mainly for the shipment of food supplies and raw and manufactured products from their river terminals to the consumers in the interior of a young and rapidly growing State.

When the New Albany and Crawfordsville railroad was built it was projected along a crooked line which brought it close to important mineral resources of which probably its builders had no knowledge, yet which have been for years its source of greatest revenue. They were the Indiana oolitic limestone and the French Lick Pluto Water. Take from that division of the Monon these two things and it would go into bankruptcy tomorrow.

Careful estimates by Mr. Stansbury were submitted, stating the cost of each of the works above mentioned, the total being $5,538,031. The legislature of 1836, which convened soon after his report, passed an internal improvement bill appropriating nearly $16,000,000 for the building of canals, railways and macadam roads. This was to be raised by the sale of State bonds. Work was begun on many of the projects, but the only one completed by the State was the turnpike between New Albany and Paoli, a distance of 41 miles. It was macadamized with limestone taken from quarries along its route, and was completed in 1839 at a cost of $12,537 per mile. In November, 1839, the Internal Improvement bubble burst; the State was unable to sell more bonds and with certain minor exceptions all public work was suspended.

One result of especial geological interest connected with this internal improvement boom, was the publishing in the House Record of 1836 of the first "Table of Altitudes in Indiana" of which I can find record. It was prepared by Howard D. Stansbury and Jesse L. Williams and gave elevations of 208 different points in the State "with regard to the plain on which the Capital of the State is built; high water of the Ohio at the head of the Falls; the surface of Lake Erie, and tide water in the Hudson."

First Geological Survey of Indiana.

David Dale Owen, son of Robert Owen, the noted philanthropist and reformer who founded the socialistic colony at New Harmony in 1825, was the first, the most learned and the most eminent of Indiana's State Geologists. He was born at New Lanark, Scotland, June 24, 1807, being only 27 days younger than Louis Agassiz the noted Swiss scientist, who also spent most of his years in America. Young Owen was educated at New Lanark and at the celebrated school of Fellenberg at Hofwyl, Switzerland, and came to New Harmony, Posey County, Indiana, in 1827. He returned to London in 1831 for two years' additional study in chemistry and geology, then returned to this country and was graduated from the Ohio Medical College at Cincinnati in 1836. It is said that he took this course in medicine to increase his knowledge of anatomy and physiology as an aid in the study of paleontology. He spent the following summer as an assistant of Dr. Gerard Troost, the State Geologist of Tennessee, and was then appointed by Governor Noble as Geologist of the State of Indiana. This appointment was made in accordance with an act entitled "An act to provide for a Geological Survey of Indiana, Approved February 6, 1837," which read as follows:

Section 1.—*Be it enacted by the General Assembly of the State of Indiana*, That the Governor be and is hereby authorized and required annually hereafter to appoint and commission a person of talents, integrity and suitable scientific acquirements as Geologist for the State of Indiana, who shall receive in consideration of his faithful performance of his duties, an annual salary not exceeding $1,500 and necessary expenses not to exceed $250, to be paid as the salaries of other civil officers of the State.

Sec. 2.—That it shall be the duty of the geologist to be appointed as aforesaid, to make a complete and minute geological survey of the whole

State, commencing with those portions in the vicinity of the contemplated public works (always having reference to the directions hereinafter provided) and thence through the other portions of the State with as much expedition and accuracy as may be consistent with minuteness and dispatch and he shall prepare and lay before the legislature a detailed account of all remarkable discoveries made and the progress of the work, accompanied with proper maps and diagrams including a geological chart of the State.

Sec. 3.—It shall further be the duty of the Geologist of the State, at those seasons not suited to the active prosecution of the geological survey, to analyze and ascertain the qualities and properties of mineral substances or soils left at his office or residence for that purpose by any citizen of the State and taken from any portion of the territory of the State.

Sec. 4.—That the said Geologist appointed by virtue of this act, shall be subject to the orders of the executive of the State and shall hold himself ready on reasonable notice to make geological examinations in the vicinity of the canals, railroads or other works of internal improvements which the legislature has or may hereafter direct to be made, *Provided*, That this act shall expire at the termination of the year 1838 unless the same be re-enacted by the next Legislature of the State.

Sec. 5.—This Act to be in force from and after its passage.

Right here I wish to call attention to certain phrases of this Act which I have emphasized in the reading. This was probably the first sum ever appropriated by a Legislature of Indiana for scientific purposes. That eminent body evidently thought it was buying a gold brick and proposed to pay for it the least sum possible. Here it was proposed to hire a man who had spent years and probably thousands of dollars in preparing himself for the work—"A person of talents, integrity and scientific attainments," who shall travel on foot or on horseback through a wilderness from one end of the State to another and make a "complete and minute" geological survey of the whole State with accompanying charts and geological maps. For this he was to receive the munificent sum of $1,500 a year and $250 for all expenses. He had to do all the work himself or else hire assistants and pay them out of his own salary or that $250. He was to do field work for nine months of the year and for the other three, instead of having his time to prepare his report and make his maps, he was to analyze soils and minerals for every crank and hobo that wanted something of the kind done. Ye Gods and little fishes! I wish the author of that bill were here tonight to take his medicine.

This then was the beginning of that short sighted parsimonious policy which has continued, toward not only the geological department but every other scientific bureau of the State of Indiana, from that day to this. The writer carried on the work of the Geological Department of the State for sixteen years with never to exceed $4,250 a year for help and all expenses, when Illinois was getting $25,000, Pennsylvania $100,000 and other states in proportion. The average politician who is chosen as a "representative" (mark the word) of the dear "peepul" of the State of Indiana knows nothing about science, cares nothing about science—sees no connection between science and the future development of the State and is afraid to vote an extra dollar even in a worthy cause for fear that he will be snowed under at the next election. The Geologist or other scientist who is dependent solely upon political appropriations to do good work in the State of Indiana has indeed a rocky road to travel.

The Geological Reports of David Dale Owen.

Based upon the discoveries which he made during his two years' term of office, Dr. Owen issued two reports, addressed "To the Honorable, the Legislature of Indiana." The first of 38 pages was published at Indianapolis in 1838 and entitled "Report of a Geological Reconnoissance of the State of Indiana made in the year 1837 in conformity to an order of the Legislature." The second of 54 pages, published in 1839, was entitled "Continuation of Report of a Geological Reconnoissance of the State of Indiana made in the year 1838 in conformity to an order of the Legislature." The first of these reports was reprinted verbatim in 1853 and was revised, enlarged to 69 pages and again reprinted in 1859. The second one was reprinted with very few changes in 1859. These reprints on the dates mentioned were probably due to the fact that in 1852 an attempt was made to reinstate a geological survey, while in 1859 it was renewed for a brief period. Although Dr. Owen fully realized the great value of paleontology in determining the relative age and consequent nature and position of the stratified formations, he showed in these two brief works, in which are outlined for the first time the principal rock formations of the area comprising Indiana, that he had the right idea of what the writer considers the true functions of a State Geologist—viz., the searching out and making known the undeveloped mineral resources of the State. In other words, he laid especial emphasis upon the economic features of his survey and did not, as did some of his successors, devote his time largely to the study and exploitation of the fossils of the regions which he covered.

In the introduction to his first report this feature of his work is set forth in the two following paragraphs:

"The science of Geology, of comparatively modern date, is now universally conceded to be one, not of mere curious inquiry, but of vast practical utility. It indicates, not only to the closest philosopher a boundless field of conjecture, whereon to erect theories of creation and systems of the world; but to the manufacturer, the raw material whence mineral riches are abundantly derived, and to the farmer, the means of improving soils that nature seems to have disfavored."

"I have considered it my duty, while surveying a country as new as ours, to remember that a State just settling is like a young man starting in life, whom it behooves to secure to himself a competency before he indulges in unproductive fancies. I have considered it the most important object to search out the hidden resources of the State, and open new fields of enterprise to her citizens. That object effected, time enough will remain to institute inquiries of a less productive and more abstract character; inquiries which are interesting in a scientific rather than a commercial, point of view."

He then laid down very briefly the Leading Principles of Geology, outlining the divisions of stratified rocks, but, curiously enough, since the doctrine of evolution was not then set forth, beginning with the most recent or present alluvium and following backward to what he calls the "Blue Limestone (Lower Silurian) formation, instead of commencing with the lower and tracing forward to the later formations.

Since these two reports of Owen form the basis for most of the work since done in Indiana Geology, he laying the groundwork for future surveys much more accurately than probably even he suspected, and since they have long been out of print, I propose to give briefly yet somewhat in detail the principal facts set forth as to the formations which he found and in part named, and the mineral resources which he discovered or made known.

His first object, as he states, was to gain a correct and connected idea of the geology of the State as a whole. He therefore, in the spring and summer of 1837, ran a line from the mouth of the Wabash to the southeastern limit of the State, "keeping as close to the meanders of the Ohio River as possible, in order to take advantage of the sections exposed on the bluffs along its banks." This line, as he states, showed the following succession of formations in the counties bordering on the Ohio River:

We first find, he says, the coal formation, consisting of repetitions of beds of sandstone, shale, seams of coal, clays, bands and nodules of iron stone and occasional beds of limestone. This prevails through the counties of Posey, Vanderburgh, Warrick, Spencer and extends to Oil Creek in Perry County. At this point there appears above the drainage of the county a bed of limestone.

"This limestone must be considered as the uppermost member of a new series or group of the stratified rocks. A succession of the various members of this inferior group is to be found prevailing until we reach the extreme western boundary of Ohio. To this group may with propriety be applied the name *Subcarboniferous*, as indicating its position immediately beneath the coal or carboniferous group of Indiana."*

This was the first use of the term "subcarboniferous" in Indiana Geology, or for that matter, probably in the United States. From the wording we see that Owen included under the name all the sedimentary rocks below the coal measures found in the State. In the 1859 edition he restricted the term subcarboniferous to that "series of limestones with subordinate fine grained sandstones and shales,"‡ lying between the coal measures and the New Albany black shale, and states "To this calcareous group I have applied the name subcarboniferous as indicating its position beneath the true coal measures, since

*1837 edition, p. 15.
‡Reprint 1859, pp. 12 and 20.

in no instance, as yet, have any workable beds of coal been found associated with these limestones." He states that in the southern portion of its range through Indiana the subcarboniferous has numerous alternations of sandstones in its upper part (constituting the Huron formation of present nomenclature) and to that group of the subcarboniferous which we now call the Mitchell limestone he gave the name "Barren Limestones," because they prevail through the Barrens of Harrison, Orange and Lawrence Counties, which he states were covered with a stunted growth of black jack oak. He mentions the characteristic sink holes and disintegrated cherts which accompany this formation, and states that, though called barren, its surface is capable of producing excellent crops. This barren limestone "passes downward into fine-grained freestones with subordinate beds of gray shales to which the name of *Knobstone* may be appropriately applied, since these silicious strata weather into peculiar knobs or hills." In this sentence Dr. Owen therefore gave the name which it still holds to a prominent formation of southern-central Indiana and which, in his second report (1838) he correlates with the Waverly of Ohio. He states that it extends from Floyd and Harrison Counties northward through Jackson and parts of Monroe, Morgan and Hendricks Counties, thus mentioning most of its present known distribution.

"At the base of this knobstone," he continues, there "occurs an important stratum—the *black bituminous aluminous slate*—which is to be seen, when the water is low, at the New Albany Ferry-Boat landing. I call it an important stratum, because this black bituminous slate resembles, both in its external appearance and chemical composition, the coal shale; and since it takes fire and burns for some time, owing to the presence of bitumen and sulphuret of iron, it is frequently mistaken for indications of coal, and even for coal itself. In no instance have I ever found it associated with perfect seams of coal; and I have but little hesitation in asserting, that no true coal will ever be found associated with it in our section of the country." He emphasizes this latter statement by placing it in Italics in his summary at the end of his report, and the writer, while serving as State Geologist, had also to emphasize it, as on several occasions persons claimed that they had discovered coal in Johnson County, and companies were even organized to sink shafts for its development.

"Under the black slate," continues Dr. Owen, "and interposed between beds of crinoidal and coralline limestones is a valuable bed of hydraulic limestone varying in thickness from two to ten feet." This is our Silver Creek limestone afterward used so extensively in Clark County for the making of natural rock cement. He referred the black slate and accompanying underlying limestones to the Devonian system of rocks, the crinoidal layer being what is now known as the Sellersburg limestone while the coralline limestone we call the Jeffersonville. He next recorded the presence of the "Magnesian limestones" of the Upper Silurian group, and finally, as constituting the surface rocks of Switzerland, Dearborn and other counties of south-eastern Indiana," the blue limestone with its associate beds of marlites and mudstone." This he correlated with the Lower Silurian, as the lowest Geological formation in Indiana.

We thus see that in this first cross section of southern Indiana, Dr. Owen recognized *all* the principal formations which we now retain, though some of them, as the Subcarboniferous and the Devonian, have been subdivided by more recent geologists.

After completing the line across the southern edge of the State, Dr. Owen ran a number of what he calls zigzag lines south of the National Road to determine the limits in the southern part of the State of the various formations above mentioned. As a result of these lines he located approximately yet fairly accurately the eastern limits of the coal area, stating that "from Oil Creek, Perry County, the line of junction between the coal formation and underlying subcarboniferous limestone runs pretty nearly north, a little west of Paoli, Bedford and Bloomington, thence it bears somewhat more to the west near Spencer, and crosses the National Road near Putnamville."

"It will therefore be a useless waste of time, money and labor to search for coal in any of the counties east of the second principal meridian, or east of the belt of limestones, that succeed to the coal formation on the east; because all experience goes to show that there are no workable beds of coal associated with these limestones, or any of the underlying formations, that crop out to the surface east of that formation. Therefore, *all search for coal in or beneath the black slate formation of Floyd, Clarke, Scott, Jackson, Bartholomew, Johnson and Marion Counties may be predicted as fruitless.*" This statement he also reiterates on page 57 of his second report, and time has proven the truth of his assertions.

From these zigzag lines he also outlined very accurately the approximate areas over which each of the formations above named constitute the surface rocks. For example, he states that the black aluminous slate (now known as the New Albany or Genesee shale) "extends through a great part of Clarke, Scott, Jennings, Jackson, Bartholomew, Shelby, Johnson and Marion Counties, towards Indianapolis; but in this neighborhood near the National Road, the strata are so completely covered by drift, that it is difficult to detect the original strata. Even the deepest wells have not penetrated through this drift."

In the fall of 1837, Dr. Owen continued his reconnaissance north of the National Road, where he "found the greater part of this northern country covered by a drift of sand, gravel, boulders and clay, sometimes to a very great depth." For this reason he found it difficult to locate outcrops and determine the formations, though he records, and correctly, that the eastern boundary of the coal formation crosses the Wabash near Attica and that the counties of Parke, Vermillion and parts of Warren and Fountain belong to that formation. He visited the border of Lake Michigan and mentions the presence of the tenacious stiff blue clay which underlies the sand of the dune region, stating that it occurs for some miles back into the country and probably accounts for the retention of so much water in the Kankakee country.

The mineral deposits, soil and growth peculiar to each of the rock formations are next treated by Dr. Owen in his first report. One of his main objects seems to have been a search for deposits of iron ore as he states that "a good iron bank is of more value to the State than a mine of gold or silver." He located deposits of bog ore or limonite in St. Joseph, Tippecanoe, Warren, Putnam, Owen, Marion, Hancock, and Clark Counties, and of iron carbonate or siderite in Warren, Parke, Fountain and Vermillion Counties. He mentions briefly the extent and character of the well known deposits of potter's clay at Troy, Perry County, and records the mining of coal on a commercial scale in Perry, Pike and Vigo Counties.

Of the soils of the various formations and their growths of indigenous trees and shrubs, Dr. Owen gives brief descriptions, claiming that that of the blue limestone or marly clay formation (the Lower Silurian) of southeastern Indiana comprises the most fertile districts of the State. Boone County at that date was mostly a swamp, and the prairies of Benton, Newton and Tippecanoe were as yet too wet for cultivation, so that he did not recognize their future great productive possibilities. The least productive land, he states, "is that on the summits and upper slopes of the Knobstone formation." However, time has shown that that overlying the sandstones of the Carboniferous and Huron formations is not far behind it in lack of fertility.

An interesting change of opinion regarding the origin of the drift soils of northern Indiana, occurs in the second or revised edition of the first report. In the original 1837 edition he says: "The fertility of the soil in Indiana is universally admitted, yet few are aware that it arises mainly from its geological position. It is well known to the geologist that that soil is most productive which has been derived from the destruction of the greatest variety of different rocks, for thus only is produced the due mixture of gravel, sand, clay and limestone necessary to form a good medium for the retention and transmission of the nutritive fluids, be they liquid or aeriform, to the roots of plants. Now Indiana is situated near the middle of the Great Valley of Northwestern America, and far distant from the primitive range of mountains, and her soil is accordingly formed from the destruction of a vast variety of rock, both crystalline and sedimentary, which have been minutely divided and intimately blended together by the action of air and water. It has all the elements, therefore, of extraordinary fertility."

In the 1859 edition that paragraph is omitted and replaced by the following: "In regard to the soils resulting more particularly from drifted materials which occupy a great area in the northern part of the State, and on the slopes adjacent to our large streams, it may be remarked, that being the *transported debris* of a great variety of formations we may infer their general fertility, since they must contain a mixture of the earthy ingredients, salts and bases, highly favorable for supplying the required elements for thrifty growth, and must possess, at the same time, the mechanical properties favorable for the retention of moisture, the permeation of air, and for the reception of the nitrogenous principals derived from the atmosphere."

This change of opinion was doubtless due to the fact that Agassiz and other geologists studied and evolved the glacial theory and the transportation of boulder soils in the early forties, and Agassiz's "Systeme Glaciarie," on which our modern knowledge of glacial action is mainly based, was issued in 1847. Before I learned that the 1859 edition of the report, which is the one I possess, was not a verbatim report but in part a revised edition, I thought that Owen had evolved the glacial theory of the transportation of soils ahead of Agassiz, but the wording of the original 1837 edition proves the contrary.

Not foreseeing the great railway development of the future or the use of fuels other than coal, he stated that "The western counties of Indiana must ultimately become the principal manufacturing districts of the State, from the fact of their geological position within the Indiana coal field; for all experience proves that manufactories have most generally sprung up and flourished in coal regions."

Of building stones he praised very highly what he called the "shell marble rock" of a quarry known as "Marble Hill," located fifteen miles below Madison, in Jefferson County, and belonging to the Niagara Division of the Upper Silurian. In the revised edition of the 1837 report no less than 14 of the 69 pages are devoted to a description of the building stone of this particular quarry. His only reference to the oolitic stone, now so famous as a building material, in the 1837 edition was as follows: "Most of the limestones in the oolitic series, that is those occurring in the counties of Crawford, Orange, Lawrence, Monroe, Owen and Putnam, make good building materials and the soil formed from them has a calcareous character and is admirably adapted for the growth of grass." In the 1859 edition this was revised to read: "Many of the beds of the Subcarboniferous limestone make good building stones. Some of the oolitic limestones take a polish and furnish a cream colored marble." For building purposes, aside from the stone of Marble Hill quarry he recommended only the freestones (sandstone) at the base of the coal formation in Warren, Fountain and Orange Counties. Also those of the Knobstone formation above the black slate and gray shales, but gave warning that these should be used only with proper precautions and by experienced stone masons.

He did not foresee the use of the shales of the Carboniferous or Knobstone formations for the making of clay products, but stated only that they "afford locally both argillaceous iron ore and carbonate of iron."

The wording of another paragraph in his summary impresses the geologist of to-day as rather curious, until he realizes that Owen's work was written before the doctrine of Evolution was set forth, and at a time when most people believed in Divine creation of the earth and its living forms. He was therefore probably somewhat cautious about expressing his ideas of the origin of stratified rocks. It is as follows: "The greater part of Indiana *must have been*, at some period of the earth's history, covered by an ocean, for most of the fossils in the limestones are of marine origin." In the second report he put aside this caution and stated that the rocks of the blue limestone in southeastern Indiana are "remarkably interesting on account of their numerous marine fossils. Some of these are in a wonderful state of preservation, and so abundant that the rock is, in fact, almost an agglutinated mass of marine shells and corals, which lived, died and became entombed in the sediments and precipitates forming in the ocean during the earliest period to which geologists are able to trace back organic existences."

In his summary he truthfully states that: "None of the precious metals are likely to be found in Indiana, unless in minute portions in the bowlder drift, or in small quantities in combination with other metals; because the primitive and metamorphic formations, in which alone productive mines of gold and silver ore occur, do not exist in Indiana. The only metals which we need look for, are iron, lead, antimony, manganese, zinc, cobalt, and possibly some varieties of copper and arsenic ores." We now know that none of these except iron ore occur in the State.

In an Appendix to the First Report, Dr. Owen offers some "suggestions as to the methods of conducting future surveys" in the State, which were most excellent provided the legislature would furnish sufficient funds, which it has never been willing to do in the 80 years which have elapsed. These suggestions were as follows: "If it be desired to make a minute geological survey of the State, it would be necessary to make, with the aid of good instruments, correct topographical examinations and maps of all the ridges and water courses, to ascertain the succession, thickness, dip and course of the different strata; to collect diligently fossil organic remains; to analyze carefully all the ores, coal, cements, marl, clays and soils, so as to estimate their intrinsic relative value; to make experiments upon the durability of certain strata for building materials; to polish different specimens of such strata as seem likely to afford good marble; to endeavor to ascertain the correspondence, dip and prevalence of the various seams of coal, and accurately determine their thickness and succession, and those of the intervening strata of sandstone, shale, limestone and clay; to make a general collection of specimens, to be arranged and deposited at the seat of Government; to determine the nature and variety of the vegetation peculiar to each formation; and, if means are provided, to make observations on the natural history of Indiana generally; to examine carefully the various species to which the fossils belong, and make a rigorous comparison between them and those found in other parts of America and Europe with a view of correlating our formations and those of other parts of the United States and the Eastern Hemisphere. This is a subject now of the highest interest to scientific men in all parts of the world, as it is to confirm or demolish theories, which materially affect the science of geology, in a practical as well as scientific point of view."

"It will at once be seen that this is a work which can be fully accomplished only by the united labors of several individuals, by the expenditure of considerable capital, and by the consumption of much time. Whether Indiana would be warranted in carrying out, at the present juncture, so expensive an undertaking, it is not for me to determine. I can but express my opinion that it would ultimately amply repay all outlays and labor."

"A more economical, and, of course, a more superficial and less satisfactory course, might be pursued—a course similar to that which was necessarily adopted during the past season. It would be for the geologist to travel from place to place, make merely ocular, or perhaps partial surveys with instruments, of the various beds of rocks, and determine, by approximation, their thickness, dip, succession, etc.; to collect, as far as time and opportunity will permit, specimens and fossils; and to follow up the before mentioned objects as far as the time and exertions of one individual may suffice for that purpose."

"This plan, of course, could not pretend to the same accuracy of detail as the former. Still much that is important might be accomplished. The more extensive plan is that pursued in the Atlantic States, and which, I presume, will ultimately be adopted in Michigan and Ohio."

Those of us who have had to carry on geological work in the State of Indiana have always been compelled to adopt the more economical and more superficial plan mentioned by Dr. Owen, solely because the great State of Indiana was too niggardly in her offerings to enable us to do the better work.

In the second year (1838) Dr. Owen continued his work along economic lines, paying especial attention to the coals, iron ores and building stones of the State, and also making a special study of the conditions under which brine or salt water occurs, since salt at that time was an important commodity and difficult to obtain. As Owen's home was in southern Indiana, where outcrops of rock were frequent and easily studied, where most of the "public works" of that period were in progress and where coal and iron ores were most abundant, we find his second report, as was his first, mainly devoted to that region. He first took up briefly each of the southern counties and described its more important mineral resources. In the chapter on Posey County he mentioned especially the siliceous marl or marl-loess deposits which outcrop six to eight feet thick in may localities, giving their chemical analysis and recommending their use for improving some of the adjacent sandy soils. He gives sections of the exposed rocks in the coal formations of Posey, Vanderburg and Warrick Counties, mentions the fruitless search for silver in Dubois County, which, despite his early warnings, was continued as late as 1905. In the chapter on Dubois and Orange Counties, Dr. Owen gives the first description in geological literature of the now world famous French Lick Springs. His remarks are as follows:

"Near the termination of the sandstone formation, but rising through the inferior limestones at the French Lick, is a saline spring, strongly charged with sulphuretted hydrogen; so much so that, after sunset in a summer evening, the odor arising from it can be perceived about half a mile from the Lick, and the ground over which it flows is black, owing to the iron which it contains being converted into a sulphuret of this metal.

"Those who reside in the immediate neighborhood of this spring and under the influence of this gas during the months of July and August are frequently attacked with fever and ague; while those living on the higher ground, and out of the influence of the immediate atmosphere of the sulphuretted hydrogen, remain quite healthy. This fact, which can be attested by all the inhabitants of this region, seems to prove that the existence of sulphuretted hydrogen in the atmosphere is one of the predisposing causes of intermittent fever."

Dr. Owen makes no reference to the mosquitoes of the region which, in those days, doubtless bred by myriads in the pools along the streams below the outlet of the springs, the runoff water being comparatively fresh after its gases had escaped into the air.

Continuing, Dr. Owen describes briefly the whetstone rock formation near French Lick and under "Harrison County" mentions and explains the cause of the numerous sinkholes and caves of his so-called Barren Limestone (Mitchell) of the region. Under "Floyd County" he gives a detailed geologic section of the formation from the bed of Silver Creek to the top of the Knobs, and also one derived from borings through the black slate and underlying strata. Continuing farther eastward he gives a section of the noted railway cut near Madison, and states that he met Dr. Locke, one of first Geologists of Ohio, with whom he traced the extent of the Magnesian limestone along the common boundary of the two states, from the Ohio River to Union County, Indiana. From here Dr. Owen passed on northwest to Wayne County, and from there to Muncietown and Andersontown, as they were then known. He describes the "white gritstones" outcropping at the falls near Pendleton and states that they might perhaps be fit for making glass, a use to which they were afterwards extensively put. Proceeding northward, he mentions the first appearance of a limestone formation on the head waters of the Wabash, ten or twelve miles west of the Ohio line, and states that "the Wabash then flows almost uniformly over ledges of rocks for about 100 miles to Delphi in Carroll County."

He considered it remarkable that a nearly flat prairie country should, in northern Indiana, form the dividing ridge between the waters flowing into the Great Lakes and those running into the Gulf of Mexico, and that the larger streams of that section, "instead of commencing by confined mountain torrents, should rise from widely expanded sluggish springs in Tamarack swamps, and flow for 30 or 40 miles with little perceptible fall." He states that there are many reasons for believing that the St. Joseph and the St. Marys, which unite near Fort Wayne and then turn and flow northeastward into Ohio, once flowed down the Wabash. Continuing southwestward, he mentions the rock, then as now, being worked in the extensive quarries at Kenneth, three miles below Logansport, and states that "The whole of the rock formation which I have just been describing, I consider as belonging to the strata inferior to the black, bituminous, aluminous slate, and belonging to the Devonian and Upper Silurian Periods of European Geologists."

Under "Carroll County" he describes the black shale outcrops near Delphi, correlating them with those at New Albany, and under "Montgomery County" he mentions the notable crinoid beds near Crawfordsville. Sections of important coal deposits in Fountain, Parke and Vermillion Counties are then given and the deposit of iron ore near Brouillett's Creek, where a large blast furnace was afterward erected, he states is the finest he had seen in the State.

Continuing southward, he examined more closely the coal seams of Clay, Vigo and other counties, and gives much information regarding their thickness and quality. No mention is made, however, of the block coal afterward developed in Clay County.

Sometime during the summer of 1838 he made a trip to the then celebrated salt region of Virginia on the Kanawha River, in order to study the strata in which the salt was obtained. This study, he asserts, convinced him that the area in western Indiana, immediately adjacent to the base of the coal measures, is almost the equivalent of that on the Kanawha and Muskingum and that "there is a tolerably fair prospect that the formation at the margin of the coal fields of Indiana will yield a profitable brine." Bores were afterward sunk near the mouth of Coal Creek, Fountain County, and a good quality of brine which yielded a pound of salt to the gallon was obtained, at a depth of 700 feet; but the industry never developed into one of importance, the opening of the Wabash and Erie Canal bringing in the Onondaga salt and putting a stop to the enterprise.*

In his summary at the close of the Second Report, Dr. Owen states that the best coal which he had seen in the State was near the Sugar Creek foundry in Parke County, and that the two thickest seams observed are on the Patoka between Pike and Gibson Counties and on Brouillett's Creek in Vermillion County. He says that the bituminous coal of Indiana shows its vegetable origin more distinctly than any coal he ever inspected, and that along the eastern margin of the coal formation he found "excellent fire-clays, potter's clay, furnace hearth-stones and slates, from which copperas and alum can be manufactured on a large scale." Limestones, he says, "are not abundant in our coal formation but are locally present and often afford good material for macadamizing turnpikes," a statement borne out by tests the writer had made at the Road Material Laboratory at Washington in 1905.

One prophecy which Dr. Owen made, which has not been fulfilled, was that "When this country becomes older and produce more valuable, the marls of the Lower Silurian could be transported by water with great advantage from Jefferson, Switzerland and Dearborn, to the counties on the Ohio and Wabash, which are deficient in lime, phosphoric acid, potash and

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*Report of R. T. Brown, 1853, 317.

clayey matter. This he says, "will undoubtedly, some day be done." Instead of transporting these marls we now grind very finely the Mitchell and allied limestones and utilize this ground material as a mineral manure. He stated that "most of the lowest beds of the Lower Silurian are vastly rich in fossils, a list and drawings of which can be furnished for publication, if required."

In this connection it may be remarked that the first edition of the 1837 report shows that he submitted with the text four charts and five plates of fossils characterizing the different rock formations. Following out the policy which I have mentioned, the legislature, to which he submitted his report, neither requested the list and drawings of fossils which he offered, nor authorized the publication of the charts. A colored geological map of the State which he prepared to accompany the second report was deposited without publication in the State Library, and all trace of both it and the charts is now lost.

Near the close of his second report, Dr. Owen states that he "considered the margin of the coal formation the mineral region of the State, and the one which, before all others, demands a minute topographical, geological survey, in order,

1. To lay down on the map accurately the boundary of the coal formation in all its meanders.

2. To examine thoroughly the saliferous rocks, and determine their exact thickness, extent, inclination and superposition.

3. To discover, if possible, new deposits of iron ore, which seem to be so frequent in this region.

4. To ascertain the extent of the freestones of this district which might be suitable for buildings.

5. To ascertain the number, thickness, relative superposition, equivalency and spaces which the various beds occupy relatively to each other, and the localities where each bed crops out on the surface.

6. To make observations on the exact dip of the coal measures, a discovery of which would indicate the depth at which any particular seam might be reached by shafts sunk in any part of the coal measures.

7. To endeavor to discover the most valuable beds of fire clays, potter's clays, grits and alum slates which appear to be common in these localities.

8. To collect and determine what may be the most characteristic fossils, not only of each system and formation, but of the different members of each group; an investigation which is intimately connected with the discovery of mineral wealth; especially with the discovery of workable coal beneath the drainage of the country.

9. To determine in what this formation agrees, and in what it differs from equivalent formations in other countries."

He ended his second report as follows:

"Although we may not be able to boast of the gold mines of Georgia and the Carolinas, or of as great a variety of metallic ores as Missouri and Tennessee; yet when we consider the area and probable thickness of our coal measures, with the number of beds of coal, and associate iron ores; their accessibility and proximity to the materials required for their reduction; the levelness, fertility and extent of the arable lands of Indiana; the prospects for an ample supply of salt, and that all these staple articles lie in the immediate vicinity of our principal navigable streams, we have every reason to be abundantly satisfied, not only with our agricultural advantages, but also with our mineral resources, which are, in fact, far greater than could be reasonably anticipated, considering our position near the center of the vast and fertile Valley of the Mississippi. Looking to the sources of wealth and the stimulants to industry which lie buried in the strata of our coal formation, we may confidently anticipate that our young and growing State will not only continue to rival her sister states as an agricultural people, but that she will also, ere long, be able to enjoy an equal share in all their commercial and manufacturing advantages."

Thus did he affirm his loyalty to his adopted State whose citizens, aside from her geologists, have never appreciated or given proper credit to the work which he did. He was the pioneer who in two years' time and in two brief reports laid the foundations of our geological knowledge of the State, and he laid them so well that in all the super-structures since erected, the builders have followed very closely his outlines and his plans.

The legislature of 1839 passed an act, approved on February 18, "Providing for an examination and report of the Mineral Resources of the State and for other purposes." The salary was continued at $1,500 with $250 for expenses. The appointee was to be a "person of suitable scientific and practical knowledge and acquirements" and was to hold his situation for only one year. In addition to examining in a detailed manner the "productive mineral resources of the State," he was to report whether in his opinion the raising of silk and the manufacture of sugar from the sugar beet can be successfully prosecuted in the State. The last section also provided that "it shall be a part of his duty to make examinations and experiments with the disease commonly called the 'Milk Sickness' with a view of the discovery of the causes and remedy of the same and to report the result of these experiments annually to the legislature."

We can find no record of the appointment being offered to Dr. Owen or to any one else. If offered to him he evidently turned it down, perhaps not relishing the new duties at the old munificent salary. It was, as we have noted, about this time that the "internal improvement" bubble fostered by the State went up in hot air. It is very probable that the office of State Geologist provided for in the act of February, 1839, went up with it.

Soon after terminating his survey of Indiana in 1838, Dr. Owen was appointed to make one of that part of the Northwest Territory now comprising the states of Wisconsin and Iowa and a part of Illinois. His report of this great undertaking was published at the expense of the Government in 1844, and is "noted for the beauty and correctness of its illustrations and the felicity of its descriptions." In it he gives a chart of the Great Illinois Coal Field (Plate IV) which, on a small scale, shows by a map the extent and position of the coal measures of Indiana. This was the first map of what is now widely known as the "Eastern Interior Coal Field," which covers an area of 47,000 square miles in central and southern Illinois, southwestern Indiana and northwestern Kentucky.

First Discovery of Gold in Indiana.

The next fact of interest which can be found recorded regarding the Geology of Indiana was the first mention of the finding of gold in the State. This was in the Journal of the Franklin Institute for June, 1850, and was in part as follows:

"Professor Frazer read to the meeting (of the Franklin Institute, May 17, 1850) a letter from Prof. T. A. Wylie, of the University of Indiana, announcing the discovery of gold in the vicinity of that place, and exhibited specimens of the gold, and of the black sand in which it is found. 'The gold has been found in the beds of the rivulets in Morgan County, about twenty miles northeast; in Jackson County, about twenty miles southeast; in Brown County, about twenty miles east, and in Greene County, about fourteen miles west of Bloomington, as well as at certain intermediate points, but not in the immediate vicinity. Where it has been found it is always in connection with a black sand which the washers call "emery." This sand is found at the bottom of the streams, usually at the upper end of the sandbars or on the margins of the streams where there is a sudden turn, and in such places as it would be naturally deposited on account of its density. The coarse gravel is sifted and washed in the usual way until nothing remains but the dense black sand. On examining closely with the microscope, there are to be perceived interspersed through it red particles of different shades, and some few yellow and green particles; of the red particles some appear to be merely colored quartz, while others are plainly distinguished by their crystalline form as garnets, and some of the darkest probably pyrope. The black particles are readily separated into two sorts by the magnet. Those attracted by the magnet, which amount in some specimens to five per cent of the whole, are evidently magnetic oxide of iron. The remaining black grains agree precisely with Dr. Thompson's description of titanate of iron or menaccanite.' The gold is in flat scales, a good deal resembling in appearance that from California."

"Professor Frazer remarked that from the account of Professor Wylie, it did not appear that this new gold field was likely to prove profitable in the working, but that it was of great interest, both in a geological and mineralogical point of view, and gave rise to an interesting inquiry as to the original locality of the minerals associated with the gold, since they are of a nature inconsistent with the rock formations of that portion of the United States."

The Geological Survey of Dr. R. T. Brown.

By 1852 the State had recovered somewhat from its Internal Improvement venture.* A number of persons interested in the more rapid development of its resources began an agitation for the renewal of the Geological Survey, and we find that on January 12 a joint resolution was passed and approved providing "That our Senators in Congress be instructed and Representatives requested to use their votes and influence to effect the passage of a law giving to the States respectively, in which there is so much unsold public lands, one township in each land office district to be applied by the proper authorities of the State for the purpose of making a Geological, Agricultural and Topographical Survey of such State." The Governor was also requested to furnish one copy of this resolution to each of the Governors of the several States, and request them to lay the same before their legislatures.

Dr. Ryland T. Brown, a scientist of repute and a citizen at that time of Montgomery County, evidently did not believe in the delay which this joint resolution entailed and we find that on the evening of January 22, 1852, he delivered to the legislators in the Hall of the House of Representatives a lecture entitled "The Geology of Indiana as an Element of Wealth to the State," in which he set forth the need of a survey which "should not only embrace the geology and mineralogy of the State, but in which the topogaphy of each county should be carefully examined and accurately marked on the map." He mentioned the great value of the coals of the State, the drift origin of most of the soils, and incidentally the occurrence of gold in the drift of Brown County. He asked that a liberal appropriation be immediately made to carry on the work, but there is no record of a bill introduced or passed to that effect.

It seems, however, that the State Board of Agriculture, which had been organized in May, 1851, had taken some action in the matter and had authorized Dr. Brown to act as its "Geological Agent," as we find on pages 299-332 of the Third (1853) Transactions of the State Agricultural Society, a letter from Dr. Brown to Governor Joseph A. Wright, president of the State Board of Agriculture, headed "Geological Survey of the State of Indiana," which is a very large title for such a brief paper. He starts out by saying: "In consenting to serve the State Board of Agriculture in the capacity of Geological Agent, I have done so without any very definite idea of what the precise duties were which the Board expected of me.

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*In the Acts of that year we find one providing that so much of the public works heretofore constructed by the State, as has not been granted to any private company, be surrendered to the counties in which they lie. One section of that act is somewhat curious in that it provides that: "So much of the National Road within the State heretofore ceded to this State by the United States, as has not been granted to any company, together with all materials to or near the same and now the property of the State, shall on or before the first day of October next be put up at public auction, after due notice of sale, by the Auditor of State in convenient lots, and sold to the highest bidder; and the proceeds of such sale shall be paid into the State Treasury."

My instructions are very general in their character, and, if I rightly understand them, leave a wide margin to my discretion."

"With the limited means at the disposal of the Board, I suppose it was not their intention to undertake, at present, anything like a systematic survey, and mapping of the State by sections; but merely to institute such local examinations as will, with the least labor, develop the largest amount of facts in relation to the resources of the State, not only in mineral wealth, but also in regard to building material, including stone, lime and timber— and whatever else may tend to call attention to, and invite the investment of active capital in Indiana."

"The labors of Dr. Owen, some years ago, have furnished us with an outline map of the Geology of the State, so that the lines of outcrop of the several formations are pretty accurately defined. There will be therefore, no loss of time necessary in defining the boundaries of the different strata, and their associated mineral treasures."

His report then follows closely along the lines of Dr. Owen's 1837 report, which had been reprinted verbatim in 1853. He states that the "Cliff rock" of the Ohio Geologists is the equivalent of the "Niagara limestone" of New York, thus introducing for the first time that name into Indiana Geological literature. His statement (p. 303) that it underlies really more than half of the territory of the State is apt to be misunderstood, and is true only in the sense that it dips deeply beneath the overlying formations to the southwest, and not that it forms the surface rock over that much of the State's area. Several pages are devoted to the quarries which had been opened at Marble Hill, Vernon, Greensburg, Logansport and other points. He called "the especial attention of the many flourishing towns in the interior of the State with muddy sidewalks to the quarries at Sand Creek, Clifty and Flat Rock which were then furnishing "flagstone for pavements of almost any required dimensions and in quantities that cannot be exhausted for ages."

Dr. Brown did not recognize Owen's name of "Knobstone," for the formation now known under that name, but called it the "Argillaceous or Chemung sandstone," regarding it as identical with the Chemung of New York and the Great Devonian or old red sandstone of Europe, in both of which conclusions he was evidently wrong. He says "On a careful examination, I am convinced that this series will, with proper care, in the selections, furnish much valuable building material," a statement which has also not been borne out in the years that have passed.

The first account of Wyandotte Cave in an Indiana work is opened with the sentence: "A minute description of this great subterranean world would, perhaps be out of place in this report. Suffice it to say that the extreme distance attained, from the most southwardly to the most northwardly point, is seven miles." He states, as have a number of other writers, that the "whole number of miles in the explored cave is nineteen and a half," while accurate measurements made by myself in 1896 show that they are 4.21. I can, however, approve most highly his closing statement that "To the curious and the lovers of the profoundly sublime, we would recommend a visit to Wyandotte Cave—it will amply repay the time, labor and expense of a visit."

In this report of Dr. Brown we find also the first written words praising the qualities of the Indiana oolitic limestone. He states that at that time it was being shipped from a quarry near Bedford for use in the construction of the United States Custom House at Louisville, that the face of the quarry "exposes one stratum of eight feet in thickness without a seam, or the slightest fault. By means of wedges, blocks may be split the whole thickness and of any desirable length. The accuracy and ease with which it may be split, its softness when fresh from the quarry, its beautiful whiteness when dry, its durability and great strength renders it all that could be desired as a stone for building purposes. The same rock, with slight local variations, extends to Gosport; occupying a band of country about ten miles in width, traversed in its whole length by the New Albany and Salem Railroad. At Mount Tabor near Gosport, a variety of this stone is now being worked which receives a high polish, and presents a finely variegated appearance, being indeed an excellent and beautiful marble."

Attention is called for the first time also to the Falls of Eel River and the statement made that he "knows of no place which combines greater advantages for manufacturing. The location is six miles southwest of the railroad, but a single lock of a six feet lift in a mill dam at Millgrove will connect the falls with the railroad by slack water. This location should be in the hands of a manufacturing company with capital sufficient to use all the power afforded." These words were written 63 years ago and for that many years this source of power has been neglected.

Twelve of the 34 pages of the report are devoted by Dr. Brown to a description of the coal measures of the State, especially those north of the National Road, and the only illustration given is a double page geologic section on the Wabash River near Lodi, Fountain County, in which six veins of coal, ranging in thickness from 18 inches to 12 feet, are shown. The 12-foot vein probably includes some black shale or else Dr. Brown drew on his imagination, as later records show no such seam in that locality.

No mention is made of the block coal of Clay County, though it had been discovered in 1851. The statement is made that at that time (1853) coal was being mined more extensively near Cannelton, Perry County than at any other place in the State. "An able and energetic company under the title of the 'American Cannel Coal Company,' has possession of about 7,000 acres of coal lands on the immediate bank of the Ohio River. About 500,000 bushels of coal are mined annually at this point, the greater part of which is consumed by steamboats on the Ohio and Mississippi rivers. In the proximity of an infallible market, and in the energy and ample capital of the company, consists the main advantage of Cannelton as a mining locality. The principal, and indeed, the only workable seam of coal, is the equivalent of No. 3 in my Lodi section. Now, each section or square mile of this coal seam will yield about one hundred millions of bushels. Other localities in the State have at least three workable seams lying one above another, making an aggregate of from 12 to 15 feet of coal, or more than three hundred millions of bushels per square mile. The price of coal, delivered on boat at Cannelton, is seven cents per bushel, or $1.96 per ton."

"The Cannelton Cotton Mill Company, whose mill was constructed in 1849," he states, "have the honor of having first demonstrated that the cheap fuel, cheap transportation, and cheap living in the west, can fairly compete with manufactories anywhere. The mill is now running 10,800 spindles, and 378 power looms, making about 600 tons per annum, or two tons per day of brown sheetings. The factory is four stories high, with an attic—is 287 feet long and 65 feet wide, with two towers in front, each 106 feet high. It is built of new Red Sandstone of the Coal formations." This is a coal measure sandstone immediately overlying the Mansfield sandstone.

The area embraced in our new State Park, "Turkey Run," was first mentioned in geological literature by Dr. Brown as follows: "The lovers of the wild and romantic in scenery are especially invited to examine Sugar Creek from the mouth of Indian Creek to its junction with the Wabash. No region in the State furnishes so many frightful precipices, rugged cliffs and deep twilight gorges as Sugar Creek, in the neighborhood of the Narrows."

In 1857 Hamilton Smith, a member of the American Cannel Coal Co. of Cannelton, Ind., prepared for the State Board of Agriculture a paper of 33 printed pages entitled "Coal Mining in Indiana." This was published in the State Agricultural Report for 1856. In it he stated that the Cannel Coal Company, composed of foreign capitalists, after due investigation, had received a charter from the State and opened their mines near Cannelton in 1837, with the expectation of furnishing fuel to the many steamers plying up and down the Ohio River. When they were ready to deliver coal they found out that the engineers would not change from wood to coal, claiming that the latter would not make sufficient steam. For a long time they operated the mines at a loss, and after 20 years were just beginning to pay dividends. The paper was illustrated with eight plates of mining machinery and one geological section of the coal formations at Cannelton. The writer claimed that a thorough geologic survey of the western section of the State would be of infinite advantage to both producers and consumers. As a member of the legislature from Perry County, he did much toward bringing about the enactment of the law creating the survey authorized in 1859.

In 1857 a well was sunk in the courthouse square in the city of Lafayette to a depth of 230 feet. It proved to be an artesian well, with a strong flow of sulphur water. Dr. Chas. M. Wetherill prepared and published* in the American Journal of Science a report of 32 pages treating of artesian wells in general and the one at Lafayette in particular. It included a description of the strata, a full analysis of the water, etc., and was the first literature on artesian wells in the State.

*Vol. XXXII, Sec. Series, p. 241-249.

The Owen Survey of 1859-1860.

In the Acts of the special session of 1858 we find that the following Joint Resolution was approved:

Whereas, The Indiana State Board of Agriculture have memorialized the General Assembly in reference to a Geological Survey, and have stated that the vast agricultural, mineral resources of the State are comparatively unknown, would be rapidly developed was such a survey made and published; therefore,

Be it resolved, The Senate concurring, that a joint committee of sixteen be appointed, corresponding with the districts arranged by said Board, of which nine shall be of the House and seven of the Senate, to whom the whole subject shall be referred.

No record of the report of this committee can be found, but the Acts of 1859, p. 112, contain the following:

An Act Authorizing the State Board of Agriculture to Cause a Geological Reconnaissance of the State to be Made, to Make Collections and Analysis of Specimens and Making Appropriation Therefor.

Approved March 5, 1859.

Whereas, The State Board of Agriculture has memorialized the General Assembly for such aid, as a full Geological Survey of the State would give in furtherance of the object for which said Board was organized, and the finances of the State being not in condition to justify such an appropriation as the plan contemplated by the memorialists, and *whereas* it is now believed that the sum of $5,000 granted by the State to such Board would be sufficient to make a geological reconnaissance of the State and the determination of the general boundaries of its Geological formations, and also to make collections and analysis of specimens of minerals, ores, earths and stones from every portion of the State, and thus prepare the way for a more full and systematic urvey to be made under the direction of the State Executive.

Section 1.—Therefore, *Be it enacted by the General Assembly of the State of Indiana,* That the sum of $5,000 is hereby appropriated out of the State Treasury and to be paid on the warrant of the Auditor of State for the purpose of making the Geological Reconnaissance, collecting and analysis of specimens of minerals, ores, earths and stones.

Sec. 2.—The Governor is hereby directed to select a suitable room in the Capitol or in any building that may be erected by the State, if a suitable one can be found, and if not to hire one suitable for the deposit of such minerals, soils, ores, fossils, maps, sketches, etc., as may be collected and made by direction of such Board, which room shall be placed under the control of said Board.

Sec. 3.—The State Board of Agriculture shall on or before the 15th of December, 1860, make a full report to the Governor of the expenditures of said appropriation with full vouchers thereof and of the results accomplished thereby. The Governor shall have 2,000 copies of said report printed for the use of the next General Assembly.

Here will be seen again the demand of the law makers that the impossible be performed, viz., the making of a complete survey of the State and the analyzing of an unlimited number of ores, minerals and soils for $5,000.

In accordance with the instructions of the Act the State Board appointed Dr. D. D. Owen for a second time as State Geologist and instructed him "to commence a thorough survey of the coal fields of Indiana as early in the spring as the weather will permit, and to procure the necessary outfit either by purchase or hire as may seem to him best, having a strict regard to economy."* Since his former connection with the Indiana Survey, Dr. Owen had, as we have noted, served the United States as Geologist of the Northwest Territory, and had also served as State Geologist of Kentucky and Arkansas.

Dr. Owen appointed his brother, Richard Owen, as chief assistant, Dr. Peter of Lexington, Kentucky, as chemical assistant, Leo Lesquereux as Paleontologist and Joseph Lesley of Philadelphia as topographer. He wrote a general statement for the final report and a condensed report on the first year's work to the State Board of Agriculture, but when the survey was only partly finished he died of malarial fever at New Harmony, Indiana, on November 13, 1860. Of him W. T. Dennis, Secretary of the State Board of Agriculture wrote: "The death of Dr. D. D. Owen is a public calamity, widely felt and deeply deplored, occurring as it did just at the time of the preparation of his detailed report of the entire operations of the survey. * * * He was known to be a prodigy of scientific learning, an excellent chemist, a thorough mineralogist, a good civil engineer and as a geological surveyor had no equal. * * He possessed the best geological collection in the western country, and in him Indiana lost her most solid man of Science."‡

The geological collection mentioned had as its nucleus a large portion of that extensive collection of minerals and fossils left by Wm. McClure. To this Dr. Owen had added by purchase and collecting until it contained 85,000 specimens. The entire collection was sold for $25,000 some years after Owen's death, to Indiana University, and was almost wholly destroyed in 1883 when the museum, laboratory and library of that institution were burned.

The result of the work done in 1859 and 1860, under the supervision of David Dale Owen and later under that of his successor, Richard Owen, was published by the State in 1862, under the title "Report of a Geological Reconnaissance of Indiana made during the years 1859 and 1860, under the direction of the late David Dale Owen, M. D., State Geologist, by Richard Owen, Principal Assistant, now State Geologist." It forms a large octavo volume of 368 pages, illustrated with wood cuts of a number of localities of especial geologic interest in the State, and with two plates of Silurian and Carboniferous fossils. In the condensed report submitted by David Dale

*Condensed Report of the Geol. and Agr. Survey of the State of Indiana for 1859 and 1860, Doc. 5, Pt. II, H. J. 1861.
‡Loc. Cit. p. 165.

Owen just before his death he had promised that one feature of the report would be chapters by himself on Agricultural Chemistry and on milk sickness, particularly the connection of the latter with peculiar geological formations. As Richard Owen states in his prefatory letter, these two papers as expected from his pen "might have greatly promoted the health of our population and increased the wealth derivable from our soil, through the useful practical suggestions designed to be conveyed." Especially of interest would have been the chapter on milk sickness, a strange and most fatal disease which has baffled the skill of the leading physicians of the country, both as to cause and cure. While much more prevalent in the days of a half century and more ago it yet occurs occasionally in the State, several deaths having resulted from it in the summer of 1916.

The first part of the Owen report, as published, begins with a preliminary chapter on the principles of geology, followed by a description of the character and sequence of each of the great rock formations which comprise or underlie the surface of the State. Beginning with the oldest of these, the Lower Silurian, it next takes up each in order, treating separately each county whose area mainly belongs to that formation. Of each it gives the main facts regarding its soils and mineral resources, such as building stone, clays, coal, mineral waters, etc., paying especial attention to the character of the soil derived from each kind of underlying rock and giving lists of fossils of each of the principal formations. It also mentions the principal crops grown, the prevailing kinds of timber, and the most prevalent diseases of each county. In fact, it is the only report yet published which, in a single volume, attempts to cover the entire State by counties in the manner described. Many of the counties are treated very briefly, a number of them not having been visited by either of the Owens, the data given having been obtained from other persons. While much valuable information of a general nature is given, there is in this part of the book not much original matter, and it impresses one as being more of a gazetteer than a scientific work on geology.

Richard Owen appears to have been more of a naturalist than a field geologist, as we find in the report many passages like the following: "On the Mississinewa, a tributary of the Wabash, we found, close to the residence of Godfrey, a son of a Miami chief, whose tribe left these fine lands only eighteen years since, bluffs in which the rocks have been weathered and water washed into fantastic pillars and natural cornices, which might serve to inspire the genius of a Michael Angelo with some new architectural design, to rival his St. Peter's at Rome. These bluffs or pillars, are here about 25 feet high, while nearer the ford they rise to 40 and 50 feet above low water. The bed of this interesting stream was, during our visit at this locality, full of confervae (simple jointed water weeds) and had more crawfish, dashing with their peculiar, quick backward movement from under the rocks into the sunshine, than I ever before saw in one stream. Various species of Unio, Cyclas, Paludina (chiefly dead) and Melania were also common; the latter leaving a track in the sand resembling that of a worm. Besides these, numerous specimens of the larva of the Phryganea, or water moth, were seen dragging their wooden habitation of cemented sticks along the bottom of the shallow fresh water coves formed by the river."*

"In this camp we noted, besides, the usual timber, abundance of the Ohio Buckeye or American Horse Chestnut (Pavia Ohioensis) the buds of which, eaten in early spring by the cattle, frequently produce in them symptoms resembling an attack of "trembles or tires," in man called milk sickness."

There are brief lists of plants noted as growing in many of the counties visited. Under Boone County it is stated "corduroy roads, dog-fennel, smart weed and elder showed the necessity in some places of attention to drainage." Botanists of the present day do not class dog-fennel and elder as plants denoting wet soil.

The prevalence of milk sickness is noted in a number of counties and by Richard Owen is usually attributed to the presence of licks, or certain springs resorted to by cattle, as when these are fenced in the disease disappears. He states specifically however, that the disease did not occur in any of the drift covered counties north of the Wabash River.

Many localities in northern Indiana are mentioned where gold had been panned from the drift along the streams. Of the work then being done in Brown County in search of this metal Owen says: "The main localities in which success has attended the washings are on Hamlin's fork of Salt Creek, three-quarters of a mile in a direct line from the west limit of Bartholomew, near Mt. Moriah P. O. Here we found extensive preparations in the way of sluices and hose, rockers, and "Long Toms," picks and shovels, etc. Notwithstanding the rain we panned out enough to convince ourselves that the black sand in many of the pockets contains a considerable amount of gold particles. Judging from what I saw here and elsewhere in Indiana of the gold localities, I should venture the opinion that gold is invariably associated with drifted quaternary materials, derived from a matrix, which finds its mountain home at least from four to six hundred miles distant, and more probably double that distance, in a northerly direction."

The first mention in Indiana geologic literature of geodes, with a description of their structure and origin, and their prevalence in a certain limestone just above the Knobstone (now known as the Harrodsburgh Limestone) is given in the chapter on the counties of the Subcarboniferous limestone.

The first detailed account in any of the reports of the physical properties and chemical analysis of the Indiana Oolitic limestone is given under the Monroe County heading, the specimens having been taken from a quarry then operated near Stinesville, Monroe County. The caves at Hamer's Mills near Bedford, on or near the farm now owned by the State University, are also mentioned for the first time. A six page description of Wyandotte Cave with poor wood cut plates of Monument Mountain and the Pillar of

*It was here also that we captured a bull-frog for camp provisions and found, on dissection of its intestinal canal, that it contained a pebble weighing at least an ounce.

the Constitution, and the first map of the cave ever published is given in connection with the matter on Crawford County. The original draft of the map was made by Rev. Horace C. Hovey from measurements made by himself and other parties between 1857 and 1860.*

The counties comprising the coal area of the State are treated more in detail than any of the others, many sections of the coal measures and brief analyses of the coal being given which were afterwards used in the Cox and Ashley coal reports. The noted Indiana Block Coal of Clay and Parke Counties is mentioned for the first time under the name of "Splint or Bog head coal," and its analysis given. The only statement regarding its quality is that "The coal is used and much liked by the proprietors of the rolling mill at Indianapolis."

"Indian" and "Trinity" springs, well known resorts in Martin County, are described for the first time, and a quantitative analysis of the water given.

The first mention of the kaolinite of Lawrence and Martin Counties is in the following words: "Near Indian Springs a remarkable white Magnesian mineral, which cuts readily with a knife, and resembles the meerschaum used for pipes, deserves an accurate quantitative analysis."

Under the heading "Counties of the Drift or Erratic Quaternary" twenty counties lying north of the Wabash River are included. In the first mention of the fresh water marl of the northern lakes and marshes (described in detail by the present writer in the report for 1900) Owen says: "The immense deposits of marl, sometimes replete with shells chiefly of the genera Physa, Planorbis, Cyclas and Unio, sometimes a clay marl, particularly in St. Joseph, LaPorte, Porter and Lake, are of great commercial and agricultural value, as well as for burning into lime, as for the fertilizing of the soil; but more particularly for the manufacture of artificial stone and brick; provided that enterprise, so successfully commenced, should extend itself as it promises." These marls have in recent years been used extensively as the carbonate of lime ingredient of Portland cement.

Emphasis is laid in several places upon the rich deposits of bog iron ore in these northern counties, but so far as known to the present writer, the only blast furnaces erected for their utilization were the ones then in operation at Mishawaka and Rochester, in which marl instead of limestone was used as a flux. These furnaces were long ago dismantled, cheap transportation by water of a higher grade of ore from northern Michigan preventing the development of the Indiana ores.

That Richard Owen was a poet-naturalist is shown by some of his descriptions, especially the following of a well known prairie plant: "In this boundless expanse, this ocean-like land, level sometimes as a floor, with perhaps no path to guide the traveler and scarcely any two objects which by comparison can enable him to estimate distances, nature has provided for the brave denizen of these American "Steppes" a diurnal polar star, a directive

*Proc. Amer. Assoc. Adv. Sci. XXXI, 1882.

sign, like the moss on the north side of trees to the backwoodsman, or almost like the compass to the wanderer on the trackless sea. A plant of the Compositae family grows abundantly in the prairies, with its thick, dry, resinous leaves, all flattened to one plane, as if fresh from the pressure of a herbarium, surmounted by a gay, yellow asteroid flower; and this plant, Silphium lacineatum, or rosin weed, even at its earliest exit from the soil, and ever afterwards, in its developments, ranges this broad foliaceous plane due north and south, thus presenting one face of the leaf east, the other west. Instead of an upper side covered with nature's varnish for protection, an under side presenting the breathing stomata of most leaf-bearing vegetation. these leaves are nearly the same on both sides, rough and resinous. To this peculiarity of ranging its leaf-plane north and south it owes the name of compass plant, and to its highly resinous composition the name of rosin-weed."

He states that about the lakes grow in abundance "Cedars, Pines, Tamaracks and Alders, the interspaces beneath dotted by such quantities of a genus from the Heath family, as to require a special train at the gathering season, under the name of Huckleberry (or Whortleberry) train; while another genus of the same family, the Cranberry, furnishes from otherwise useless swamps, the palatable relish to heighten the savory flesh of the native buffalo, deer or pinnated grouse, which formerly enlivened these vast plains or still rush and whir through the prairie."

The first description which can be found of the Dune region is in the following words: "We found a small river, Trail Creek, with fifteen to twenty feet of water near its mouth and wide enough for a moderate sized vessel to turn in, cutting through a sand drift which has blown up to form a ridge from 100 to 176 feet high and in some places only twenty feet wide on the top. It extends west, we were informed, to Indiana City, and some asserted to Chicago, so closely washed by the waves that the sand lately rolled down in an arenaceous avalanche, denominated the Hoosier slide. Yet, in the early settlement of the country between the lake-waters and this sand ridge the mail stage and other carriages were driven undisturbed by the lake waters, along the beach, from Michigan City to Chicago."

The Northern Penitentiary then in course of construction by convict labor was next mentioned, and of Michigan City he said: "As a matter of home interest it seems highly desirable that Indiana should maintain here or at some other point, if there be a better, along her Lake-coast, a harbor worthy of the State; otherwise her commerce is necessarily diverted to outlets in the adjoining States, the cost of transportation thereby increased to our citizens, and the profits of the carrying trade also lost to them."

That the question of draining the Kankakee Marsh was under consideration 60 years ago is shown in a footnote in the Owen report which is as follows: "A company has been recently organized for the straightening of the Kankakee River, which in its windings is three times as long as the direct line; by means of which, and the removal of obstructions, they hope to deepen the channel and form a drain that will run off its high waters and that of its tributaries more rapidly than now, and into which cross ditches can be cut, thereby rendering many thousand acres so much drier than at present, as to bring land up from three and four dollars per acre to thirty and forty."

That portion of the report devoted to the detailed descriptions of the counties closes with that of Benton County in the following words: "Flights of cranes were seen and we frequently shot, for camp use, the pinnated grouse, or, in the groves, the wild pigeon, besides startling the meadow lark and a few smaller birds from their prairie nests. For the geologist and physical geographer, the botanist and zoologist, as well as the lover of scenery such as the boundless vision of the day and the gorgeous sunset of the evening often afford, this ocean-like prairie region, and these island-like groves are replete with interest and instruction."

Chapter III of the report is entitled "The Physical Geography of Indiana," and deals with its altitudes, water sheds, and the part which the State plays as a part of the Hydrographic Basin of the Mississippi River. The most interesting portion of this chapter is that in which is set forth the evidence to prove that our prairies are but the beds of vast extinct fresh water lakes and estuaries; also to show that the muck and peat deposits of the northern part of the State are but forms of incipient coal.

Richard Owen closes his part of the report and this chapter with the following statement, dated Camp Tippecanoe, June 20, 1861: "It was the intention to subjoin a chapter on Drainage; also one on Paleontology, systematically arranging the fossils of Indiana obtained from the different formations, etc., then to follow with an exhibit of the main facts collected regarding the localities, causes and other concomitants connected with milk-sickness, and finally to close with a miscellaneous chapter containing suggestions with regard to the best mode of prosecuting the Survey, the most useful manner of arranging the State collection for reference, lithologically, paleontologically and zoologically, as well as recommendations regarding the formation of minor illustrative collections for public schools; but a call to serve my country in maintaining the Union and the Constitution precludes the possibility of completing that design, and compels me to close the report."

He returned from the war with the rank of Colonel, was afterward, until 1879 at the head of the Department of Natural Sciences in the State University, and died at New Harmony, Indiana, on March 21, 1890.

Following Owen's report in the volume of 1862 is a Report of the chemical analysis of thirty-three Soils of Indiana, by Dr. Robert Peter, Professor of Chemistry at Lexington, Kentucky. Soils from each of the great rock formations of the State are analyzed and the tables of constituents were accompanied by valuable introductory and explanatory remarks, setting forth the now well known facts "that certain elements, essential to vegetable and animal development, are gradually consumed from the soil in the crops —that the soil is not a unit in composition—that while the great bulk of it acts only mechanically, or physically, in the support of vegetables, the mineral elements which are essential for the nourishment and growth of organic beings, vegetable or animal, are found in it only in relatively small proportion, and must be carefully husbanded and restored to it in order to maintain constant fertility. Such a process as this, by which the land would be constantly kept up to the height of fertility and would annually yield abundant crops without any diminution of its richness, would be the perfection of agriculture."

In other words, if only a single element of a plant's food is absent from the soil, that soil is barren as far as the growth of that particular plant is concerned. For example, the muck soils of northern Indiana will not produce corn or wheat because they are deficient in potash. The work done by Owen and Peter was the first serious effort of the State's scientific workers to show the farmers of the State the value of a chemical analysis to determine what element of plant food is lacking in their soils. Not one farmer in a hundred read that report or paid any attention to its teachings. The legislators of that day did not appreciate this chapter in Owen's work, and made no move toward continuing the study of the soils of the State. As a consequence millions of dollars have been spent in the 60 years that have passed for fertilizers that were worthless to the persons buying them because they did not contain the constituent needed, and in almost every county thousands of acres of land are left untilled or are tilled at a loss because of a lack of a certain element of fertility which is unknown to the owner and therefore not supplied by him.

The brief chapter on soils in the report of 1862 is followed by one entitled "Report on the Distribution of the Geological Strata in the Coal Measures of Indiana," by Leo Lesquereux, the noted paleo-botanist of that period. This was the first attempt to correlate and properly place the various coal veins in different parts of the State by a study of the plant remains in the coal itself, or in its overlying or underlying strata. Prof. Lesquereux, whose home was in Columbus, Ohio, spent but five weeks in the field. His paper of approximately 50 pages was for a time regarded as probably of more scientific value than any other in the report, but his conclusions have only in part been adopted by more recent students of the coal geology of the State.

When David Dale Owen in 1859 accepted the directorship of this second Geological Survey, with its princely appropriation of $5,000 for all salaries and expenses, he evidently assumed that if he could make a good showing for the sum expended the next legislature would continue the Survey and increase the appropriation. One of his day dreams, which is set forth in several places in his 1837 and 1838 reports and also in the condensed report made in 1860, was that a topographical survey would eventually be authorized which in time would cover the entire State. Since not one legislator in twenty would know the difference between a topographical map and a map of the moon, he concluded to prepare for them an object lesson, and so employed J. Lesley of Philadelphia to prepare a topographical map of a portion of Perry County. In the brief report of Mr. Lesley which accompanied the map, he stated "that the cost of extending such a series of examinations over the whole State of Indiana I estimate at $150 per township—field and office work included." Of the map itself Richard Owen says: "The beautiful map executed by that accomplished Topographical Geologist, Mr. J. Lesley, is now framed and suspended in the Geological Room of our State Capitol." Where it is now only the Gods of the past know and they are forever silent. In his coal report of 1898, George H. Ashley commented on this work of Mr. Lesley as follows: "It is of no small interest that Mr. Owen, almost simultaneously with the starting of the reconnaisance of the State, should start a detailed topographical map of its area. Unfortunately the lapsing of the survey prevented further work of the kind and as a result the State has paid out in the past for successive partial reports on the same areas more than enough to have made complete detailed maps and reports, showing topography, location, extent and value of all rocks or minerals of economic importance, surface geology and distribution of soils."

On account of the Civil War and the questions of importance which arose immediately after its close, we have little to record of Geological activities in Indiana between 1862 and 1869.*

In 1866 there appeared a pamphlet of 30 pages, the title page of which was as follows: "Report of a Geological Examination made on the lands of the Wabash Petroleum and Coal Mining Company, in Warren, Fountain and Parke Counties, Indiana, by Richard Owen, Professor of Natural Science, Indiana State University and State Geologist of Indiana. Analyses of the Ores, by E. T. Cox, Chemical Geologist."

The pamphlet was issued by the company and was an advertising of their holdings in the counties mentioned. It contains analyses of many coals, iron ores, limestones and clays; also of the bituminous shales above the coal, which the company proposed to grind and use in making roofing.

Dr. Ryland T. Brown appears to have been the leader in geological and scientific work in the State during that period. There was published in the State Agricultural Report of 1867 a paper by him entitled "An Essay on the Natural Resources of Indiana." In it he speaks very highly of the oölitic stone, by that time being quarried extensively in Lawrence, Monroe and Owen Counties. He also stated that Prof. Lesquereux "has the honor of inaugurating the great work of the systematic examination of the Coal Measures of Indiana."

In 1868 there was issued for private distribution a pamphlet entitled "Indiana and her Resources," compiled at the request of Conrad Baker, Acting Governor of the State, by R. T. Brown.

In 1869 the legislature of the State, at the earnest solicitation of Dr. Brown and the leading members of the State Board of Agriculture passed an act authorizing a Geological Survey, creating the office of State Geologist, etc. Since that date the office of State Geologist has been in continuous operation, though the title of the office, the duties imposed and the salaries and expenses allowed have, as we shall see, been changed on several occasions

*A geological map of the State on the scale of five miles to the inch is said to have been published at Cincinnati by N. Sayler in 1865, but the writer has never been able to see a copy of it.

to meet political and other exigencies. The act creating the office, approved March 5, 1869, was as follows:

An Act providing for a Geological Survey and for the collecting and preserving of a Geological and Mineralogical Cabinet of the Natural History of this State, and creating the Office of State Geologist, defining his duties, fixing his salary, and appropriating a sufficient sum of money to defray the necessary expenses of said Survey and for the collection and preservation of said Cabinet.

(Approved March 5, 1869.)

Section 1.—*Be it enacted by the General Assembly of the State of Indiana,* That a Department of Geology and Natural Science is hereby established in connection with and under the control of the Indiana State Board of Agriculture for the collection and dissemination of information in relation to Geology and other Scientific investigations, to be made as hereinafter provided for the promotion of Agriculture, mining, the arts and manufacturing.

Sec. 2.—The Governor is hereby authorized to appoint a suitable person as State Geologist to take charge of said Department, and said Geologist shall hold his office for a term of two years and until his successor shall be appointed as aforesaid, with an annual compensation of $1,800 to be paid in quarterly payments; and in addition said Geologist shall be paid also for the necessary traveling expenses incurred while engaged in prosecuting the field surveys and for the chemical reagents used in the analytic work.

Sec. 3.—Said State Geologist shall have a thorough practical knowledge of Geology and Analytical Chemistry, and shall establish his office at Indianapolis in a room or rooms furnished him by the State Board of Agriculture and he shall be required to supply himself *free of cost to the State,* with all the apparatus necessary to fit up an analytical laboratory, adapted to making chemical analyses of soils, ores, metals, mineral waters, or any other substances that may be thought of value or of general interest to the citizens of the State.

Sec. 4.—Said State Geologist shall from time to time make a survey of a portion of the State in order to be able to complete a thorough geological survey of the whole State, and it shall be his duty also to collect, properly label and arrange in the Agricultural rooms, specimens of the ores, coals, building stones, clays, soils and organic remains of quadrupeds, birds, reptiles, fishes, crustaceans, mollusca, insects and all other objects of natural history peculiar to the State, and as far as practicable of other States and countries also.

Sec. 5.—The State Geologist shall also be required to issue Annual Reports to the Indiana State Board of Agriculture, embracing the full results of his labors each year; which reports shall be published along with the Proceedings of the said State Board of Agriculture.

Sec. 6.—That in order to carry the provisions of this act into effect, the sum of $5,000 be and is hereby annually appropriated and placed in charge of the State Board of Agriculture for their disbursement in accordance with the provisions herein made and provided and it shall be the duty of the State Geologist to file with the State Board of Agriculture a detailed statement, accompanied with the proper vouchers for all moneys expended by him in carrying out the provisions of the act.

Sec. 7.—That there shall be printed and bound annually in separate volumes 2,500 copies of the Report of the State Geologist, to be paid for as provided by law for the printing, binding and distribution of the laws and journals.

Sec. 8.—Emergency clause.

The Cox Survey, 1869-1879.

In accordance with the act above cited, Governor Baker appointed Edward Travers Cox of New Harmony, Ind., to the office of State Geologist. That gentleman had been a chemical and geological assistant of David Dale Owen on both the Kentucky and Arkansas Surveys and had done some work on the Illinois Coal Survey. In the introduction to his first report, that for 1869, Mr. Cox says: "Soon after receiving the appointment I proceeded to pack my large and valuable collection of minerals, fossils, shells and other objects of natural history, also my chemicals and chemical apparatus, etc., etc., preparatory to making my residence in Indianapolis and with a view of arranging them in the rooms of the Geological Department at the State House. On arriving at the Capitol with this collection, it was soon made manifest that the room set apart for the use of the State Geologist was totally inadequate to hold the natural history specimens and chemical apparatus, and to be used at the same time, as office and laboratory. From a high appreciation of the importance of the labor to be performed, the State officers, with one accord, decided to have a small addition, suitable for a chemical laboratory, built on the east side of the State House, adjoining the rooms of the Indiana State Board of Agriculture." This was on the site of the present State House. When the new building was begun, the laboratory of Mr. Cox and the nucleus of the present State Museum, which he and his assistants had gotten together, were moved to the building at the southeast corner of Market Street and Capitol Avenue, and from there the Museum was moved to its present quarters in the State House. Continuing, Mr. Cox says: "The limited amount of funds at my disposal would only admit of the employment of a small corps of assistants, who were kept at work but a small portion of the season." One of these was Dr. G. M. Levette, one of the best naturalists ever connected with the State Survey and who continued with it for a number of years. Another was Dr. Rufus Haymond of Brookville, who prepared the report on the Geology of Franklin County. Of that county Mr. Cox says: "Although neither valuable metalliferous ores nor coal are to be found in this county, the law contemplates a complete survey of the entire State, and it was therefore deemed necessary to pay some attention to the resources of such counties as well as those more favored with mineral wealth. Franklin County was selected on account of being the home of the assistant, who was thus enabled to accomplish the same amount of work at a less cost than if sent to some distant county."

"Prof. Frank H. Bradley, late of Hanover College, Ind., was engaged to make a survey of Vermillion County, he having previously acquired an extensive knowledge of the geology of that county from examinations made while surveying the adjoining counties in the State of Illinois."

Thus was begun a survey of the State by single counties often isolated one from another, and often selected to satisfy the demands of some politician or other person of temporary prominence. The rocks and mineral resources of Indiana were formed or deposited where they now lie when the only boundary lines were those of the ocean's beach, and the only politician the "fittest" inhabitant of the seas. Therefore a county boundary line and a politician have, or rather should have, no connection whatever with a geological survey. The county boundary line was in great part banished from the Survey in 1895. The politican still has much to say regarding the office and at present I see no practical way of getting rid of him.

The first mention of Indiana Block Coal under that name is also made in the Introduction to his first report by Mr. Cox, as follows: "On my first visit to Brazil, in Clay County, the general impression seemed to prevail that the peculiar variety of coal familiarly known as 'block coal,' or 'Brazil coal,' was confined to a small basin, isolated from the great bituminous coal fields of Indiana and Illinois, and limited to an area of a few square miles. Indeed, I found at Brazil, those who were presuming enough to stand in the door of Rigby's Hotel and point out to me the extreme limits of the "Block coal" field in every direction. Of the fallacy of this prevailing opinion I felt it to be my first duty to disabuse the public mind, and the splint or 'block coal' has been traced from the southern limits of Greene County to Warren County on the north." It has since been shown that the true block coal extends northward from Brazil only to Raccoon Creek in Parke County and that the coals farther north mentioned by Mr. Cox are a semi-block of somewhat inferior quality.

The body of the first or 1869 Report of Cox is largely devoted to the geology of the coal fields and iron deposits of Clay, Greene, Parke, Warren and Fountain Counties, prepared by himself, and those of Vermillion County by Prof. Bradley. It was accompanied by a portfolio containing outline maps of Greene, Clay and Vermillion Counties, on which were shown the approximate bounds of each of the workable veins, and the location of all mines and outcrops of coal and iron ores. A colored "vertical section of the geological formations from Greencastle to Terre Haute, made from outcrops and sections of bores along the line of the T. H. & I. (now Vandalia) railroad" was also included.

Regarding the character and value of the surveys of the various coal-bearing counties published in the reports of the State Geologist from 1869 to

1883 and made under the supervision of Mr. Cox and his successor, John Collett, I quote as follows from Dr. George H. Ashley, who, as a specialist in that line, is much more competent to judge than I. Mr. Ashley says:* "The character of the field work in the various counties varied greatly. Several of the counties never received more than a preliminary survey. Thus in Warrick County three sections were obtained, the coal from one mine analyzed and four pages of descriptive text given. On the other hand, in some of the counties, the field work extended over several seasons and the reports on these counties were, as a rule, correspondingly complete and detailed. In such cases the abundant columnar sections obtained, especially those by Mr. Collett, have proven of inestimable value in the present survey. The correlation of the coals and the location of points on the maps appear to have been, to too large an extent, guess work, and this factor of unreliability prevented more than an occasional use of those parts of the reports in my survey. * * No attempt at colored geological maps was made in connection with the reports of the coal counties. As stated above, the field work was more of the character of an examination than a survey, the maps as a rule showing only the points at which data were obtained, without attempting to show the distribution of particular coal beds or formations. A large part of the errors in stratigraphy of the earlier surveys are doubtless due to lack of surveying methods or the systematic tracing of the coal beds and their accompanying strata."

The paper of Dr. Haymond on Franklin County in the 1869 report of Cox is devoted mainly to its physical geography, there being within its bound no economic resources other than the soils and flagstones afterward quarried extensively near Laurel. He includes a list of the principal trees and descriptions of the ancient earthworks of the county. Following his regular report, however, are two papers of more than passing interest to the naturalist. These are entitled "Mammals found at the Present Time in Franklin County," and "Birds of Franklin County, Indiana." Full notes on the habits of the 31 species of mammals and 163 of birds listed show Dr. Haymond to have been a close and careful observer. These two papers were the first of many which have since appeared treating of the fauna or flora of the State, most of which have been published either in the annual reports of the State Geologist or in the Proceedings of the Indiana Academy of Science.

Second Report of Cox.

The Second Report of Cox, covering the work done on the Survey in 1870, was issued in 1871. It contained an excellent lithograph frontispiece of the "jug rock" near Shoals, Martin County; also lithograph plates of the large frame hotel, bath house and creek at Indian Springs, the first hotel at West Baden, and of blast furnaces in Clay and Vigo Counties. Except for the crude

*23rd Ann. Rep. Ind. Dept. Geol. & Nat. Resources, 1898, pp. 8 and 9.

plates in Owen's '62 report, these were the first full page illustrations showing features connected with the geology or resources of Indiana.

In the introduction, Cox states that the summer's work "proves the continuance of the Block or iron smelting coal from the northern limits of the Indiana coal basin to the Ohio River, a geological discovery of incalculable advantage to the State, as the day cannot be far distant when this coal, which is unequalled for smelting iron, will induce the building of blast furnaces along the entire eastern margin of the coal basin." Subsequent surveys have proven this statement to be wrong, the true "block coal field" being limited to Clay and the southern third of Parke Counties and a small area near Patricksburgh, Owen County.

In the introduction we find also the first mention of a new assistant who, for a number of years thereafter, was closely connected with the history and development of Indiana Geology. Of him Mr. Cox says: "To Prof. John Collett, of Vermillion County, was assigned the duty of making a detailed survey of Sullivan County, a labor which he has performed in a highly satisfactory manner, as the able and minute report of the geology of that county, published in this volume, will bear testimony. He has made known many interesting facts in the stratigraphy of the coals, and collected a large number of organic remains, which serve to increase our knowledge of the vertical range of the fauna and flora of the coal measures."

Several railways had by this time been constructed or were being built through portions of the coal area. Among these was a part of what is now known as the Evansville and Indianapolis railway. Col. J. W. Foster of Chicago had made an examination and report of the resources along this proposed line, and Prof. Cox felicitates himself regarding this as follows: "It is highly flattering to me that this able report bears testimony to the accuracy of my previous geological work, and fully confirms all that I have said in regard to the value of the block coal for the manufacture of iron and steel, and sets forth the incalculable advantages possessed by Indiana for controlling the iron market of the new West, and for conducting the most gigantic metallurgical operations in the country."

The body of Cox's second (1870) report is devoted almost wholly to the geology of the coal districts, the reports on Daviess, Martin and Sullivan Counties being in detail and accompanied by maps, while several other counties were treated more briefly. A full account of the mineral waters at Indian, Trinity, French Lick and West Baden springs, including quantitative analyses, was given. There is also a section of an artesian well, 1629 feet in depth, put down on the river bank at Terre Haute, and a statement regarding two oil wells in the same city, as follows: "The first, or Rose well, was sunk to a depth of seventeen hundred and ninety-three feet. It was bored for water, and strict attention was not paid to the character of the rocks after passing through the coals in the upper part of the section. At 1,629 feet a vein of oil was struck which yielded about two barrels per day. The oil was shut out and the bore continued to a depth of 1,793 feet, having reached an abundant flow of good sulphur water. The second well was bored on the bank of the Wabash River, about one mile west of the first. This work was undertaken by a company expressly for oil. Experienced borers were employed and the record of the strata passed through may be relied on as accurate. A little oil was found, but not enough to justify pumping."

"A third well was bored by the same company a quarter of a mile east of the first, which passed through the same succession of strata detailed in the section. The black slate was passed through at 1,600 feet; and 25 feet lower down, in limestone, which I refer to the Corniferous, a vein of oil was found which yields twenty-five barrels per day."

These were the first deep wells producing crude petroleum in commercial quantities in the State of Indiana, and were the subject of a paper entitled "On the Oil Wells at Terre Haute," by Dr. T. Sterry Hunt, a noted oil specialist of Montreal, Canada. This paper he read at the Indianapolis meeting of the American Association in August, 1871, and it is reprinted in part by Cox in his second report. Cox also included a paper entitled "Western Coal Measures and Indiana Coal" which he had read before the same meeting of the Association.

The final paper in the 1870 report was the first local list of plants published in the State. It was entitled "Manual of the Botany of Jefferson County, by A. H. Young of Hanover College, Ind.", and enumerated with notes 609 species representing 315 genera and 87 families.

Third and Fourth Reports of Cox.

The third and fourth reports of Cox, treating of the work done in 1871 and 1872, were published in one volume in the latter year. His assistants during these years were John Collett, Barnabas C. Hobbs, Prof. R. B. Warder and Dr. Levette. The beginning paragraph of the introduction to the volume is as follows: "It gives me pleasure to be able to note the continued prosperity and rapid extension of our mining and manufacturing industries. Districts that were but yesterday covered by a primeval forest, or only broken here and there by the quiet pursuits of the husbandman, have been awakened by the whistle of the locomotive and the puffs of the stationary engine; coal begrimed miners throng the streets of mining villages of a year's growth, and the work of mining and shipping coal is pushed forward with an energy and zeal that is unprecedented in the West, and far outstripping the hopes of the most sanguine utilitarian."

He states that Perry, Dubois, Pike, Parke, Dearborn, Ohio and Switzerland Counties were surveyed in detail and preliminary examinations made in eleven other counties, most of which were in northern Indiana. The volume was accompanied by a portfolio of maps of the counties surveyed in detail. These were uncolored, and exhibited the same kind of data as did those of the first and second reports.

Cox describes a new blast furnace which had been erected near Shoals to utilize the iron ore of the vicinity. It was the last one of twelve which were built in the State, all of which went out of blast many years ago. Eastern furnaces with lower railroad rates and better facilities for handling ore, and the opening of the great ore deposits of the Superior region led to the dismantling of all these pioneer furnaces of Indiana.

As with the two preceding volumes, this one also was largely devoted to the geology of the coal measures, treating them by counties and not as a whole. Many analyses and sections of coal were given, and the paper by Hamilton Smith, previously mentioned, was included. Under Dubois County there is first mention of the deposit of tripoli near Ferdinand, which for a number of years was sold for polishing purposes.

An illustrated paper most interesting to naturalists is included in the 1872 volume. It is a "Report on the Wyandotte Cave and its Fauna," by that eminent scientist, E. D. Cope of Philadelphia. While attending the meeting of the American Association at Indianapolis, he made a side trip to Wyandotte, and collected the forms of life which he could find therein, sixteen species in all. Five of these, an arachnid, three crustacea and a myriopod, he described as new, notable among these being the blind crayfish of our southern Indiana caves. The descriptions of three beetles from the cave, two of them blind, which were drawn up by Dr. Geo. H. Horn, are also included in Cope's paper.

Following the county reports in the volume is one entitled "Meteorology of Vevay, Switzerland County," by Chas. G. Boerner, and another illustrated one on the "Manufacture of Spiegeleisen, Speculum or Glittering Iron," by Hugh Hartmann, Ph. D., of Omaha, Nebraska, who for many years was an assistant in the Spiegeleisen works of Hanover, Prussia. This form of iron ore, used in the production of Bessemer steel, was at that time made only in Germany, and Cox was attempting to get a factory started in Indiana.

Fifth Report of Cox.

The fifth report of Cox, embracing the observations made in 1873, was published in 1874. It was a volume of 494 pages, with maps of Clark, Floyd, Lawrence, Knox, Gibson, and Warren Counties in a pocket at the end, and a frontispiece map of "Bone Bank", a noted aboriginal burying place on the eastern bank of the Wabash in Posey County. Mr. Cox had been appointed by Gov. Hendricks to represent the State at the Universal Exposition held in Vienna, Austria, in 1873. He took with him a small display of native Indiana woods, and also a collection of the mineral resources, of which he says: "Large characteristic specimens of caking coal, block coal, and cannel coal were obtained from mines in various counties of the State. Along with the coals were specimens of pig-iron smelted with raw block coal, clay, ironstone from the coal measures, fire clay, fire brick made from the clay, building stone and specimens of various colored ochres from Owen, Green, Martin and Dubois Counties."

"In addition to the natural products of the State I prepared a pamphlet, of which 8,000 copies were published in English and German, for distribution along with the Geological, Agricultural and School Superintendent's Reports. Col. W. R. Holloway also sent over a box of 'Holloway's History of Indianapolis,' to be given to those who desired them. In the distribution of books treating of the mineral, agricultural and educational advantages of this country, our State was unsurpassed, and it cannot fail in producing good results."

"The coal and iron, especially the fine large cubes of block coal, were examined with the greatest interest by the European iron masters, and was of no less interest to the International jury who were appointed to examine into the character and merits of all minerals on exhibition. This jury was made up of distinguished geologists and mining engineers from different countries, and after a careful examination of its merits made the State an award of a medal."

The first 70 pages of the report are devoted to an account of the exposition, in part written by Hugh Hartmann, who also has a second article on the manufacture of Spiegeleisen. The remainder of the volume is devoted to the geology of the counties whose maps were included as mentioned above. Under Clark County, the ancient stone fortifications and mounds on the Ohio River, three miles east of Charleston, are described in detail, as is also the "old stone fort" at the mouth of Fourteen Mile Creek, and the "Bone Bank" above mentioned. The latter was said to be 1,500 feet long, 80 feet wide and 35 feet above low water.

The report on Clark and Floyd Counties is well written, and was prepared by W. W. Borden, an eccentric scientific character of southern Indiana, who afterwards made a fortune in Western mining ventures and established a large museum at Borden, Clark County. He gives the first detailed account of the hydraulic limestone used for making natural rock cement, and states that in 1873, 391,000 barrels were manufactured in Clark County. He also describes in detail and gives analyses, of both the New Albany black shale and the Knobstone, which have abundant outcrops in the counties which he surveyed. He states that at one time a large factory was erected at New Albany in which the black shale was ground, mixed with coal tar and spread on felt for roofing, but experience showed that it would not stand exposure, and the enterprise was soon abandoned.

The surveys of Lawrence, Knox, Gibson and Warren Counties were made by John Collett. They give the detailed sections of many outcrops, and numerous lists of fossils from the different formations.

In a thin, laminated sandstone found beneath some black shale near the base of the coal measures on Pine Creek, Warren County, Collett discovered what he called "reptilian tracks." One fragment of the stone showed four tracks, each having five toes, while other slabs contained one or two tracks each. Cox named the animal from the tracks alone, *Colletosaurus indianaensis.* He published a full page plate of the track and called them "fossil footprints of an air-breathing reptile," yet states that "two pairs of tracks of hind and fore feet are quite distinct and from their position seem to indicate that the animal was allied to the Batrachians, and progressed like a frog, by jumps, while on the other hand the five digits on either foot relate it to the Salamanders." At the present time, reptiles and batrachians are classified as belonging to very distinct orders. The giving of a scientific name to an animal of which no trace is left except its "footprints on the sands of time," brings to mind Rafinesque and the scientific names he gave to seven varieties of thunder and lightning.

Under Lawrence County, Collett describes briefly Shiloh, Dry, Grinstaff's, Connelly's, Hamers and Donnelson's caves, and mentions one blind fish, five crustaceans and four insects as inhabiting them. He states that "many wells in this region are fed by the underground brooks, and from these it is not unusual to draw up eyeless fish and crustaceans, inhabitants of the adjoining caves."

Since Orange and Lawrence Counties are at present coming rapidly to the front as one of the leading apple growing districts of the State, the following paragraph, written by Collett forty-three years ago, is of more than passing interest. "Advantage is taken by the enterprising citizens of the equalization of temperature found to exist on the summit of the surrounding sharp hills, which are 200 to 250 feet high, to plant extensive orchards, which produce highly remunerative crops of excellent fruit. It has been frequently observed here that in cold weather ice of considerable thickness forms in the valley, when no frost has fallen upon the hills just above. This arises from the fact that cold air is heavier than warm air, and in obedience to gravitation descends, and may fill the valley, leaving the peaks above bathed in warmth. Such facts invite the attention of fruit growers."

Under Knox County there is in this report a full page lithograph plate of the "Pyramid Mound" near Vincennes, with descriptions of it and other mounds, and of the kitchen middens or shell heaps near Edwardsport and Vincennes. Collett, who was a man of vivid imagination and fluent powers of description, says of the kitchen middens: "They signify the permanent residence of a people relying on agriculture and aquatic life for sustenance; hence we infer, that the people whose existence is indicated by these shell heaps were not related to our savages. Again, stone cists and vaults containing the bones of many persons of all ages and sexes, irregularly mingled with remains of funeral fish food, are often found, sometimes as intrusive sepulchres on sides or tops of the mounds; we conclude that these are the remains of the conquerers of the most ancient people who were afterwards themselves dispossessed by the Indians—An intermediate littoral 'Race of Fishermen,' who to some extent adopted the habits, usages and even religion of the conquered."

Of the mound builders he continues: "More ancient than these shell heaps, dating back beyond the thousand years noted by the annual growth of our forests, are numerous monumental remains of which the past is silent. 'Not entirely voiceless,' they tell us of a people who once possessed the valley of the continent. Peaceful and law-abiding, they were skilled in agriculture and the arts of the 'stone age,' and executed works that required the united and persistent efforts of thousands, under the direction of a well matured design. In the comparative absence of warlike implements, we conclude that this work was a labor of love, and not of fear; that it was inaugurated and directed by a Regal Priesthood, to erect votive temples in honor of the Sun, a visible Creator of comfort, food and life."

Following the work of Collett, the volume contains also a brief paper by Dr. Joseph Gardner on the Tripoli of Dubois County, in which he states that tripoli has for its basis the "silicified skeletons of organic bodies," of which he figures five, and also that the Dubois County material is made up almost exclusively of the skeletons of sponges.

The volume is ended with a "Report of Observations" made in seven counties of northern Indiana by G. M. Levette. These refer mainly to the streams, lakes, artificial mounds, bog iron ore, marl and peat deposits of the region. Just now, when the high cost of living is the main problem of existence, and coal at times threatens to become as high priced as its sister diamond, the following words, written by Levette are worthy of quotation: "Immense deposits of peat occur in the lower lands, along the marshes and over the 'bridged lakes.' A partly completed fill of the Baltimore, Pittsburg & Chicago Railroad broke through the crust of a subterranean lake, a half mile west of the town of Albion, and exposed a deposit of peat 18 feet in thickness. In the dim, distant future when the wants of a dense population shall demand the cultivation of every available foot of this fertile section of country and fuel shall have become the costliest item of household economy, these deposits of peat will be sources of wealth to the owners and objects of practical interest to those who consider the success and well being of the community."

Sixth Report of Cox.

The work done by the Cox Survey, during the year 1874 was described in his Sixth Report, issued in 1875. Scott and Jackson Counties were surveyed and mapped by Borden, Brown County by Collett and Jackson County by Cox. In the introduction Cox says: "Previous to this year we have not been able to find any fossils in the Black Shale except some small species of *Lingula* and *Discina* which are so closely allied to Carboniferous species that it was not considered prudent to rely upon them for the identification of the age of the strata. During the year, 1874, however, Mr. Borden has had the good fortune to find in the Black Shale at Lexington, Scott County, a large number of well preserved fossils from which we can, with propriety, refer the New Albany Black Shale to the Genesee, and the Goniatite shale, which rests upon it, to the Kinderhook group of Illinois."

The white kaolin of Lawrence, Owen and Martin Counties, though mentioned by Owen in 1862, was not recognized as a clay until 1874. Near Huron, Lawrence County, the outcropping kaolin had long been known to its natives as mineral tallow and the locality as Anderson's "taller bank." Some workmen, while digging out the underlying iron ore for the blast furnace at Shoals, laid bare, in the summer of 1874, the full thickness of the stratum of kaolin and the attention of Mr. Cox was called to it. In his introduction to the Sixth Report he devotes eleven pages to a description of the kaolin, which he named "indianaite," and of its variety allophane, giving analyses and his theory of their origin. The latter is of interest as coming from a chemist of his repute. He says: "The clay lies immediately beneath the Millstone grit or pebbly conglomerate of the coal measures and here occupies the place of a bed of Archimedes limestone which is seen in *situ* about two miles southeast of the mine. The overlying sandstone is very ferruginous and the base, where exposed to the weather, has decomposed and covered the clay in places to a depth of eight or ten feet with ferruginous sand and pebbles. There is a constant oozing of water from this sandstone which has, no doubt, played an important part in the chemistry of the clay and hematite deposit, for, though similar in its chemical composition to kaolin, this Lawrence County clay differs physically and owes its origin to an entirely distinct set of causes and effects. While kaolin is derived from the decomposition of the feldspar of feldspathic rocks, such as granite, porphyry, etc., the porcelain clay of Lawrence County has resulted from the decomposition, by chemical waters, of a bed of limestone and the mutual interchange of molecules in the solution, brought about by chemical precipitation and affinity."

In other words, he asserted that the Lawrence County kaolin, which has a clay base of 45% silica, 38% alumina and 16% combined water, is the result of the chemical action of water percolating through a sandstone upon the beds of limestone. How such water can change the elements calcium and carbon into silica and alumina passeth understanding.

The most plausible explanation of the origin of the Indiana kaolin is that set forth by Ashley,* which was based upon a theory of Lesquereux, viz., that the kaolin occupies the horizon of Coal I, the coal and kaolin being never found at the same place though often they occur but a short distance apart, and that the kaolin was formed by the burning of a vein of coal immediately above a vein of underclay, the impurities of the latter being consumed and the kaolin left as a residue.

This kaolin was used for a time for making porcelain ware but, being wholly non-plastic, was not found suitable for the purpose and so Cox's prophecy that: "The importance of the discovery of this clay can hardly be overestimated, since it places within our reach the means of becoming independent of Europe for fine grades of chinaware," was not fulfilled. It was afterwards shipped for ten years to Philadelphia and used in the making of alum cake, a product used in paper manufacturing. For the last 20 years or more the deposits have not been worked.

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*23rd Ann. Rep. Ind. Dept. Geol. 1898, 931.

About 20 pages and four plates of the 1874 report are given to a chapter on "Antiquities," based upon an investigation made by Mr. Cox and F. W. Putnam of the Peabody Museum in the fall of 1874. A full description of the stone fort at the mouth of Fourteen Mile Creek and of other earthworks in Clark and Jefferson Counties is given, with illustrations of their plans, and of stone pipes and other objects taken from them and other mounds throughout the State.

Under his description of Jackson County, Cox states that in the vicinity of Rockford a thin limestone "passes upward into greenish gray, hard, calcerous shale, filled with fossil cephalopod shells, in a fine state of preservation. The Goniatites and Nautili of this locality are among the most interesting fossils found in the country. They are eagerly sought for by collectors and have given to Rockford a world wide notoriety. The rock is easily decomposed when exposed to the air and its fossils are found ready weathered out on the newly exposed surface after floods in the river. The children of the village keep a sharp lookout for them and the outcrop, which is only two or three feet thick, and from 150 to 200 feet long, is diligently searched from day to day after each freshet or heavy rain. Large numbers are collected and sold, for what they can get, to the scientists who are attracted to the locality. They go by the name of "snake rocks" and if you ask for Goniatites or Nautili, as I did, you will be told that they know nothing about such things, but on the other hand, if you inquire for "snake rocks" you will find that nearly every boy and girl in the village will have a few and are ready for a trade."

In the report on Brown County, Collett tells how the ridges of Knobstone withstood the onward movement of the first glacial invasion of the State, so that all the land directly southward comprises a driftless area. He says: "Approaching the central areas from the east, from the west and from the valley of Bean Blossom Creek at the north, it was found that the county was enclosed by a wall of hills ranging from 350 to 450 feet in height. In valleys to east, west and north, glacial drift was present, mounting well up on the sides of the hills. But within this walled space the scarcity or entire absence of boulders showed that the ice drift had only for a short period, or never intruded, Bean Blossom Ridge marking the extreme southern limit of the local glacier foot. Against and upon this wall-like ridge the stranded ice seems to have been continually massed and melted by each recurring summer's sun. It sent torrents of water south across the county, wearing slight depressions in the ridge as at Low Gap and the source of Greasy Creek, bearing fine sediment, some gold dust and black sand, and but few or no pebbles or boulders. The long continued melting of ice loaded with the most enduring debris of the Laurentian rocks, as greenstone, quartzite, quartz, gold and magnetite, deposited large quantities of these imported materials in Bean Blossom Valley. The rapid current of the ice water would naturally carry down stream the lighter sand and gravel, and sort out and leave behind the heavier rocks, gold and magnetite in considerable quantities. Still above the outside wall of the county, several peaks, notably the Weed Patch Knob, rise from 50 to 125 feet. Around their sides the ice water has deposited slight terraces containing minute pebbles and some imported material, as if to record the highest flood upon this meter of the great glacial river; while white and bare, these storm scarred summits looked out over the winter wild, and saw that rigid river of ice menace their base, or turn to right and left into the two White River Valleys, and float by in a stream of ghostly silver. Remarkable as witnesses of the early Quaternary, their elevation above the ocean reaches back beyond the time which saw the Carboniferous, Mesozoic and Tertiary seas to the west, bury their treasures of warmth and wondrous animal life as they shrunk from existence." And on a later page he adds: "The summit of Weed Patch Hill has not been under water since it emerged from the subcarboniferous ocean, and, from all the evidence seen, it was an unconcerned spectator of the grand phenomenon which signalized the glacial age. It takes its name from the fact that just before it was first visited by the early pioneer, a tornado had scalped some 100 acres of the tip-top plateau, prostrating a magnificent forest of large poplar, oak, walnut and cherry trees. Weeds and grass succeeded in luxuriant growth, which, together with the trunks and branches of the fallen trees, were burned by each summer's fire, and commenced a miniature prairie; weeds and vines became the prevailing vegetable growth, and hence the name."

In his report on Scott County, Borden states that "Resting on the New Albany black shale are found large fossil trees. Some of these specimens are of great size; all are silicified and so hard that a fragment with a sharp edge will scratch glass. One which was exhumed and exhibited at the Indianapolis Exposition of 1873, measured over 16 feet in length and two feet in diameter, and had a jointed structure, which is a characteristic feature of all these fossil trees. Another measuring 19 feet in length and three feet in the broadest part, being somewhat flattened, was taken from the black shale, a short distance northeast of Vienna, and exhibited at the Indianapolis Exposition for 1874." He concludes his report with a list of fossils taken from the Black Shale, and also a list of those found in the Lower and Upper Silurian rocks of Jefferson County by Dr. W. J. S. Cornett of Madison.

Following the report of Borden are the first two papers ever published on the fishes of Indiana. They are also among the first, if not the first, ever written by their author, the world-renowned Ichthyologist, David Starr Jordan. One is entitled "The Sisco of Lake Tippecanoe and its Relatives." The Sisco, he states, are fishes belonging to the Salmonidae or trout family, a group distinguished at "once among our fresh water fishes by the presence of the so-called 'adipose' fin, behind the dorsal fin, in connection with a scaly body and naked head with no barbels about the mouth." Those found in the northern Indiana lakes inhabit the deepest water except in the spawning season late in autumn, when, says Jordan, "they come in myriads into the streams which enter the lakes. There are large numbers of persons who are engaged night and day taking them with small dip nets. Those who live in the neighborhood put up large quantities of them, they being the only fish caught in the lakes that will bear salting." In the paper he described as new, the Indiana species, and mentions with full notes its nearest relatives, one of which is the well known "white fish" or lake herring of the markets.

The second paper is a "Synopsis of the Genera of Fishes to be looked for in Indiana." This includes a key to 81 genera and is followed by a list of 88 species, with notes on distribution, common names, etc.

The final paper of the 1874 report is entitled "A Partial List of the Flora of Jefferson County, Indiana," by John M. Coulter of Hanover College, in which he lists with full notes 721 species belonging to 367 genera. This also was one of the author's first ventures, and we have thus, side by side, in this Sixth Report of Cox, the initial efforts of two of the country's greatest scientists in their respective lines.

Seventh Report of Cox.

In the preface to his Seventh Report, published in 1876, Cox complains of the meagreness of the appropriation allotted for State Printing, stating that "it has been found impossible to publish more than a part of the county geological maps and the numerous horizontal sections that have been prepared to show the continuity of the seams of coal and associated beds of shales, sandstones and limestones. These sections are of great importance to present the geology in a clear and comprehensive manner. It is hoped, therefore, that the legislature will make a special and adequate appropriation to enable the geologists hereafter not only to publish what maps and sections are needed to make comprehensive the dynamical geology of the various counties, but also to cover the necessary expenses of engraving and publishing plates containing figures of the characteristic fossils of the various geological formations as this will render the report more useful to students in the universities, colleges and high schools of Indiana."

The legislature failed to comply with his request, and his next report was not printed until 1879. This was one of the causes which led up to his quitting the Survey in the latter year. The first 77 pages of his Seventh Report were devoted to a discussion of the combustible properties and analyses of Indiana coals. Next comes reports on the surveys of Vigo* and Huntington Counties by Cox himself.

Of the Niagara limestone near Huntington he says: "The great disorder of the strata, mainly due to false bedding or peculiar arrangement of the material constituting the present rocks, has led many to infer that this irregularity was due to earthquake or volcanic action. This is the more deceptive

*In the report on Vigo County Cox states that Col. Francis Vigo, in honor of whom Vigo County was named, had moved from St. Louis to Vincennes, prior to the capture of the latter place by George Rogers Clarke, that he conveyed to that officer the information which enabled him to capture the post, and advanced money to feed and clothe his suffering army. This money was not recovered until after Vigo's death, but the latter left a clause in this will that in event of its recovery $500 "should be given to the county which had honored him by adopting his name, to be expended in buying a bell for its courthouse."

since the apparent elevations have their surfaces capped with enduring beds of chert or impure flint. Huntington is located on one of these flint ridges and the locality was known to the Indians by the name of 'We-pe-cha-an-gan-ge' or flint place. The flint of this locality was of great value to the Indians as the material of which they fashioned their arrow points, spear points and flint knives." The Niagara stone itself was then, as now, extensively used at Huntington in the making of lime, 617,000 bushels having been produced in 1875.

Following Cox's reports on the counties mentioned is a paper by Lesquereux entitled "Species of Fossil Marine Plants from the Carboniferous Measures," in which are described and illustrated with two plates, five species of crinoids, one of which he named after Cox.

The geology of Jennings and Ripley Counties is next treated in detail by W. W. Borden, and that of Orange County by Drs. M. N. Elrod and E. S. McIntire of Orleans, Indiana. Dr. Elrod continued at intervals as an assistant on the survey until 1895.

Reports accompanied by maps on Vanderburg, Owen and Montgomery Counties, by John Collett, follow next in order. In that flow of language for which Collett was noted he says of the Ohio River at Evansville: "It is the 'Belle Riviere' of the early French adventurers—the beautiful river of song and story. Always navigable, without interruption from drought or winter's ice at this point, it is the great artery of trade and economic life to the bordering region, and bears upon its bosom a fleet of steamers equalling in value and tonnage that of some internal seas. Belted by broad alluvial plains or high bluffs, from which interesting views full of picturesque beauty may be attained, the river and valley have been compared by tourists to that Mecca of travelers, the Rhine of Europe."

Of the new State Park on McCormack Creek, Owen County, he writes: "Springs seeping from crevices in the rock, or springing from the summit, cool the air and reach the bottom in a cloud of spray, the wild, romantic scenery, reverberating roar of falling water, cool air breathed by the cavernous rocks, renders the valley a favorite picnic ground, while disciples of Walton are greeted by their finny friends. Still ascending the creek, a wild, rattling roar, intensified by quick, sharp echoes, shakes the air, confusing the mind by its overwhelming ubiquity. The falls would be insignificant in a wider valley, but in this narrow canyon it is full of never tiring interest."

He also described in detail the Cataract Falls of Owen County, stating that "the river, within a distance of three-fourths of a mile, by two plunges, falls 81 feet, passing through a deep, narrow channel cut in St. Louis limestone," and also that "these cataracts of Eel are the grandest falls in this region of the West. In winter they put on their festal robes. The trickling springs flute and corrugate the sides of the chasm with moldings, columns and pilasters of ice. The trailing bushes and limbs of trees are coated by the ever rising spray, and every terminal twig is gemmed with lustrous crystals, which, in the sunshine, blaze with a thousand tiny rainbows."

In the long and detailed report on Montgomery County, Collett has ten or twelve pages devoted to the "Glacial Epoch," in which he gives an interesting account of the changes wrought in that region by the moving and melting ice. He states that "East of Sugar Creek and south of Crawfordsville was an extensive body of water, covering nearly 100 square miles, the silt and shore line of which is so plainly lacustral and marked that its existence could not have terminated more than a few thousand years ago. The phenomena of this basin have long been noticed and studied by Col. James H. Harney, in whose honor as the discoverer I have given it the name of Ancient Lake Harney."

He includes a "List of 110 Species of Fossils found in the Keokuk (Harrodsburgh) Group at Crawfordsville," most of which are crinoids from the famous beds near that city. Of the area now known as the "Shades of Death" he says: "Little Ranty, flowing from the south, approaches in a flume-like passway cut 50 feet deep in heavy sandstone, and thence rushes in a filmy sheet 45 feet down an almost perpendicular bank of dark shale, like an endless ribbon with warp of silver and woof of sparkling crystals. The cascade is nestled away in an amphitheater, 200 feet in diameter, crowded with shrubs, ferns and tenderest wild plants, here untrodden and unseen. Traveling ferns creep over and cling to the ragged masses of tufa, which guard the narrow entrance from the eye of the careless observer. More than 100 feet above, tall oaks and pines, encircling the rim, swing their branches together across the cove and chasm. At the 'rookery' all the buzzards living within ten or fifteen miles, meet each summer evening for information, converse and mutual assistance."

Following Collett's papers in the Seventh Report there is one of 35 pages by G. M. Levette, entitled "Observations on the Depth and Temperature of some of the Lakes of Northern Indiana." In gathering data for this paper Levette had been accompanied by Caleb Cooke, one of the Curators of Peabody Museum at Salem, Massachusetts. Together they dredged and sounded 15 lakes in Fulton, LaPorte, Kosciusko, Noble, LaGrange and Steuben Counties. Of the origin and future of these lakes Levette said: "They are without exception mere basins or depressions in the glacial clay. No stratified rocks have been found in the bottom or on the shores in a single instance, but, on the contrary, the numerous deep bores which have been made in that region, from time to time, prove that from 80 to 200 feet of glacial drift overlies the stratified rocks throughout the entire lake region of northern Indiana."

"Wet boggy marshes and small lakes which have become dry and arable within the memory of white men; extensive deposits of peat, from five to 50 feet in depth; blind lakes or bodies of water which are covered with a few feet of peaty soil, some of which sustain a growth of forest trees; the annually receding shores of many of the smaller lakes, and the perceptible yearly accumulation of 'marl or fresh water lime in the shallow portions of many of them, all lead to the inference that at no very distant period in the past, the lake area of this region was two or three times its present extent; and further, that if the agencies now at work continue to accumulate material on their shores and beds, not many centuries will elapse before these now numerous and interesting gems of the landscape will be known only to the students of ancient geography."

A list of the Mollusca and turtles taken in the lakes is given at the end of Levette's paper. The fishes and crustacea were turned over to the Peabody Museum, where, says Levette, they were to "be examined by Prof. Putnam, free of cost to the Geological Survey, and full suites of all the species collected, properly labeled, and returned to the State Museum at Indianapolis, and all new species figured and described for publication in this or a subsequent report," but we can find no record of them in this or following reports.

The final paper in the volume is a "Catalogue of the Flora of the Wabash Valley below the mouth of White River and Observations thereon," by Dr. J. Schneck, of Mt. Carmel, Illinois. In the introduction Dr. Schneck gives much information of value regarding the physical characteristics of the region, the time of leafing and flowering of many species, a table of measurements of the larger trees, a mention of the plants which had recently become extinct, etc. In the list proper he mentions with notes 867 species representing 444 genera as occuring in the area covered.

The writer had the pleasure on several occasions of spending a day or two at a time in company with Dr. Schneck in a study of the Cypress swamp of Knox County and in the region south of the Patoka River in Gibson County. He was a most agreeable companion, a botanist of learning, especially regarding the oaks and other trees of that portion of the State. Of the oaks he furnished foliage and fruit to many of the eastern botanists and Schneck's red oak, *Quercus schneckii* Britton, which occurs from Ohio and southern Indiana west and south to Iowa, Missouri, Florida and Texas, was named in his honor.

Eighth, Ninth and Tenth Reports of Cox.

The results of the work done by the Indiana Survey during the years 1876-'77 and '78 were not printed until 1879, when they appeared in a single volume of 541 pages as the "Eighth, Ninth and Tenth Reports of Cox." The first 170 pages of the volume are devoted to a general discussion of the Geology and Archaeology of the State. This Cox starts out by controverting to some extent the statement of the wise man with which I begun this paper, viz., that the "Geology of the surface of Indiana is simple." He says that "The geological history of Indiana appears tame and devoid of the marvelous interest which attaches to those regions of country where the forces generated in the earth's laboratory have made themselves conspicuous by the metamorphism of the rocks, and the tilting, folding and fracturing of its crust. Here the elements concerned in the building up of strata leave no trace of violent cataclysms, and the rocks presented to view lie regularly bedded at an inclination or dip, to the westward and northward, so gentle that its existence can only be made known by observations extended to points that are far distant from one another. Not a single true fault, or upward or downward break and displacement of the strata has yet been discovered. From this, then, one might be led to suppose that the geologist would have but little trouble in tracing and making up a complete and accurate record of the geological history of the State. But this very monotony of action and uniformity of strata is, perhaps, more perplexing and defiant to deal with and read correctly, than where turbulence prevailed and marked the pages of geological time with bold and well defined characters. There is also another great drawback to investigations in Indiana, due to the immense deposit of glacial clay, sand, gravel and boulders which spread over so large a portion of the State, and cover up the beds of stratified rock."

He introduces for the first time, Mr. S. A. Miller of Cincinnati, Ohio, stating that he has "very obligingly, at my request, furnished a complete catalogue of all the fossils which have been found in the Lower Silurian rocks over a portion of Ohio, Indiana and Kentucky. Mr. Miller's work on the American Paleozoic Fossils, has very justly won for him the reputation of the very highest authority on American fossils, and this list, coming as it does first from his pen, cannot fail to be of incalculable value to collectors of Lower Silurian fossils."

With this introduction began that period in the history of the Geological Survey of the State which continued until 1895, in which paleontology rather than economic geology became the predominant subject treated. Miller, Hall, White and others described thousands of species of fossils from all formations of this and adjoining states, and published altogether 191 plates in the Indiana reports.

The Catalogue of Miller, with bibliographical notes, comprises pages 22 to 56 of the volume. He includes with it the minutes of a special meeting of the then flourishing Cincinnati Society of Natural History, held Jan. 23, 1879, at which its more prominent members passed a resolution eliminating from geological nomenclature the term "Cincinnati Group," which had previously been extensively used to designate the Trenton, Utica shale and Hudson River formations in southeastern Indiana and the adjoining portions of Ohio and Kentucky. Of this resolution Miller says: "The Cincinnati geologists, neglecting the study of the Trenton Group of Kentucky, and overlooking the evidences pointing to the Utica slate age of the small exposures in the banks of the Ohio near Cincinnati, contented themselves, with the study of the richer fields, in the exposures of the Hudson River Group in Ohio and Indiana, and permitted geologists from abroad who knew little or nothing of the rocks in question, to flatter them with a local name until the absurdity of the position became so manifest and the injury to science so apparent that they resolved, notwithstanding their local pride, to abandon the worse than useless synonym, and to raise their voices in behalf of exact science and the well established law of priority in geological nomenclature."

In this introductory chapter, Cox treated at length the hydraulic cement rocks of southern Indiana, giving many analyses of the rocks and cement. The pages devoted to Archaeology are of interest in that they describe somewhat in detail and show maps of prehistoric forts and mounds near the junction of the Miami and Ohio Rivers in Indiana and Hamilton County, Ohio, and also those on the White River near Anderson, Indiana, which are now part of a public park belonging to that city.

This introductory part of the volume is followed by reports, accompanied by maps, of Wayne County, by Cox, and Harrison and Crawford Counties by Collett. In the Wayne County report is included a sketch of "Observations on the Prehistoric Earthworks of Wayne County, Ind.," by J. C. McPherson, which is illustrated by three maps, and in which he quotes two stanzas of a poem by John Finly, author of the "Hoosier's Nest," which was inspired by the discovery of a skeleton in one of the mounds. They are as follows:

"Year after year its course has sped,
Age after age has passed away,
And generations born and dead,
Have mingled with their kindred clay,
Since this rude pile, to memory dear,
Was watered by affection's tear.

* * * * * * * * * *

No legend tells thy hidden tale,
Thou relic of a race unknown!
Oblivion's deepest, darkest veil
Around thy history is thrown:
Fate, with arbitrary hand,
Inscribed thy story on the sand."

The Wayne County report also includes a section of interest to botanists, it being, a list of the ferns, mosses, hepaticae and lichens of that county, by Mrs. Mary P. Haines of Richmond in which 17 species of ferns, 84 of mosses, 20 of liverworts and 29 of lichens are enumerated.

Between the Wayne and Harrison County reports are interpolated a table comprising 36 pages of altitudes in Indiana and adjoining states, by Jesse L. Williams of Fort Wayne, Ind.; and also a "Catalogue and Check List of the Trees and Woody Shrubs of America North of Mexico," by John W. Byrkit of Indianapolis.

In his report on Harrison County, Collett includes a List of Fossils of the Carboniferous and underlying formations of the county, and a list and description of new species of "fishes teeth," by Dr. J. S. Newberry. An interesting account, covering six pages and including analyses of the fragments is given of a large meteorite which fell near Buena Vista, Harrison County, in 1859, the larger pieces of which, called the "Indiana Meteorite," are now in the British Museum at London.

The report on Crawford County is largely devoted to the numerous caves, large and small, found in the limestone rocks, Cope's paper on the fauna of Wyandotte being reprinted. Of Little Wyandotte, Collett gives the length as "about 2,000 feet." Accurate measurements by the writer showed it to be 415 feet. A new map of Wyandotte, prepared by Collett and illustrated on the margin with seven lithographs of views within the cave, accompany the report. "A table of distances measured and estimated by Washington Rothrock, a guide of 28 years' experience" (Collett, in a footnote, says they are "generally estimated") is printed on the map, and gives the total length as 23.5 miles. In the description of the Pillared Palace is a sentence which the average scientist of today will accept "cum grano salis." "Ceiling, cornices and shelves" Collett says, "are fringed with stalagmites and frosted with a never ending medly of strange, crooked, writhing, twisting, unsymmetrical sprigs of white limestone, *pushed out of the solid rock and still growing by propulsion from the bottom.*"

All told, Prof. Cox issued, while serving as State Geologist, ten reports, published in seven volumes, comprising 2,954 printed pages, 25 plates and accompanying maps of 30 counties.* His works contain hundreds of geologic sections and chemical analyses, and a vast store of information regarding the stratigraphy, economic resources, paleontology, botany and natural history of the State, but, in the opinion of the author of his biography† "they contained little that was new or impressive." Their main defect is *repetition*, the same facts regarding the drift, the stratigraphy, the paleontology, the caves and many other subjects being repeated again and again. This was due to the treatment under county headings by a score of assistants, each having his own views which he wished to get before the public. Could the contents of the Cox reports be assorted, assimilated, condensed and, under the proper headings, be republished in one or two volumes, they would furnish a work replete in interest and most valuable as a reference work in our schools and colleges.

After closing his work on the Indiana Survey in 1880, Cox opened an office in New York City as a consulting geologist. He afterward moved to Albion, Florida and became the geologist of a large company engaged in the mining of phosphate. He died in Jacksonville, Florida, Jan. 6, 1907, at the ripe old age of 86 years.

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*The counties mapped were Brown, Clark, Clay, Crawford, Daviess, Dearborn, Dubois, Floyd, Gibson, Greene, Harrison, Jackson, Jefferson, Knox, Lawrence. Martin, Montgomery, Ohio, Owen, Parke, Perry, Pike, Scott, Sullivan, Switzerland, Warren, Wayne, Vanderburgh, Vermillion, and Vigo.

†Smithsonian Miscellaneous Collections, LII, 1910, p. 84.

THE COLLETT SURVEY, 1880-1884.

As has already been noted, the act passed in 1869 established a "Department of Geology and Natural Science" and created the office of State Geologist which Cox filled for ten years. It fixed the salary at $1,800 and appropriated $5,000 per annum, out of which this salary and all other expenses were paid. This appropriation was, in 1873, increased to $8,000 per annum.

For some time there had been a demand that a bureau of Statistics be established in the State. Jas. D. ("Blue Jeans") Williams had become Governor in 1876. He was noted for his frugality, and was opposed to creating a new department. A compromise was finally effected by which the new Bureau was to be combined with that of the already existing Department of Geology, and an act was passed and approved March 29, 1879 "establishing a State Bureau of Statistics and Geology." Those sections of this act which pertain especially to this paper are as follows:

Section. 1.—*Be it enacied by the General Assembly of the State of Indiana,* That a Department of Statistics and Geology is hereby established for the collection and dissemination of information, hereinafter provided, by annual printed reports made to the Governor and Legislature of the State.

Sec. 2.—The Governor is hereby authorized to appoint, as soon after the passage of this act as convenient, and thereafter biennially, some suitable person to act as Chief, who shall have power to employ such assistants as he may deem necessary, and said officer and assistants shall constitute the Indiana Bureau of Statistics and Geology, with headquarters to be furnished by the State; *Provided,* That such Chief of the Bureau of Statistics shall be an expert in the sciences of geology and chemistry.

Sec. 3.—The duties of said bureau shall be to collect, systematize, tabulate and present in annual reports, as hereinafter provided, statistical information and details relating to agriculture, manufacturing, mining, commerce, education, labor, social and sanitary conditions, vital statistics, marriages and deaths, and to the permanent prosperity of the productive industry of the people of the State.

Sec. 5.—The Chief of said Bureau shall be the curator of the geological cabinet, museum, chemical laboratory, apparatus and library, and shall, from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains, and other objects of natural history peculiar to the State and other States and countries.

Sec. 6.—The annual compensation of the Chief of said Bureau shall be twelve hundred dollars, to be paid out of the Treasury of the State, as provided by law for similar expenditures; and in addition thereto, the sum of twenty-five hundred dollars be and the same is hereby annually appropriated out of any funds in the State Treasury, not otherwise appropriated, for two years, to be expended, or so much of it as may become necessary in the discretion of the Chief of said Bureau, in carrying out the purpose of said Department, as herein provided. It shall be the duty of the Chief of said

Department to render annually to the Governor a detailed statement, accompanied with proper vouchers for all moneys expended by him in carrying out the provisions of this act: *And Provided further*, That no greater expenditure of money, or liability therefor, shall be made or incurred by the Chief of said Bureau, or his assistants, than the sum herein appropriated for carrying into effect the provisions of this act.

Here was frugality exemplified to a standstill. For $3,700 per annum for all salaries and expenses, the Chief of that Bureau was expected to carry on the work now done by the Department of Geology, The Bureau of Statistics and the State Board of Health, for section 3 provided that statistical information relating to social and sanitary conditions, vital statistics, marriage, death, etc., should be collected, tabulated, etc. Cox refused to continue the work and on April 25, 1879, John Collett received his commission as chief of the Department of Statistics and Geology for the official term of two years. Collett at first retained G. M. Levette, who had served through Cox's regime, as chief assistant, but, says Collett, on "June 30th, Assistant Levette withdrew, when John T. Campbell was installed in his place as First Assistant with John N. Hurty, Chemical Assistant, and Geo. K. Green, Geological Assistant, on special duty.

The First Annual Report of the new Department was issued in 1880. It was a volume of 514 pages, devoted almost wholly to statistics, the introductory chapter only being headed:

"THE STATE OF INDIANA"

"GENERAL INFORMATION FOR INTENDING IMMIGRANTS AND INVESTORS OF CAPITAL—SOIL, PRODUCTS, STONE, COAL AND NATURAL AND COMMERCIAL ADVANTAGES."

Pages 450 to 496 inclusive were under the heading "Vital Statistics and Sanitary Reports," and comprise the first "Report of the Indiana State Health Commission," now the State Board of Health. This report included a brief paper by E. T. Cox entitled "Influence of Geology upon Local Diseases," from which I quote as follows: "I will at this time call attention to a disease which once prevailed in special localities, and remnants of it may still be found in some parts of the State. I allude to what is commonly called milk sickness. This disease was variously attributed to plants, or the water, or the poisonous exhalations from some mineral substance contained in the soil. The origin of this disease could often be traced to circumscribed limits, and this seemed to favor the theory that it was due to one or the other of the above substances. While employed under the late Dr. D. D. Owen on the geological survey of Kentucky, in 1857, it was made a special point to examine the water chemically for metallic poisons and other substances, and the mineral character of the land where this disease prevailed among the cattle. The localities in that State and at that time were alarmingly numerous, and we were given an abundance of work to do in the analysis of water. Though hundreds of samples were thus examined, in no single instance were we able to detect the presence of mineral poisons in the quantity of water possible to submit to analysis in the field. And the various plants which it was claimed would, if eaten by cattle, bring on the disease, when put to the crucial test, were likewise found to be harmless."

"I am sorry that the notes taken while engaged in this investigation have been mislaid or lost, and cannot be referred to now. The investigation led us to this conclusion, that, though the cause could not be attributed to the vegetation or poisons in the water, that the prevailing formation in the neighborhood of the disease was argillaceous shales—and that the disease was brought about by some form of miasma similar to that which produces chills and ague; in other words, it is zymotic; and that the clay shales, which are microscopic in an eminent degree, had or may have had something to do with its formation."

Colletts' First Report on Geology.

The second volume issued by the Bureau of Statistics and Geology contained 164 pages and 11 plates devoted to the latter subject. Two thousand copies of the portion on Geology, were printed separately, and the work is therefore known as Collett's first report on Geology. Issued in 1881, it contained the results of the geological work done in 1879 and 1880, which, on account of the small sum available, was very little; Collett giving the expenditures for the geological work done in the two years as follows:

Traveling expenses of Chief of Bureau	$65.00
Survey of Monroe County, Mr. Greene	150.00
Surveys in other districts, Mr. Greene	15.00
Drawing figures for Prof. White's paper, Mr. McConnell	65.00
Drawing maps, Mr. Morrison	20.00
Synopsis of Mollusca, Dr. Stein	25.00
Increase of cabinet	50.00
Total	$505.00

In a brief introductory chapter headed "Geology of Indiana," he states that "During the last year a company was organized at South Bend, which has since been engaged in the manufacture of Portland cement from the gray clays and calcareous marls found along the shores of the ancient lakes of St. Joseph County." This was the pioneer Portland cement factory in Indiana, and was the first one in the United States to successfully use marl and clay as the cement ingredients. It was operated on a small scale until 1894, the output never exceeding 20,000 barrels a year, or about one-third the amount produced each day by the large mills now operating at Mitchell, Indiana. Collett gives the results of analyses of the raw materials and the completed product, made by Hurty, together with those of tests showing the tensile strength of the latter, and states that "the tests afford convincing proof that here in Indiana is made a Portland cement fairly rivaling the best foreign brands," a statement which was afterward substantiated by the United States Government, which annually purchased much of the output for use in the arsenal at Rock Island, Illinois.

In this introductory there are two pages devoted to the Mammoth and Mastodon in Indiana, in which it is stated that the remains of 25 mammoths and 30 mastodons had, up to that date, been found in the State. There are also accounts of the excavations of large pre-historic mounds at Vincennes and Worthington, with descriptions and illustrations of the objects found in them.

The first Geological map of the State published in or with any of the reports was a single page one in connections with this chapter. Of it Collett says: "The outline geological map of the State, printed herewith, is upon so small a scale that it must be regarded as merely a rough sketch. It shows, however, with reasonable accuracy, the surface exposures of the rocks of the several geological formations."

Following the introduction, there was a report on the Geology of Putnam County by Collett, and of Monroe County by Geo. K. Greene, each with a double page outline map. In the former is given an account of the quarries, then extensively operated for flags, bridge, dimension and rubble stones at Putnamville, and located on lands now forming a part of the new "Penal Farm." Collett gives an analysis of the stone and a section of the quarry. Since it is soon to be extensively operated by the State, the following paragraph is quoted from his account: "The product has been in use, severely exposed to the extreme vicissitudes of our variable climate, including changes of 60° of temperature in a single day, for over forty years It has shown capacity to resist the action of frosts, fire and ice. Samples, taken as a rule, from the exposed parts of the quarry when first opened in 1838-'40, may be seen in piers, etc., of the bridges and culverts on the National road and in the locks of the canal, the steps of the mother and branch Banks of State, at Indianapolis, and also the steps of the Terre Haute House at Terre Haute, and of the old University Building at Greencastle. As pavement, step stones, and for curbs it is unrivaled. Its quality of hardness renders it desirable for piers and rip-raps exposed to the action of ice and waves."

A "Synopsis of the Molluscous Fauna of Indiana," by Dr. Frederick Stein of Indianapolis follows the report on Monroe County. It gives the names and distribution in the State of 181 species of land and fresh water shells, and was the only check list of the Mollusca of the State available until the one prepared by L. E. Daniels was published in 1903.*

The final paper in the volume is one on Paleontology by Dr. C. A. White of the Smithsonian Institution, and is entitled "Fossils of the Indiana Rocks." It includes full descriptions, accompanied by 11 plates of figures, of a few

*27th Rep. Indiana Dept. Geol. & Nat. Resources, 1903, pp. 629-652.

of the more important species characteristic of each of the great rock formations of the State.

In the introduction of this Second volume, Collett sets forth the needs of the Bureau of Statistics and Geology, and asks that a total of $12,000 be appropriated by the Legislature of 1881; $6,000 for the Division of Statistics; $5,000 for that of Geology and $1,000 for "increase of the State Museum." Hon. Albert G. Porter had been chosen Governor in 1880. A man of education and of progressive tendencies, he understood the need and value of scientific work, and favored, therefore, an increase of the sum appropriated for such purpose. The legislature was responsive, and we find a separation of the Departments of Statistics and Geology, and by an act, approved April 14, 1881, the establishment of a Department of Geology and Natural History, which was as follows:

An Act to Provide for the Establishment of a Department of Geology and Natural History in This State.

(Approved April 14, 1881.)

Section 1.—*Be it enacted by the General Assembly of the State of Indiana*, That a Department of Geology and Natural History is hereby established for the purpose of continuing the geological and scientific survey of this State, of discovering and developing its natural resources, and disseminating information in regard to its agricultural, mining and manufacturing advantages.

Sec. 2.—That the Governor shall appoint a competent and suitable person who shall be skillful in geology and natural science, as State Geologist, and who shall be the Chief of said Department; and said Chief shall have the power and be authorized to call to his assistance such help as he may deem necessary, but in no case to exceed the amount of expenditure authorized by the General Assembly. Said State Geologist, when commissioned by the Governor, shall take an oath of office as other officers, and shall serve for a term of four years; but said State Geologist may be removed by the Governor for cause, and a successor appointed in his stead, and the Governor shall fill any vacancy which may occur from any cause. The compensation of said State Geologist shall be $1,800 per year, which shall be paid as other salaries are required by law to be paid.

Sec. 3.—It shall be the duty of said State Geologist to continue the geological survey of the State, by counties or districts, and to complete and revise the same, as may be practicable. He shall give special attention to the discovery of minerals, stones, or other natural substances useful in agriculture, manufacture or the mechanical arts; he shall be curator of the geological cabinet, museum, apparatus and library, and shall, from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains and other objects of natural history peculiar to this State and other states and countries.

Sec. 4.—The offices of the geological department shall be in such rooms as may be assigned for this purpose and he shall keep such office and the State Museum open during the usual business hours of other offices of the State, when not engaged in field or other work requiring his absence therefrom.

Sec. 5.—The State Geologist shall make to the Governor an annual report of his labors and discoveries, and of all useful information he may have obtained in such service, including such descriptions and figures in geology, paleontology and archaeology as may promote science and aid in the diffusion of knowledge; and 5,000 copies of such report shall be printed and published in like manner as other official reports.

Sec. 6.—An appropriation of $5,000 annually shall be, and is hereby, made for the next succeeding two years, which shall include the salaries of the State Geologist and his paid assistant, and if any part thereof shall remain unexpended, it shall remain a part of the general fund of the State, to be used as other general funds of the State are used.

Sec. 7.—All acts and parts of acts inconsistent herewith are hereby repealed.

We find in this act four facts of importance, viz, (a) the change of name to "Department of Geology and Natural History;" (b) the increase of the length of term of the State Geologist from two to four years; (c) the first recognition of a "State Museum" under that name; (d) an appropriation of $5,000 per annum to carry on the work.

Collett was reappointed State Geologist by Governor Porter, and in his first report of the new department, that for 1881, published in 1882, has the following statement regarding the State Museum: "Additional cases were procured through funds appropriated for geological purposes, in the hands of the State Board of Agriculture and Mr. Geo. K. Greene was engaged to arrange the fossils and specimens in their proper cases. The cabinet, when first received from my predecessor, by actual enumeration, consisted of 8,912 specimens, mostly undressed fossils, generally without labels. At present it embraces, well arranged, properly classified and labeled, 44,424 specimens."

"Doc" Hurty, who was connected with the new department as "special chemist to the Geologist," must have taken an interest in the museum, for on the next page Collett continues: "There is now on exhibition a pretty full set of germs, minerals and crystalline rocks, implements of the 'mound builder,' or stone age, fishes and reptiles of northern Indiana, etc., land and fresh water shells, and beetles; fossils of the coal measures and Lower Carboniferous periods. In fossils of the Lower Silurian, Upper Silurian and Devonian ages, the collection is a nearly complete exhibit of the specimens peculiar to the State, and may not be readily excelled." On second thought, however, we conclude that the printer must have been to blame and put in an "r" where it did not belong.

Second Report of Collett.

As usual, Collett begins the report with a chapter on the general "Geology of Indiana," including a table on the quarry industries of the State, compiled by the U. S. Census Bureau, a chapter on oolitic limestone, with analyses, another embodying the results of the physical tests showing the "transverse strength and elasticity of all building stones" from Indiana and other States, made for the State House Commissioners before letting the contract for the present edifice.

Following these are reports on Shelby County by Collett, Fountain County by R. T. Brown, Delaware County by A. J. Phinney and Bartholomew County by Dr. M. N. Elrod, each accompanied by a double page outline map.

Under Shelby County, Collett describes what he called the "Collett Glacial River," so named by Dr. J. L. Campbell, Prof. of Geology and Civil Engineering in Wabash College, and former president of the Academy of Science, who at that time was also connected with the U. S. Geodetic Survey. He furnished Collett a letter published in the report on Shelby County, giving the main facts regarding this old valley. Of it Collett says: "Crossing the western bounds of Shelby County, this great stream of water and ice-bergs impinges against and is obstructed by the hilly district of Brown and Johnson Counties having an elevation of 400 to 500 feet above the valley, and is deflected south perpendicular to the dip or along the strike of the rocks to the southern boundary of the State at Jeffersonville. This valley is a wonderful exhibition of energy and forces which have ceased to exist. The volume may be estimated by the amount of the erosion, which exhibits a width of five to ten miles, and depth of 300 to 500 feet as measured by the wall-like bluffs of the adjoining high lands. The mighty ships which sailed upon this river sea were silvery bergs of ice, scattering boulders along its shore line, or in its depths as discovered in deep wells in Scott and Clark Counties, its broad eastern pathway indicated by Lower Silurian fossils, found in Ohio and eastern Indiana. Economically it furnished an inclined plane, utilized as the roadway of the railroad from Indianapolis to Jeffersonville" and Campbell closes his letter with the following paragraph: "This wide valley was cut in the otherwise level plane by the mighty river, wide and deep, whose life continued during the melting of the glacier, in the period intermediate between the geologic and the modern, but its tracings furnish an interesting feature in the topography of the State."

In the report on Bartholomew County, Dr. Elrod also devoted two or three pages to this same "glacial valley," he having added the name Valley to the one used by Campbell and Collett.

The last 200 pages of the volume, as well as 55 accompanying plates, are devoted to two papers on paleontology. The first is a reprint of Prof. James Hall's paper entitled "Descriptions of the species of Fossils found in the Niagara Group at Waldron, Indiana,"* with 36 plates. The second is "Fossils of the Indiana Rocks, No. 2" by Dr. C. A. White, with 19 plates, 12 of which were of fossil corals, drawn and engraved but never published by John W. Van Cleve of Dayton, Ohio. The majority of these corals were from the Devonian formation and the most of them occur in the noted bed of that age at the falls of the Ohio near Jeffersonville.

Third Report of Collett.

The next report of Collett, covering the work done in 1882, was issued in 1883. On page 7 he states that "The total number of specimens in the State Museum at the time of last year's report was 44,421. Additions made during the year give at present a grand maximum of over 100,000 specimens, valued by distinguished experts—Prof. Hall, State Geologist of New York, and others—at more than one hundred thousand dollars." This statement is of especial interest when taken in connection with another in the final volume issued by Collett.

The first part of the report contains two short papers of scientific interest. One, entitled "United States Survey and Growth of Timber," explains the system used by the first Government Surveyors of the State, and includes a reprint of the "General Instructions of the Surveyor General to Deputy Surveyors." It may not be known to all members of the Academy that the original township sheets made by these early surveyors are in the land department of the State Auditor's office, and much use was made of them in getting up the maps, accompanying the geological reports issued between 1895 and 1910.

The second paper referred to was by H. W. Beckwith of Danville, Illinois, and is entitled "Indian names of Water Courses in the State of Indiana."

The body of the volume contains Geological reports on the following counties: Newton and Jasper by Collett; Marion by R. T. Brown; Decatur by M. N. Elrod; Jay by David S. McCaslin and Randolph by A. J. Phinney. Following the report on Randolph County, Dr. Phinney has a paper entitled "Catalogue of the Flora of Central-Eastern Indiana," which he designates as the "Alpine or elevated District of the State." It covers Delaware, Randolph, Jay and Wayne Counties, and lists with time of blooming and local distribution 789 species belonging to 370 genera.

About one half of the volume is devoted to Paleontology. There is a continuation of "Van Cleve's Fossil Corals," identified and compiled by Prof. Jas. Hall, with 14 plates; also descriptions of new species of corals by Hall, with 14 plates, and a paper on the Spergen Hill Fossils by the same author with four plates. The final paper is entitled "The Diatoms of the Waters of Indiana," by Rev. G. L. Curtis. It comprises only eight pages of matter pertaining to diatoms in general, and is accompanied by six plates on which are shown figures of 108 species, none of which are described in the text.

*First printed in the 28th Report of the Regents of New York University.

Collett, however, in the introduction to the volume, mentions this paper as follows: "The Rev. Dr. Curtis has given the results of years of careful research in the microscopic study of the animalculae which have their habitat in the potable waters of Indianapolis and vicinity. By these figures every one can see the forms of the animals which it delights his soul to swallow. These drawings have been submitted for criticism to the best experts in diatomacean forms, and are pronounced by them to be good, while the accompanying descriptions and nomenclature are fully up with the advanced knowledge in natural history."

Fourth Report of Collett.

The fourth report of Collett, entitled "The Thirteenth Annual Report of the Indiana Department of Geology," was issued in 1884. It was accompanied by the first colored Geological Map of the State issued by a State Geologist. This was on a scale of nine miles to the inch and showed on the margins a vertical section of the exposed strata of the State, and a horizontal section across the State from Vincennes to Lawrenceburg, near the Ohio and Mississippi (now the B. & O. S. W.) railway. Of this map Collett wrote: "The accompanying geological map of Indiana gives a fair exhibit of the surface geology of the State. It is a compilation of all the labors of my distinguished predecessors and their assistants. Much of the geology of the northern and northwestern areas is given, not accessible before the surveys of Newton and Jasper Counties. The map comprises over one hundred years of labor and study of these devotees to science, as well as the results of thousands of miles of travel with pick and hammer. It is believed that it will be appreciated by our citizens as a chart giving years of study and labor, condensed in a single sheet, and invaluable to teacher, student and citizen."

In the introductory portion of the volume G. M. Levette has an article on the "Fuel Value of Coals," accompanied by tables of 392 analyses of Indiana coals compiled from the reports of Owen and Cox, and 57 analyses of coals from other States for comparison.

This is followed by the usual county reports, viz., Posey County by Collett; Morgan, by R. T. Brown; Rush, by M. N. Elrod; Johnson, by D. S. McCaslin and Grant by A. J. Phinney. These were each and all of the usual type of county reports in the Cox and Collett volumes, and contain nothing worthy of especial mention in this review.

A "Glossary of Terms commonly used in Geological Reports," suggested and largely prepared by Dr. W. T. S. Cornett of Madison, Indiana, follows and ends Part I of the volume.

Part II is devoted to Paleontology and embraces two papers. The first, entitled "Principles of Paleozoic Botany," by Leo Lesquereux, is accompanied by 22 plates illustrating the remains of the more important plants of the coal measures of the State. Collett in an introduction says: "As the greatest riches of the minerals of Indiana lie in its coal beds, which are entirely composed of plants, I have thought it advisable to give an exposition of the vegetable remains, which found in connection with coal beds, indicate the nature of their compounds. The only man deeply versed in that part of Natural History is Prof. Leo Lesquereux, of Columbus, Ohio, who, as an intimate friend and fellow citizen of Prof. Agassiz, was encouraged by him to come to America, and, who, since his arrival here in 1848, has given the most of his time to the study of the fossil plants of North America. His studies, published in numerous State and Government Reports, fill many volumes, and as a Paleontologist, Lesquereux is as widely known in Europe as he is in this country. I have, therefore, proposed to him to prepare for this report a Manual on the Principles of Vegetable Paleontology, and I now offer it to the State as a work which will be of great value to the students and colleges of Indiana, and to those of the United States, and which at the same time may be read with pleasure and profit by all persons interested in the coal beds."

The second paper is a continuation of those of Dr. White on the fossils of the Indiana rocks, this being No. 3. It is entitled "Fauna of the Coal Measures," and comprises 158 pages and 17 plates. Both papers contain valuable introductory matter on the general features of the Carboniferous period, the origin of coal, etc.

Fifth Report of Collett.

The legislature of 1883 failed to pass a General Appropriation bill, and says Collett in his fifth and last report, filed on November 2, 1884, "There has been no public fund for expenses whatever since May, 1883, as the special appropriation of $5,000 per annum ended at that time." He also states that his term of office expires by law in April, 1885. I earnestly urge that such an office should be maintained and filled by a competent man, on whom citizens may call, without money or price, for information as to their mistakes or discoveries, and where those from abroad can obtain information of the wealth and resources of Indiana. This is believed to be more important to the State than additional field work or Paleontological descriptions and discoveries."

Regarding the State Museum he says: "It has constantly increased. Several thousand specimens are in boxes and cases not on the shelves, for want of funds to clean them. These will more than fill the cases when the present Chief removes the contents of the twenty cases which are his private property."

It is well to remember here that he had stated in the 1882 report that the museum contained over 100,000 specimens valued at $100,000. The specimens which he here says were in boxes and cases were mostly duplicates of those on display. When he left the office he took with him the contents of the 20 cases, or the "more than 50,000 specimens" which were added in 1882. These and other withdrawals made before 1895, left a number of empty cases, so that in that year there were probably not over 30,000 specimens, though no actual count or catalogue of them has been made in recent years.

On account of the failure of the appropriation, the report for 1884 was necessarily brief. A reprint of the geological map was made and sent out with the volume. The latter contains what are called "Geological and Topographical Surveys of Hamilton and Madison Counties, by R. T. Brown, and Fayette and Union Counties by M. N. Elrod." Why the word "topographical" was added to the title, unless to fill space in a brief volume, is beyond comprehension.

A small cave was discovered in 1884 near Greencastle, Putnam County, and under the title "University Cave," a description of it is given. Two other brief papers are entitled "Fish Culture in Indiana" by R. T. Brown, and "How to Prepare and Cook Fish and other Animal Food," by E. T. Cox.

"The Drift Deposits of Indiana" by Dr. J. S. Newberry, and a chapter on the "Ohio River Floods of 1884," together with a reprint of the glossary of the preceding report, complete the 122 pages of the first part of the volume.

The second part is made up of a paper entitled "Post-Pliocene Vertebrates of Indiana" by E. D. Cope and Jacob L. Wortman. The names of the authors are a sufficient guaranty of its value. In their letter of transmittal they state that "It has been our endeavors to present in the following list a popular account of each species, detailing at the same time, in cases of extinct ones, whatever legitimate inferences can be drawn in regard to their size, probable habits, range and relations to living allies."

Keys, full descriptions, accompanied by six plates, together with popular accounts of their habits, give much knowledge regarding those strange mammals that moved backward and forward in unison with the advancing and receding glaciers, over the area which we now call Indiana.

It was at this period that politics began to play an important part in the history of the Indiana Geological Survey. Collett, a republican, had first been appointed by Jas. D. Williams, a democrat, and afterward, for four years, by A. G. Porter, a republican. Isaac P. Gray, a democrat, was elected Governor in the fall of 1884, and Collett, when he wrote the last paragraph I have quoted about the State Museum, had evidently seen the "handwriting upon the wall." According to a strict interpretation of the law, the Governor was obliged to choose some one for the place, "who shall be skillful in geology and natural science." Such a person was somewhat difficult to find among worthy democrats in those days, as all of Collett's assistants, who had had experience in the work, were republicans.

The Thompson Survey, 1885-1888.

Maurice Thompson of Crawfordsville, a civil engineer and popular writer of short stories, afterward the author of "Alice of Old Vincennes" and other novels, was finally picked for the place. Regarding Geology and Natural Science, the only writing which he had done up to that date, as far as I can learn, was a small pamphlet entitled "The Redheaded Family," which treated of the habits of our common woodpeckers.

Thompson was appointed in the spring of 1885, and naming three assistants of democratic proclivities, namely, W. H. Thompson, his brother, S. S. Gorby, and Stephen E. Lee, and retaining Phinney and Brown, he began searching for those facts which had remained undiscovered since the days of David Dale Owen.

First Report of Thompson.

Thompson's first report, the "Fifteenth Annual Report of the Department," covering the work done in 1885 and 1886, was issued in the fall of the latter year. In his preface he mentions his discovery of the "Wabash Arch," concerning which Gorby had a special paper in the report. Of it Thompson says: "A few years ago, while engaged in making some preliminary railroad surveys, I noted at a number of points in northern Indiana evidences of a line of disturbance affecting the rock strata across the State, in a direction generally east and west." This supposed upheaval or arch, which was discussed in detail in the next three of four volumes issued by the Department, has been shown by Phinney and Kindle to be a "figment of the fancy." Phinney's conclusions will be given under another heading, and Kindle, writing of it, says: "Many of the dips recorded by the author of this hypothetical arch afford evidence against it. About half of them are east or west dips, while the supposed arch has an east and west axis, which calls for north and south dips and fails to explain the others." On a later page Kindle, in discussing the domes or tilted rocks at Wabash, Delphi and Kentland, which furnished the main evidence on which Thompson and Gorby based their supposed arch, continues: "There is at present no positive evidence as to the nature of the forces which produced these domes. It seems probable, however, that they may be analagous in origin to the 'mud lumps' at the mouth of the Mississippi. The study of these interesting masses of the recently elevated sea bottom shows that they rise up in domes or anti-clinals and preserve their regular bedding. Whatever the cause may have been which produced the Indiana domes, there is clear evidence that they were developed about the close of the Niagara period."*

Thompson began his report proper with what he calls a "Compendium of the Geology and Mineralogy of Indiana," which in his preface he states is aimed "To present in the shortest form a clear outline sketch of all that has been discovered and reported upon by my own corps and by predecessors in office, so that this volume might, in a certain degree, place the student who cannot get the earlier reports, in a situation to fairly understand the geology of Indiana." He followed the custom of his predecessors and continued the survey of isolated counties, his "compendium "of 60 pages being succeeded by reports on the Geology of Tippecanoe, Washington and Benton Counties by

*28th Rep. Ind. Dept. of Geol. & Nat. Resources, 1903, pp. 404-411.

Gorby; Henry County by Phinney; Clinton, Marshall and Starke Counties by W. H. Thompson; Boone County by Gorby and Lee, and Hancock County by R. T. Brown.

These county reports are followed by a paper of especial interest to botanists, and probably the only one of permanent scientific value in the volume, entitled "The Origin of the Indiana Flora," by John M. Coulter and Harvey Thompson. After a discussion of the topographical features of Indiana, they divided the State into "seven distinct botanical regions, each differing from all the others in conditions of soil, moisture and topography and consequently in climate and vegetation." A list of the most characteristic plants of each region was then given. Following these lists is a discussion of the main causes and means of the migration of plants and the origin of the North American flora. This was succeeded by a list of 342 plants common to the northeastern United States and Europe. Of plant migration into Indiana they say: "Lying, as the State does, in the very central northern part of the country, it became the common meeting ground of migrations from various directions. As the glacial times were beginning, and streams of migrations began to set in from the north, the hardy invaders began to take possession of the soil and the more tender natives retired southward before the same conditions. Two distinct streams of northern migration have been made out, one from the northeast, the other from the northwest, the former being the first in point of time and apparently the most important in results. With the coming on of warmer conditions, and the consequent melting and retreat of the glaciers, these arctic plants were compelled to move northward again, some as has been said, finding suitable conditions of growth in our deep valleys or highlands. The more southern forms spread northward again within the State, but never regained the foothold they had lost."

"Plants from the east and south that have since come in, and are still coming to us, have mostly reached us by the great river systems of the Ohio and Mississippi. Plants from the west, the most recent of our invaders, have come chiefly along lines of railroad, most important lines for plant advance. At least five distinct directions have thus been clearly made out from which our plants have come to us. First, from the northeast; second, from the northwest; third and fourth, from the east and south; and fifth, from the west." They then give lists of the species which came in from each of these directions and conclude that of the 1191 plants then known from the State more than four-fifths have a range north and east of Indiana.

In the latter part of the year 1886 Natural Gas was first discovered in Indiana, and the final paper of the Thompson Report was devoted to a discussion of this then little known fuel. Of it Thompson wrote: "The discovery of gas at Findlay and at other points in northwestern Ohio, created a furor for well boring, which ran all over Indiana, and the drill began its work at whatever point money was to be had to pay for the expensive operation. The consequence has been a loss to the citizens of Indiana of many thousands of dollars. The State Geologist was not consulted, save in two or three instances where work had already been begun. Everybody took it for granted that because Ohio had great reservoirs of subterraneous gas, Indiana also possessed them, whereas it is true that of wells bored but a short distance apart, even in the best areas of the Ohio gas region, some are successful while others are utter failures."

While the report was in press gas was struck in Indiana at Eaton, Delaware County, and Kokomo, Howard County, and the paper ends with sections of each well and remarks on the character of the Indiana gas. It also includes a section of the well 2,730 feet in depth put down in the court house yard at Bloomington, Indiana, in search of artesian water.

With the completion of his second report in December, 1888, Maurice Thompson, "on account of continued bad health was compelled to resign as State Geologist," and S. S. Gorby was appointed to fill the vacancy. He edited the report of Thompson, which did not appear until the latter part of 1889. It was accompanied by a colored geological map of the State, based upon the one issued by Collett but showing the various supposed natural gas areas of the State.

Second Report of Thompson.

The volume begins with the usual introductory chapter, in which Thompson mentions that the State Museum had been "transferred to its present rooms in the State House and all the specimens of the vast collection relabeled, rearranged and reset in the new cases." He then adds the following paragraph: "The notion that the chief end of geological study is to collect fossils and classify them should be driven from the mind of every student. Paleontology has its place of practical utility as a sign language by which the rocks impart their secrets to us, and through which we may reach the significance of things otherwise meaningless; but, on the whole, the discovery of a ledge of good building stone is more to be prized than a mine of crinoids or a hill full of trilóbites, pentramites and the rest. The discovery of the potato was of more value to mankind than all the works of Darwin, Huxley, Tyndall and Agassiz combined. Nor is this belittling these great men. It simply means that though one should make plain as day the origin of life it would be as nothing compared with a discovery of cheaper food for the poor and shorter hours of labor for the toilers. Abstract study is for the man and woman of leisure; the concrete is for the busy, earnest worker. The greatest good to the greatest number is a maxim which would force the report of a State Geologist into a practical channel; still the larger part of the literature of even popular science must deal with the technical rather than with the untechnical, and we must depend upon the intelligence of the people to enforce a system of education which shall set the popular thought on a level with enlightened investigation. It is by such means that civilization is broadened and bettered year by year." We see from this statement that Thompson's views were sound as to the chief functions of a State Geologist, and that they differed widely from those of his immediate predecessor and successor in the office.

Thompson followed the introductory, from which I have quoted, with an article entitled "The Drift Beds of Indiana." The numerous bores sunk for gas in 1887 and 1888 had developed a large amount of information regarding the thickness and character of the drift in different parts of the State, much of which he incorporates in this paper.

In a section devoted to the "Wabash Arch" he again sets forth his arguments in favor of its presence, stating that: "Careful study of the rock outcrops and of the sections obtained from gas wells in northern Indiana have fully confirmed the report made by Prof. Gorby in which evidence of a notable disturbance in the Niagara strata was traced across Indiana far into Illinois."

"The name *Wabash Arch* has been objected to by the State Geologist of Ohio, Prof. Orton; but we shall keep it, notwithstanding. If men who claim to be devoting their lives to science would trouble themselves less about the jargon of nomenclature and more about gathering facts, we should see much better progress in the direction of practical scientific success. We have given the name *Wabash Arch* to the upheaval in Indiana, and Wabash Arch it shall be. If Prof. Orton takes away the name, he must take away the upheaval along with it."

A paper on "Fossils and their Value" by W. H. Thompson includes "A Corrected List of the Fossils found at Crawfordsville, Ind." by Chas. Beechler. "An Outline Sketch of the most Valuable Minerals of Indiana" was also prepared by W. H. Thompson, in which he asserts his belief in the theory first set forth by Cox, that the kaolin beds of Indiana were formed by the action of water charged with silicates and alumina upon beds of limestone, and states that "Next to our coals, our natural gas and our building stones, these magnificent beds of kaolin will in the future be the greatest source of our mineral wealth."

Dr. Chas. R. Dryer enters the arena of Indiana Departmental Geology for the first time in this volume, where he has reports upon the Geology of DeKalb and Allen Counties, in which the data obtainable regarding the moraines, and lakes, kames and other features of the glacial formed topography are excellently set forth.

A partial report on Marshall, Starke, Pulaski and White Counties by W. H. Thompson contains many notes of interest, regarding the Kankakee and Tippecanoe Rivers. Of the latter stream he says: "There are many fine streams in the State of Indiana, but not one that can be compared with this river. Its rare beauty, its splendid fishing, the good shooting to be had along its banks, the numberless cold springs that bubble out of the high bluffs, the small green islands that are met at almost every turn of the stream, the clear water flowing over the assorted sand and boulders of the northern drift, or the masses of heavy green grass attached to the bottom and waving in the moving water like a tiny forest in a 'broad and equal blowing wind,' lend a charm against which few hearts are proof."

The present writer has traveled this stream in a row boat from Tippecanoe Lake to its mouth. He has also traveled every other large stream of the State except the Whitewater in like manner. He can, therefore, from actual experience assert that W. H. Thompson was right when he said that no other stream in the State can compare with the Tippecanoe in the variety and beauty of its scenery.

S. S. Gorby the new State Geologist, contributed to the second report of Thompson a paper on the Geology of Miami County; also one on "Natural Gas and Petroleum," and a third on "The Structural Features of Indiana," the last named is based largely upon data obtained from the records of the hundreds of gas wells which had been recently sunk in the State, the object of the paper being to show the approximate depth at which Trenton Rock, the oil and gas bearing formation, would be found in the different sections of the State.

The final paper of the volume is one on paleontology by S. A. Miller and is entitled: "The Structures, Classification and Arrangement of American Paleozoic Crinoids into Families." It includes the characters of the families and genera and descriptions, accompanied by ten plates of figures, of many new species.

Between 1888, the date of issue of Thompson's second report, and 1892, the date of appearance of the next report of the Department of Geology, politics and Geology were badly mixed. Maurice Thompson was evidently wise when he resigned in December, 1888, and we suspect that politics had more to do with his resignation than did the state of his health. As we have noted, S. S. Gorby was appointed by Governor Gray to fill the vacancy.

In the election in November, 1888, General A. P. Hovey, a republican, had been chosen Governor and all the candidates for State office on the republican ticket had also been successful. The Democrats, however, had carried the legislature by a good working majority, and when that body met in January, 1889, it immediately proceeded to make the Governor as much of a nonentity as possible, by taking from him the most of his appointive offices and vesting them in itself. On February 26 it passed, over the Governor's veto, a bill with the following title;

"An Act establishing a Department of Geology and Natural Resources in the State of Indiana, and providing for a Director of the Department; abolishing the Department of Geology and Natural History, and the office of State Geologist connected therewith; abolishing the offices of Mine Inspector and State Inspector of Oils; repealing all laws or parts of laws conflicting with any of the provisions of this act, and declaring an emergency."

Those sections of this act which pertain especially to the office and duties of the State Geologist were in part as follows:

Section 1.—*Be it enacted by the General Assembly of the State of Indiana,* That a Department of Geology and Natural Resources is hereby established for the purpose of continuing and perfecting the geological and scientific survey of this State, of discovering, developing and preserving its natural resources; recommending and securing the enforcement of laws providing for the health and personal safety of all persons engaged in developing or using the products of its natural resources, and collecting and disseminating information concerning its agricultural, mining and manufacturing advantages. The said Department shall comprise four divisions, as follows:

First. The Division of Geology and Natural Science.

Second. The Division of Mines and Mining.

Third. The Division of Mineral Oils.

Fourth. The Division of Natural Gas.

Sec. 2.—The General Assembly shall, immediately after the taking effect of this act, elect a competent and suitable person, skilled in geology and natural sciences, Director of the Department of Geology and Natural Resources, who shall be State Geologist and Curator of the Museum and Chief of the Division of Geology and Natural Science. He shall take an oath of office, as other officers and hold his office for a term of four years, and until his successor is elected and qualified. He shall appoint the chiefs of divisions provided for in this act, and such other assistants as he may deem necessary in prosecution of the work in the Division of Geology and Natural Science, but in no case shall the expenditures under his direction exceed the amount authorized by the General Assembly. The compensation of the Director of the Department shall be two thousand dollars per year, to be paid as other salaries are required by law to be paid.

Sec. 3.—It shall be the duty of said Director to continue the geological survey of the State, by counties or districts, and to complete and revise the same as may be practicable. He shall give special attention to the discovery of minerals, stones or other natural substances useful in agriculture, manufacture or the mechanical arts. He shall be curator of the Geological Cabinet, Museum, apparatus and Library, and shall, from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains and other objects of natural history peculiar to this State and other States and countries. He shall also have general supervision of the work in the several divisions herein provided.

Sec. 4.—The offices and Museum of the Department shall be in the rooms now occupied by the same in the State House, and the same shall be kept open during the usual business hours of other offices of State, except when the Director may be engaged in field work or other business requiring his absence.

Sec. 9.—The Director of the Department shall make to the Governor an annual report of his labors, together with the reports from the various divisions, including all discoveries and useful information he may have obtained in such service, including such maps, figures and descriptions in geology, paleontology and archaeology as may promote science, and in the diffusion of knowledge, and assist in advertising the natural resources of the State; and eight thousand copies of such reports shall be printed and published in like manner as other official reports."

From the title and from the first two sections quoted it will be seen, that for political reasons only the name of the Department was changed, that the legislature took upon itself the appointment of State Geologist and changed his title to "Director of the Department." It also took from the Governor, by abolishing their offices and creating new ones under different names, the appointments of State Mine Inspector and State Supervisor of Oils. It gave the appointments of these officers to the State Geologist and at the same time created (by a section of the act not quoted) the office of Inspector of Natural Gas, the filling of which it also vested in him.

On the next day after the passage of the act, the legislature appointed Gorby State Geologist for a term of four years, and he immediately appointed the heads of the new divisions provided for in the law.

Governor Hovey refused to recognize the validity of the act as passed and in May, 1889, appointed John Collett as State Geologist; Gorby having possession, refused to give up the office and the matter went to the courts. It seems to have been pushed through rapidly, for in November, 1889, we find a decision of the Supreme Court* in which that august body held that the legislature had no power to create an office and then fill it; that when created the office must be filled either by appointment by the Governor or by some other State officer designated by the legislature, and if that body did not so designate the appointive power, the office must be filled by an election by the people; that in creating the office of "Director of the Department of Geology" and then attempting to fill it unconstitutionally left the office vacant without an appointive power being designated, and that the Governor had the right to fill the vacancy until the next general election. It held, moreover, that the office of State Geologist was an administrative one and therefore should, according to the constitution, be elective and that the act of 1889, aside from the clauses taking from the Governor the power to fill the vacancies when the offices were created, was valid and would stand as law.

By that decision and not by any act passed by the legislature the office has continued to be and is to-day an elective one, and Indiana is the only State in the Union, and we believe the only country on earth where a Geologist is so chosen. For some unexplained reason Collett did not attempt‡ to take over the office, and the case was kept in court by Gorby's lawyers until the next summer, when there was a further decision by the supreme court on some minor points. Meanwhile Gorby had been nominated by the democrats for State Geologist for a term of four years, and our worthy brother member, John M. Coulter, had received the nomination from the republicans. The people of the State, in November, 1890, turned John M. down and Gorby continued to hold the office and draw the salary.

*The State ex. rel. Collett vs. Gorby. Supreme Court Rep. 122, p. 17.

‡John Collett died at Indianapolis March 15, 1899, aged 71 years. He was a graduate of Wabash College in the class of 1847, and received from his Alma Mater a Ph. D. degree in 1879. He was elected a State Senator in 1870, and was appointed a State House Commissioner in 1878.

The Gorby Survey, 1889-1894.

Since politics and not rocks had been the chief subject of discussion in the interim, it was four years between the issue of the sixteenth report, the last one put out by Thompson, and the seventeenth, the first one published by Gorby. The latter was a volume of 705 pages without an index. The usual introduction is followed by a paper of 96 pages entitled "A Report upon the various Stones used for Building purposes and found in Indiana," by Maurice Thompson who, in spite of his health, continued to act as chief assistant. One half of the paper is given to detailed statistics of the quarries of the State. Reports upon the geology of Steuben and Whitley Counties by Chas. R. Dryer, Carroll County by Maurice Thompson and Wabash County by M. N. Elrod and A. C. Benedict follow in the order mentioned. The report on Steuben County includes "A Partial Catalogue of the Flora of the County," by E. Bradner, 729 species being mentioned.

These county reports are followed by those of the State Inspector of Mines, the State Supervisor of Oils and the State Supervisor of Natural Gas, these officers having been made appointees of the State Geologist during the political turmoil of the past four years.

As crude petroleum had been discovered in paying quantities in the Trenton Rocks of Indiana in 1891, there is a short paper entitled "Petroleum in Indiana," by A. C. Benedict, in which the facts regarding the discovery are set forth and the history of petroleum from the earliest time treated somewhat in detail.

The reports of these officers are followed by two papers of interest to the zoologist. The first, "A Catalogue of the Butterflies known to Occur in Indiana," was by the present writer. It comprised 44 pages in which 108 species were listed, with synonymy and notes on distribution and life habits. In the quarter of a century that has passed, but three additional species have been recorded from the State.

"The Batrachians and Reptiles of the State of Indiana," by Dr. O. P. Hay, then Professor of Zoology in Butler University, was a more extended paper, comprising keys, full descriptions and life histories of all the known Indiana species of this interesting group of vertebrates.

The final paper on paleontology is by S. A. Miller. It is devoted wholly to the descriptions of new species from Indiana, Missouri and other states, and is accompanied by 20 plates. The author must have had as much trouble in finding new names for his species as does the Pullman Company at the present time for its sleeping cars, as 13 are named *gorbyi*, five *benedicti*, three *colletti* and nine *indianaensis*.

Second Report of Gorby.

The second volume issued by Gorby appeared in 1894 and contained 356 pages and 12 plates. In it Dr. Chas. R. Dryer, published the results of his work in 1893 upon the Geology of Noble and LaGrange Counties, and also a paper entitled "The Drift of the Wabash-Erie Region," accompanied by a map of the "Drift Deposits of Northeastern Indiana." This is a summary of the results of his study of the drift in the six counties surveyed by him for the Thompson-Gorby reports, viz., Allen, DeKalb, Whitley, Steuben, Noble and LaGrange, in the order mentioned. Taken as a whole, the work of Dryer as set forth in these reports is the most accurate and valuable exposition extant of the great drift region of northeastern Indiana.

The report on Noble County was accompanied by a paper on the flora of the county by W. B. Van Gorder, which lists, with notes on local distribution, 724 species, representing 363 genera.

Another paper in the volume of value at the time it appeared, especially to those interested in the search for Trenton Rock gas and oil, is that of E. P. Cubberly, entitled "Indiana's structural Features as Revealed by the Drill." From the records of hundreds of bores put down in the State in search of these bitumens, Cubberly prepared 16 colored sections on a horizontal scale of 30 miles and a vertical scale of 500 feet to the inch, each crossing a different portion of the State. Each section showed the relative depth and thickness of each of the geological formations of the State at certain points along its course, and thus enabled one to determine the different elevations or depressions of the Trenton Rock referred to sea level.

The final paper, as usual, was by S. A. Miller, on paleontology. It was illustrated with 12 plates, and descriptive wholly of new species of different families of fossils, many from outside the State. Seven were named in honor of Gorby, four after Greene and three each after Benedict and Collett.

Third Report of Gorby.

During his six years' service as State Geologist, Gorby issued but three reports. The third, which appeared in 1894, contains 296 pages, and comprises a paper on the "Geology of Cass County" by Elrod and Benedict, the reports of the Inspectors of Mines, Gas and Oil, and a paper of 150 pages entitled "The Lampreys and Fishes of Indiana," by Dr. O. P. Hay. The latter was a valuable contribution to the zoological literature of the State, giving keys, full descriptions, distribution, feeding habits and food value of the 150 species of lampreys and fishes found in Indiana.

Miscellaneous Work From 1869 to 1910.

Before taking up the work accomplished by the Department of Geology from 1895 to date, we will mention briefly some of that done in the State by individuals not connected with the Department, between the beginning of the Cox Survey and 1910. The papers published during the first ten years of this period were mostly archaeological rather than geological in nature. One entitled "Mounds at Merom and Hutsonville on the Wabash," by F. W. Putnam, appeared in the Proceedings of the Boston Society of Natural

History for 1872, and contains a description of the remains of the "Fort Azatlin" of Collett, a prehistoric fortification on the river bluff at Merom, Sullivan County. It encloses five small mounds and 45 large circular depressions or pits, varying in width from ten to thirty feet. These, says Putnam, "were the houses of the inhabitants or defenders of the fort who were probably further protected from the elements and the arrows of assailants by a roof of logs and bark or boughs." Other interesting details of the fort are given, as well as a diagram showing its outlines and the location of the enclosed pits and mounds.

In 1873 there was published in the Annual Report of the Smithsonian Institution a paper on the "Antiquities of Knox County, Indiana and Lawrence County, Illinois," by A. Patton, in which he describes excavations he made in three large artificial mounds near Vincennes, Ind. He calls them "three of the most beautiful mounds in the West," Sugar Loaf being 70 feet high and 1,000 feet in circumference at base, Pyramid 43 feet high and 714 feet in circumference and North mound 36 feet in height and 847 feet in circumference. Besides numerous skeletons and a few arrow heads, he found many varieties of small shells," some of the specimens having no living representatives in this locality or any climate as far north as this, which indicates either that the mounds were constructed when the locality enjoyed a warmer climate than now, or that the shells were brought from the south. From the numerous small mounds in the vicinity he concludes that "The beautiful little valley in which Vincennes now stands was doubtless once the site of a great city occupied by the mound builders, and their villages and farms were scattered over the country as ours at present."

The Smithsonian Reports of 1881 and 1882 also contain papers on the mounds and earthworks of Vanderburgh and Franklin Counties by S. Floyd and G. W. Homsher.

Dr. T. W. Chamberlain, the well known head of the Department of Geology in Chicago University, published, between 1881 and 1884, several noteworthy papers in the Annual Reports of the Director of the U. S. Geological Survey and in the American Journal of Science, in parts of which he gave the results of studies he had made on the moraines and other drift deposits of Indiana. In the principal one of these papers, entitled "The Terminal Moraine of the Second Glacial Epoch," he describes in detail two moraines which are prominent in Indiana. The first one he calls the Moraine of the Lake Michigan Glacier, 200 miles in length and 90 to 150 miles in width, shaped like an immense U, embracing the great lake between its arms, the southern extremity of the U crossing Lake, Porter and LaPorte Counties, Indiana. The second he termed the Moraine of the Maumee Glacier whose southern boundary crosses the State through Parke, Montgomery, Putnam, Morgan, Bartholomew and Fayette Counties. In describing the latter he recognizes Collett's "Glacial River," mentioned in the second report of Collett, stating that it "was one of the great avenues of discharge from the ice border, and has left its record in broad belts of gravel gathering into a great trunk stream."*

In April, 1881, the legislature passed an act providing for a survey of the Kankakee region, and Dr. John L. Campbell of Wabash College was appointed by Governor Porter as Chief Engineer. He began the field work in July, 1882, with John M. Coulter, Albert B. Anderson‡ and Alfred R. Orton as chief assistants. The results of his work are set forth in a pamphlet with accompanying map, published in 1883, entitled "Report upon the Improvement of the Kankakee River and the Drainage of the Marsh Lands in Indiana." He found that the difference in level between the source in St. Joseph County and the point where it leaves the State, a distance of 77 miles as the crow flies, or 240 by the meanderings of the stream as it was then, was but 97.3 feet, or a fall of but 1.3 feet to the mile in a straight line or only 5 inches to the mile along the line of flow and that in August, 1882, at average low water, the volume of discharge at the State line was 1,271 cubic feet per second, while during the spring floods it is estimated at 25,000 cubic feet per second. The area drained by the river and its tributaries in Indiana is over 1,600 square miles, or approximately one million acres. As a result of his survey he reported that "The drainage and recovering of the Kankakee marshes will include (a) the construction of a better main channel than now exists for the flow of the river; (b) the straightening and deepening of the beds of the streams which flow into the main stream; (c) the digging of a large number of lateral ditches through the swamps to the improved channels. The portion of the work which seems properly to belong to State and National Supervision is the improvement of the main stream. The other parts of the work may be left to the owners of the land, to be executed under our general drainage laws." He estimated the cost of reclaiming the marsh lands under the plans proposed at that date, as about $315,000, or less than $2.00 an acre for the 160,000 acres which would be drained.

In 1884 there was published under the auspices of the Western Reserve Historical Society a paper of 86 pages entitled "The Glacial Boundary in Ohio, Indiana and Kentucky," by Prof. G. Frederick Wright of Oberlin College, Ohio. In this paper there was a map showing for the first time the southern limits of the glacial drift in Indiana, though they had been approximately set forth the year before by Dr. Chamberlain in his paper on terminal moraines. In the opening paragraph Prof. Wright says: "When, ten years ago, I began my investigations concerning the kames of the Merrimac valley in Eastern Massachusetts, I little thought to what it would lead; and, after having traced the boundary of the glaciated area from the Atlantic Ocean to the southern part of Illinois, I am equally in doubt as to what the future has in store in this most interesting line of exploration." Of the glacial boundary in Indiana he says: "The boundary line enters Indiana from Kentucky a little below Aurora. In Indiana the line still continues to bear in a southerly

*Third Ann. Rep. U. S. Geol. Surv. 1883, p. 333.
‡Now Judge of the Federal Court at Indianapolis.

direction through Ohio and Jefferson Counties, grazing the edge of Kentucky again opposite Madison and reaching its southernmost point near Charleston, in Clark County, Indiana. From here it bears again to the north through Scott and Jackson Counties to the line between Bartholomew and Brown and follows this to the northeast corner of Brown. There again it turns to the southwest, touching the northeast corner of Monroe, where it again bears north for ten miles, to near Martinsville in Morgan County. Here again the line turns west and south, passing diagonally through Owen, Greene, Knox and Gibson Counties, and into Posey as far as New Harmony, where, for the present, I have left it." Farther on he says: "Everywhere over the glaciated region the till, or ground moraine, has been forced like putty into the gorges formed by the erosion of pre-glacial streams, so that nothing is more common throughout this region than to find that the old channels have been buried, and the streams forced to flow in new channels of modern date." Several of these old preglacial channels are in eastern Indiana and were discovered and their courses traced for scores of miles, during the boring for gas and oil between 1888 and 1910.

In 1890 this pamphlet by Prof. Wright, illustrated, much enlarged, and with an extended introduction by Dr. Chamberlain, was published as Bulletin No. 58 of the U. S. Geological Survey. Prof. Wright had in the meantime traced the boundary line of the glacier across Illinois to the Mississippi River, and in this bulletin he describes in detail the character of the drift in each of the Indiana counties which the boundary line crosses.

In 1886, Dr. J. C. Branner, then Prof. of Geology in Indiana University, published a small colored geological map of the State.

The "Hoosier Mineralogist and Archaeologist," a small magazine published in Indianapolis in 1885 and 1886, contained a number of short articles of interest on the mounds of Decatur, Rush and other counties. There were also two on the "Archaeology of Wyandotte Cave," by Rev. H. C. Hovey. In the January, 1886, number of this magazine there is an account of the first annual meeting of the Indiana Academy of Science.

Between 1882 and 1891, C. S. Beechler, of Crawfordsville, published in the American Geologist, several papers on the "Keokuk Group," giving notes on stratigraphy, lists of fossils found near Crawfordsville, etc.

The discovery of gas in Indiana in 1888 and petroleum in 1891, furnished a theme for a number of papers which treated of these bitumens. One of the first of these was by Frank Leverett, who has since become noted as a student and authority on glacial geology. It appeared in the American Geologist for July, 1889, was entitled "Studies in the Indiana Natural Gas Field," and gave records of the numerous bores first sunk for gas in Indiana, with conclusions based thereon. He gave the approximate outlines and general trend of the "Cincinnati Anticlinal," stated that there was "probably an axis of upheaval running from Royal Center west to Kentland," and suggested the possibility that thorough exploration "might bring to light one or more profitable oil fields in Indiana."

In 1889 there appeared from the pen of Edward Orton, then State Geoogist of Ohio, a notable paper of 188 quarto pages* and seven maps and sections, entitled "The Trenton Limestone as a Source of Petroleum and Natural Gas in Ohio and Indiana," in which he discussed in detail all theories respecting the origin of gas and petroleum, and gave the early history of the Ohio and Indiana fields, accompanied by a colored double page map of the then producing areas. He described fully the geology of the formations in which gas and oil were found, giving especial attention to the Trenton limestone and to the geological structure of the Cincinnati uplift or "Cincinnati Axis" of Newberry, a great broad anticline which, beginning in Tennesee and Kentucky, extended north and north-westward through southwestern Ohio and eastern Indiana and is supposed to have had much to do with the general distribution of petroleum in the Trenton rock area of the latter State.

In his remarks on the Indiana gas field as then known, Orton wrote: "The heart of the Indiana gas field, as has been shown, is in six counties, viz.: Delaware, Blackford, Madison, Grant, Howard and Hamilton. These counties embrace an area as fertile and beautiful as any of equal extent in the noble state to which they belong. Wealth has been rapidly accumulated in them from agricultural sources since the country was first occupied. Thriving towns have sprung up; manufactories have been established on a large scale. It is not often that great mineral wealth is directly associated with great agricultural resources, but in this case the wonderful stocks of power that have so recently been discovered are added to regions that were already preeminent for the wealth of their soils and forests. These favored districts ought to reap an enormous advantage from the addition that has thus been made to their resources. *To this end it is necessary that they speedily learn the real nature of their newly discovered sources of power and speedily introduce a wise economy in the use of the same.* A vandal-like waste has characterized the early exploitation of most of the subdivisions of the field."

Thus as early as 1889 did Edward Orton, one of the greatest of the Geologists of the Central-west, warn the citizens of the Indiana gas field of the danger of the waste. Did they heed that warning? Never! During the next six years they came to believe that they had the world by the tail. They were the discoverers—the owners, the users, the wasters of a fuel supply which, in their opinion, would never fail. The boom of the gas belt days! Who that lived there then will ever forget it? Flambeaux lighted the highways and byways by night so that they gleamed more brilliantly than the "broadways and brightways" of the Hoosier capital to-day. Crossroad hamlets of a score of inhabitants came to count their citizens by the thousand. Villages and towns of a few hundreds grew into cities of thirty thousand. Factories by the hundreds were induced to locate, the promise of free gas which should be perpetual being the lode-star which attracted them from far

*Eighth Ann. Rep. U. S. Geol. Survey, 1889, Pt. II, pp. 475-668.

and wide. The wild-catter and the oil and gas producer, urged on by the town-site promoter, and the city lot speculator, continued to delve deep into the depths of the Hoosier State in search of those riches of stored power, there hidden since the sun gave up its heat and light to the plant cells of the old Silurian seas. With their iron drills they sunk for gas alone in fifteen years, twelve thousand vents to the Trenton rock. Through these there poured natural gas valued, even at the extremely low price at which it was sold, at $81,213,911. So greedy were they, so ignorant of the real value of this gaseous fuel and the manner of its formation, so reckless in its consumption, that at the end of a quarter of a century there remains only the dregs of the plenty that has been.

One of the most valuable and extensive papers ever published on Indiana gas was the one entitled "The Natural Gas Field of Indiana," by Dr. A. J. Phinney, then of Muncie, who had been an assistant on the State Survey under Thompson and Gorby. It appeared in 1891 in the Eleventh Annual Report of the U. S. Geological Survey, and contained an introduction by W. J. McGee on "Rock Gas and Related Bitumens," in which he says: "When exploitation for gas began in Ohio, in 1886, the geologist literally sat at the feet of the prospector, gathering such crumbs as fell from his hands, and found himself utterly unable either to guide efforts or to predict results. Less than two years later the laws governing the distribution and accumulation of gas and oil were so fully developed that the rock gas problem claimed a solution as satisfactory as that of the well known artesian water problem; and to-day the geologist predicts the success or failure of a prospect bore for gas or oil about as readily and reliably as he can prognosticate artesian water or coal."

With all due respect to the opinion of Dr. McGee we must consider the latter part of this statement strongly overdrawn. If the supposed gas or oil field be in a hilly or mountainous country where the outcrops and anticlines can be readily traced it is probably true, but if in a comparatively level country or in one in which the surface is deeply covered with drift, the geologist cannot accurately predict the success or failure of any bore unless it be in a partly developed field, where he has been able, by a series of accurate surface levels to trace the trend and width of the anticline of the productive formation. Even then the texture of the producing rock may vary greatly and cause many wrong predictions. Had the statement of Dr. McGee proven true, the great majority of working geologists in the United States would have long since adopted petroleum geology as a specialty and would be no longer concerned about the high cost of living.

Continuing, Dr. McGee says: "The solution of the problem of rock gas and petroleum marks an era in science no less than in industry. Millions of dollars were probably spent by prospectors in gathering data, but the credit for the solution of the problem belongs chiefly to three individuals: I. C. White of the University of West Virginia; Edward Orton, State Geologist of Ohio, and A. J. Phinney, a practicing physician and amateur geologist of Indiana."

Dr. Phinney's paper of 126 quarto pages was accompanied by a colored geologic map of the State on a scale of 20 miles to the inch, showing the outlines of the principal formations and the area of the then known gas field, and also by a Hypsographic map on the same scale showing the approximate distance above or below sea level of the Trenton rock or gas producing rock in all parts of the State. He treats his subject under the following chapter headings: "History of the Investigation;" "Geologic Structure of Indiana;" "Conditions of Gas Accumulations;" "Gas Pressure and Measurement;" "The Gas Field and the Borings within it;" "Record of Borings outside the Gas Field," and "The Care of Gas Wells."

Under the head of Geologic Structure he showed the fallacy of Gorby and Thompson's supposed "Wabash Arch," stating that the "phenomena which have given rise to the hypothesis of its existence are to be attributed to the building up of coral reefs and rocky prominences or to inequalities in the sea bottom," and that, "in view of the supposed bearing of this hypothetic arch upon the gas supply of northern Indiana, it seems well to emphasize the fact that the supposed axis of upheaval is at its nearest point ten miles distant from the most northerly point where gas has been found in paying quantities."

In 1896 Frank Leverett published in the Seventeenth Annual Report of the Director of the U. S. Geological Survey an extended paper, accompanied by six colored, double page maps, entitled "The Water Resources of Illinois, in which he gives considerable data relating to western Indiana, especially that portion drained by the Kankakee and Wabash Rivers and their main tributaries. He calls the first map a "Topographic Map of Illinois and Western Indiana," the contour lines shown on the Illinois portion being omitted from the Indiana side for obvious reasons. He includes also a "Map of the Pleistocene Deposits" covering the same territory on which is shown the area covered by each of the more important divisions of such deposits as "glacial ridges," "till plains," "loess covered till," etc. The drainage area of the Kankakee River is given as 5,302 square miles, of which 3,207 are in Indiana. The river itself is "remarkably regular in its flow, because of the great marsh along the first 90 miles of its course through which it flows and which acts as a storage reservoir and constant feeder for the lower course." A third map shows the "Geologic formations of Illinois and Western Indiana," the Indiana portion being based upon "Phinney's map" of 1890, while a fourth map he designates as a "Hypsographic Map of the St. Peter Sandstone showing the distribution of Artesian Wells and Deep Borings," the data regarding the Indiana wells shown being given in an accompanying table.

In 1897, Leverett published a similar paper entitled "The Water Resources of Ohio and Indiana,"* that portion devoted to the latter State being the most

*28th Ann. Rep. U. S. Geol. Survey, 1897, pp. 419-559.

complete monograph as yet issued on its streams, deep wells and other sources of the water supply. In a chapter on the physical features of the two states, he gives the mean altitude of Indiana as estimated by Henry Gannett to be 700 feet above tide, but 2,850 square miles of the State being above the 1,000-foot contour and but 4,700 below the 500-foot contour. He states that "the large area of Devonian shale in northern Indiana, though covered now with a drift to a height of 200 to 400 feet above Lake Michigan, has a rock surface about as low as the lake level."

Indirectly he eliminates the "Collett Glacial River theory of Campbell, Collett, Elrod and Chamberlain in the following words: "The Knobstone or Waverly formation on the west border of the basin occupied by the Devonian shale has an abrupt and nearly continuous relief of 300 to 400 feet, with occasional knobs 500 to 600 feet above the basin. This escarpment is so abrupt in the unglaciated districts from Brown County southward to the Ohio River as to resemble a river bluff and it is but natural that this feature, taken in connection with the rapid descent from the Niagara to the Devonian shale on the east border, should have led some of the earlier students to consider the low tract occupied by the Devonian shale to be due to a large river."

A full discussion of each of the great drainage systems of the State is given with data regarding the length, depth, gradient, rock floor and other features of each of the larger streams. In one place he says that "arrangements are being made by the U. S. Survey for a special investigation of the water powers of Indiana," but such investigation has not as yet come to pass. The statement that "It has long been known that the Wabash once received the drainage from the portion of Indiana now tributary to Lake Erie, the channel connecting the Maumee with the Wabash being still a plainly marked feature along the Wabash railway from Fort Wayne to Huntington," recalls David Dale Owen's remarks, made in 1837, regarding this fact.

The average fall of the Wabash is given as 16½ inches per mile, and its approximate length 500 miles, while the west fork of the White, with a length of 275 miles has a fall of three feet to the mile. He does not give the measurement of the stink which is now the most noticeable phenomenon along the course of the latter stream between Indianapolis and Gosport.

Valuable information is given in the paper regarding the deep-well water supply of each of 57 cities and towns of the State, Tables, including data, regarding the supply of those cities and towns which use surface water from streams, lakes or shallow wells are also given; the analysis of the water being shown in a number of instances. The paper is accompanied by three double page colored maps showing respectively the topography, the geologic formations and the pleistocene deposits of the two states.

In 1899 this paper on the "Water Resources of Indiana" was followed by two supplemental papers* by Leverett entitled "Wells of Northern Indiana," and "Wells of Southern Indiana," in which much additional detailed information, especially regarding shallow wells in the country regions, is given.

*Water supply and Irrigation papers of the U. S. Geo. Surv., Nos. 21 and 26.

There was issued by the Chicago Academy of Science* in 1897, an illustrated paper by Leverett entitled "The Pleistocene Features and Deposits of the Chicago Area," which includes much valuable information regarding the drift topography of the northern portions of Lake, Porter and LaPorte Counties, Indiana. Full details are given regarding the Valparaiso Moraine, which "consists of a more or less complex belt of the Wisconsin Drift Sheets and receives its name from the city of Valparaiso, Porter County, which is situated on its crest." The old beaches of the southern end of Lake Michigan are also fully described and much information given concerning the present beaches of the lake and the dune area along its border.

Another paper by Leverett, issued in 1899 as Monograph XXXVIII of the U. S. Geological Survey and entitled "The Illinois Glacial Lobe" is invaluable to all students of the glacial geology of Indiana. It is a quarto volume of 817 pages, with 24 maps and plates, which discusses in detail the drift deposits of the first invasion of a great ice sheet which "extended south and southeast to the unglaciated tracts of southern Illinois and southern Indiana." The border line of the drift is traced in detail over its tortuous course across Indiana and colored maps showing the glacial boundary and present drainage of southwestern and south-central Indiana are included.

The Valparaiso Moraine system which, as already noted, covers a portion of northwestern Indiana, and the old "Glacial Lake Chicago," a large extinct lake of the same area also receives much attention in this volume.

In 1902 Geo. H. Ashley, then connected with the U. S. Geological Survey, published‡ a paper on the "Eastern Interior Coal Field," which was accompanied by two double quarto-page colored maps showing the exact boundaries of that field which comprises the coal areas of Indiana, Illinois and northwestern Kentucky. Of the field he says: "It is estimated to have a total area of 46,000 square miles, of which 6,500 occupying parts or all of 26 counties, lie in Indiana, 35,000 in Illinois, and 4,500 in Kentucky." Accounts are given of the stratigraphy of the coal-bearing rocks and the general structure of the field, which "is that of an elongated basin whose lowest portion is in southeastern Illinois, toward which the strata dip from every direction. * * * The dip in Indiana averages about 24 feet to the mile running up to 100 feet to the mile in a few places."

There are also sections devoted to the number and extent of workable beds and the character of the coal in each State. He says that in Indiana "Coal has been found at 20 horizons, as many as 17 beds having been struck in a single drilling within a vertical distance of 800 feet, most of them being thin, but beds sufficiently thick to be workable occur at eight different horizons, though as a rule not over three are workable at any one point."

The U. S. Geological Survey in 1882 began the making of parts of a topographic map of the entire United States. This map is published in atlas sheets of widely scattered areas. Each sheet is of convenient size, 20 x 16½

*Bull. No. II of the Geol. and Nat. Hist. Survey.
‡22nd Ann. Rep. U. S. Geol. Surv. 1902, pp. 265-305.

inches, and is bounded by parallels and meridians. Each four cornered division of land, corresponding to an atlas sheet, is called a "quadrangle," and the scale used is usually two miles to an inch. On these sheets are shown three groups of features: (1) *water*, including streams, lakes, ponds, canals, etc. (2) *relief*, shown by contour lines of mountains, hills, valleys, etc.; (3) *culture* or works of man, as towns, cities, roads, railroads, etc. This topographic sheet is the base on which the facts of geology and the mineral resources of the quadrangle are represented. The topographic and geologic maps of a quadrangle are finally bound together and with descriptive text, form a folio of the "Geologic Atlas of the United States."

In 1902, the first one of these completed folios, treating of a quadrangle wholly within the State of Indiana, was issued.* It treated topographically and geologically a quadrangle of 938 square miles in southwestern Indiana and included nearly the whole of Pike County and considerable portions of Gibson, Vanderburgh, Warrick, Spencer and Dubois Counties. It was called the Ditney folio, since the quadrangle included the Ditney Hills, which are a prominent topographic feature in the southwestern part of the area covered. The general and pleistocene geology of the Ditney folio were worked out and mapped by Myron L. Fuller, and the economic geology by George H. Ashley. Both are given in great detail and the folio furnishes a permanent and most valuable reference work on the area covered.

Another notable work on glacial geology was issued by Frank Leverett in 1902.‡ It is a quarto volume of 802 pages and 26 maps and plates and is entitled "Glacial Formations and Drainage Features of the Erie and Ohio Basins." He includes much information of interest and value on the Illinoian drift of southeastern Indiana, on the early Wisconsin drift of the same region, on the drainage systems of the State and on the great Glacial Lake Maumee, a portion of which once extended into northeastern Indiana and drained into the Wabash River. One valuable feature of the volume is a Bibliography of Glacial Geology of the U. S. brought down to the year 1900.

A second folio of the U. S. atlas was issued in 1904 which covered a quadrangle of 938 square miles in southwestern Indiana and southeastern Illinois, and included the greater parts of Vanderburg, Posey and Gibson Counties in the former state. It is called the Patoka folio, after the town and river of that name in Gibson County. The area covered adjoins that of the Ditney folio on the west and takes in the cypress swamp area of southwestern Knox County. The geologic work was done by M. L. Fuller and F. G. Clapp. Very full notes on the glacial economic geology of this region are given, and it also includes a list, with measurements, of the larger trees and shrubs

*In the making of these quadrangle maps and folios the U. S. Survey properly ignores all state and county boundaries. A folio put out in 1900, and known as the Danville folio, included a narrow strip along the western side of Warren and Vermillion Counties, Indiana, and a second, known as the Chicago folio, issued in 1902, comprised a part of the northwestern corner of Lake County.

‡Monograph XLI, U. S. Geol. Survey.

of the area, this being in large part compiled from the writings of Dr. J. Schneck and Robert Ridgeway.

In addition to the Ditney and Patoka folios, the U. S. Survey has to date completed the topographic map sheets of twelve quadrangles in southwestern Indiana, the region covered comprising parts or all of most of the coal measure counties south of the National Road. The names of these quadrangles, each of which covers about 930 square miles, are as follows: Clay City, Vincennes, Petersburg, Princeton, Boonville, Haubstadt, Velpen, St. Meinrad, De Gonia Springs, Mt. Carmel, New Harmony and Owensboro. They have also issued topographic sheets of the Bloomington quadrangle* which covers the western half of Monroe, southeastern corner of Owen and the eastern third of Greene County, and in northwestern Indiana the Tolleston quadrangle covering the northern third of Lake County and a portion of the southern end of Lake Michigan. It is presumed that the folios of these respective quadrangles will be issued as fast as the geologic work on them is completed.

The above constitute the more important papers relating to the geology and archaeology of Indiana published outside the State Reports between 1869 and 1910. Other short ones of minor importance published before 1893 are mentioned by Marsters and Kindle in their "Geologic Literature of Indiana (Stratigraphic and Economic)," a bibliographic paper published in the Proceedings of the Academy for 1893. A number have also appeared in the different volumes of the U. S. Geological Survey and the Proceedings of the Indiana Academy, where they can be readily found by anyone interested.

The Blatchley Survey, 1895-1910.

In April, 1894, the present writer, then serving as the "Head of the Department of Science in the Terre Haute High School," was chosen in the State Convention from a field of four as the candidate for State Geologist on the Republican ticket. Looking back from a viewpoint of 22 years, the recipient of that honor realizes that in that convention he had the only real political battle of his life, and that his victory was won not by himself (for in political lore he was then the veriest tyro) but by the combined efforts of his friends, chief among whom were a score or more of the older members of this Indiana Academy of Science, to whom today he takes pleasure in giving due credit for his first nomination. In November, 1894, he was elected over his Democratic opponent, Mr. E. T. J. Jordan, for a term of four years, and was renominated and re-elected in 1898, 1902 and 1906, and renominated but defeated at the polls in 1910. His successor, Mr. Edward Barrett of Plainfield, is also a member of your Academy, and has served as State Geologist since January 1st, 1911.

Of the value of the work accomplished by the Department of Geology

*The Geology of this quadrangle by J. W. Beede, with colored map, was published in the 39th (1914) Report of the Ind. Dept. of Geol. and Nat. Resources, pp. 190-312.

during the sixteen years of the writer's service as Director it is more meet that others should give testimony, therefore only a few facts regarding its nature will be mentioned. Its results were published in sixteen annual reports and one bulletin, aggregating 15,039 octavo pages of text, 557 plates and 44 folded maps included in the volumes, 38 of the maps being colored. In addition there was issued separately a colored sectional geological map of the State, five feet, nine inches by three feet, eight inches in size, on a scale of four miles to the inch, and also a colored wall chart of the Indiana coal fields, 3 x 4 feet in size on a scale of four miles to the inch.

The first sentence of the first report issued by the writer sets forth his views of what the founders of the Department of Geology had in mind when by law they created the Department. That sentence is as follows: "The Department of Geology was primarily instituted to determine the location and extent of those natural resources of the State which are of economic importance, and to make known to the world at large the leading facts concerning their accessibility and value for commercial, agricultural or manufacturing purposes." The sentence as written and quoted embodies the *economic* or most important duties which he deemed it imperative to perform. The next sentence brought out the *scientific* phase and was as follows: "A secondary duty which falls to the Department is the gathering and disseminating of accurate knowledge concerning the origin or formation of such resources and the publishing of descriptions of such fossils and objects of natural history as are found to accompany them or are of general scientific interest." These two sentences are all that will be quoted from the sixteen annual reports which were issued between 1895 and 1911.

To fulfill in the best manner possible, with the limited means at command, the duties as set forth in these two sentences, made necessary the abandonment in great part of the old county survey system and the adopting of that of taking up each resource separately and issuing a monograph or detailed report on its distribution, economic value, etc. Following this plan, the results of studies of the clays and sandstones of the coal measure formation were published in the 1895 report, those of the petroleum fields in 1896, 1903, 1906 and 1910; the oolitic limestone in 1896, with a revision in 1907; the coal deposits in 1898, with a supplemental report in 1908; the Niagara limestones in 1896, 1897 and 1899; the marls of northern Indiana and other materials for making Portland cement and the hydraulic cement rocks in 1900; the mineral waters and the Knobstone shales in 1901; the Lower Carboniferous limestones in 1902; the lime industry in 1903; the clays and shales of the entire State in 1904; the roads and road materials in 1905; the peat and iron ore deposits in 1906; the soils in 1907, 1908 and 1909 and the water powers in 1910. The years mentioned are those of the report in which the paper is published. In a number of instances, as in that of the papers on coal and road materials, the results of two or three years' work done by a number of assistants, are incorporated in a single monograph. During the soil survey, begun in 1907 and continued in 1908 and 1909, the soils of 32 counties in southern Indiana were studied and classified, and the area covered by each of the type soils shown on accompanying maps. Surveys had previously been made of eight counties by the U. S. Bureau of Soils so that the survey of 40 counties had been completed by 1910. Mr. Barrett has since continued the soil survey work and has covered most of the remainder of the State. In addition to the more important economic papers above mentioned, there were numerous shorter ones scattered throughout the volumes.

Now the writer wishes it distinctly understood that he did only a small proportion of this work. While he planned it and in great part directed it, the major portion was done by his assistants; by George H. Ashley, now Director of the Coal Surveys for the U. S. Geological Survey; T. C. Hopkins, now Professor of Geology in Syracuse University, N. Y.; E. M. Kindle, now Paleontologist for the Canadian Geological Survey; Claude E. Siebenthal, now in charge of one of the Divisions of the U. S. Survey; A. E. Taylor, now at the head of one of the Departments of the U. S. Soil Survey, and Chas. W. Shannon, now State Geologist of Oklahoma. They and a score of others served as assistants during the sixteen years that the writer was Director of the State Survey. All were loyal, efficient helpers who did their share and did it well. Each was given full credit for his work, his paper appearing under his name and his alone in the volume in which it was printed. Looking out upon them now where they occupy positions of honor and of trust at the hands of the nation or of other states, I am proud to remember that they did their first work at a meagre salary on the Indiana Geological Survey between the years 1895 and 1910. It was the recognition of the value of that work, by persons competent to judge, that brought them first and lasting renown as geologists and as scientists.

Taking up the more purely scientific or secondary phase of the work as set forth in the second sentence quoted, the writer concluded that since the Department was first christened the "Department of Geology and Natural Science," and later the "Department of Geology and Natural History," that its founders had in mind the study of all forms of living things in addition to the rocks and fossils. Again several of the older members of the Academy of Science had the results of a number of years of observation and study locked up in manuscript form, for which at that time there appeared no avenue of publication. It was decided therefore, that if possible, a part of each annual volume should be devoted to one or more papers on the botany, zoology or paleontology of the State. There appeared, therefore, in the volumes as issued, monographs or other important papers on the crayfish of the State by Hay; the cave fauna by Blatchley; the birds by Butler; the mollusca by Call and Daniels; the dragonflies by Williamson; the flowering plants and ferns by Coulter; the Devonian fauna and stratigraphy by Kindle; the Orthoptera by Blatchley; the stratigraphy and paleontology of the Niagara of Northern Indiana by Kindle; the insect galls by Cook; the fauna of the Salem limestone by Beede and Cumings; the spiders and other Arachnidae by Banks; the stratigraphy and paleontology of the Ordovician rocks by

Cumings; the mushrooms by Reddick; the mammals by Hahn and the beetles by Blatchley. In addition to the papers mentioned a contract had been made by the writer with Dr. O. P. Hay of Washington, D. C., for his paper on the "Pleistocene Period and its Vertebrata," which appeared in Mr. Barrett's first report.

At no time during the writer's service as Director was there an appropriation of more than $4,120 per annum for all salaries of assistants and of expenses both for the field and office of the Department proper and also the State Museum. This sum did not include the salary of the Director, which was $2,500 per annum for the first twelve years, and $3,000 per annum for the last four years.

As showing some of the returns which the State received for this sum, it may be said that in addition to the scientific papers above mentioned as published in the reports and which are now used as reference or text books in the high schools, colleges and universities of the State, the value of the State's mineral resources advanced from $16,860,674 in 1895 to $44,971,003* in 1910, an increase of $28,110,329 or 166 per cent. The value of the coal mined in the State in 1910 was $20,813,659 or $3,952,985 more than the total value of all the resources in 1895. If only one-third, or $9,337,000 of this increase be attributed to the advertising done by the Department of Geology, and the taxes on this be computed at 2.5%, they would amount to $233,419 per annum, which would be a pretty fair profit on the $7,120 invested by the State each year in the Department of Geology.

We have now completed our sketch of a century's work on the geology of Indiana. We have seen how the yearly output of its natural resources, other than soils and timber, have increased from a few pelts of raccoons and muskrats to a value of 45 millions of dollars. A century ago the white man received from the red one this fair domain as the God of Nature made it. To-day it is furrowed, creased, scarred, pierced full of bores and shafts and pit holes, its rivers, sewers, its forests devastated, its soils depleted of their fertility. The white man, ruled by the Gods of greed and mammon, has left unscathed only a few spots as nature made them, spots like "Turkey Run," the "Shades" and some of the wilder tracts in the southern counties. He has left these solely because they were too rough to till, or were wholly

*The following table compiled from "Mineral Resources of the United States" for 1895 and 1910, shows the value of the mineral resources of Indiana for the two years mentioned:

	1895.	*1910.*
Coal	$3,642,623	$20,813,659
Clays and clay products	3,117,520	8,180,839
Portland Cement	....	6,487,508
Limestone	1,658,976	4,472,241
Crude petroleum	2,807,124	1,568,475
Natural Gas	5,203,200	1,473,403
Mineral waters	17,531	514,958
Miscellaneous resources	413,700	1,459,920
Total	$16,860,674	$44,971,003

devoid of coal, oil, gas, stone or some other resource which would bring him gold. When a few hundred men and women desire to keep for the "glory of the past," these spots as they are, the men to whom gold is god, step in, seize control and demand $10,000 ransom for the release to the nature lovers.

The first settlers, the pioneers of a century ago, were content with little. They came, they saw, they conquered a few acres from Mother Nature. Building their cabins wherever a spring purled forth from a hillside to furnish water, they raised their meagre crops, planted orchards for their posterity, hunted, fished, trapped and lived their days in peace and content. But soon westward the wave of civilization found its way, bringing with it desire, greed, discontent, demand for the luxuries as well as for the necessities of life. Then it was that our citizens began to ask "what is there beneath the surface that will bring us wealth?" To answer that question David Dale Owen, Ryland T. Brown, Richard Owen, E. T. Cox, John Collett, Edward Orton and a score of others whom I have mentioned, gave their knowledge and the best years of their lives. All honor, then, to the memory of the geologists of the century that has gone—to the men who were the pioneers that pointed out where the stored resources of a great commonwealth could be found.

INDEX TO A CENTURY OF GEOLOGY IN INDIANA.

The Early History of Chemistry in Indiana.

H. W. Wiley.

On a centennial occasion, it would be expected that in giving some account of the development of a science, it should cover the whole statehood period of the state. In the case of chemistry, it was still a young science when Indiana was admitted into the Union. I doubt, however, if any one of the members of the convention which adopted the Constitution of Indiana had ever any training, even of the most primitive kind in this science. It is true the makers of our State had views of future educational expansions.

As long ago as 1804, I learn from the history of Indiana University, is was enacted by the Congress of the United States when providing for the organization of Indiana territory that every section numbered 16 should be reserved in each town especially for the support of schools within the same, and in addition to this an entire township in the regions of Detroit, Kaskaskia and Vincennes should be reserved for the promotion of a seminary of learning. In 1816, when the Congress of the United States provided for the admission of Indiana as a State, it was provided that one additional township should also be reserved for the promotion of a school of higher learning. This additional township when located caused the county in which it was placed to be named in honor of President Monroe. The Indiana Territorial Legislature carried out the early purpose of founding an institution of higher learning by providing for the establishment of the Vincennes University in 1806. The science of medicine was also recognized. Of the three professors which at least should be appointed, one was to be a professor of physic.

The original Constitution of Indiana adopted at Corydon in 1816 contained a provision for the improvement of the school lands already granted or which should hereafter be granted for school pruposes and in the second section of this provision, it was declared to be the duty of the General Assembly to provide by law for a general system of education, ascending in a regular gradation from township schools to a State University. A state seminary was organized, at least on paper, in 1820, under the provisions of these organic acts. Among the original trustees were David Harvey Maxwell, a brother of my maternal grandfather.

I mention these historical facts to show that it was the purpose of the founders of Indiana to provide liberally as a State for higher education. This provision for state education, however, was not all the advantage which Indiana was to receive. The necessity of an educated ministry led early in the history of the State to the organization of institutions of higher learning. the primary purpose of which was to provide an educated ministry. Among the earliest religious bodies taking practical steps to this end was the Presbyterian Church and as early as 1828 the academy which afterwards became

Hanover College was put into practical working order. The earliest recorded provisions for the teaching of chemistry that I have been able to find in the short time at my disposal is in the first catalogue of Hanover, that is extant, issued in 1833. This catalogue shows that chemistry was taught as a five hour course during the second session of the Junior year, using Mitchell as the textbook. During 1838 this course was transferred to the first session of the Senior year. In 1841 the college year was divided into three terms and chemistry was taught through two terms, the second term Junior and the first term Senior.

Also the first effort to teach agricultural chemistry happened to have been made in Hanover College and I believe this was the first attempt in the State. During the year of my birth, in 1844, in reorganizing the teaching of chemistry, it was recognized with the announcement words "Chemistry and its Application to Agriculture."

In 1849 and 1850, the first records of experimental chemistry at Hanover College are found. The catalogue for the college year 1849–50 has this significant announcement: "Besides the textbook recitations in Anatomy, Physiology, Chemistry and Geology, courses of lectures accompanied with illustrations and experiments will be delivered by Professor Stone." The catalogue for 1849–50 also announces that the laboratory is supplied with the apparatus most necessary for chemical experiments.

I am personally acquainted with the teaching of chemistry in Hanover College for the years 1863 to 1867 inclusive. We had regular textbook recitations and from two to four experimental lectures were delivered by Dr. J. W. Scott each week. As assistants in preparing for these lectures, he took certain young men who had taken special interest in chemistry and who were nearing their graduation. It was my good fortune to assist Dr. Scott to a considerable extent during my Junior and Senior years. I have rarely seen a better course of experimental chemistry in any of the institutions I have attended than was given by Dr. Scott with the meagre apparatus at his command. He had the remarkable faculty of utilizing simple apparatus in the best possible manner. Once every year he made the very difficult experiment of producing a small quantity of that very dangerous explosive, iodide of nitrogen. I never knew him to fail in this experiment. Every year after it had been carefully prepared, the small quantity was taken out of the building to a safe distance and exploded with a long fishing pole to the end of which a little grease had been attached.

During the time that Professor John M. Coulter was teaching science in Hanover, the catalogue makes the announcement that the subjects covered by his instruction were taught by textbooks, lectures, observations, excursions, collections and experiments and that "large and valuable additions have been made to the Philosophical Apparatus, (under which the chemical apparatus was included), Cabinet, Herbarium and Museum."

In the early period of teaching chemistry, Dr. J. W. Scott was by far the ablest professor of experimental and didactic chemistry at Hanover. He had a most pleasing manner, was clear and explicit in his statements and always interesting in his illustration and experiments. Indeed to Dr. Scott may be ascribed the real introduction of chemical lectures and experiments as a means of instruction.

Under Professor Young, chemistry has assumed the dignity of a science which demands even in a small college the entire time of at least one professor. It is to be expected that in the near future, with its increasing funds, Hanover will have a Professor of Chemistry devoted solely to this one study.

Dr. Scott had a natural aptitude for scientific teaching. He perhaps had not more training than Michael Farraday had. He had Farraday's technique though never was given the opportunity for its development that Farraday had. Dr. Scott came to Hanover in 1860 and remained until 1878. When his son-in-law, Benjamin Harrison, became a United States Senator, Dr. Scott was given a clerical position in the Pension Bureau. On my first visit of any length of time to Washington in January, 1883, I called on Dr. Scott at his office and talked over the old times of the laboratory at Hanover. When Benjamin Harrison became President of the United States Dr. Scott was already a nonegenarian. One day, shortly after Mr. Harrison's inauguration, Dr. Scott appeared in my office in the Department of Agriculture during the morning hours. I said, "Doctor, you are having a vacation today." "Yes," he said, "I have been dismissed from the Public Service." He said this quite solemnly and I, of course, was very much astonished that with a father-in-law as President of the United States such an indignity should have been heaped upon him; and then he went on, with a merry twinkle in his eye, "I have been demoted to spend the rest of my days in the White House." As in most cases of elderly persons who stop an active life, leisure did not agree with Dr. Scott's plan of existence. As might have been expected, he did not live through the Harrison administration. I consider that Dr. Scott conferred great blessings on humanity by his long course of teaching and especially by his aptitude in adapting himself to teaching in a most instructive and interesting way sciences in which he had had no special training.

The first professor of natural sciences in the State University was John Hopkins Harvey. He was appointed a Professor of Mathematics in the State Seminary, which later became the State University, in 1831. When the State Seminary became the College of Indiana Professor Harvey was elected Professor of Mathematics and Natural Sciences. He resigned this position in 1832 to accept the professorship of Mathematics and Astronomy in Hanover College. In 1836 he was made Professor of Natural Philosophy, Chemistry and Geology in Hanover College.

One of the most illustrious of the Professors of the State University was Theophilus A. Wylie. He was appointed Professor of Natural Philosophy and Chemistry and began his duties in 1837. He left the Indiana University at the end of one year and went to Miami. He returned, however, to Bloomington in 1854. He remained an active teacher in the university until 1886, when he was retired with the honorary title of emeritus Professor of Philosphy.

Professor Robert Milligan taught Natural Philosophy and Chemistry in Indiana University for two years, from 1852 to 1854.

One of the most distinguished teachers of chemistry in early times in Indiana was Professor Richard Owen. Dr. Owen was appointed Professor of Natural Philosophy and Chemistry in the Indiana University in 1863 and held that title until 1867. In 1867 the title of his professorship was changed to Natural Science and Chemistry which position he held from 1867 to 1879. Dr. Owen not only was a distinguished scientist in the general sense of that term at that time but was particularly an expert in geology. In 1873, Dr. Owen was elected as the first President of Purdue University. Before the University was opened, however, in 1874, he resigned, never having entered actively upon his duties.

In the Northwestern Christian University, now Butler College, in so far as its early days are concerned, chemistry was one of the sciences taught by Professor Ryland T. Brown. Professor Ryland T. Brown was a type of the many sided man. A preacher of great renown and power, he at the same time was a devoted student of the sciences as they were known and taught in his day. He was particularly a geologist and taught geology by modern methods. He also was quite accomplished in the theory of chemistry, though not a practical analyst. In the early days of Butler as illustrated by the courses of 1865 which are the earliest that I can lay my hands on, chemistry was taught, in the Sophomore year, 1st and 2nd terms, Silliman's textbook being used. Applied Chemistry was taught in the third term by lecture. In 1868, I became connected with Butler College as an instructor in Latin and Greek and had ample opportunities of observing Dr. Brown's method of teaching science. I joined on more than one occasion his geological excursions with great pleasure and benefit. He was an interesting speaker and knew his subject well but only from the didactic and theoretical point of view. In 1871 Dr. Brown was appointed chemist of the Department of Agriculture.

In the fall of 1875, I was elected Professor of chemistry in Butler College. but held that post only a short time. I fitted up a working laboratory where a dozen or more students could work in chemical problems and this was opened to the students at the beginning of the Fall session of 1873. During this college year, about a dozen young men and women worked at these desks in simple chemical analysis and syntheses. It was, I believe, at that time the largest working room for students in chemistry in Indiana. From 1874 on, chemistry again fell back into the general natural science class. Under Dr. Jordan's professorship, chemistry was taught by F. W. Achilles during 1875. In 1879 Professor O. P. Hay and W. M. Thrasher, Professor of Mathematics, taught chemistry in Butler. The working laboratories were continued when the college was moved to Irvington and chemistry was taught by Professor Hay for several years.

In 1874 I became Professor of Chemistry at Purdue. I immediately fitted up a laboratory where large numbers of students could be accomodated. As I remember, we had working desks for about 25 or 30. During 1874–75 the students in chemistry at Purdue University, among other things, were taught the making of ordinary chemical compounds as instruction in applied chemistry. A large and very fine collection of these compounds was prepared and exhibited at the World's Fair in Philadelphia in 1876. As far as I know, this was the first chemical exhibit of a college or university at a World's Fair. There may have been earlier exhibits but I have not happened to come in contact with them. At the time I left Purdue in 1883 the working laboratory had become enlarged and more fully equipped and with a larger number of working students.

Among the men who succeeded me at Purdue have been many whose eminence has been acknowledged. Among them were Robert B. Warder, who was one of the first original workers in physical chemistry in this country. He originated the methods of studying chemical reactions by means of their speed and the factors which retarded or accelerated the reaction.

Following him came Professor Neff who as a worker in organic chemistry obtained world wide renown. After a distinguished career at Purdue, he was made head Professor of Chemistry in Chicago University, where he still further distinguished himself until his premature death, the result of overwork. He came to the notice of Purdue University in the following manner. The late Professor Joy of Columbia University wrote to me that he knew a young man whom he had met during his residence in Germany who had distinguished himself most signally in his chemical studies and who was a Harvard graduate and desired to get a professorship in the United States. I called attention of the Purdue authorities to Professor Joy's commendation and in this way Professor Neff came to Purdue. Following Professor Neff, Dr. Stone became Professor of Chemistry. Had he not so signally distinguished himself as an Executive Officer he would be worthy of a place among the stelligeri by reason of his researches in agricultural chemistry.

Among the younger men who have taught chemistry in Indiana and who have made a reputation for themselves I desire to call attention to W. G. Emery. He was Professor or Assistant Professor of Chemistry at Wabash for some time. He was appointed to the chemical service of the Bureau of Chemistry after a brilliant examination by the Civil Service Commission, and has distinguished himself particularly in pharmaceutical chemistry in the position which he now occupies.

Among the earlier workers in chemistry in Indiana not connected with didactic institutions I must recall the services of Dr. Levette in the Geological Survey. When I first came to Indianapolis in 1868, I made the acquaintance of Dr. E. T. Cox, the State Geologist and through him of Dr. Levette.

At that period of my chemical studies, I had never seen anyone engaged in a quantitative analysis. I frequently went to Dr. Levette's laboratory in the State House to watch him in what I thought to be the most delicate and scientific work which I have ever seen. He was engaged particularly in the analysis of Indiana coals and did much, in connection with Professor Cox, in the development of the mineral resources of the State. One striking experiment which I shall never forget was the making of a hard and glistening coke. He conceived the idea that if pressure were placed upon a piece of coal which was in process of distillation that the resulting coke would be hard and firm, resembling to a large extent anthracite. He considered that the hardness and luster of anthracite coal were due to the fact that it had been developed under high pressure. By attaching a mercury guage to the delivery tube of the small crucible in which the coal was distilled he succeeded in getting a residue which in hardness and luster very greatly resembled anthracite. Dr. Levette was the first chemist in Indiana who determined the fuel value of coal by quantitative analysis.

The great chemical industries of Indiana have grown up largely since my withdrawal from the State and I am, therefore not able to give from my own knowledge any account of the hundred of chemical workers who must have distinguished themselves in the industries of Indiana during the past third of a century.

Perhaps I may be allowed to refer, as it is a matter which concerns my own activities largely, to the first chemical studies ever made in Indiana in so far as I know on the adulteration of foods. Dr. W. W. Vinnedge was a member of the State Board of Health in the years 1880 and 1881 and perhaps for a much longer period. I had become interested at that time in the adulterations of sugars and syrups and I suggested to him that the State Board of Health make a small appropriation to enable me to study the adulteration of sugars and syrups offered for sale in the State of Indiana. An appropriation of $50 was made for this purpose. With this money, I collected a great many samples of sugars and syrups exposed for sale in the State and examined them in the laboratory of Purdue University. In so far as I know, the first report on food adulteration of an official character ever published in the State was issued by the Board of Health in the publications of the report which I submitted to them, giving the results of my studies.

I have already called attention to the fact that as far back as 1844, Hanover College had made studies of chemistry in its relations to agriculture. It was at this period that Liebig's work in agricultural chemistry first became generally known and although I have no evidence other than this fact, I feel quite certain that it was the knowledge of the work of Liebig coming to the faculty and trustees of Hanover that led them to make this study.

As a contribution to the history of chemistry in Indiana I must refer to the fact that in 1881 the Legislature of Indiana passed an act creating a State Chemist who was to be the Professor of Chemistry at Purdue University and defining his duties. These duties were at that time confined to the examination of commercial fertilizers offered for sale in the State with a view of determining whether or not they met the standards claimed. The first official control of foods and fertilizers, therefore, in the State of Indiana must be awarded to Purdue University, I held this position of State Chemist until my retirement from Purdue University in 1883. The duties of State Chemist devolved upon my successor. Subsequently the statute was changed so that the duties of the State Chemist were discharged by the Director of the Agricultural Experiment Station. This list of men who have become eminent in the chemical profession in the Institution of Indiana and its industries is not very large. This is due perhaps entirely to the fact that my absence from the State has put me out of touch with what the chemists have been doing and, therefore, the omissions of many names of eminent chemists is due to my ignorance. To some extent, however, this is not the case. With the exception of the State University and Purdue University, the educational institutions of Indiana are not able as a rule to employ more than one and sometimes not one chemist devoted wholly to that profession. The result is that as the professors have to dicharge a multitude of duties in connection with their scientific work they do not become eminent in any one branch thereof. This is no reflection whatever, however, upon the splendid work which these men have been doing for science in an environment which many persons would think very unsuited to fruitful results. It is not always the well equipped laboratory and abundant supplies of reagents that produce eminent chemists. Like poets, they are born, not made. This is brilliantly illustrated in the history, in my opinion of the world's greatest scientist, Michael Farraday. The value of the work which these men have done without gaining world wide reputation for eminence in any particular branch rests as an eternal monument to their devotion to duty and to their skill as teachers.

I cannot close this hurried sketch without calling attention to two or three of the earlier scientific workers of Indiana that I have not yet mentioned and men whom I have had the honor and pleasure of knowing. Among these I mention first Professor Tingley, who was for many years connected with Ashbury, now Depauw University. Professor Tingley was one of those splendid workers who not only had skill but imagination and perhaps had he been able to devote himself to one single branch of science would have acquired wide eminence. I, as a young man, knew Professor Tingley quite well though I never had had the opportunity of hearing him lecture but once. When the question of producing light from electricity was first broached, and this I think was along about 1868 or 9, Professor Tingley, at my invitation came to the High School of Indianapolis to give an illustrated lecture on electricity. He brought with him a large battery made of alternate pieces of gas coke taken from the inside of gas retorts and roughly shaped and zinc plates. This battery he had constructed himself. He put up a number of large cells, 20 or 30 in all, and properly connected them for developing the electrical current with sufficient intensity of voltage, to make a small arc, bringing the two opposite poles of the battery together by means of carbon electrodes and holding them in his hand with proper insulation, he separated them very slightly and produced a brilliant spark and, when he could hold his hand steady enough, it was a continued glow. This was the first electric light I ever saw. It may not be out of place to add here that the first dynamo ever seen west of the Alleghanys was one purchased by me for Purdue University at the close of the Centennial Exposition in Philadelphia. This Gramme machine is still in good condition and may be seen among the treasured possessions of Purdue University. The first electric light ever shown from a dynamo was shown from the tower of Purdue University about November, 1876. Thus, Dr. Tingley's small spark of light had in six years grown to be a splendid illumination which was cast by means of a reflector from the tower of the laboratory at Purdue on various parts of the city of Lafayette. In the year 1878 I saw the first electric lighted city street, namely, the Avenue De L'Opera in Paris. Thus in eight years, Tingley's spark had grown to illuminate a great world capital. Now as we gaze everywhere on brilliant electric lights we can hardly realize in 1870 they were entirely unknown.

Another scientific worker in Indiana who taught chemistry more or less, although astronomy was his specialty was Professor Campbell of Wabash. His distinguished services to education and science are known to all. It was he who originated the idea of the centennial exposition and who was its permanent secretary.

Professor Hougham connected for some time with Franklin College was another early worker in chemistry in Indiana filled with enthusiasm and who possessed a very great degree of skill in manipulation and experiment. His particular liking was physics but he did much in the early teaching of chemistry.

To undertake to give now the present condition of chemical teaching in Indiana and of the chemical industries would require a book and I shall not venture into this field, entirely too large for illustration at the present time.

It is well in all great fields of investigation to stop for a while and look back to the little beginnings of them all. In this way, we not only get a better understanding of the importance of the early work and the services of the early workers but we also get a point of view by means of which we can estimate the great distance which we have come.

I trust that this brief review of the early history of chemistry in Indiana may serve to impress us with the magnitude of its present proportions and of the wonders which it is doing for the discovery of the unknown and the welfare of humanity.

Indiana's Feeble-Minded.

Dr. Geo. S. Bliss

The first recorded attempt to educate a feeble-minded person was made in the year of 1800 by Dr. Itard, a French physician, connected with one of the Institutions near Paris. In 1836 an attempt was made to educate ten idiots at the School for the Deaf in Hartford, Connecticut. The first public institution in the United States was established at Massachusetts in 1848 in connection with the Perkin's Institute for the Blind in South Boston. Gradually this work was taken up by state after state until in 1879 Indiana established its first institution for the care of the feeble-minded as an adjunct to the Sailors' and Soldiers' Orphans' Home at Knightown, Indiana, under the name of The Asylum for Feeble-Minded Children. In 1887 the Legislature gave the institution an independent existence and changed its name to that of Indiana School for Feeble-Minded Youth. It appropriated $10,000.00 to buy land at or near Fort Wayne, and gave the Board of Trustees $40,000.00 for buildings thereon, and authorized the Board to rent temporary premises and take charge of the feeble-minded children then in the Knightstown Home.

Until 1887 there were received only feeble-minded who could be improved. The law of 1887 broadened the scope of the institution to care for feeble-minded, epileptic, and paralytic. The Trustees tried to find temporary quarters in Fort Wayne without success. The buildings of the new Eastern Hospital for the Insane at Richmond, Indiana, were almost completed, and upon recommendation of the Governor permission was obtained to occupy the uncompleted buildings by the school.

May 1st, 1887, the sixty children at Knightstown were removed to Richmond. In the beginning of the year 1888 plans were made and completed for the Institution to accommodate about four hundred inmates on the present site at Fort Wayne. That same year appropriations amounting to $187,300.00 were made to build the main building, and on the 8th of July, 1890, about three hundred inmates were moved from Richmond to their new home in Fort Wayne. This institution has gradually grown until there are present today 1,388.

Children are admitted to the institution under two acts. An act allowing children from six to sixteen to be sent to the institution for the purpose of training, and an act allowing adult women from sixteen to forty-five to be sent there as a protection to themselves and the community.

This, however, is only a very small part of the number of feeble-minded in Indiana that should today have State care. The most conservative estimate that can be made is that there are at least six or seven thousand in Indiana today requiring State care. This leaves between four and five thousand at large in the State now needing institutional care but receiving nothing.

Feeble-mindedness is a condition and not a disease. It is not susceptible of cure; it is susceptible of immense improvement in many cases under proper care and training. I believe, however, that the training should be of such a nature as to fit the individual for a useful life in the institution or under supervision elsewhere. He should be given some work in the school of letters because, if he can be taught to count, to read, and to write, his services may be more easily used in the industrial pursuits with which he should be occupied. The chief value of training lies, however, along industrial lines, and I believe, that our present institutions for the feeble-minded generally give too much attention to the school of letters and too little attention to the industrial training of their inmates. While it is true, that because of his lack of judgment and application the feeble-minded individual can not be taught a trade, strictly speaking, yet he may be taught to do good work in some of the trades under proper supervision. The robust out-of-door life on the farm is particularly suited to the adult male feeble-minded; and could, I believe, be very readily extended to the adult female feeble-minded in the cultivation of small fruits, raising of poultry and chickens, and work of that character. At the institution at Fort Wayne, we make very largely with the help of the inmates all the brick that are used in the institution; we successfully conduct a farm of 500 acres furnishing employment for the able-bodied boys and men; we make all of our own shoes, our own mattresses, all the clothing worn by the inmates including the tailored suits for the boys, dresses for the girls, and underwear; also do the necessary sewing for the institution in the manufacture of bed and table linen. Besides these industries, we find employment for our boys in the carpenter shop, in our green house, helping to handle our coal, and care for the lawns and grounds of the institution. With the help of a few employes our girls do all the laundry work, the work in our kitchens and dining rooms, and the general house work of the institution. We believe and put in practice the theory that occupation is the salvation of the feeble-minded as well as the normal individual.

These people furnish the material for a very large part of our charitable work in this State. They constitute fifty per cent of our paupers; they number, at least, twenty-five per cent of the people in our correctional and penal institutions; they are incompetents that exist in every community; lazy, shiftless, worthless members of society; perhaps able to eek out a precarious living under the most favorable conditions when health is good and wages are plenty, but becoming quickly submerged under any stress or strain of social existence. They like the drunkard are the first men turned off from jobs and the last men hired. Every last one of these people should be segregated from society; should be put somewhere, where it would be impossible for them to reproduce their kind, and my personal belief is that these people, both men and women, should be put into farm colonies with inexpensive buildings and under such conditions that many of them can earn their own support. Our present institution at Fort Wayne is crowded to its doors.

We have a great many applications on the waiting list, and were it possible for us to receive all of these on the waiting list our waiting list would be immediately doubled. Inasmuch as many social workers throughout the State feel that the long waiting list makes it impossible for them to get many of their cases in there, I sincerely hope the coming Legislature will make more provision for this class of people. If each member of this body will take it upon himself to see the representative from his district and show him the needs that you have in your own communities for the care of these people, I feel sure you can help this matter to a great extent.

A Century of Zoology in Indiana, 1816-1916

By Barton Warren Evermann.

Director of the Museum, California Academy of Sciences.

One hundred year ago Indiana was, zoologically, scarcely more than a *terra incognita.* At the beginning of the nineteenth century not a single naturalist had set foot within its borders; its wonderful hard wood forests,—the richest the world has ever seen, its broad prairies, its multitude of beautiful lakes and gently flowing streams, had never been invaded by the collector. The only information the world had regarding the fauna of Indiana was contained in brief mention by travelers of certain of the more conspicuous animals seen by them in their journeys. In the Paris Documents, 1718, as quoted by Mr. Butler, it is stated that "from the summit of the hill at Ouiatenon* nothing is visible to the eye but prairies full of buffaloes."

Col. George Croghan in his journal for 1765, published in 1831, tells of a trip he made down the Ohio, and mentions buffalo, deer, bear, and other animals which he observed. Doubtless many of these were seen on the Indiana side of the river.

Thomas Hutchins who in 1778, published in London a "Topographical description of Virginia, Pennsylvania and North Carolina, comprehending the rivers Ohio, Kanawha, Cherokee, Wabash, Illinois, Mississippi," etc., mentions the buffalo as being" innumerable" northwest of the Ohio River, from the mouth of the Kanawha, far down the Ohio. This clearly covered Indiana.

In April, 1808, the great ornithologist, John James Audubon, came with his young wife to Louisville, Kentucky. He had floated down the Ohio in an "Ark," and doubtless noted many birds and mammals on the way. Although he probably saw no buffalo, he has this to say of that animal: "In the days of our boyhood and youth, buffaloes roamed over the small and beautiful prairies of Indiana and Illinois, and herds of them stalked through the open woods of Kentucky and Tennessee; but they have dwindled down to a few stragglers, which resorted chiefly to the 'Barrens,' but towards the years 1808 and 1809, and soon after they entirely disappeared."

During his residence at Louisville from 1808 to 1811, and at Hendersonville for several years from 1811, Audubon's collecting trips doubtless took him sometimes to the Indiana side of La Belle Rivière and doubtless he added to his cabinet a number of birds taken on Indiana soil.

In March, 1810, that other great American ornithologist, Alexander Wilson, floated down the Ohio from Pittsburgh to Louisville. In a letter to

*Also spelled Ouantenon. This was in the Wea Prairie near the Wabash in Tippecanoe County.

his friend, Alexander Lawson, dated February 22, 1810, just before starting on this memorable trip, Wilson wrote: "I have therefore resolved to navigate myself a small skiff, which I have bought, and named the *Ornithologist*, down to Cincinnati, a distance of five hundred and twenty-eight miles." On February 23 he adds: "My baggage is on board—I have just time to despatch this and set off. The weather is fine, and I have no doubt of piloting my skiff in safety to Cincinnati. Farewell! God bless you!"

On April 4, he again wrote Lawson, from Lexington, Kentucky, giving a most interesting account of the trip down the river. He did not terminate his river journey at Cincinnati as originally intended, but went on to Louisville, 192 miles further, where he arrived March 18. On March 5 when about 10 miles below the mouth of the Sciota, he saw his first flock of paroquets. That night he spent on the Kentucky side where he was entertained by a squatter who explained to him the art and mystery of bear-treeing, wolf-trapping, and wild-cat hunting. "But notwithstanding the skill of this great master," Wilson remarks, "the country here is swarming with wolves and wild cats, black and brown; according to this hunter's own confession he has lost sixty pigs since Christmas last; and all night long the distant howling of the wolves kept the dogs in a perfect uproar of barking." He spent the night of March 16 at Vevay, Indiana, where he found about the only people, during his entire trip, for whom he had a kindly word. The next day he observed a number of turkeys from time to time on the Indiana shore and "lost half the morning in search of them." "On the Kentucky shore," he remarks, "I was decoyed by the same temptations, but never could approach near enough to shoot one of them."

On March 18, Wilson reached Louisville where he remained until the 24th and where he met Audubon, of which fact, however, he makes no mention in either his journal or his letters. But Audubon does. He says: "One fair morning I was surprised by the sudden entrance into our counting-room at Louisville of Mr. Alexander Wilson, the celebrated author of the 'American Ornithology,' of whose existence I had never until that moment been apprised. This happened in March, 1810. How well do I remember him, as he then walked up to me! His long, rather hooked nose, the keenness of his eyes, and his prominent cheekbones, stamped his countenance with a peculiar character. His dress, too, was of a kind not usually seen in that part of the country; a short coat, trousers, and a waistcoat of gray cloth. His stature was not above the middle size. He had two volumes under his arm, and as he approached the table at which I was working, I thought I discovered something like astonishment in his countenance. He, however, immediately proceeded to disclose the object of his visit, which was to procure subscriptions for his work. He opened his books, explained the nature of his occupations, and requested my patronage. I felt surprised and gratified at the sight of his volumes, turned over a few of the plates, and had already taken a pen to write my name in his favor, when my partner rather abruptly said to me, in French, 'My dear Audubon, what induces you to subscribe to this work. Your drawings are certainly far better; and again, you must know as much of the habits of American birds as this gentleman.' Whether Mr. Wilson understood French or not, or if the suddenness with which I paused, disappointed him, I cannot tell; but I clearly perceived that he was not pleased. Vanity and the encomiums of my friend prevented me from subscribing. Mr. Wilson asked me if I had many drawings of birds. I rose, took down a large portfolio, laid it on the table, and showed him,—as I would show you kind reader, or any other person fond of such subjects,—the whole of the contents, with the same patience with which he had shown me his own engravings. His surprise appeared great, as he told me he never had the most distant idea that any other individual than himself had been engaged in forming such a collection. He asked me if it was my intention to publish, and when I answered in the negative, his surprise seemed to increase. And, truly, such was not my intention; for, until long after, when I met the Prince of Musignano in Philadelphia, I had not the least idea of presenting the fruits of my labors to the world. Mr. Wilson now examined my drawings with care, asked if I should have any objections to lending him a few during his stay, to which I replied that I had none. He then bade me goodmorning, not, however, until I had made an arrangement to explore the woods in the vicinity along with him, and had promised to procure for him some birds, of which I had drawings in my collection, but which he had never seen. It happened that he lodged in the same house with us, but his retired habits, I thought, exhibited either a strong feeling of discontent or a decided melancholy. The Scotch airs which he played sweetly on his flute made me melancholy too, and I felt for him. I presented him to my wife and friends, and seeing that he was all enthusiasm exerted myself as much as was in my power to procure for him the specimens which he wanted. We hunted together, and obtained birds which he had never before seen; but reader, I I did not subscribe to his work, for, even at that time, my collection was greater than his. Thinking that perhaps he might be pleased to publish the results of my researches, I offered them to him, merely on condition that what I had drawn, or might afterwards draw and send to him, should be mentioned in his work as coming from my pencil. I at the same time offered to open a correspondence with him, which I thought might prove beneficial to us both. He made no reply to either proposal, and before many days had elapsed, left Louisville, on his way to New Orleans, little knowing how much his talents were appreciated in our little town, at least by myself and my friends.

"Some time elapsed, during which I never heard of him, or his work. At length, having occasion to go to Philadelphia, I, immediately after my arrival there, inquired for him, and paid him a visit. He was then drawing a white-headed eagle. He received me with civility, and took me to the exhibition rooms of Rembrandt Peale, the artist, who had then protrayed Napoleon crossing the Alps. Mr. Wilson spoke not of birds or drawings. Feeling, as I was forced to do, that my company was not agreeable, I parted from him; and after that I never saw him again. But judge of my astonishment some time after, when on reading the thirty-ninth page of the ninth volume of 'American Ornithology,' I found in it the following paragraph:

" 'March 23, 1810.—I bade adieu to Louisville, to which place I had four letters of recommendation, and was taught to expect much of everything there; but neither received one act of civility from those to whom I was recommended. one subscriber, nor one new bird; though I delivered my letters, ransacked the woods repeatedly, and visited all the characters likely to subscribe. Science or literature has not one friend in this place.' "

Evidently the lonesome trip down the Ohio must have been a hard one for our Scotch ornithologist or else he must have been a dyspeptic, as witness the following in his Journal under the same date, March 23; "Every one is so intent on making money that they can talk of nothing else; and they absolutely devour their meals that they may return the sooner to their business. Their manners correspond with their features. Good country this for lazy fellows; they plant corn, turn their pigs into the woods, and in the autumn feed upon corn and pork,—they lounge about the rest of the year." And again on March 24: "Weather cool. Walked to Shelbyville to breakfast. Passed some miserable log houses in the midst of rich fields. Called at a Squire C's, who was rolling logs. Sat down beside him, but was not invited in, though it was about noon."

And on March 29: "Wherever you go you hear people talking of buying and selling land; no readers, all traders. The Yankees, wherever you find them are all traders. * * * * * Restless, speculating set of mortals here, full of lawsuits, no great readers, even of politics or newspapers." And he concludes: "These few observations are written in Salter White's garret, with little or no fire, wood being a scarce article here, the forest being a full *half mile* distant."

After remaining at Louisville three years Audubon moved his store to Hendersonville, Kentucky, where he conducted a store and grist mill for several years. While there he was visited by that enthusiastic, albeit, somewhat eccentric naturalist, Constantine Samuel Rafinesque. It was during this visit to Audubon, probably about 1818, that occurred the amusing incident of the violin and the new species of bat. According to Audubon:

"That night, after we were all abed, I heard of a sudden a great uproar in the naturalist's room. I got up and opened the door, when to my astonishment I saw my guest running naked, holding the handle of my favorite Cremona, the body of which he had battered to pieces in attempting to kill the bats which had entered the open window! I stood amazed, but he continued jumping and running around and around till he was fairly exhausted, when he begged me to procure one of the animals for him, as he felt convinced that they belonged to a new species. Although I was convinced of the contrary, I took up the bow of my demolished violin, and giving a smart tap to each bat as it came up, we soon has specimens enough."

Most of the dates I have thus far given are before the beginning of the one hundred years with which we are primarily concerned at this time. I call attention to them simply to remind you that our state was in the original "Buffalo belt," and that our forefathers were quite justified in placing that magnificent animal on the the Great Seal of Indiana.

Even a cursory examination of the State Seal will enable us to understand why the buffalo became extinct in Indiana. At the rate of speed shown in the Great Seal, if kept up, the buffalo must have reached the plains of Kansas within a few hours!

With the possible exception of a few specimens of birds collected by Audubon and Wilson on Indiana soil, the first naturalist to pay any attention to the Indiana fauna was Rafinesque. This indefatigable student of nature came from Philadelphia to Lexington, Kentucky, in 1818, where, through the good offices of his friend, John D. Clifford, whom he had known in Philadelphia, he secured the professorship of botany and natural history in Transsylvania University, located at Lexington.

A number of circumstances doubtless contributed to induce Rafinesque to go west. Perhaps the most potent of all was the *wanderlust*. Early in life he determined to become a great traveler; and in his writings he tells, with evident pleasure, of many of his long journeys and collecting trips. In one place he mentions his "32 years of travels in America." He had no doubt heard of the famous New Harmony community on the Wabash, a society that must have appealed to him strongly. He also had heard of Audubon at Henderson, Kentucky, and longed to visit him, which he did in 1818. Then at Louisville, at the Falls of the Ohio, dwelt Tarascon, a friend of his youth in Marseilles.

These, and his desire to see new places and new animals and plants, were too strong for him to resist, so, in the summer of 1818, he started out on foot, for the west. Reaching Pittsburgh, he continued his journey down the Ohio in an "ark," a sort of flatboat common on the Ohio in those days. Opportunities were afforded for many stops on the way, which Rafinesque fully improved by making short and hurried trips ashore, in which he obtained collections of natural history specimens of many kinds. Perhaps he paid most attention to the fishes and the plants. He doubtless made a number of landings on the Indiana side of the river between Cincinnati and the Falls of the Ohio, and a number of the fishes he later described were obtained or observed in Indiana waters. We can imagine with what child-like delight and enthusiasm our pioneer naturalist viewed this new world, for it was to him, as Professor Call has so well said, "a veritable new world; the plants and animals had never before been either collected or studied. The hand of the husbandman had not yet destroyed much of the primitive forest; untold wealth of natural forms appealed to Rafinesque, the nature-lover, as they have rarely appealed to any man. Today even, in the face of the check which specialization furnishes to scientific investigators, few men could withstand this lavish display of new and unknown forms! They were on every hand, in every glade and mead, in every brook and spring, the creeks, the rivers, the very rocks, themselves. Like a schoolboy, Rafinesque searched and found, studied, described, drew, sent abroad, the wonderful forms in which he almost alone, now reveled."

Rafinesque remained at Lexington eight years, teaching students and collecting and studying the local fauna and flora during the college year, but during the vacations going far afield in search of new and undescribed plants, fishes and shells. That on more than one of these excursions he came to the Ohio and crossed over into the Hoosier state, is quite certain. The Falls of the Ohio was a favorite collecting ground, and that place is the type locality for many of his new species of fishes. It is also the type locality for seven new species of lightning which he described in perfectly proper binominal form! We may not, however, count this circumstance as a part of the century's progress in zoology in Indiana! The evidence of progress lies, perhaps, in the failure of our later naturalists to discover any additional new species in that field!

In the fall of 1825, upon returning to Lexington from one of his long collecting trips, Rafinesque found that during his absence, his effects had been removed from his room in the college building and stored in the garret, and the room which he had formerly occupied turned over to another professor.

This was an indignity which our sensitive naturalist could not endure, and he at once left the college as he says "with curses both on it and the president, which reached them both soon after, for the President died of yellow fever in New Orleans, and the college was burned with all its contents."

Recently, while looking over a number of Rafinesque's original field notebooks, now in the library of the United States National Museum, I found in one of them a loose sheet evidently the last sheet of a letter which had been addressed to Rafinesque by the librarian of Transylvania University, asking the return of certain books. The situation had evidently become acute, as evidenced by the closing words of the letter, which are in the nature of an ultimatum, as follows: "I am directed to commence such suit without delay if the books are not returned to the library.

Yours respectfully,

H. Graham."

On the back of this sheet are lead pencil drawings of three fishes, —Rafinesque's way of showing his contempt for the librarian's ultimatum.

I cannot resist the temptation of recording here a most remarkable and important fact regarding Rafinesque, which is not generally known. It is no less than complete evidence that our eccentric naturalist had a very clear comprehension of the essential principles of evolution as early as 1832, twenty-six years before Darwin.

In 1832 and 1833 Rafinesque published in Philadelphia a periodical which he called the "Atlantic Journal and Friend of Knowledge." In March, 1915, while examining a bound copy of this journal, kindly loaned to me by my friend Dr. John Van Denburgh, I was amazed to find on page 163, a most remarkable document, which I here quote verbatim et literatim. This extremely interesting letter shows clearly that our eccentric naturalist, regarded by some as a fool, by others as a knave, was neither—certainly not a fool—but a man of remarkable vision who grasped clearly all the essential principles of the evolutionary origin of species. Much of what he said in this letter to John Torrey would sound well today in a discussion of the origin of species. He even uses the word 'mutation', in a strictly De Vresian sense, thus anticipating Professor De Vries's "Die Mutations-theorie" by nearly three-quarters of a century. And all this 26 years before Darwin's "Origin of Species," and just as Darwin was entering upon his voyage around the world in the *Beagle*, to which he was indebted for so much of the data which led him to his theory!

The article to which I refer is as follows:

124. Principles of the Philosophy of new Genera and new species of Plants and Animals.

Extract of a letter to Dr. J. Torrey of New York dated 1st Dec. 1832 . . . I shall soon come out with my avowed principles about G. and Sp. partly announced 1814 in my principles of Somiology, and which my experience and researches ever since have confirmed. The truth is that *Species and perhaps Genera also, are forming in organized beings* by gradual deviations of shapes, forms and organs, taking place in the lapse of time. There is a tendency to deviations and mutations through plants and animals by gradual steps at remote irregular periods. This is a part of the great universal law of PERPETUAL MUTABILITY in every thing.

Thus it is needless to dispute and differ about new G. Sp. and varieties. Every variety is a deviation which becomes a Sp. as soon as it is permanent by reproduction. Deviations in essential organs may thus gradually become N. G. Yet every deviation in form ought to have a peculiar name, it is better to have only a generic and specific name for it than 4 when deemed a variety. It is not impossible to ascertain the primitive Sp. that have produced all the actual; many means exist to ascertain it: history, locality, abundance, &c. This view of the subject will settle botany and zoology in a new way and greatly simplify those sciences. The races, breeds or varieties of men, monkeys, dogs, roses, apples, wheat * * * and almost every other genus, may be reduced to one or a few primitive Sp. yet admit of several actual Sp. names may and will multiply as they do in geography and history by time and changes, but they will be reducible to a better classification by a kind of genealogical order or tables.

My last work on Botany if I live and after publishing all my N. Sp. will be on this, and the reduction of our Flora from 8000 to 1200 or 1500 primitive Sp. with genealogical tables of the gradual deviations having formed our actual Sp. If I cannot perform this, give me credit for it, and do it yourself upon the plan that I trace.

C. S. R."

But Rafinesque did not live to do this, neither did John Torrey do it for him.*

I shall not take time here to list the numerous papers relating to the fauna of the Ohio Valley which Rafinesque published between 1818 and 1832, nor to enumerate the many new species of fishes, mollusks, and plants which he described. Many of his papers dealt directly with fishes and shells that occur in Indiana; in many instances the specimens on which the descriptions were based came from Indiana streams, and many others from that portion of the Ohio bordering Indiana.

Rafinesque was therefore the first naturalist to study the fishes of the Ohio. Our first knowledge of the ichthyological fauna of southern Indiana dates from Rafinesque's arrival at Lexington in 1818, when Indiana as a State was but two years old. To the Transylvania University belongs the honor of having had as a member of its faculty this all round naturalist who was the first to collect and study the fishes beyond the Alleghenies; and to that institution must attach also the stigma of having driven from its halls the only member of its faculty whose name has survived to this day.

The New Harmony Community

In 1815 there was established on the banks of the Wabash in Posey County, Indiana, a settlement or community which was destined to play a most important part in the social, literary and scientific life of the state. The settlement was established by George Rapp and his followers who migrated to the Wabash Valley from Butler County, Pennsylvania. These people called themselves Rappists or Harmonists, and their new village they named New Harmony. The society was a communistic organization, all property being held in common.

In 1824 Robert Owen purchased the land and other property of the Harmonists. He and his followers undertook to continue the venture along somewhat the same lines. Among the members of the new community were many men and women destined to become prominent in the affairs of the state and the nation. The vanguard of these came to New Harmony in 1825. They were spoken of as the "boat load of knowledge." Among those whom we should mention and who concern us most, were Robert Owen, David Dale Owen, Richard Owen, Alexander Maclure, William Maclure, Thomas Say, Mrs. Say and Charles Alexander LeSueur.

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*Dr. L. Stejneger also discovered this interesting letter and re-printed it in *Science* for May 18, 1906, pp. 785-786, where it apparently did not attract the attention it deserved.

Among still others who were either members of the community or who visited New Harmony in the early days should be mentioned the following:

Francis Joseph Nicholas Neef, a native of Alsace and an officer of the Rhine, for some time an assistant of Pestalozzi at Neufchâtel, whose system of education he was the first to introduce in America. Both David Dale Owen and Richard Owen married daughters of Professor Neef. Madame Mary D. Fratageot, an able Pestalozzian teacher and head of the Industrial School; Frances Wright, anti-slavery lecturer; Maximillian von Neu Wied, Prince. Prussian classicist and naturalist who visited New Harmony twice; Sir Charles Lyell, the English geologist; H. R. Schoolcraft, artist and Indian authority; Josiah Warren, merchant, printer and musician; Dr. Gerard Troost, geologist and naturalist, for whom Holbrook named the yellow-bellied terrapin (*Pseudemys troosti*); John Chappelsmith, artist and engineer, who made the cuts of fossils for various scientific reports of that day; Robert Henry Fauntleroy, a native of Virginia, prominent in the U. S. Coast and Geodetic Survey, who studied at New Harmony magnetic declination and intensity; James Sampson, born in Boston, 1806, came to New Harmony about 1825 where he died 1890, collector of natural history specimens, especially land and freshwater shells and archæological specimens; Col. Charles Whittlesay, geologist; F. B. Meek, eminent paleontologist; Leo Lesquereux, distinguished paleobotanist; E. T. Cox, a Virginian. state geologist of Indiana 1868–1880, who got his training under the Owens; Dr. Elderhurst, eminent chemist; Dr. C. C. Parry, noted botanist; and Prof. A. H. Worthen, state geologist of Illinois 1858–1886.

All of these had more or less to do with the development of science, literature and art in Indiana.

To us the most important of these was Thomas Say, who has been called "the Father of American Entomology," "the Father of American Conchology," and, as if that were not enough, "the Father of American Zoology."

Thomas Say was born in Philadelphia, July 27, 1787. As a child his greatest delight was in collecting beetles and butterflies, In 1825 he was induced to accompany William Maclure and the Owens to New Harmony where "science and letters, it was confidently affirmed, would soon arise like the orient sun to enlighten our benighted western world."

And the prophesy was not entirely lacking of fulfillment. New Harmony did become, and remain for many years, the literary, scientific and art center west of the Alleghenies; and even to this day, it continues to hold its place among the most enlightened and cultured communities in a state distinguished for its scientific and literary prestige.

Before going to New Harmony, Thomas Say had already made valuable contributions to entomological literature. At New Harmony and in the surrounding country he found a rich field and he continued without abatement his collecting of specimens and describing of new species.

During the ten years which Say lived at New Harmony, he devoted all his leisure time to his favorite pursuits.

Two parts of his "American Entomology" were published in Philadelphia before he went to New Harmony, and the third part was also completed and soon afterwards published.

Little or no time, however, was lost on account of his moving. New contributions to entomological science began to appear soon, and continued until his death. During these years Say described more than a thousand new species of insects, some 400 of which are mentioned specifically as having been found in Indiana. Doubtless many of the great number which he recorded simply "Inhabits the United States," were actually found by him in the vicinity of New Harmony.

Many of Say's entomological papers were printed at New Harmony, and bear the imprint, "New Harmony, Indiana. Printed at the School Press."

But Say was more than an entomologist. Besides being the foremost American of his time in that field of zoological science, he was also the foremost American conchologist of his time.

Perhaps the most pretentious single work undertaken by Say was his "American Conchology, or Descriptions of the Shells of North America, illustrated by colored figures from original drawings executed from nature." "The object of this work," said the author, "is to fix the species of our molluscous animals by accurate delineations in their appropriate colours, so that they may be readily recognized even by those who have not extensive cabinets for comparison."

It was Say's intention to elucidate the mollusks of all North America. His plan was to introduce in the first part or number of the publication the species found in the United States so that those subscribers who might wish to limit their inquiries or expenditure to the shells of the Union might be accommodated.

The work was issued in parts or numbers and was sold by subscription. The price per number was $1.50, the subscriber having the privilege of withdrawing his name after having received and paid for four numbers, should he desire to do so. The publishers, however, pledged themselves to reduce the price of future numbers to one dollar, "after the subscription list shall justify a reasonable hope of a *reimbursement of the actual expenditures*."

I have not been able to determine that this very desirable situation was ever realized; apparently it never was, as I find that No. 5 was advertised at the usual price, $1.50.

The plates in Say's American Conchology are from drawings by Mrs. Say, are all excellent in every way and faithfully portray the species represented. They far surpass in artistic merit and scientific accuracy many of the illustrations found in modern zoological publications. Mrs. Say was Miss Lucy May Sistare, evidently an accomplished and talented woman of unusual artistic ability and her assistance was invaluable to her husband in his scientific work.

Although only about a dozen species are definitely credited to Indiana in this work, it is certain that Say conceived the idea of writing an American Conchology after he came to New Harmony. He no doubt wrote all of it at New Harmony, He doubtless spent much time observing and collecting the shells of that region.

It is hardly conceivable that he could have lived nine years on the banks of the Wabash without becoming deeply interested in the wonderfully rich molluscous fauna of that river, a stream richer in the Unionidæ (freshwater clams) than any other river in the world; a river which has supplied more and better shells to the pearl button manufacturers during the last two decades than any other stream in the world. The Wabash has more species of fresh-water mussels than any other stream. I recall with great pleasure many delightful days spent with the late Dr. J. T. Scovell collecting Unios in the Wabash near Terre Haute, and our pleasant evenings identifying our specimens and arranging them in our cabinets. When I tell you that we obtained at least 47 species within a few miles of Terre Haute, you can understand how rich the Unio fauna of the Wabash really is. And we can appreciate with what delight Thomas Say entered upon the study of this wonderfully interesting fauna at a time when most of the species were new and undescribed.

It will ever remain a matter of profound regret that Say died prematurely, before he had completed his studies of the mollusks of the Wabash valley.

The house in which Say first lived was still standing in 1888 when I had the pleasure of visiting New Harmony. It has since been remodeled and is said to be now not recognizable. In this house Say doubtless did much of the work on his "American Conchology," and here were written many of his later entomological papers.

Thomas Say died at New Harmony, October 10, 1834. In the yard at the rear of the house in which he died is a monument of white marble about 6 feet high, erected in 1846 by Alexander Maclure at the request of his brother William Maclure, the life-long friend of Say.

On a beautiful day in September, 1888, Dr. Richard Owen took me to view this monument. Although in his seventy-ninth year, Dr. Owen, without the aid of glasses, read to me the inscriptions on this simple but beautiful shaft. It is worth while to record them here. On the east face:

Thomas Say. The Naturalist. Born in Philadelphia, July 27, 1787.
Died at New Harmony, October 10, 1834.

On the south face:

One of the founders of the Academy of Natural Sciences of Philadelphia
January 25, 1812.

On the west face:

The friend and companion of William Maclure whose surviving brother erected this monument, 1846. A. M.

And on the north face:

Votary of science even from a child,
He sought her presence in the trackless wild;
To whom the shell, the insect, and the flower
Were bright and cherished emblems of her power.
In her he saw a spirit all divine,
And worshipped like a pilgrim at her shrine."

Charles Alexandre Le Sueur, artist, traveler, and naturalist (probably about 1780–1846), was another distinguished member of "the boat load of knowledge" that came to New Harmony in 1825, and who contributed materially to the knowledge of the zoology of the state. Le Sueur had been a great traveler. He had gone around the world with Péron and La Pérouse. He had traveled widely in New England, New York and Pennsylvania, and only shortly before coming to New Harmony he had returned to the United States from the West Indies. He had already gained recognition as an artist of unusual ability. He was one of the founders of the Academy of Natural Sciences of Philadelphia, in the museum of which he was a curator from 1817 to 1825.

To the *Journal* of the Philadelphia Academy he contributed, between the years 1817 and 1825, no fewer than 27 papers in which he described about 187 new species of which about 90 were fishes, many of which occur in the Great Lakes and in the streams of Indiana.

Le Sueur was a naturalist in a broad sense, interested in many groups, including fishes, mollusks, reptiles, worms, corals, and ascidians, his chief interest, however, being in fishes. Dr. Richard Owen says that Agassiz apparently regarded Le Sueur second only to himself as an ichthyologist! His chief interest lay in fishes, and he was "the first to study the ichthyology of the Great American Lakes." He even projected an Ichthyology of North America and issued a prospectus of the proposed publication.

Immediately on his arrival at New Harmony Le Sueur began studying the fishes, turtles and mollusks of the region. He was the first naturalist to explore the Indian mounds in Indiana. Professor Richard Owen, in a letter dated December 14, 1886, to Dr. Jordan, described Le Sueur as he knew him in 1828, as "about 50 to 55 years of age, tall, rather spare of muscle, but hardy and enduring. He permitted his beard to grow, which at that time was quite unusual; hence he sometimes platted it and tucked it almost out of sight when he went from home. In New Harmony he usually went barenecked, often bareheaded, and in summer occasionally barefooted, or at least without socks. His hair had been dark, but was sprinkled (as well as his beard) with gray. His manner and movements were quick; his fondness for natural history (as it was then called) led him to hunt and fish a good deal. In summer he was fond of swimming in the Wabash, and I frequently accompanied him. He instructed me how to feel with my feet for *Unios* and other shells as we waded sometimes up to our necks in the rivers and ponds searching to add to our collections. When he went fishing with others he always exchanged his fine common fishes for the smallest and to them most indifferent-looking, when he recognized some new species or even variety."

Two of our most common turtles, the Map Turtle (*Malacoclemmys geographicus*) and the Soft-shelled Turtle (*Aspidonectes spinifer*) were described by Le Sueur.

Dr. Eigenmann has called my attention to an article by the late French naturalist Vaillant, "Note sur L'Oeuvre Ichthyologique de C. A. LeSueur," in the "Extrait du Bulletin de la Société Philomathique de Paris, tome VIII, No. 1, page 15, 1895–1896."

Vaillant states that LeSueur, after having returned to France from the expedition to Australia in 1804 and after having aided in the publication of the first volume of the narrative of that voyage, accompanied William Maclure to North America from whence he did not return to France until 1838. He was made conservateur of the Museum of Havre, his native city, and there he died December 12, 1846.

It appears that LeSueur projected a large work on the ichthyology of North America. He even went so far as to issue a prospectus giving the conditions of publication. This was issued in 1827 while he resided at New Harmony.

The wording is as follows:

"Proposals

for publishing by subscription

a work on the

Fishes of North America

with plates drawn and colored from nature

By

C. A. Le Sueur.

This will be published at New Harmony, Indiana, in numbers, with four colored plates in each, and the necessary letter-press containing descriptions of the species represented. Twelve numbers will constitute a volume.

Messrs. Tiebout and other artists from Philadelphia, who were there occupied on the "American Entomology," are engaged for this work.

Books with colored plates are generally beyond the reach of persons of limited means; but it is intended that the present work shall be adapted to the circumstances of all. The price to subscribers will therefore be forty cents each number.

Subscribers	*Names*	*Residence*	*Copies.*"

Apparently this prospectus and a first brochure of six leaflets accompanied by five plates, is all of this work which was ever published. Some other parts and a number of original drawings, are among the articles which LeSueur's family deposited in the library of the Museum of Natural History at Paris.

After the death of Thomas Say, a number of years passed before any naturalist appeared to continue the study of the fauna of Indiana. So far as I have been able to learn it was not until sometime in the 50's that we had another productive zoologist within our borders. This was Dr. Rufus Haymond of Brookville. Dr. Haymond was a practicing physician of Brookville with a deep interest in natural history. He apparently was a keen observer with the instincts of a real naturalist. He not only noted the species of animals that came under his observation, but he studied their habits, abundance, and distribution. He was especially interested in mammals and birds. In 1856 he published in the Proceedings of the Academy of Natural Sciences of Philadelphia, a paper on the "Birds of Southeastern Indiana," in which he lists 138 species. Thirteen years later, in the Eleventh Annual Report of the Indiana State Board of Agriculture and the Report of Prof. E. T. Cox, State Geologist, for 1869, Dr. Haymond published lists of the mammals and birds of Franklin County, Indiana.

On pages 203-208 of this report is found his list of the "Mammals found at the present time in Franklin County." In this, the first faunal list of the mammals of Indiana, Dr. Haymond records 32 species. The list is annotated with many interesting and valuable notes on the habits and abundance of the various species.

Speaking of the otter, he thinks it barely possible that a few still linger along the Whitewater, but he had seen none for many years. He says the last black bear was seen in the country about 1839. "They once were very numerous and their claw marks may still be seen on the smooth bark of hundreds of beech trees." Speaking of gray squirrels and black squirrels he believed them to be different species, contrary to the view held by mammalogists. He states that "30 to 40 years ago about one in six of the squirrels was black but now (1869) there are no black squirrels in southeastern Indiana."

Pages 209-235 of the same report are devoted to the "Birds of Franklin County, Indiana." This list is an extremely interesting one. The total number of species recorded is 163, and Dr. Haymond remarks: "This concludes the list of all the birds of the county which I have observed and been able to identify. Doubtless many others visit this section which I have not observed, and I have seen many which I have not been able to identify."

His annotations are so interesting that I feel constrained to quote a few of them, as they will impress us with the great changes which have taken place in our avi-fauna in the last 50 years.

Of the Pigeon Hawk he says: "Occasionally seen following the flight of pigeons in their migrations; very rarely seen at other times." He says the "Cooper's Hawk destroys more young chickens and quails than all the other hawks together. They fly with amazing rapidity, and scarcely ever miss taking their prey."

Of the Carolina Paraquet he states that he never saw but one flock, and "that in June, many years ago;" but old inhabitants assured him this bird was very numerous at the time of the first settlement of the country.

Of the Wild Pigeon he says it is "Still seen in large numbers, though evidently they have been constantly diminishing in numbers for the last forty years, and are probably not half so numerous as they formerly were. In the months of January and February, 1854, these birds roosted about two miles from Brookville, notwithstanding the country is thickly inhabited. No one who did not see them, or who has not seen a 'pigeon roost,' can form any adequate conception of their numbers."

The Wild Turkey had become practically extinct in Franklin County even as early as 1869, and the Ruffed Grouse was becoming rare.

The Wood Duck he says was very common along the Whitewater.

Dr. Haymond never saw but one Canvasback Duck in the county. That was in March, 1855. He had a chance to taste it and pronounced it "very tender and juicy, but with such a fishy flavor that it could scarcely be eaten."

Of the White Pelican he says its visits are like those of the angels, "few and far between."

It is thus seen that many of our most interesting native birds had become or were becoming quite rare as early as 1869.

At a meeting of the State Board of Agriculture, January 6, 1870, an appropriation of $100 was made and placed at the disposal of the State Geologist, Prof. E. T. Cox, for the purpose of putting up a case in the room of the Indiana State Board of Agriculture, for the specimens of Indiana birds and mammals. This was apparently the first allotment of funds for state museum purposes. It shows that but little attention had been given by the state authorities to the natural history of the state.

In the Geological Survey report for 1873 mention is made of the commercial fisheries of Lake County. For the year 1873 the shipments of fish from Michigan City totaled about 270 tons, valued at $27,000. The whitefish made up nine-tenths of the entire catch. the muskallunge and Mackinaw trout forming the other tenth.

These important food fishes are much less abundant now in Lake Michigan; indeed, the muskallunge is practically extinct in that lake, and the Mackinaw trout is rare.

It was stated that the fishermen often take the species of duck known as oldwife (*Harelda glacialis*) in their gillnets set at a depth of 180 feet. On one occasion as many as 300 were taken at one haul.

In 1873, in a report on the geology of Lawrence County, Professor John

Collett called attention to the interesting animal life found in some of the caves in southern Indiana. In Donnelson's cave "thousands of bats gather in the fall and remain through the winter in hibernation, hanging in clusters, like swarms of bees, from the ceiling or sides of the cave; the clusters of bats varying from 20 to several hundred, or in measure, from a quart to a bushel."

He also records other species of animals found in Connelley's, Hamer's and Donnelson's caves. Eyeless fishes, crustaceans and crickets are mentioned. Collections were made by Doctors Elrod and Sloan and forwarded to Prof. A. S. Packard and Dr. E. D. Cope, who identified the specimens.

This appears to have been the first study made of the fauna of Indiana caves, so exhaustively continued recently by our own Dr. Eigenmann.

Under instructions from Professor E. T. Cox, State Geologist, Dr. George M. Levette assisted by Mr. Caleb Cooke, in 1875, took soundings and temperatures of 13 of the small lakes in northern Indiana.

Besides making soundings and taking temperatures of the water, these gentlemen made notes on the fishes and mollusks of the lakes examined. This was, so far as I know, the first serious attempt to learn anything about the fauna of our northern lakes. Dr. Levette's report was published in the Seventh Annual Report of the Geological Survey of Indiana, for 1875. It is an extremely interesting and valuable document. Considerable attention was given to the fishes and turtles and a great deal to the mollusks.

Dr. Levette was primarily a conchologist. In this report he records some 20 species of Unionidæ which he obtained in Indiana north of the Wabash. He also lists 19 species of univalves which he collected in the same waters and which had been identified for him by John W. Byrkit of Indianapolis. He also recorded 9 species of turtles from the same region.

Dr. Levette was the first naturalist I ever met. As a young man I spent a portion of the summer of 1876 in Indianapolis in the office of Professor Daniel Hough in the bookstore of Bowen and Stewart, on Washington Street. Professor Hough and Dr. Levette were intimate friends and were frequently together. Professor Hough, one of the best men I ever knew, was interested in archeology, as also was Dr. Levette. They both occupied rooms in a building which I think, stood at the southwest corner of Washington and Illinois streets. I frequently visited them there. In the rooms of each were what seemed to me at that time great quantities of specimens of Indian axes, mortars, spear and arrow heads, Unios and other mollusks, and turtle shells.

Many of the shells and turtles were the collections Dr. Levette had made the previous summer in northern Indiana. And I remember with what delight he exhibited them to me, and how interested he was when I showed some slight knowledge of the habits and distribution of some of the species, gained from my days of loitering as a boy along Wild Cat Creek and "on the banks of Deer Creek."

Dr. Levette's report on "Observations on the Depth and Temperature of some of the Lakes of Northern Indiana" was transmitted to Prof. E. T. Cox, State Geologist, December 31, 1875. It is printed as pp. 469-503, of the Indiana Geological Survey Report for 1875.

Caleb Cooke, who was Dr. Levette's assistant in these investigations, was one of the curators in the Peabody Museum at Salem, Massachusetts. Dr. Levette speaks of him as a "gentleman of extended and varied experience in collecting and preserving natural history specimens for museum use, as well as for scientific study." Mr. Cooke being associated in the same institution with Prof. F. W. Putnam, an arrangement was effected by which all the fishes collected would be examined by Professor Putnam, and full suites of the species collected, properly labeled, would be supplied to the State Museum at Indianapolis; and all new species figured and described in the Indiana Geological Survey reports. This arrangement, however, was never carried out.

While Prof. E. T. Cox was not a zoologist, he was nevertheless appreciative of the importance of making known the fauna and flora of the state. He did much to call attention to these natural resources of Indiana, and in his various reports as State Geologist are found numerous references to the birds, mammals, fishes and mollusks of our commonwealth.

Ichthyology

The greatest impetus ever given to zoological research and investigation in Indiana occurred when David Starr Jordan (Gainesville, N. Y., Jan. 19, 1851—), came to Indianapolis in 1874 as a teacher of natural history in the high school of that city. He was then a young man scarcely out of his teens, of great physical and mental vigor, with unbounded energy and enthusiasm, and already appreciative of the richness of the fauna and flora of the state. After one year in the Indianapolis high school Jordan was called to the professorship of natural history in the Northwestern Christian University (now Butler University) at Irvington, and his college chum at Cornell, Herbert Edson Copeland, came to take his place in the high school. Copeland was also interested in fishes and he and Dr. Jordan spent many a happy day along Fall Creek, Pogue's Run and White River observing, collecting and studying the fishes which inhabit those waters. This was the beginning of serious study of the fish fauna of Indiana, and one of the most delightful nature stories that has ever been written resulted directly from these days spent along Fall Creek. I refer to the story of the "Johnny Darters" by Jordan and Copeland, published in the American Naturalist for 1876.

Herbert Copeland (1849—Indianapolis, 1876) was an enthusiastic student of these fishes, and a most active and well-equipped naturalist, whose early death at Indianapolis in 1876 deprived American Ichthyology of one of its ablest workers.

Fortunately for the Indianapolis schools and for Indiana, another of Jordan's college associates came to take the place in the high school made vacant by the death of the lamented Copeland. This was Alembert Winthrop Brayton, our own distinguished fellow member, Dr. Brayton, who has ever since been a resident of Indianapolis, who has brought honor and renown to the city and the state, and whom we all love and delight to honor. Professor Brayton at once became associated with Dr. Jordan in ichthyological investigations.

Dr. Jordan's career as ichthyologist and all round naturalist may be said to date from his arrival at Indianapolis in 1874. Indeed, the first new species of fish Dr. Jordan ever described came from Indiana. This was the Cisco and the type locality is Tippecanoe Lake. The specimens were collected by Judge J. N. Carpenter of Warsaw, Indiana, and were by Prof. E. T. Cox turned over to Dr. Jordan who described them under the name *Argyrosomus sisco*, in the American Naturalist, Vol. IX, for 1875. And it is an interesting and singular coincidence that the last new species of fish Dr. Jordan has described from Indiana is *Etheostoma tippecanoe* from the outlet of that lake.

The considerable collection of fishes made in the small lakes in northern Indiana in the summer of 1875 by Caleb Cooke under the direction of Dr. Levette, and which, it was originally intended would be reported on by Professor F. W. Putnam, was really turned over to Dr. Jordan who published a full report thereon in Vol. 29 of the Proceedings of the Academy of Natural Sciences of Philadelphia in 1877. In this paper 10 new species were described. From this time on fish papers from Dr. Jordan's pen or from those of his students and collaborators came thick and fast, and many of these papers related to the fish fauna of Indiana.

I do not know that I can do better than to enumerate the students and others who received their inspiration directly or indirectly from Dr. Jordan and who have contributed to our knowledge of the fishes of Indiana. In doing so I may be permitted to comment briefly on the work they did.

As already mentioned the first to be associated with Dr. Jordan in ichthyological work was Herbert Copeland. Then came Alembert W. Brayton, Charles H. Gilbert, Joseph Swain, Seth Eugene Meek, Carl H. Eigenmann, Elizabeth Hughes, Charles L. Edwards, Morton W. Fordice, Barton Warren Evermann, David Kopp Goss, Bert Fesler, Willis Stanley Blatchley, Charles Harvey Bollman, William L. Bray, Oliver P. Jenkins, Howard Walton Clark, Fletcher B. Dresslar, Martin Luther Hoffman, Jennie E. Horning (Mrs. Francis M. Walters), Chancey Juday, Clarence Hamilton Kennedy, Edward M. Kindle, Philip N. Kirsch, Charles Leslie McKay, William J. Moenkhaus, Robert Newland, Herbert G. Reddick, Douglass Clay Ridgley, Albert B. Ulrey, Joseph H. Voris, Fred C. Test, Albert J. Woolman, Ulysses O. Cox, J. Rollin Slonaker, and doubtless others.

Nearly all of this rather formidable list of zoologists were students of Dr. Jordan, chiefly at Indiana University, where he went from Butler University in 1879.

In the spring or early summer of 1879 it became known that a professor of natural sciences was to be selected by the Board of Trustees of Indiana University to succeed Dr. Richard Owen who had resigned on account of age. Our fellow-member, Dr. A. W. Brayton (Avon, N. Y., March 3, 1848—) thought he might like the place, so he made a trip to Bloomington to look into the matter. Dr. Jordan went along to recommend him to the trustees. I remember very distinctly meeting them on the train as they were returning to Indianapolis and Dr. Jordan telling me, jokingly, that he had done all he could to induce the board to offer the position to his friend Brayton. He told them all the good things he could about Brayton and how eminently well-fitted he was to succeed the distinguished Dr. Owen. The trustees listened to Dr. Jordan most respectfully and then offered the position to *him!* Brayton moved to make it unanimous and there was nothing Dr. Jordan could do but accept!

The twelve years (1879–1891) spent by Dr. Jordan at Indiana University were among the most productive of his life, not only in relation to zoological science in general but to zoology in Indiana in particular. The influence upon the state was epoch making. The effect upon the state of training so many of its young men and women in the method of science and sending them out over the state and beyond its borders imbued with the spirit of the real naturalist who seeks truth, who sees things as they are, and who knows animals when he meets them in the open, can not be overestimated. Many and varied were the problems in zoological science that these young men and women investigated, studied, and attempted to solve. They were by no means confined to the fauna of Indiana. In ichthyology their field was world-wide. It is true, however, that the richness of the Indiana fauna appealed to many of these young naturalists, and zoological literature has been greatly enriched by their contributions. I shall first refer briefly to some of the work that relates especially to the fish fauna of Indiana. I shall begin with Dr. Jordan's life-long and most able and distinguished ichthyological associate,

Charles Henry Gilbert

(Rockford, Ill., Dec. 5, 1859 ——)

Gilbert was discovered in the Indianapolis high school by Herbert Copeland, and it was Copeland who started in him the fire which has never ceased to burn. Upon Copeland's death Gilbert, while yet a mere boy, went with Jordan to Butler University, and with him he has ever since remained most intimately associated.

The first joint paper by Jordan and Gilbert was published January 17, 1877, in the Indiana Farmer, and, very appropriately, it was a list of the fishes of Indiana. Gilbert was then scarcely more than 17 years old. In the same year Dr. Jordan published in the Proceedings of the Philadelphia Academy a paper "On the Fishes of Northern Indiana," based on the Levette-Cooke collections.

Then followed in 1878 to 1883 nearly a hundred papers by Jordan and Gilbert on systematic ichthyology, most of them concerning the fishes of the Pacific Coast of the United States.

In 1883 appeared the Synopsis of the Fishes of North America, by Jordan and Gilbert, a great work of more than a thousand pages in which were described all the species of fishes then known from North American waters. Many original references to the fishes of Indiana are found in this work.

Most of Dr. Gilbert's ichthyological work has been extra-limital so far as Indiana is concerned, as has also that of Dr. Jordan. But much of the actual study was done in Indiana. Among Dr. Gilbert's studies of the fish fauna of Indiana may be mentioned his work on the fishes of the Switz City Swamp in Greene County and that on the fishes of White River. Of course, both he and Dr. Jordan devoted much time to the fishes in the various streams about Indianapolis. Dr. Gilbert's more recent papers have been among the most important contributions to our knowledge of the fishes of the Pacific and of the life history of the species of Pacific coast salmon.

Joseph Swain

Doctor Swain (Pendleton, Ind., June 16, 1857 ——), the distinguished president of Swarthmore College, was deeply interested in fishes in the early 80's. With Dr. Jordan and various students he collected fishes in the streams of Kentucky and Indiana. The subject of Swain's graduating thesis at Indiana University in 1883, was "The Rainbow Darter." Besides describing a new darter *(Hadropterus scierus)* from Bean Blossom Creek, Indiana, he, as junior author with Dr. Jordan, contributed some 15 papers to the literature of systematic ichthyology.

Seth Eugene Meek

The late Dr. Meek (Hicksville, O., April 1, 1859—Chicago, Ill., July 6, 1914), was one of Dr. Jordan's most enthusiastic and energetic students. He studied the fishes of the region about his home (Hicksville, Ohio) and those in the vicinity of Chicago, the studies in each case extending across the line into Indiana. He also collected extensively in Iowa, Nebraska and Arkansas, but his most important work was done on the fishes of Mexico, Central America and the Canal Zone. Dr. Meek contributed more than 50 papers on fishes and reptiles. At the time of his death Dr. Meek was the best authority on the fishes of Mexico and Central America. Dr. Meek and the present writer began their contributions to ichthyological literature in 1883 in a paper entitled "A review of the species of the genus Gerres," of which they were joint authors. From that date until Dr. Meek's untimely death we remained most intimately associated in scientific work.

Carl H. Eigenmann

(Flehingen, Germany, March 9, 1863 ——)

Dr. Eigenmann of the Indiana University contingent, is one of the most able and productive of American ichthyologists. He has been and still is, indefatigable in ichthyological investigation; his list of publications embraces more than 150 titles, many of them important monographs. During his long residence in Indiana he has naturally given much attention to the fish fauna of the state. He first studied the fishes of Bean Blossom Creek and he and Morton W. Fordice published an interesting paper on the results. They list 40 species, 32 of which were obtained in a single day's collecting. Among Dr. Eigenmann's more important papers that relate directly to the zoology of Indiana are those giving the results of his studies of cave faunas. It may be doubted if any phase of American zoology has been more comprehensively or satisfactorily studied than this by Dr. Eigenmann and his student assistants.

Barton Warren Evermann

The present writer (Monroe Co., Iowa, Oct. 24, 1853 ——), who also sat at Dr. Jordan's feet at Indiana University and there received inspiration, has published more than 200 articles, reports and books on various natural history subjects, chiefly fishes and birds. Many of the fish papers were as junior author with Dr. Jordan. In 1882 to 1886 he explored the streams of Carroll and Howard counties and, jointly with Dr. Jenkins, published an annotated list of the species of fishes obtained. In 1886 to 1891 he studied the fish fauna of Vigo County. In 1888, with the assistance of Charles H. Bollman, he collected the fishes of southwestern Indiana, and with Albert J. Woolman (then one of his students) he examined St. Joseph River at South Bend and Mishawaka, Yellow River at Plymouth, Lake Maxinkuckee, Eel and Wabash rivers at Logansport, and Deer Creek at Camden. The results of these investigations were set forth in a paper published by Dr. Jordan. In 1899 to 1913, as a part of the survey of Lake Maxinkuckee, much attention was given to the fishes by Dr. Evermann, Mr. H. Walton Clark and Dr. Scovell, with the result that more is now known of the fishes of that lake than of any similar body of water in America. The total number of species of fishes known to inhabit Lake Maxinkuckee is 63, a much larger number than has been found in any other lake, even of much greater size, anywhere in the world. The report on this work has been completed and is now awaiting publication. He has also published reports on the food-fishes of Indiana (junior author with Dr. Jordan), two new darters (*Etheostoma aubeenaubei* and *Hadropterus maxinkuckiensis*) from Lake Maxinkuckee, a new shad (*Alosa ohiensis*) from the Ohio River, with notes on the other food-fishes of that river, a list of the fishes known from the Great Lakes, and a list of the fishes of Franklin County, Indiana. He is also junior author with Dr.

Jordan of a four-volume work of over 3,300 pages on the Fishes of North and Middle America in which all species then known are described, and of another large popular work on American Food and Game Fishes.

Willis Stanley Blatchley

Professor Blatchley (North Madison, Conn., Oct. 6, 1859 ——) is perhaps the most active and enthusiastic naturalist that Indiana has ever produced. He has not specialized in any one subject to the exclusion of interest in others. He is an all-round naturalist, deeply and intelligently interested in nature in all her various aspects. Having been a student of Dr. Jordan's very naturally his first published papers relate to fishes, but very soon he turned his attention more strongly to other fields, chiefly entomology. Only Mr. Blatchley's work in ichthyology will be considered here, his other activities being reserved for mention elsewhere in this report.

Blatchley's first paper was on the American species of the genus Umbra, published in 1885. In the same year appeared two other papers, one a review of the species of the genus Pimephales, the other on the genus Aphredoderus. These fishes all occur in Indiana.

Oliver Peebles Jenkins

(Bantam, O., Nov. 3, 1850 ——)

Professor Jenkins has contributed ten or more papers to ichthyological literature. Two of them relate to the fishes of Indiana, namely, a list of the fishes of Vigo County, Indiana, published in 1885 and 1888, and Notes on Indiana fishes (with Barton Warren Evermann), published in 1888. In the summer of 1887, Dr. Jenkins and the present writer collected and studied the fishes of the Gulf of California particularly in the vicinity of Guaymas, the results of which were published by the National Museum in 1889 and 1891. Later, Dr. Jenkins studied the fishes of the Hawaiian Islands, on which he published four important papers in 1900 to 1903.

William J. Moenkhaus

Dr. Moenkhaus (Huntingburgh, Ind., Jan. 6, 1871 ——) has contributed a number of interesting papers on fishes: Variation in the color-pattern of *Etheostoma caprodes*, 1893; Some cases of mimicry in fishes, 1894; Variation of North American fishes, 1894; Notes on a Collection of fishes from Dubois County, Indiana, 1895; Variation of North American fishes, II, 1895; Material for the study of the variation of *Etheostoma caprodes* Rafinesque, and *Etheostoma nigrum* Rafinesque, in Turkey Lake and Tippecanoe Lake, 1897; Experiments in the hybridization of fishes, 1901; An aberrant *Etheostoma*, 1901; Description of a new darter (*Hadropterus evermanni*) from Tippecanoe Lake, 1903.

Besides those who have contributed several papers each to the elucidation of the fish fauna of Indiana there are several others who have written one or more short papers on the fishes of the state.

I shall refer to them briefly.

Charles Harvey Bollman, was joint author with Barton Warren Evermann of a list of the fishes observed in the vicinity of Brookville, Indiana.

Ernest P. Bicknell and Fletcher Bascom Dresslar reviewed the genus Semotilus, 1889, a genus represented in Indiana by one of our most abundant and familiar species.

Morton William Fordice, as joint author with Carl H. Eigenmann, published a list of the fishes of Bean Blossom Creek, Indiana, in 1885; also a review of the North American species of Petromyzontidæ, in 1886 (joint author with Dr. Jordan); also a review of the sturgeons of North America, in 1889 (joint author with Philip H. Kirsch). Dr. Philip H. Kirsch, for several years Indiana State Fish Commissioner, besides his official reports as Commissioner, wrote several fish papers. One of these was an account of the fishes of Eel River and its tributaries, another was on the fishes of the Maumee River basin, both published in 1894.

Albert J. Woolman wrote a valuable paper on the fishes of Kentucky, published in 1890. He also assisted the present writer in collecting and studying the fishes of Northern Indiana in 1888. He also wrote on the fishes of Florida and Mexico.

Albert B. Ulrey studied the fishes of Wabash County, Charles Leslie McKay who lost his life in Alaska in 1883, reviewed the family of sunfishes, of which there are many speices in Indiana. David Kopp Goss, Charles Lincoln Edwards, Bert Fesler, William L. Bray, Martin Luther Hoffman, Jennie E. Horning (the late Mrs. F. M. Walters), Elizabeth Hughes, Rosa Smith (now Mrs. C. H. Eigenmann), and Robert Newland, while students at Indiana University under Dr. Jordan, did more or less work on fishes, and each published one or more papers, none of them, however, dealing directly with Indiana fishes. Among the students of Dr. Eigenmann who have done some work on the fish fauna of Indiana, I may mention C. H. Kennedy, Edward M. Kindle, Herbert C. Reddick, D. C. Ridgley, Joseph H. Voris, and Earl E. Ramsey. Most of these did work at the Indiana University Biological Station at Turkey and Winona lakes. Among the students of Dr. Evermann who have worked more or less in ichthyology may be mentioned Albert J. Woolman, Cloudsley Rutter, Hiram W. Monical, D. C. Ridgely, Joseph H. Voris, William J. Moenkhaus, J. Rollin Slonaker, Ulysses O. Cox, and Fred M. Chamberlain. Each of these has made contributions of value to our knowledge of fishes. Special mention should be made of Mr. Chamberlain's valuable studies of the life histories of Pacific Coast Salmon.

From the foregoing review of the progress of ichthyology in Indiana during the century just ending, it is seen that nothing whatever was known of the fishes of Indiana in 1816. Not until two years after Indiana became a state were any of its fishes collected or studied. The first work was that of Rafinesque in 1818. Then came a period of more than half a century during which practically nothing was added to our knowledge of the fishes of the state. But with the coming of Jordan to the state in 1874, the study of the fish-fauna of Indiana began in earnest and has so continued to this day. The streams and lakes of Indiana have been more carefully examined than have those of any other state. The fishes have been more carefully collected and studied and are better known. More species are known from Indiana than from any other state. The Wabash has the richest fish fauna of any river in the world; it has more than three times as many species of fishes as are found in all the waters of the United States draining into the Pacific. Lake Maxinkuckee, with its 63 species, has the richest fish fauna of any lake in America, if not in the world.

Practically all this work on the fishes of Indiana has been done by home talent, by native Hoosiers and by others who came to the state to live and do their scientific work; but, great as has been their contribution to the ichthyology of Indiana, their contributions to the ichthyology of the rest of the world are vastly greater.

While much work has been done on the fishes of Indiana, a vast amount still remains to be done. There are many streams and lakes in which there has been no collecting. Indeed, not a single stream has been thoroughly studied, and only one or two lakes have received even a fraction of the attention they deserve. The geographic distribution of each species within the state, its food, enemies, rate of growth, spawning habits, food value, and ecological relations, are all important problems concerning which our knowledge is far from complete. These are some of the problems that the right sort of State Fish and Game Commission would take up for serious investigation.

Mammalogy

Mention has already been made of Haymond's list of the mammals of Franklin County, Indiana. Reference should also be made to a number of general publications in the early part of the century in which some Indiana mammals are mentioned. Audubon and Bachman in their quadrupeds of North America, Vol. 2, 1851, mention the buffalo as having occurred in Indiana. Robert Kennicott in his quadrupeds of Illinois, injurious and beneficial to the farmer (1856), refers to several mammals from Indiana. Professor Baird in his mammals of the Pacific Railroad Survey, 1857; Doctor Jordan in the various editions of his Manual of Vertebrates (1876, 1878, 1880, 1888, 1890, 1899); Dr. J. A. Allen in his history of the American bison (1877), Dr. Elliott Coues in his Fur-bearing animals (1877), and Coues and Allen in their North American Rodentia, all make some references to certain mammals as occuring in Indiana.

After Dr. Haymond, the next paper of a faunistic nature dealing with our mammals is Dr. Frank W. Langdon's Mammalia of the vicinity of Cincinnati, published in 1881. In this list are several references to Indiana localities for the species mentioned. A year later Dr. Langdon published a synopsis of the Cincinnati fauna in which similar Indiana references occur. In this same year (1882) Dr. Brayton published his report on the mammals of Ohio, containing many references to Indiana localities.

Many of these publications were compilations which did not represent any original investigation or study of the Indiana mammalian fauna. But about this time there began to appear in the Journal of the Cincinnati Society of Natural History, the American Naturalist, the Bulletin of the Brookville Society of Natural History, the Indiana Farmer, and elsewhere, short papers of a very different character, papers which told about the animals which the writers themselves had seen, observed and studied in the open, in their natural environment. These papers were by two young men at Brookville,—Edgar R. Quick and Amos W. Butler, some of them joint productions. The first was by Mr. Quick in 1881 on the white-footed mouse, which was followed the next year by one on the common meadow mouse; also by another short paper on mammals found in Franklin County. In 1884 Quick and Butler published in the American Naturalist a valuable paper on the habits of some Arvicolinæ. In the same year Mr. Butler published a paper on Local Weather Lore in which interesting references are made to various animals. Then followed numerous papers on Franklin County mammals by Mr. Butler: Observations on the muskrat; Observations on faunal changes; The common meadow mouse; Some more mice; Meadow mice in southeastern Indiana, all in 1885; Zoological miscellany in 1887 and 1888. Our smaller mammals and their relation to horticulture, in 1891; Our Indiana shrews, in 1892; Bibliography of Indiana mammals and a preliminary list of Indiana mammals (joint author with Barton W. Evermann) in 1893; The mammals of Indiana, in 1894; Indiana—a century of changes in the aspects of nature, in 1895; and Life in the forest—mammals, in 1898.

Barton Warren Evermann has made a few contributions to our knowledge of the mammalian fauna of Indiana. In 1888 he published the first record of the occurrence of the star-nosed mole in Indiana; in 1894, a bibliography of Indiana mammals and a preliminary list of Indiana mammals (with Amos W. Butler); and in 1911 (with H. Walton Clark) an annotated list of the mammals of Lake Maxinkuckee and vicinity.

Another Indiana naturalist who made valuable contributions to the literature of the Indiana mammalian fauna is the late Dr. Walter L. Hahn. Dr. Hahn spent the month of August, 1905, in field work studying the mammals of the Kankakee region in northwestern Indiana, the results of which he published in 1907 as "Notes on mammals of the Kankakee Valley." In 1908, there appeared from Dr. Hahn's pen, three valuable papers dealing with Indiana mammals: "Some habits and sensory adaptations of cave-habiting bats;" "Notes on the mammals and cold-blooded vertebrates of the Indiana University farm, near Mitchell, Indiana;" and "the Mammals of Indiana." The last of these, published in the "Indiana Department of Geology and Natural Resources" for 1908, is the most important publication yet issued on the mammalian fauna of Indiana.

In it are given full descriptions of all the 66 species known from the State, and much interesting and valuable information regarding their abundance, distribution, and habits.

In Dr. Hahn's untimely death on St. Paul Island, Bering Sea, May 31, 1911, zoological science lost one of its most promising young men.

While considerable collecting of the mammals of the state has been done, our knowledge is very incomplete. There are doubtless many species belonging to the local fauna which have never as yet been recorded from the state.

And then, the habits and the economic relations of the various species have been studied scarcely at all. As an illustration, the possibilities of fur-farming in Indiana have received no serious attention. This is a matter well worthy serious consideration. The muskrat is particularly worth experimenting with. The hundreds of small lakes and ponds dotting every county in the northern part of the state, each surrounded or bordered by large areas of marsh land such as affords an ideal home for muskrats, should be considered with reference to muskrat farming. The muskrat is very prolific; its fur is popular and brings a good price, that of northern Indiana muskrats being particularly fine and bringing very high prices.

A little attention to this question, a little experimental muskrat farming, will demonstrate, I confidently believe, that northern Indiana is an ideal country for this industry; an industry which once started, will add thousands of dollars to the income of the farmers of northern Indiana.

Ornithology

Mention has already been made of the relation to our state of the two great American ornithologists, John James Audubon, and Alexander Wilson. This relation was slight at best. It is certain that Wilson on his trip down the Ohio in March, 1810, observed certain species of birds on the Indiana side of the river and actually tried, apparently without success, to collect specimens of the wild turkey just below Vevay. That Audubon in the several years that he lived at Louisville and Henderson, on the Kentucky side of the Ohio River, made some collecting trips to the Indiana shore, is a very safe assumption. But neither of them so far as I have been able to learn, ever published anything on the birds of Indiana. I have also mentioned Dr. Rufus Haymond and his list of birds of Franklin County. I shall now speak of the more recent ornithologists who have contributed to our knowledge of the avi-fauna of Indiana.

ROBERT RIDGWAY

(Mount Carmel, Ill., July 2, 1850 ——)

And first of all, it is a great pleasure to head the list with the greatest and most productive systematic ornithologist that America has ever produced. Mt. Carmel, Illinois, where Mr. Ridgway was born, is so close to the Indiana line that we may with propriety claim him as one of our own; indeed, he was a resident of Wheatland, Knox County, Indiana, for some years where he studied the birds and wrote much regarding them. Professor Ridgway has contributed more than 500 papers, some of them formidable volumes of hundreds of pages, to the literature of ornithology and other natural history subjects. Some of these deal directly or indirectly with the avi-fauna of Indiana. His first paper, a note on the nesting habits of the belted kingfisher, appeared in the American Naturalist for March, 1869, after which followed numerous papers on the birds of southeastern Illinois, all of which were almost equally applicable to southwestern Indiana.

AMOS WILLIAM BUTLER

(Brookville, Ind., Oct. 1, 1860 ——)

We now come to the Father of the Ornithological Renaissance in Indiana, the Father of the Indiana Academy of Science, our own distinguished and much beloved Vice-President, Amos W. Butler, Mr. Butler has contributed more to our knowledge of Indiana birds than all other writers combined. His first paper, which appeared when he was scarcely more than 21 years old, was a list of the birds of Franklin County, Indiana. This was in 1882, some 13 years after the appearance of Dr. Haymond's list of birds of the same county. Since 1882, numerous papers and reports on the ornithology of Indiana have been published by Mr. Butler, as follows: Observations on faunal changes, 1885; A list of the birds observed in Franklin County, Indiana, 1886; The Cerulean warbler, 1884; Zoological Miscellany, 1887 and 1888; Notes on the range of the prothonotary warbler in Indiana, 1888; A catalogue of the birds of Indiana, 1890: Our birds and what they do for the farmer, 1890; Notes on the range and habits of the Carolina parrakeet, 1892; Some notes concerning the evening grosbeak, 1892; Notes on Indiana birds, 1891; Further notes on the evening grosbeak, 1893; The range of the crossbills in the Ohio valley, 1892; 1893; Bibliography of Indiana Ornithology, 1893; Notes on Indiana birds, 1893; Notes on the birds of 1894; An orchard talk, 1895; The Birds of Winona, 1895; Indiana; a century of changes in the aspects of nature, 1895; Additional notes on Indiana birds, 1895; From wilderness to civilization, 1896; The Bobolink in Indiana, 1896; Some additions to the Indiana bird list, 1896; Notes on Indiana heronries, 1897; The recent occurrence of the raven in Indiana, 1897; The birds of Indiana, 1897; Brünnich's Murre in Indiana, 1897; Bird life in Indiana, 1898; Notes on Indiana birds, 1899; Conditions affecting the distribution of birds in Indiana, 1903.

Mr. Butler has given special attention to the occurrence of rare species in Indiana; he has been, and still is, most persistent and indefatigable in verifying all reports and records of rare birds in the state.

Edward William Nelson

(Manchester, N. H., May 8, 1855 ——)

In Nelson's "Additions to the avi-fauna of Illinois, with notes on other species of Illinois birds," published in 1876, a number of references to birds in the Wabash Valley may be found. In 1877, he recorded the Louisiana heron as occurring in Indiana, and in his birds of Northeastern Illinois published the same year, he recorded many observations made on birds in Indiana about the south end of Lake Michigan. In still another paper published in 1877 on birds observed in southern Illinois he includes species noted on the Wabash and White rivers in Indiana.

Barton Warren Evermann

The present writer began studying the birds of Indiana in the fall of 1877. His first published notes appeared in the *Delphi Journal* in the winter of 1878-79, and related to the winter birds observed in the vicinity of Camden. After these brief notes, followed other short articles and faunal lists of which the following may be mentioned: An unusual nesting site of the chewink, 1881; Bluebirds' eggs, 1882; Bird notes from Bloomington, Indiana, 1883; Bird migration, 1884; Arrivals of birds at Camden, Indiana, 1884; A day with the birds of a Hoosier swamp, 1886; White eggs of the bluebird, 1886; Some rare Indiana birds, 1887; Bird migration, 1887; Birds of Monroe County, Indiana, 1887; An addition to the list of birds of Monroe County, Indiana, 1887; Birds of Carroll County, Indiana, 1888; The Wood Ibis in Indiana, 1889; The movements of birds, 1889; Migratory birds, 1889; Notes on owls, 1890; The Indiana bird law, 1891; The feeding habits of the coot and other water birds, 1902; Habits of the chimney swift, 1905; Bird life on an Indiana farm, 1906; Owls of Carroll County, Indiana, 1909; The birds of Lake Maxinkuckee and vicinity (with H. Walton Clark). Besides these he has published a number of papers relating to the birds of California.

Various other persons have made contributions to our knowledge of the birds of Indiana. Among these may be mentioned the following:

Dr. Frank W. Langdon in his study of the birds of the vicinity of Cincinnati no doubt often wandered across the Indiana line.

William Brewster in an article on the prothonotary warbler recorded observations made in Knox and Gibson counties, Indiana.

Joel Asaph Allen in the Memoirs of the Boston Society of Natural History for December, 1868, published a list of 72 species of birds which he had observed the preceding June at Richmond, Indiana. Dr. Allen also published in 1878 a note on the early nesting of the shore lark near Indianapolis.

Dr. Jared Potter Kirtland (1793–1877) of Cleveland, Ohio, in a letter dated 1857, published in 1874, mentions a number of Indiana birds.

Dr. Elliott Coues in his Birds of the Northwest makes reference to some Indiana birds.

Dr. David Starr Jordan in the various editions of his Manual of Vertebrates (1876–1900) has numerous Indiana references to birds. In 1879, Dr. A. W. Brayton published in the Transactions of the State Horticultural Society a catalogue of the birds of Indiana, with keys and descriptions. This was the first important list of the birds of the entire state.

In 1881 Edgar R. Quick recorded the occurrence near Brookville of *Catharista atrata* and *Chen hyperboreus*, and in 1882, published some notes on the winter birds in the vicinity of Brookville. In the same year Dr. J. M. Wheaton published his large volume on the birds of Ohio in which there are numerous Indiana references.

Fletcher M. Noe of Indianapolis published brief notes on rare Indiana birds in 1884, 1885, 1886, 1888 and 1890.

In 1889, Maurice Thompson published in the Indiana Geological Survey Report a preliminary sketch of the aquatic and shore birds of the Kankakee region. Three years later R. Wes McBride published some notes on Indiana birds; Prof. A. B. Ulrey published some notes on the American bittern; James E. Gould had a note on the nesting of the bald eagle at English Lake; and E. M. Kindle wrote of the arrival of some migratory birds in Johnson County, Indiana. In 1893, U. O. Cox published a list of the birds of Randolph County, Indiana, and Mr. McBride published notes on the rose-breasted grosbeak in Michigan and Indiana.

In concluding the list of ornithologists who have added to our knowledge of Indiana birds I must not fail to mention Mrs. Jane Louisa Hine who died at her home at Sedan, Indiana, February 11 of the present year, in the eighty-fifth year of her age. Early in her long and useful life Mrs. Hine became interested in birds. When the present writer was superintendent of bird migration observers in Indiana and the southern peninsula of Michigan during the eighties, Mrs. Hine was one of his most energetic and reliable observers. She published numerous articles on birds in the Farmer's Guide, of Huntington, Ind., and supplied many interesting notes to Mr. Butler which he published in his Birds of Indiana. She also published in the Auk in 1894, a very interesting article on the ruby-throated hummingbird.

Herpetology

Much good work has been done on the reptiles and batrachians of Indiana. A little was done by Rafinesque, Say, and Le Sueur between 1818 and 1835; a little by Dr. Haymond between 1850 and 1870, after which the field was left practically unworked until 1882 when the Reptiles and Amphibians of Ohio by W. H. Smith, was published in Vol. IV of the Geological

Survey of Ohio. This annotated list mentions most of the species found in Indiana.

In the American Naturalist for 1885, Mr. Butler published a paper on Hibernation of the lower Vertebrates in which there are recorded interesting observations on certain species of turtles and frogs. To the Journal of the Cincinnati Society of Natural History Mr. Butler furnished several contributions to Indiana herpetology.

1886, Edward Hughes published in the Bulletin of the Brookville Society of Natural History a preliminary list of the reptiles and batrachians of Franklin County. This list is annotated and records 40 species.

In 1887, Dr. O. P. Hay (Jefferson Co., Ind., May 22, 1846 ——) published a preliminary catalogue of the Amphibia and Reptilia of Indiana; and in 1893 appeared Hay's "Batrachians and Reptiles of Indiana," a very useful publication of more than 200 pages in which are given full descriptions of all the species then known from this state.

Professor Blatchley has observed, collected and studied the reptiles and batrachians of Indiana for many years, and has contributed a number of faunal lists and other important papers, among which may be mentioned the following: Notes on the batrachians and reptiles of Vigo County, Ind., (1891); How plants and animals spend the winter (1897); Indiana caves and their fauna (1896); Notes on the batrachians and reptiles of Vigo County, Ind. (1900); and On a small collection of batrachians and reptiles, with descriptions of two new species (1900).

As a part of their survey of Lake Maxinkuckee Evermann and Clark gave attention to the reptiles and batrachians of that region, and in the Proceedings of this Academy for 1914 they published an annotated list of the snakes. The number of species recorded by them as occurring in the vicinity of Lake Maxinkuckee is 10. They have ready for publication similar annotated lists of the turtles and batrachians, 9 species of the former and 18 of the latter.

Conchology

As already stated in the introduction to this paper, the study of the molluscous fauna of Indiana began with Thomas Say at New Harmony in 1825 to 1834. But even earlier than Thomas Say was that versatile naturalist, Constantine Samuel Rafinesque, who visited New Harmony in 1818, and who began describing the fishes and mollusks of the Ohio the same year. His first paper dealing in part with the shells of Indiana appeared in 1818 and was entitled "Discoveries in natural history in the Western States." This was followed in rapid succession in 1818 to 1820, by a half dozen other papers each dealing more or less with the mollusks of Indiana. In these various papers several new species are described.

In M'Murtie's Sketches of Louisville and its Environs, etc., first edition, 1819, is a list of the mollusca of the vicinity of Louisville and the Falls of the Ohio, for which the author says he is indebted to the "politeness of that accomplished and skillful naturalist, Mr. Rafinesque."

In 1823, D. H. Barnes published a paper on the genera Unio and Alasmodonta in which some Indiana shells are described and figured. Five years later Barnes published another paper entitled Reclamation of Unios.

In the general works of Poulson, Conrad, Lea, Binney, Prime, Stimpson, Tryon, Harper and Wetherby, Call, Wright, Walker and others, will be found much of value and interest, but practically nothing relating to mollusks as a part of the fauna of Indiana.

Not until 1844, or 10 years after the death of Say, was anything further published on the shells of this state. In that year, Dr. John T. Plummer published in the American Journal of Science and Arts, a list of the shells observed about Richmond, Wayne County, Indiana. About 30 species are recorded. In the summer of 1875 Dr. George M. Levette of Indianapolis, in connection with his study of the lakes of northern Indiana, made considerable collections of shells in that region. The species were listed in the State Geological Survey report for 1875. Mr. John W. Byrkit of Indianapolis identified the univalves of which there are 19 species and subspecies in the list. Besides these there are 20 species of Unionidæ.

Five years later (1880) Mr. Fred Stein contributed to the Indiana Geological Survey Report a paper on the mollusks of the state. This appears to have been the first attempt to catalogue the mollusks of the entire state. In 1885 Dr. R. Ellsworth Call (Brooklyn, N. Y., May 13, 1856–1916) published a paper on the geographic distribution of the Unionidæ of the Mississippi Valley.

Then followed a number of valuable papers by Dr. Call: On the genus Campeloma, in 1886, and 1887; Contribution to a knowledge of Indiana Mollusca, in 1894; On the Geographic and hypsometric distribution of North American Viviparidæ, in 1894; The Unionidæ of the Ohio River, in 1894; The Strepomatidæ of the Falls of the Ohio, in 1894; A Revision and Synonymy of the Parvus group of the Unionidæ, in 1896; Second Contribution to a knowledge of Indiana Mollusca, in 1896; On a small collection of Mollusks from Northern Indiana, in 1896; Fishes and shells of the Falls of the Ohio, in 1896; and the hydrographic basins of Indiana and their molluscan fauna, in 1897.

The most voluminous and complete contribution to the conchology of Indiana is that by Dr. R. Ellsworth Call, a Descriptive Illustrated Catalogue of the Mollusca of Indiana, printed in the 24th Annual Report of the Indiana Geological Survey for 1899. This document lists 186 species of mollusks for the state, and is by far the most valuable contribution to Indiana conchology.

In the 26th annual report of the Indiana Department of Geology and Natural Resources, for 1901, Mr. L. E. Daniels has a useful Check-list of

Indiana Mollusca, with localities, in which 276 species of mollusks are credited to the State.

In 1898, Frank C. Baker (Warren, R. I., Dec. 14, 1867 ——) of the Chicago Academy of Sciences, published a valuable report on the mollusca of the Chicago area, which contains a good deal of matter relating to Indiana localities.

In 1885, D. R. Moore and Amos W. Butler published in the Bulletin of the Brookville Society of Natural History a list of the land and freshwater mollusca observed in Franklin County, Indiana. This paper enumerated 63 species as occurring in that county, and was, up to then, the most important local list of Indiana mollusks that had been published.

In 1893, E. Pleas printed in the NAUTILUS a list of some 123 species and subspecies of mollusks found within five miles of his home near Dunreith. This is a mere list without annotations.

Charles Dury of Cincinnati has published some brief notes on the mollusks of the vicinity of Cincinnati in which mention is made of some Indiana localities.

Ulysses O. Cox, in 1893, published some notes on the mollusks of Randolph County, Indiana.

The late Josiah T. Scovell (Vermontville, Mich., July 29, 1841—Terre Haute, Ind., May 8, 1915) one of the founders of this Academy and until his death in 1915, an honored member, during the years of his long residence at Terre Haute, was deeply interested in the Unionidæ of the Wabash River, as was also the present writer while a resident of Terre Haute from 1886 to 1891. We worked together in collecting, caring for and studying the shells. Many a day we spent together wading in the Wabash searching for new or desirable specimens and many an evening was even more pleasantly devoted to studying, identifying and arranging our collections. The freshwater mussel fauna of that portion of the Wabash is a remarkably rich one, as evidenced by the fact that our collections contained representatives of at least 47 species of Unionidæ taken within 10 miles of Terre Haute.

During the physical and biological survey of Lake Maxinkuckee, conducted more or less intermittently from 1899 to 1913, much attention was devoted to the Uniondæ of that lake. These studies were carried on by Dr. J. T. Scovell, H. Walton Clark and the present writer. Special attention was given to the life histories of the different species, and it is doubted if the molluscous fauna of any other body of water in America has been so thoroughly studied. The number of species of Unionidæ known to inhabit this lake is 13, one or two of them, as *Lampsilus luteolus*, being very abundant and of commercial importance.

In 1903, T. J. Headlee and James Simonton made a study of the mussels of Winona Lake, from which they recorded eight species. In the same year Blatchley and Daniels published a paper on some mollusca known to occur in Indiana.

But as Dr. Call has truthfully said: "There has never been made a geographic study, within this state, of its mollusks. Nor have systematic collections ever been made of so much as even a single stream. * * * * The first essential condition to a complete study of the geographic distribution of Indiana mollusca lies in complete and painstaking local collections. This is not the task of a week nor of a single season. * * * * * What is done must be done systematically and thoroughly and at once" before the great changes being brought about by civilization result in the extinction of the species.

Entomology

As loyal Hoosiers, either by birth or choice, we can all feel a just pride in the fact that the "Father of American Entomology," Thomas Say, chose Indiana as the field of his labors and as his home. Here he lived from 1825 until his death in 1834; here he did much, perhaps most, of his entomological field work and laboratory study; and here, in historic and beautiful New Harmony, rest his remains.

With the passing of Say, the study of the insects of Indiana practically ceased for nearly 50 years. I have not been able to examine the literature critically; for my present purpose it is not necessary that I should do so.

It is enough to know that since Say's time, very little entomological work was done in Indiana for many years.

The subject of entomology seems to have lain dormant until about 1885 when John Caspar Branner, (New Market, Tenn., July 4, 1850 ——), distinguished geologist, came to Indiana University as head of the department of geology in that institution. Dr. Branner was, and is, more than a geologist. His interests are many. Among the things in which he was deeply interested in those days was entomology, not as a field in which he himself was working or intended to work, but as a field which offered splendid opportunities for original investigation to those of his students whose tastes inclined then in that direction. Dr. Branner told some of his students of the richness of this field. Some of them became interested. Perhaps the first of all was my college classmate, Jerome Fee McNeil who studied the *Myriopoda* of Indiana, and in 1886, published descriptions of twelve new species, chiefly from Indiana. Later he published other papers on this group and upon the *Orthoptera*.

Another young man whom Dr. Branner discovered was Charley Bollman at that time a boy of 17 or 18 of unusual promise. He very soon became interested in birds, fishes and myriapods, but most deeply in myriapods.

He and McNeil did much collecting together, and each soon began to publish the results of his studies. Bollman's first paper on these animals was one describing ten new species of myriapods in 1887. This was followed by 12 or more papers containing descriptions of many new species of myriapods, a large proportion of which were from Indiana.

At the time of Mr. Bollman's untimely death at Waycross, Georgia, July 13, 1889, he left several uncompleted manuscripts dealing with myriopoda. These and all his previously published papers were brought together, edited, and published by Dr. L. M. Underwood, in Bulletin 46, United States National Museum. Practically all that is known about the myriapods of Indiana we owe to Charles H. Bollman. His early death was a great loss to zoological science and to Indiana.

But the one who has done most for Indiana entomology is another Indiana University man who received inspiration from Jordan and Branner. I refer to W. S. Blatchley. Blatchley began observing and studying the insects of the state in the early 80's, and soon began publishing papers on grasshoppers, butterflies and beetles. Following a number of short papers, there appeared in 1903 a large volume of 558 pages on the Orthoptera of Indiana, an illustrated descriptive catalogue of all the species of this group known to occur in the state. In 1910 appeared another monumental work of 1,386 pages on the Coleoptera or Beetles of Indiana. And only recently (November, 1916) Professor Blatchley has published another volume of 682 pages and 155 illustrations on the "Rhynchophora of Northeastern America." This monograph includes of course descriptions of all the species of that group known from Indiana.

These three great volumes are among the most important entomological publications ever issued and contribute enormously to the knowledge of the insects of Indiana.

Another Indiana man who has contributed many important papers to the entomological literature of the state is Mr. Edward Bruce Williamson (Marion, Ind., July 10, 1878 ——) of Bluffton. Mr. Williamson has specialized in the Odonata or dragonflies and is the American authority on that group.

I have not been able to consult a full list of his papers, but I find that he has contributed probably more than half a hundred titles to this subject. Mr. Williamson has studied the Odonata of Indiana very carefully. One of his first papers, published in the 24th Annual Report of the Department of Geology and Natural Resources of Indiana in 1900, is a descriptive list of all the species of dragonflies then known to occur in Indiana. Many of Mr. Williamson's papers which followed relate to the Odonata fauna of Indiana. These papers are not only taxonomic and faunistic, but they contain much regarding the life histories of these interesting insects.

Still another Indiana man who has written on the Odonata of Indiana is Clarence H. Kennedy, who studied the dragonflies of the Winona Lake region and published a list of the species. Dr. Charles B. Wilson (Exeter, Me., Oct. 20, 1861 ——) of Westfield, Massachusetts, while a member of the Lake Maxinkuckee survey party studying the parasites of the fishes of that lake, also collected and studied the dragonflies of that region. His report is now in the hands of the U. S. Bureau of Fisheries, awaiting publication.

The late Dr. F. M. Webster (Lebanon, N. H., Aug. 8, 1849 — 1916), one of the ablest economic entomologists that America has ever produced, in the several years during which he was a member of the faculty of Purdue University, made important studies of the economic relations of many of the insects of the state, the results of which are found in the bulletins of the Purdue University Agricultural Experiment Station and elsewhere.

Various others have contributed to our knowledge of the insect fauna of Indiana, but space and time will not permit even an enumeration of them, even if the literature were at hand to enable me to do so.

It will suffice to say that in the century's progress in zoology in Indiana, entomology has not lagged behind.

"A century of zoology in Indiana" is a pretty broad subject. The field of zoology is very wide. The different groups of living things which come under the term zoology are many. I have in this paper treated of only a few of them; I have considered only the mammals, birds, reptiles, batrachians, fishes, mollusks and insects. The crustaceans, worms, and various other groups I have not considered at all.

So numerous and so productive have been the workers in zoology in Indiana that the limits of this paper have permitted me merely to enumerate the more active ones and to comment in the briefest manner on the splendid work they have done for Indiana.

I must not fail to mention, briefly at least, the educational institutions in Indiana which have been centers of zoological research and inspiration. While it is true that it is the workers in the subject, the men themselves, who create the enthusiasm, nevertheless the institutions, with which they are connected exert a collective influence which augments that of the individual workers. It is with pleasure that I mention Earlham, Moores Hill, Hanover, Wabash, Vincennes and Butler Colleges; DePauw, Indiana and Purdue univers ties; the Indiana State Normal School and Valpariso Normal University, as institutions which have each contributed much to the progress of zoological science in Indiana. Each of these has had in its faculty men of enthusiasm, magnetism and vision,—such as Joseph Moore and David Worth Dennis at Earlham; Charles Wesley Hargitt and A. J. Bigney at Moores Hill; Glen Culberson at Hanover; John Merle Coulter at Wabash; O. P. Jenkins and W. W. Norman at DePauw; Stanley Coulter at Purdue; and O. P. Hay and H. L. Bruner at Butler. All these as teachers have done much for zoological science. There are other institutions and other teachers that I might mention, did space permit.

The list of investigators and teachers whom I have mentioned is a formidable one. What these men have done and what a number of them are still doing for the zoology of Indiana, great as it is, is only a small part of what they have done and are still doing for zoology in general. These men have by no means confined their studies to the fauna of Indiana; indeed, their work on the animals of Indiana has been largely merely incidental to their studies of the larger problems of systematic zoology, geographic distribution, and other phases of zoological science to which they have contributed of their time and thought. Nor was the work of many of these students of nature confined to any one field. Nearly all of them were and are all round naturalists, interested in and appreciative of nature in whatever garb she may be dressed. A number of them have contributed much to the popularization of natural history.

Indiana authors have during recent years put Indiana in the front rank in the field of literature as a producer of fiction of lasting value, and about this we hear a great deal and are justly proud. It is no less true, though we hear little about it, that Indiana occupies in the world of science even a more distinguished place. Her chemists, her botanists and her zoologists have put Indiana on the science map and are keeping her there.

Review of Public Health Work in Indiana.

J. N. Hurty.

For the present Indiana health law, and consequently for all the good which may have come from the same, the Indiana Medical Association has all the credit and praise.

The first effort to secure a public health law in Indiana was made by this association in 1855. The effort failed at that time and was not seriously attempted again until 1875. In that year, Dr. Thaddeus M. Stevens, of Indianapolis, made a motion that a Committee on State Board of Health be appointed. The motion prevailed, and to the said committee the following named gentlemen were appointed:

Thaddeus M. Stevens, M. D., Indianapolis; James S. Anthon, M. D., Indianapolis; J. W. Hervey, M. D., Indianapolis; Z. W. Burton, M. D., Mitchell. All of these gentlemen were busy, indeed very busy practitioners.

This committee drafted a bill to establish a State Board of Health, and introduced the same into the Legislature of 1875. It failed to pass. The same committee introduced a similar bill at the next session of 1877. It passed the Senate, and, after certain amendments, passed the House, but the senate failed, for some reason, to concur in the bill so amended.

Until the year 1878, the idea of the formation of a State Board of Health, or the enactment of State laws regarding public hygiene, was too often confounded with efforts to have laws passed regulating the practice of medicine. Seeing the difficulties that would result from such a confusion of subjects, Dr. Stevens introduced the following resolution at the session of the Indiana State Medical Society, 1878:

"Resolved, That a committee of three be appointed to draft a bill for the 'Regulation of the practice of medicine in Indiana, and also to define the duties and privileges of pharmaceutists and druggists within the State, and that such bill shall be put upon the basis of equal recognition of all schools and sects of medicine so far as the examination of candidates for practice and their privileges are concerned, they to have separate boards.' "

A committee was formed in accordance therewith, since which time the two subjects mentioned have been intelligently separated.

At the same meeting of the Society the following resolutions were offered by Dr. Stevens:

"Resolved, That the Committee on State Board of Health as now constituted by this Society, shall be called the State Health Commission, with power to associate with them a competent civil engineer, and that the State Geologist shall be an ex-officio member of such commission. That the duties of such commission shall be to make investigation as to the causes and means of preventing disease in the State, and that they, at any time they see fit, may petition the Legislature for police power, so that they can enforce such measures as they may deem necessary to the object above mentioned."

"Resolved, That in cases of vacancies occurring in such Board of Commissioners, they shall be filled by the State Society."

The Committee on State Board of Health, composed as above mentioned, and who by the above resolutions were authorized to add to their number, and so form the Indiana State Health Commission, met at the Grand Hotel, Indianapolis, in October, 1878, and organized by electing Lemuel Moss, D.D., of Bloomington, and J. L. Campbell, LL.D., of Crawfordsville, members. E. T. Cox, State Geologist, was also, in accordance with the action of the State Society, a member ex-officio.

The Commission further organized as follows: Wilson Hobbs, M.D., President; Thaddeus M. Stevens, M.D., Secretary; G. W. Burton, M.D., Treasurer; J. L. Campbell, LL.D., Civil Engineer; Lemuel Moss, D.D., J. W. Hervey, M. D., Prof. E. T. Cox, ex-officio member.

Subsequently a bill was drawn up to confer police powers upon the Commission, in accordance with the resolution above mentioned.

During December, 1879, the Commission formed Local or District Health Commissions, consisting of a chairman for each and a member from each county society; the duties of such district commission to be to collect sanitary and vital statistics in their localities, and report the same to the Secretary of the State Health Commission.

At the session of the Indiana State Medical Society, held May, 1880, the following resolution was adopted:

"Resolved, That the Indiana State Medical Society direct each county society in the State to require of each of its members to keep a record of birth and sex of these born, of death and causes of death as occurring in their practice, and a note of any epidemic or endemic diseases in their precincts; also such other facts as they may deem proper in connection with vital and sanitary statistics, and report the same to the local commission as instituted by the State Health Commission so that said local commission can report the same to the State Health Commission for the purpose of making a condensed report to the State Medical Society, and that each county society shall cause to have issued blanks to each of its members, according to a form to be furnished by the State Health Commission, and that the Secretary of this Society notify each county society of this action, etc."

Dr. Stevens, in commenting upon this resolution, said:

"Thus is formed a complete chain from State to Local Health Commissions, and to each physician of the State belonging to organizations over which the parent one, the State Medical Society, has control.

"Only two links in the chain of a perfect working organization are lacking, viz.:

1. Police power conferred upon the State and Local Commission or similar bodies.

2. Means to defray expenses.

"Those two links must be supplied by the Legislature of the State. To this end we hope the Commission, the profession and people in general will work."

In a review of the reports of the Indiana Medical Association may be found many papers upon the subjects of State medicine and hygiene. In 1873, Dr. Sutton, of Aurora, presented a report on "Diseases of Indiana for the Year 1872." He said: "At the meeting in the spring of 1870, it was suggested that some plan should be adopted by which we might have the annual report of facts, showing the health or sickness in the different counties, the prevailing diseases, the season of the year in which different forms of disease most frequently prevailed, etc. To procure such information, committees were appointed at that time in each Congressional District, who were to report to the Society at its next annual meeting. This plan, after being tried two years in succession, not succeeding as well as desired, a committee was appointed at the last meeting (1872) to collect facts and report to a chairman, who was to condense and embody the information received, into one report, to be presented at its meeting of 1873. Dr. Sutton made a report embracing forty-two counties, reviewing the diseases prevalent in the different months and giving the opinions of the various writers from their respective counties concerning their sanitary conditions and sanitary needs."

In the report of 1874, Dr. Washburn, of Logansport, in an article entitled "Medical Legislation," speaks of the necessity of the State collecting accurate vital statistics, and urges that a proper registration law be enacted. In the report of 1875, Dr. Stevens read a paper entitled "State Boards of Health." He said, "We hope this Society will not adjourn without appointing a committee, whose duty it shall be to advocate this step and bring it before the profession and the people." In the report of 1876, we find that the president's address, Dr. Helm, of Peru, was wholly devoted to advocating the passage of a health law establishing a State Board of Health and Registration. He thoroughly presented the subject and made a plea that the Society arouse and do all it could to further the efforts of its committee in this matter. In the report of 1877, Dr. Hervey, of Indianapolis, read an exhaustive paper entitled, "How to Secure Medical Legislation." He therein eloquently urged the passage of a State health law.

In the report of 1878, Dr. L. D. Waterman, the president, devoted his official address to the subject of State medicine. He said in part: "In this State, no enactments to protect the people from unnecessary diseases and epidemics have been passed." He announced this condition to be a disgrace to the State and urged the Association to stronger effort in the matter of health legislation. Dr. Waterman exhaustively reviewed the economics of health control, estimating the value of a human life unnecessarily lost at one thousand dollars. In the report of 1879, Dr. Stevens read a paper entitled, "Report of Public Hygiene in Indiana." In this paper, Dr. Stevens ably set forth an argument in favor of the supervision of the public health by the State.

In the report of 1880, will be found President Weist's address entitled, "Problems in Relation to the Prevention of Disease." In his address, he said: "While we as physicians, mean to give our chief thoughts to the practical facts of medicine that we may relieve suffering and thus lessen the sum of human sorrow, we will fail in the transport of our whole duty, if we do not recognize that outside of the sick chamber and beyond the limits of hospital wards, lies our highest work—work that has for its object the prevention of disease, not its cure. In this same report of 1880 will be found an article by Dr. Hervey entitled, "Some of the Unsolved Problems of Public Hygiene." In this paper, Dr. Hervey, in his well-known eloquent manner, again made a plea for the legal protection of the people against unnecessary disease and health.

The following year, 1881, Dr. Hervey was the president of the Society, and the subject of his address was "The Advance of Medicine." This meeting of 1881 was unusually rich in articles upon hygiene. Including the address of the president, there were four papers as follows: "Sanitary Progress," Dr. J. W. Crompton; "State Medicine," Dr. Stevens; "Hygiene," Dr. Hervey; "Infectious Diseases," Dr. L. C. Johnson. In this year was passed the first health law of the State of Indiana.

The first annual report of the State Board of Health of Indiana was for the year ending October 31, 1882. The members of the Board were Dr. J. W. Crompton, Evansville, Ind.; Dr. Wm. Lomax, Marion, Ind.; Dr. W. W. Vinnedge, Lafayette, Ind.; Dr. J. M. Partridge, South Bend, Ind.; Dr. Thad. N. Stevens, Indianapolis. Dr. Crompton was the president, and Dr. Stevens the secretary and executive officer. This first report is an exceedingly valuable one. It gives in detail the work of the Board, contains various essays upon sanitary subjects and presents the first official tables of vital statistics for Indiana. The population of the State in 1880, according to United States Statistics, was 1,909,916. The total deaths reported from all causes was 11,398, showing a death rate of 5.96 to each one thousand of population. This fact indicated that certainly less than one-third of the deaths were reported, for surely the death rate could not have been at the time less than 18 to 20 in the thousand. It was therefore apparent that the first effort to collect the vital statistics of Indiana, while not wholly a failure, was far from being a success.

Although all that time, the board put forth most strenuous exertions to secure accurate reports of births, deaths, marriages and contagious diseases, poor success attended their efforts. In the report for 1900 issued by the State Board of Health the number of deaths reported was 15,846. This calculated to an estimated population of 2,500,000, gives a death rate of 6.3 to one thousand of population. We observe here only a very slight improvement in vital statistic reports between the years 1881 and 1896. If we were to go deeper into the analysis of this matter, we would find that, upon the subjects pertaining to vital statistics, it was possible to obtain only about one-third of the real number.

The health law which was passed in 1891, and is but a modification of the law of 1881, says, Section 10, "It shall be the duty of all physicians and accoucheurs in this State, to report to the Secretary of the Board of Health of the town, city or county, in which they may occur, all births and deaths which may occur under their supervision, with a certificate of the cause of death, and such correlative facts as may be required in the blank forms furnished, as provided in this act. When any birth or death may occur, with no physician or accoucheur in attendance, then such birth or death shall be reported by the household where, or under whose observations, such birth or death may occur, with the cause of death, if such be known."

It may seem strange that under this very positive law, so unmistakable in its language, that it was impossible with the most strenous exertions to collect anything like correct vital statistics in the State of Indiana.

A slight effort, however, to collect the vital statistics of the State, disclosed where the trouble lies. In the first place, the State health law made the county commissioners, the councils of cities and the town trustees of towns, boards of health ex-officio. It further required that these boards of health should appoint a secretary, who shall be health officer and serve one year from the first of January next ensuing, the compensation of said health officer to be determined by the appointing authority. It is obvious that an officer whose tenure is but one year can not become proficient in his work. It was found to actually be the case that new health officers enter upon the duties of their office with nothing like a good understanding of what these duties were. It was usual for practitioners desiring this place to bid for it. If the preceding officer has received a compensation of $100.00 per year, numerous applicants would appear who would offer to do it for varying amounts, less than what had been previously paid.

As the appointing power was composed of citizens who had never given a single thought to the subject of hygiene, and who, consequently, did not appreciate its importance, this matter of lowness of bid for the position is a great hindrance. It therefore not infrequently happened that the men who were not actuated by high motives and who were not moved by the forces which make medicine, scientific and honorable, found positions in the health service. Despite however, the demoralizing conditions which were bred by the law, there were in the health service a large number of the noblest practitioners of the State. These were the ones who collected and presented the most accurate and reliable reports. From the other class, it was frequent to hear the argument, when pressed to put forth greater efforts to do good work, that the pay does not warrant them in doing more than they have done.

One great trouble, therefore, in the correct collection of vital statistics, seemed to lie in the tenure of office given to health officers and the method of compensation.

On the part of physicians, when they were reproached for not promptly reporting as the law commanded, the argument was frequently heard that the State has no right to impose a duty upon its citizens without according proper compensation, and therefore the statute is unconstitutional. In reply to this the Attorney-General said: "All physicians hold a special license and are protected by the State, and this would be class legislation if the state were not permitted in turn to impose duties upon the physicians for their privileges." The Attorney-General further said: "We need not inquire whether the provisions of the statute are unjust or not. These matters are for consideration of the legislative department of the government. We may observe that it is difficult to discover any injustice in requiring the medical profession to make known to the work statistics which may promote and are promoting the public health." That the State Society undoubtedly believed that it was the moral and professional duty of the medical profession to make reports of births, deaths and other matters pertaining to vital statistics, was proved by the resolutions which it passed, calling upon its members to voluntarily report.

Disease Prevalence.

Beginning January 1898, the State Board of Health began the collection each month of reports upon disease prevalence. The method adopted was that known as the Michigan method, the same having been in use in that State for over twelve years, and securing to that State most valuable information. One or more observers are selected in each county and the postal card blanks which are sent out, set forth plainly the observer's opinion as to the prevalence of disease for that month in the region under his jurisdiction.

Another advance made in State sanitation at that time was a provision of the State Board whereby physicians might have certain bacteriological and chemical examinations made, without cost. The Legislature appropriated $1,200 as a special sum for the suppression of contagious diseases. It was this sum from which the cost of food analyses, water analyses and bacteriological examinations for the diagnosis of diptheria and consumption was paid. Any physician could invoke the aid of the health authorities in the above way.

Another advance which seemed worth mentioning, is the publication of a Quarterly Health Bulletin. Said Bulletin gave the analysis of the statistics reported for its quarter, also a report of disease prevalence, and any matters which might seem to be of general sanitary interest.

The State Board in 1897 gave the following table during the status of typhoid in Indiana and three other states:

RATE PER TEN THOUSAND DEATHS.

	Mass.	*Ohio.*	*Mich.*	*Ind.*
Typhoid Fever	3.1	5.5	4.1	13.4
Consumption	21.2	20.4	19.4	20.0
Diphtheria	7.8	7.2	8.2	9.8
Scarlet Fever	2.1	1.2	2.2	1.3

"All but Indiana," said the report have put forth extra efforts to prevent typhoid fever and diptheria, and not until very lately have unusual exertions been made in any of the States to control and suppress consumption. The efforts made in all the States named, to suppress and control diphtheria and scarlet fever, are of the same character, viz., quarantine and its attendant precautions. The introduction of diphtheria anti-toxin has certainly lessened the mortality from diphtheria, and it is probably that to this agent we must look for still further improvement. From the table it will be observed that Massachusetts, Ohio and Michigan have worked hard, with a good measure of success, to suppress typhoid fever. The rate per ten thousand deaths, from typhoid in Massachusetts, is 3.1; in Ohio, 5.5; in Michigan, 4.1; while in Indiana it is 13.4. What a serious comment this is upon our State. Why should Indiana permit ten people to die, where Massachusetts saves them, disease and death are not a source of wealth and power and we can ill afford to permit this fearful destruction to continue. It is a reflection, too, upon the morals of the State, for typhoid fever, like sin, is a reproach to any community. One thousand, four hundred and eighteen deaths were reported from this disease in 1897, and as shown above, this can not be more than one-third of the real number. We must, therefore, estimate the deaths from this preventable disease to have been in the neighborhood of four thousand. This means at the very least twenty to twenty-five thousand cases. What a fearful waste of life and what an awful subordination of liberty and loss of happiness. Prodigious indeed is the responsibility of the medical profession in this matter.

The cure of the trouble lies first, in disposing of the wastes of life by proper sanitary methods, and second, in securing to every home, pure drinking water. In Indiana, as in other States, typhoid seems to be a rural disease. That is, if we count with what is truly rural our small towns and hamlets. Well drained cities, possessing good water supplies, always have low typhoid rates."

It seems fair to account in the following way for the prevalence of typhoid and bowel disorders on the farm: A man buys a farm. A site for his house is selected almost entirely from the standpoint of convenience, health not materially entering into the calculation. Water is supplied by digging a hole into the ground or driving down an iron pipe. The position of the well is in the rear of the house and if the surface contour permits, is frequently placed below the level of the house in order to save digging or driving so deep as would be necessary on higher ground. The next step is to establish, not too far from the house and well, a privy and its vault or perhaps a cheap privy standing flat on the ground. The stable and barn are erected nearby, instead of being placed at a distance. Living at this place now begins. All goes well for a few years. It is not long, however, until there is more or less complaint of summer nausea and diarrhea. Indigestion, too, appears, despite the farmers outdoor life and ample food. The doctor is called, tonics and digestives are given and temporary relief is secured. If warned concerning drainage and water supply and if the warning is heeded, the cause of the illness is removed and health improved. Otherwise the next summer finds matters not improved, probably worse. Finally typhoid having been bidden, obeys the call. The susceptible have the disease and the weak are borne to their last resting places. A measure of immunity is secured by those who survive, and those who did not have the disease were probably immune. Had the well been driven in the front yard, had an earth closet been built and sanitarily conducted, had the family properly cared for their garbage and household slops, had the barn been built at a good distance from the house, had the house been well above the ground with a dry, clean cellar beneath, typhoid would not have found there a congenial soil."

Realizing the importance of hygiene, and the growing demand for experts trained in matters pertaining to the public health, Purdue University, in 1895, established a Department of Sanitary Science. Aside from the required general subjects the junior students attending the University are offered courses in technical chemistry, microscopic technique, and biology of water supplies, with an elective in chemistry or biology. The seniors are given organic and physiological chemistry, bacteriology and a general course of lectures in sanitary subjects, such as the germ theory of disease and its practical applications, vaccination and immunity, the pollution and purification of water supplies, methods of sewage disposal, theory and the practice of sand and mechanical filtration of sewage and water, etc. These senior studies are required as well in the pre-medical course, which was also established in 1895.

The first year (1895-96) bacteriology was taken by eight students, six being regular seniors from the science, pre-medical and agricultural courses, and two graduate students who were taking special work in sanitary science. The second year the number was six, one graduating from the regular sanitary science course, the others being science and pre-medical.

In 1896, the Sanitary Science Department of Purdue issued five bulletins relating to the Public Health:

No. 1. The Nature of Sanitary Science and Its Value to the State.

No. 2. Some Sanitary Aspects of Milk Supplies and Dairying.

No. 3. On the Purifications of Water Supplies of Cities and Towns.

No. 4. Typhoid Fever in Indiana and Its Possible Connection with the Water Supplies.

No. 5. Sewage Disposal of Cities and Towns.

The Health Laws of Indiana.

The first health law passed in 1881 and already referred to, was amended in 1891 and made less effective for the amendment modified the clause commanding the reporting of infectious diseases, deaths and births, so that it had little force. In 1909 the original health law was again amended and made better, indeed very much better in many respects. Through amendment, the vital statistics part was left out entirely and an entirely new vital statistics law written and passed, however, the said vital statistics law was not passed until 1913.

In 1903 the quarantine law was passed. This law was written principally by an attorney, who was a member of the legislature, and who had had small pox. He felt aggrieved at the way he had been treated under the health law and therefore was interested in what he termed "A Sensible Quarantine Law."

The law referring to public nuisances defining such and setting forth how they should be abolished was passed in 1914. The Sanitary School House law, a most excellent statute requiring that all school houses built after its passage should be sanitary was passed in 1911. The Medical School Inspection law which gave to school authorities the power and right to institute medical inspection of school children was passed in 1911. In this same year (1911) the law intended to prevent blindness among infants, which was called ophthalmia neonatorum was passed. So called Hydrophobia law which diverted part of the dog tax for Pasteur treatment was passed in 1911. The Sterilization law was passed in 1907, as also was the Anti-toxin law. The Sterilization law provides for the sterilization of confirmed criminals, idiots, rapists and imbeciles. The Anti-toxin law as its name implies provided for the free distribution of anti-toxin among the poor. The Anti-Rat law intended to lessen the number of rats, both for economic and public health reasons, was passed in 1913. This same year (1913) the Public Water Supply law was passed. Also the Public Playgrounds law. In 1915 the legislature enacted the present Anti-Tuberculosis law. This law was written by a man who called himself a wall-paper cleaner and was passed without difficulty through the legislature after a wise comprehensive bill prepared by the State Board of Health and the State Anti-Tuberculosis Society had been almost insultingly "turned down." There is very little in this law that deserves commendation. The Drug Sample law was passed in 1907. Its intent being to prevent the free distribution of drug samples, which so frequently resulted in the poisoning of children. Children ate the sugar coated samples, thinking they were candy. The Pure Food Drug law was first enacted in 1899. The State Board of Health first presented the law in 1897, when it was rejected, almost unanimously by the legislature. The first pure food law had no provisions for enforcement and it was not until 1905 that a Laboratory of Hygiene was given to the State Board of Health for the enforcement of the Pure Food Law and also for making Bacteriological Pathological examinations and studies in the interest of the public health. In 1907, the Pure Food law was revised and greatly strengthened. The Sanitary Food Law was passed in 1909. This law prescribes the sanitary conditions which must exist in all food producing establishments and makes unlawful the employment of diseased employees. The Renovated Butter law which required the labeling of "Renovated" or "Process" butter, was passed in 1911. The Cold Storage law regulating the cold storage of foods was passed in 1911. The Clean Milk Can law was passed in 1913. This law commands the thorough cleansing of milk cans and milk bottles and prescribes a penalty of not less than $10.00 or more than $50.00 against any milk handler who does not keep his receptacles clean.

Syllabus of Health Statutes.

Indiana Health Law passed in 1881, amended in 1891 and again amended in 1909.

Quarantine Law passed in 1903.

Sterilization Law passed in 1907.

Anti-toxin Law passed in 1907.

Drug Sample Law passed in 1907.

Pure Food and Drug Law passed in 1907, amended in 1911.

Law Governing Sanitation of Food Producing Establishments passed in 1909.

Prevention of Infant Blindness Law passed in 1911.

Hydrophobia Law passed in 1911.

Renovated Butter Law passed in 1911.

Cold Storage Law passed in 1911.

Vital Statistics Law passed in 1913.

Sanitary Schoolhouse Law passed in 1913.

Medical School Inspection Law passed in 1913.

Anti-Rat Law passed in 1913.

Public Water Supply Law passed in 1913.

Weights and Measures Law passed in 1913.

Clean Milk Can Law passed in 1913.

Public Playgrounds Law passed in 1913.

Establishment of Sanitary Districts, passed in 1913.

Housing Law passed in 1913.

County Hospital Law passed in 1913.

Sanitary Mattress Law passed in 1913.

Fertilizer Reduction Plant Law passed in 1913.

Mausoleum Law passed in 1913.

False Advertisement Law passed in 1913.

Cigarette Law passed in 1913.

Transportation of School Pupils Law passed in 1913.

Schoolhouse Civic and Recreation Center Law passed in 1913.

Child Neglect Law passed in 1913, amended in 1915.
Anti-Tuberculosis Law passed in 1915.
Full Sized Sheet Law passed in 1915.
Drainage, Sanitary and Reclaiming District Law passed in 1915.
Sanitary Packing and Shipping of Rags and Paper Stock, passed in 1915.
Cutting Weeds Along Public Highways passed in 1915.

A Century of Botany in Indiana.

John M. Coulter.

The opening of the century we are celebrating was remarkable in the history of American botany. During the two preceding centuries American botany had been developing under European influence. It began to develop under home influence approximately in 1815. About this date a number of American publications appeared dealing chiefly with local floras, and marking the beginning of American botanical publication by American botanists. A mention of these publications will illustrate the fact that what seemed to be the psychological moment for the beginning of American botany expressed itself in several almost simultaneous publications; and it will also serve to introduce us to the beginnings of botany in Indiana.

In 1813, Muhlenberg, a Lutheran minister of Philadelphia, published the first catalogue of North American plants, which of course was a very meager representation of a great continental flora. In 1814, Bigelow, a physician of Boston, published a flora of Boston and vicinity. In 1815, Barton, Professor of Botany in the University of Pennsylvania, published a flora of Philadelphia. In 1817, Rafinesque, a man of hybrid origin and a wanderer, published his "Flora of Louisiana." Louisiana had been admitted as a state five years before, as a part of the much more extensive "Louisiana Purchase." In this *Flora*, Rafinesque mentioned certain plants as extending up the Mississippi and its tributaries, some of which he had observed in Indiana. The year 1817, is so near the beginning of our century that botany in Indiana has been said to be, in a general way, contemporaneous with Indiana as a state.

Since Rafinesque may be regarded as the pioneer Indiana botanist, a brief mention of this singular man will be appropriate. When Jordan began his study of fresh water fishes, he encountered the pioneer work of Rafinesque, and proceeded to uncover the facts of his life. Finally, in 1895, the Filson Club of Louisville published an elaborate memoir by R. E. Call, in which all available information in reference to Rafinesque was brought together. This restless and unique naturalist came to the United States for the second time in 1815, and began his wanderings of twenty-five years, which extended as far west as the Mississippi. He followed down the Ohio river, exploring for the first time the flora of Ohio, Kentucky, Indiana, and Illinois, settling for a time in that famous community at New Harmony on the Wabash. Jordan calls attention to the fact that in that day New Harmony was a center of American science. The first scientific contact with Indiana plants, therefore, was along the Ohio, and especially at the falls of the Ohio, and in the vicinity of New Harmony.

Rafinesque's vivid description of his experiences in traveling through the forests of our nascent state is worth preserving. He traveled always on foot because, as he said, horses were never made for botanists, and his impression of his travel through the primeval Indiana forest is as follows:

"Mosquitoes and fleas will often anoy you or suck your blood if you stop or leave a hurried step. Gnats dance before your eyes, and often fall in unless you shut them; insects creep on you and into your ears. Ants crawl on you whenever you rest on the ground; wasps will assail you like furies if you touch their nests. But ticks, the worst of all, are unavoidable when you go among bushes, and stick to you in crowds, filling your skin with pimples and sores. Spiders, gallineps, horse-flies, and other obnoxious insects, will often beset you or sorely hurt you."

Rafinesque was not only a pioneer in the study of Indiana plants, but also a pioneer in the use of the laboratory method in teaching science. He was the first teacher of natural history west of the Alleghenies, his one academic position being that of Professor of Natural History and the Modern Languages in Transylvania University at Lexington, Kentucky. He thought that his students should be introduced to the actual things studied; and so he brought plants into the class-room. This was such an innovation in the method of the time that the faculty could not stand for it. They voted that such unseemly conduct must be discontinued, and the action as taken reads as follows, according to the documents referred to. "This practice must be discontinued, since it breaks up the discipline of the class-room, diverts the attention of students from more serious things, and is more entertaining than instructive."

Other botanists touched Indiana casually during the general period of Rafinesque, and for that reason may be associated with him as forming a pioneer group. It seems that Michaux, a conspicuous name in the early history of American botany, visited Indiana in 1795, spending a part of August in journeying from Clark's Hill to Vincennes. He recorded about 20 plants as having been discovered in Indiana.

In the summer of 1816, contemporaneous with Rafinesque, David Thomas made his way along the Ohio from the eastern part of Indiana, and finally reached Vincennes, and records the names of 95 plants.

In 1818, shortly after Rafinesque had entered Indiana, Nuttall, the predecessor of Asa Gray at Harvard, journeyed down the Ohio, his recorded stops being at Lawrenceburg, Rising Sun, Vevay, Troy and some place near Newburg.

Such was the beginning of botany in Indiana. It was the phase of botany that naturally precedes every other phase in an unexplored country, and a century ago all the world needed exploration so far as plants were concerned. For the next 65 years, approximately, botany in Indiana developed as it was developing everywhere in the United States. A botanist was necessarily a taxonomist; not only that, but his taxonomy was restricted to vascular plants, and chiefly to flowering plants. A few of the earlier publications including Indiana plants will indicate the various methods of attack.

In 1835, Riddell, one of our western botanical explorers, published a synopsis of the flora of the western states, including an area represented by ten or twelve states now, extending from Ohio on the east, and including the Northwest Territories on the west. The synopsis includes lichens, liverworts and mosses, in addition to the vascular plants, and still the list enumerates only 1,802 species, among which were all the known Indiana plants; but it set the pace, and subsequent explorers filled in the gaps.

Shortly after this, Prince Alexander Philip Maximilian visited New Harmony, and in 1839 published a list of sixty trees growing in the vicinity of that scientific center. This is the first published list of Indiana trees, so far as I know, and it is no wonder that the forest of the lower Wabash should have attracted Prince Maximilian's attention, for it represents the culmination of our Indiana tree vegetation.

Another interesting early publication is that of Lapham, a botanist identified with Wisconsin rather than with Indiana, but who published in 1853 a list of the grasses of the states bordering on the great lakes. First the trees and then the grasses of Indiana were selected for special consideration.

During the next twenty-five years, this kind of work continued as the only phase of botany in Indiana, or anywhere else in the United States. An increasing number of naturalists, as all botanists of that time could be called, collected and recorded the vascular plants of their neighborhoods. County lists multiplied, occasional state lists appeared, and now and then particular families were singled out for presentation. It may be of interest to know that the bibliography to which I have had access includes 132 titles dealing with the taxonomy of the vascular plants of Indiana, representing 45 authors. As a result of all this work, the vascular flora of Indiana became gradually known, and finally what may be called the first stage of botanical development ceased to be the dominant phase, and gave place to a second.

This does not mean that such work has been completed even yet, but it does mean that it is now only local and occasional, rather than general and universal.

One who searches among the titles of this taxonomic period, as it may be called, can obtain occasional glimpses of other phases of botany in the nascent stage. A taxonomist occasionally was interested not only in the classification of his collections, but also in habitats and distribution, and was thus the forerunner of the ecologist. Now and then a botanist can be detected who watched the development of some plant from its seedling stage to its maturity, and was thus the forerunner of the morphologists of today, who study the ontogeny of plants. But morphology was gross, and ecology was "without form and void."

It was approximately in 1880 that the change came. Ever since 1850, European botany had been feeling the stimulus of Hofmeister, and had been developing what is known as modern morphology, the morphology of minute structures. The laboratory with its microscopes and re-agents and sections was replacing field exploration. There are perhaps at least three reasons why modern morphology did not reach the United States for thirty years after its birth in Europe. One is that our flora was still new and intensely interesting. A second is that in the person of Asa Gray, through his Manual and texts, there was a dominating influence in the field of botany, such as would be impossible now. The third reason is perhaps the best one, and that is that our botanists had not begun the habit of going to Europe to study. In fact, botany was not as yet a full fledged profession; it was only an incident. Botanists were chiefly amateurs, and in addition there were a few teachers of the subject, who taught many other things besides.

At last some botanists went to Europe, and as a result, in 1880, Bessey introduced us to an American presentation of modern morphology as developed by Sachs. Then it was that botanical laboratories began to appear in this state, with microscopes and laboratory guides. In Wabash, in Purdue, and a little later in Indiana, the work began, presently extending to all the colleges, and finally invading the high schools. Not only did instruction in modern morphology begin, but also research, and morphological papers began to issue from several of our laboratories.

We should appreciate this phase of morphology in passing. Just as in the case of taxonomy, many morphologists have moved on, but there is always an old guard that never moves on. Perhaps the most significant change introduced by the new morphology was that its material was the whole of the plant kingdom. No longer were the vascular plants the sole representatives of botany; but there was a curious rigidity about the morphology of these earlier days. The mature structures only were studied and pigeonholed. Definitions were rigid and facts were observed as facts, with no thought of their inter-relationships. You will all recall those days as the period of "types," when a few types were selected to represent the whole plant kingdom. The theory was that it was better to discover all the facts about a single plant, than to discover the important facts about plants in general. In other words, there was as yet no conception as to the relative values of facts. And still this was the beginning of botany as a distinct profession in Indiana, and chairs of botany began to be differentiated from chairs of natural history or biology. This is bound to be the case when collecting is replaced by technique. Almost any one with the instinct of a naturalist can collect, but to section and interpret needs special training.

It was approximately in 1890 that a further refinement of morphology entered the field. Strasburger was dominating botany in Europe, and many American students worked in his laboratory. As a result, from 1890 cytology began to be represented in our laboratories. It represented the further development of technique; it led to the development of ontogeny, so that the study of mature structures gave way to the study of developing structures; and finally comparative ontogeny led to the development of evolutionary sequences. As a consequence, much of our old morphology was relegated to an anatomical rubbish heap, and facts were selected that were significant in an evolutionary scheme. Other phases of botany have been added since in schemes of instruction, but so far as I can judge from bibliography, the current production of Indiana botany deals chiefly with taxonomy and the various phases of morphology, in both of which field there have been notable contributions.

Concurrent with the development of morphology in Indiana, which began approximately in 1880, and sharing in its later development from 1890 to the present time, interest in the lower plant groups began to appear. Thanks to morphology this interest did not express itself merely in collecting and naming these forms, but in studying them, in many cases uncovering complicated life histories. As a result, the list of titles is much shorter than in the taxonomic period, but the contributions represent a very different type of work. I have discovered fifteen such titles, but they all represent time and technique. These titles run from mosses down to Myxomycetes, and notable among them are contributions to our knowledge of the parasitic fungi.

It would be out of place for me to mention the names of all who have shared in making the history of Indiana botany. If this sketch is ever published, there should be appended a full bibliography of the work of Indiana botanists. Furthermore, it would be invidious to select a few names for special mention, for we have all shared in making this history. You know the men who have worked and those who are still working in this state.

There is one further fact connected with the botanical history of Indiana that seems worthy of mention. It is not personal because it belongs to all of us. In 1875, before we had emerged from our purely taxonomic stage, an insignificant-looking botanical journal began to appear each month. Its home was on the banks of the Ohio, but its stimulus was Asa Gray at Harvard, who month by month rebuked, advised and contributed. For nearly twenty years that journal had its home in Indiana, and naturally it contains much Indiana botany, as well as botany in general. As the years went on it grew in size and influence, always in the editorial care of Indiana botanists, until now it is a fair representative of American botany, and has had no small share in the development of American botany. This journal is distinctly a Hoosier by birth, but its influence has reached wherever the science of botany is cultivated.

Now that the days are over when botany was represented exclusively by local lists of species, botany knows no state boundaries. Botany in Indiana is no longer Indiana botany. Your contributions are not for a particular locality, but for the science of botany in general. The men who for a time worked in Indiana and are now working elsewhere are in a sense still Indiana botanists. They are colonists that you have sent into other fields to continue the work they began here; but Indiana is the mother country where the first inspiration came.

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The Sand Dune Region as a National Park.

L. F. Bennett.

The almost unanimous popular approval given the project to make a National Park in the Sand Dune region of Northern Indiana has far exceeded the hopes of the most enthusiastic originators of the idea. Letters have been received from people who live several hundred miles from the Dune region asking what they can do to help to preserve the Dunes as a National playground and park.

Senator Taggart introduced a resolution in the Senate in which the Secretary of the Interior was asked to investigate and to report to Congress at its next session the desirability of establishing a National Park in the Dune region. The Secretary appointed Mr. Stephen T. Mather who has the National Parks of the United States under his supervision, to conduct a hearing in Chicago and to investigate by a personal study the Dune area.

The hearing was conducted October 30, 1916, in the Federal Building in Chicago. There was not a dissenting voice from the twenty-five or more men and women who spoke. Artists, scientists, financiers, representatives of womens clubs, landowners, all were of one accord. They believed that the Dune area should be saved and that it can best be done by the National government.

Blatchley in the 22nd Annual Report of the State Geologist says in his description of the Dunes:

"The dunes constitute the most striking and characteristic feature of the shore line. They are great sand ridges, sometimes continuous for a mile or more, but more often broken or cut by 'blow-outs' into isolated rounded hills. The highest of these hills in Porter County is Mt. Tom, in section 12 (37 north, 6 west), northwest of old City West. Its crest is 190 feet above Lake Michigan.

Northeast of Miller's, Lake County, are a number reaching a height of 150 feet above the lake. In some places, notably about Dune Park, Porter County, the ridges are for long distances wholly destitute of vegetation. Their bared surface, 50 to 100 feet in height, with the sand piled just as steeply as it will lie, gleams and glistens in the sunlight and reflects the summer's heat with unwonted force. Other ridges and rounded hills, especially those back some distance from the lake, are often covered with black oak, northern scrub pine (Pinus banksiana Lambert), stunted white pine (Pinus strobus L.), and many shrubs and herbs peculiar to a soil of sand. The roots of this vegetation form a network about the sand grains and prevent the leveling of the dunes. In time, however, a tree is uprooted, or a forest fire burns off the vegetation. The protecting network of rootlets is destroyed. A bare spot results over which the winds freely play. A great storm from the north or northwest scoops out a small bowl-shaped cavity, and carrying the sand either south or southeastward, drops it over the hillside. The cavity is cut deeper and wider by succeeding storms, and a great 'blow-out' in time results. Where a few years before stood a high hill or unbroken ridge now exists a valley, or a cavity in the hillside, acres, perhaps, in extent, and reaching nearly to the level of the lake. The sands which once were there now constitute new hills or ridges which have traveled, as it were, a greater distance inland. In many places the drifting sands have wholly or partly covered a tall pine or oak tree. Where but partly covered, its dead (sometimes living) top projects for a few feet above the crest of hill or ridge. One may rest in its shade and not realize that he is sheltered by the upper limbs of a large tree whose trunk and main branches lie far beneath him embedded in the sands."

There are about thirty-three miles of shore-line in Lake and Porter Counties; of this there are about twenty miles between Gary and Michigan City unoccupied. The dunes district varies from three-fourths of a mile to a mile or a little more in width. It represents the present beach merged into the Tolleston beach of Lake Chicago.

People who have seen dunes in many parts of the earth say that the Dunes of Indiana are unique in many respects and differ from all others in the relation they bear to the adjoining regions. They are located in an area of sufficient rainfall for all kinds of farming of their latitude, and they are located on the shore of one of the largest bodies of fresh water on the earth.

The chance to study one phase of geology is here unsurpassed, and the botanist finds almost a paradise in the study of rare plant types. "The tamarack swamps are worth going miles to see." The flora is considered most diversified in the country. The students of bird life have an opportunity to see bird residents and bird visitors perhaps not equalled in any area of like size in the United States.

The Dunes region is within reach of several millions of people at the present time, and in a generation hence the population about Lake Michigan will undoubtedly be more than doubled. All of the large national parks are in the west and it is impossible for most people to go to them. The Dunes can be reached in a few hours ride at the longest by great numbers who would thoroughly enjoy them and be benefitted by an outing in such a place. There is something here for everyone. The hills, the valleys, the steep slopes of sand and their difficult climbs, the various kinds of vegetation, the outlook over Lake Michigan and the lands to the south, furnish enjoyment to every visitor to the region. The air here is the purest, the chance to get from every care is the best. No noise, nothing to disturb or prevent a day of keenest pleasure. He would have a dull intellect indeed who would not enjoy a day's outing in the Dunes.

The historical associations connected with the southern shore of Lake Michigan are many and belong to the early history of Michigan, Indiana, and Illinois. It was along the Lake Michigan beach that all of the overland communication occurred between Fort Dearborn and Detroit in the early part of the last century.

It would be a national calamity, "a calamity against nature" if the Dunes are not saved. "There is no other spot with anything like the artistic, scientific, historical and sociological characters and advantages so near a great center of population." The government of the United States should provide this playground for the millions of boys and girls of the present and of the centuries to come.

What is to be done must be done soon because the lands are rapidly becoming more valuable and if not obtained by the government will be given over to manufacturing purposes.

Let us hope that our Congress will rise to the occasion and give to central United States this great area which is known to the scientists of the whole world as the most unique of its kind, as a National Park. And further may we ask that the Park be named for our Hoosier poet, The Riley National Park of America.

THE CULTIVATION OF TRYPANOSOMA BRUCEI.*

CHARLES BEHRENS.

From the Bacteriological Laboratory, Purdue University, Lafayette, Indiana.

The first successful cultivation of Trypanosoma Brucei was announced by Novy and MacNeal in 1903.[1] The medium which gave the best results was prepared by adding to a 1 to 8 meat extract 2 per cent peptone; 0.5 per cent sodium chloride; 1 per cent normal sodium carbonate; and 2 per cent agar. Two parts of defibrinated rabbit blood was added and the mixture was allowed to solidify in an inclined position. The medium was then inoculated with two drops of white mouse, rat, or guinea-pig blood, very rich in trypanosomes. An invisible growth occurred in the water of condensation at 25°C. Novy and MacNeal after testing fifty animals (mice, rats, and guinea-pigs) found that only four gave positive results, or 8 per cent. In 1905 Smedley[2] reported that three out of ten attempts or 30 per cent were positive.

Because of the inconsistent results a number of experiments were made using media of quite a different nature. The first attempt along these lines was to use a medium in which the meat constituent was replaced by an extract made of beans and peas. This was obtained by macerating and boiling 1 per cent of each with distilled water. The usual amounts of sodium chloride, normal sodium carbonate and agar were added to this extract. One part of bean and pea agar was mixed with two parts of defibrinated rabbit blood, well agitated and solidified in an inclined position. On inoculating the medium with two drops of defibrinated trypanosomal rat blood and subsequent incubation at 25°C more constant results were obtained than with the original Novy-MacNeal medium.

A second medium was made similar to that employed by Nicolle[3] in the cultivation of Leishman-Donovan bodies. In this medium no meat extract or alkali was added. It was prepared by dissolving 2 per cent of agar, 2 per cent of peptone, and 0.5 per cent of sodium chloride in distilled water. To this modified Nicolle medium two parts of defibrinated rabbit blood was added, the same as in the case of the other media.

A third medium was employed and was made as follows: 125 gms. finely chopped lean beef, and 250 cc. of water were allowed to digest over night in the cold, or for one hour at 55°C, boiled and filtered. The filtrate was then dialyzed in a large thin collodium sac against running distilled

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*The strain of Trypanosoma Brucei used in these experiments was supplied thru the kindness of Dr. F. G. Novy, Ann Arbor, Michigan.

1. Jour. Am. Med. Assn. 1903, p. 1266, "Contributions to Medical Research" dedicated to V. C. Vaughan, Ann Arbor, 1903, p. 549. Jour. Infect. Dis., 1904, 1 p. 1.

2. Jour. Hyg., 1905, 5 p. 38.

3. Arch. de L'Inst. Pasteur de Tunis, 1908, p. 55. Ann. de L'Inst. Pasteur, 1909, 23, p. 361.

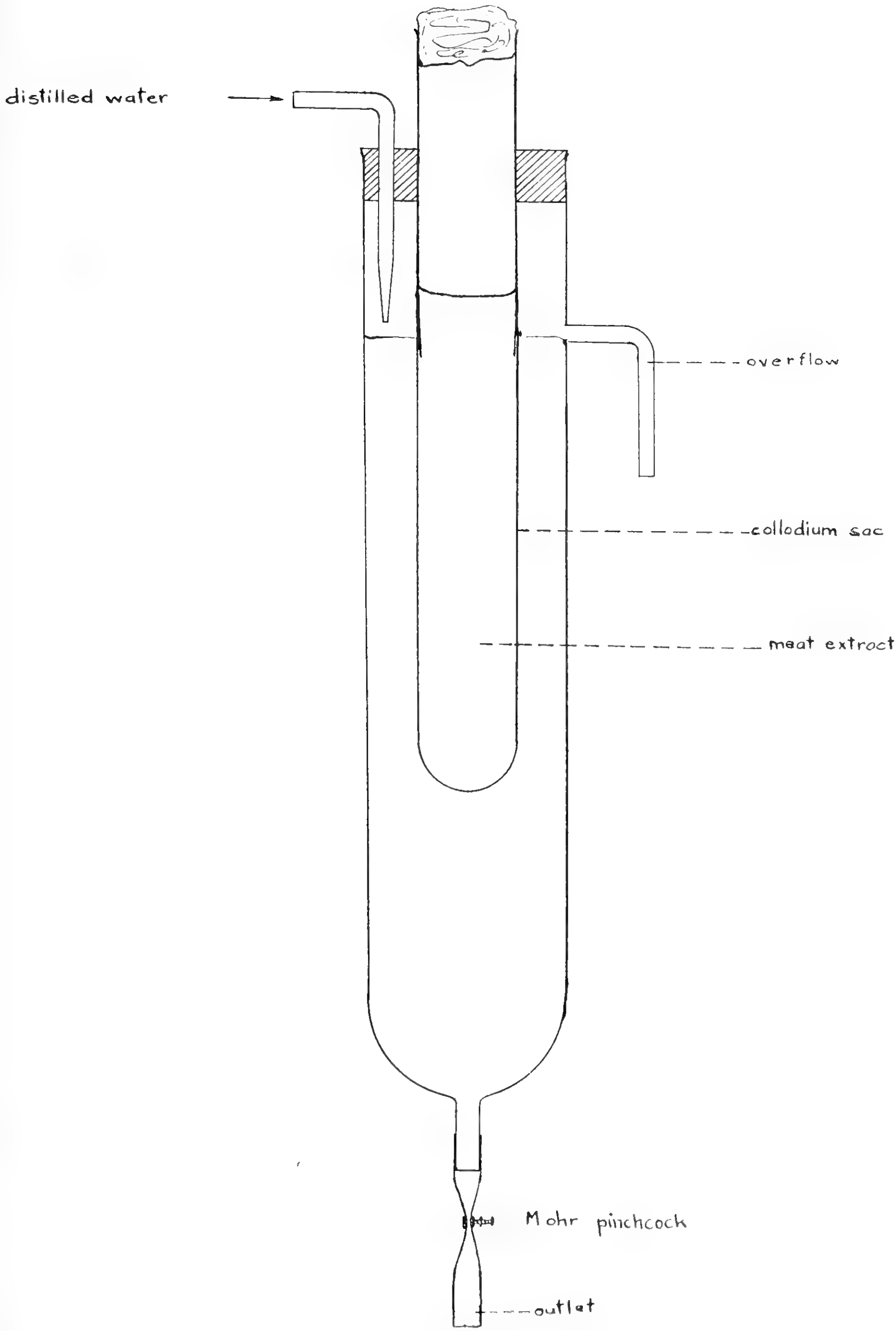

Figure I—Dialyzing Apparatus. One-fourth Size.

water (see figure I) until it gave no test for chlorides, this required twenty-four to forty-eight hours. The same results may be obtained in a comparatively short time by dialyzing in warm (50°C.) running distilled water, thus not only cutting down the amount of distilled water used and time required but also the degree of bacterial development. The dialyzed filtrate was diluted to one liter with distilled water, plus 2 per cent peptone; 0.5 per cent sodium chloride; .01 per cent calcium chloride; 1 per cent normal sodium carbonate and 2 per cent agar. One or 1½ cc. of this agar was placed in each tube and sterilized in an autoclave by heating to 105°C. for fifteen minutes. This dialyzed nutrient medium was also diluted with two volumes of defibrinated rabbit blood.

In order to ascertain the relative value of these media a series of cultures were carried out. For this purpose the blood of an infected rat was transferred by means of a Pasteur capillary pipette, bent at right angles (figure II) to usually

Figure II—Pasteur Capillary pipette. Full Size.

twelve tubes of each medium and incubated at 25°C. in an almost horizontal position. Six comparative trials were thus made. The results of these experiments were decidedly favorable to the dialyzed medium, since 80 per cent of the tubes gave a positive growth. In case of the original Novy-MacNeal medium which was the least favorable, only 25 per cent of the tubes gave positive results. On the modified Nicolle medium 48 per cent of the tubes were positive. The bean and pea medium revealed the presence of cultural forms in 53 per cent of the tubes (chart I).

No advantage was found by increasing the blood constituent to three parts to one of agar whereas, if it were decreased to one part no growth occurred. Also no benefit resulted by altering the amount and kind of alkali. Inoculated tubes of the various media were placed in atmospheres of different gases, such as hydrogen, nitrogen, and carbon dioxide, but all such attempts proved to be total failures, therefore, it seems that the ordinary aerobic conditions are best.

Having apparently a satisfactory nutrient agar it seemed advisable to improve the blood constituent of the medium. Various attempts were made in this direction. Defibrinated rabbit blood was transferred to sterile centrifuge tubes and centrifugated for ten minuted at about 8,000 revolutions per minute. The serum was then drawn off by means of a Pasteur bulb pipette (fig. III) and diluted to the original blood volume with 0.5 per cent sodium chloride solution. This clear diluted serum was then mixed with the dialyzed agar medium, in a ratio of two to one. The remaining blood cells were likewise diluted with salt solution to the original blood volume and the resulting suspension was added to the dialyzed agar in the same ratio of two to one.

Serum inactivated for one-half hour at 56°C. was also mixed with the dialyzed agar. As in the previous experiments these media were inoculated with trypanosomal rat blood and incubated at 25°C.

The results of the examination of these media at the end of 14 or 21 days showed that the diluted and inactivated serum gave practically 100 per cent positive growths, whereas, the diluted blood cell medium gave but 38 per

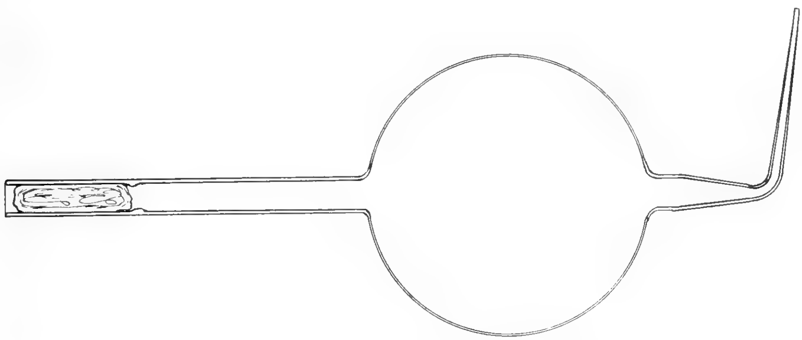

Figure III—Pasteur Bulb pipette. Full Size.

cent successful cultures (chart I). Therefore, it would seem advisable in attempting isolation of Trypanosoma Brucei to employ dilute or inactivated serum rather than defibrinated whole rabbit blood. Successive transplants of the cultural forms on serum agar gave at all times a very rich growth, in fact the growth in some cases became so extremely rich that a white film resulted which was easily detected by the eye. The organisms of nagana, therefore, maintain themselves without the presence of hemoglobin. This fact was also noted in regard to Trypanosoma Lewisi.

Isolations were attempted using ascitic fluid instead of serum and in no instance were cultures obtained. The culture medium described by Rh. Erdmann[4] was also used and proved to be a total failure and as a matter of fact the easily cultivated rat trypanosome of Lewis could not be grown successfuly by this method.

The appearance of Trypanosomes of nagana *in vitro* is very characteristic. They occur either singly or in groups ranging from a few to many hundreds

4. Soc. Exp. Biol. and Med. 1914, XII, pp. 57-58.

in number. The groups are not usually arranged symmetrically like in the rosettes of Trypanosoma Lewisi, but the effect is that of a writhing mass with the flagella directed outward, being very suggestive of the snakes on a Medusa head. However, at times symmetrical arrangement results and because of the presence of one or more highly refractive globules and the direction of the flagella presents the picture of a jeweler's "sunburst." Therefore, Trypanosoma Lewisi and Brucei are easily and readily distinguished from each other *in-vitro*. Again, since the former only infects rats and the latter causes nagana in all the laboratory animals they may be easily separated when occurring simultaneously in cultures or in the blood of a rat.

The presence of the highly refractive globules in the cultures *in-vitro* previously referred to and their entire absence in the blood type seems to indicate an unfavorable medium. It is then probable that with an improved medium cultures may be obtained which would more nearly resemble the blood type.

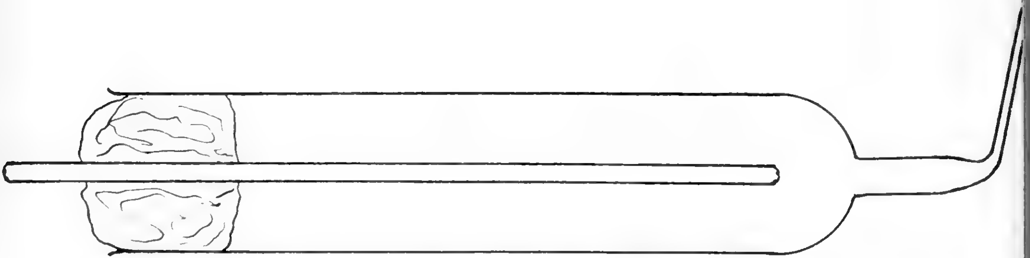

Figure IV—The Novy carodit artery pipette used in bleeding rabbits. One-half Size.

The best results obtained in this direction were by employing a 1 to 8 nutrient veal extract agar. This was made as follows: 125 gms of chopped veal and 1000 cc. of distilled water were thoroughly mixed and allowed to digest over night in the ice-box. The mixture was then strained thru muslin, 2 per cent peptone; 0.5 per cent sodium chloride; 0.5 per cent normal sodium carbonate; and 2 per cent agar was added. This nutrient veal agar was then boiled and filtered thru cotton, one cc. placed in each tube and sterilized in an autoclave by heating to 105°C. for twenty minutes.

The blood used in this cultural medium was drawn from the carotid artery of a rabbit under aseptic conditions by means of a special Novy pipette (fig. IV) and immediately defibrinated. It was then drawn up into a Pasteur bulb pipette and transferred to sterile large special centrifuge tubes (fig V) and centrifugated for 5 minutes at 8000 revolutions per minute. This divides the blood into three layers serum, white, and red blood cell layers.

By means of bulb pipettes the desired constituents of the blood may be removed.

Shortly before use the desired number of agar tubes were melted in the water-bath, cooled to 60° C. and two volumes of defibrinated rabbit blood minus the white blood cell layer were added. The mixture was thoroughly

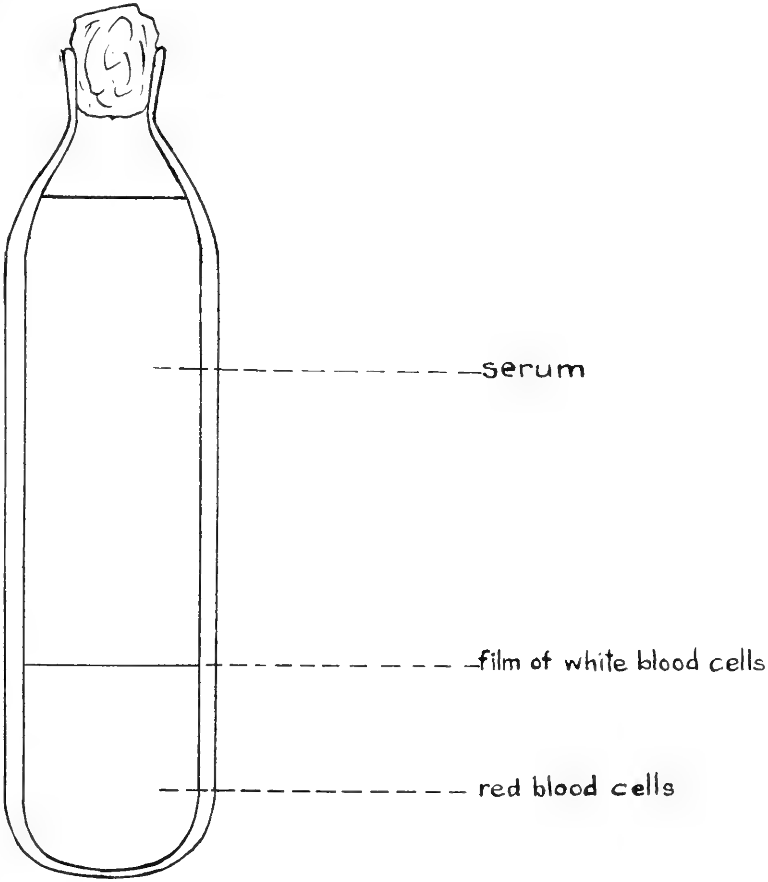

Figure V—Centrifuge tube. Full Size.

agitated by rolling in the hands in an upright position, by tapping on the tube, or by employing both methods. This well mixed medium was allowed to solidify in an incline position. It was found advisable to employ the blood of rats which were in the early stages of the infection, having about twenty-five organisms per field (4 mm. objective). Trypanosomal blood from guinea-pigs is not suitable for isolation work. A white rat showing the desired number of organisms in its blood was etherized, after which its blood was drawn from the heart by means of a sterile special Novy heart pipette[6] (fig. VI). A droplet of this defibrinated nagana blood was smeared over the surface of the medium by means of a capillary pipette and incubated at the usual temperature of 25° C. after the tubes had been rubber capped to prevent dessication.

Cultural forms were observed as early as the fourth to the sixth day. It is advisable, however, not to disturb the tubes until after a period of 14 days

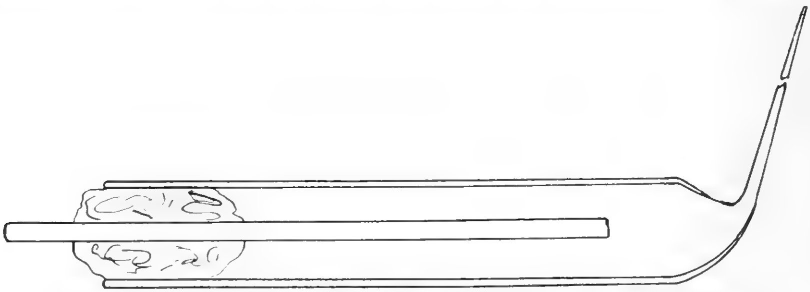

Figure VI—The Novy heart pipette used for bleeding rats. Full Size.

has elapsed when all the cultural tubes may be examined and transplants made. Transfers should be made by means of the capillary pipette instead of with a platinum loop and to perpetuate the cultural type transplants should be made weekly. This medium gave 100 per cent positive growth. These cultural forms are practically devoid of large globules. altho small ones were present, and in that respect more nearly resemble the blood type which is free from globules. They differ from the latter type in that the centrosome is near and usually situated anterior to the nucleus. Also the undulating membrane is not nearly so conspicuous as in the blood form.

Intraperitoneal and subcutaneous injections of these cultural forms after several successive growths (generation seven) *in vitro* will infect rats and guinea-pigs and the organisms which develop in the blood of the animal after an injection of the cultural form are identical with those of the blood type.

Summary

One part of a veal nutrient agar, plus two parts of defibrinated rabbit blood devoid the white blood cell layer yields constant results and seems to indicate that the conditions are more nearly ideal for the cultivation of trypanosoma Brucei *in vitro*.

6. Jour. Infect. Dis. Vol. 20, 1917, p. 502.

The difference between the organisms grown upon the veal blood agar minus the white blood cell layer and upon the dialyzed dilute serum or in-inactivated serum agar is in the size of globules, being smaller on the former medium.

The organisms grown upon the improved medium differ from the blood type because of the presence of small globules; the position of the centrosome; and the less conspicuous undulating membrane.

The blood of rats in the early stages of Nagana, showing about twenty-five trypanosomes per field is best suited for isolation work. Infected guinea-pig blood is not desirable for this work.

The best results are obtained when blood is used in a ratio of 2 to 1 of agar and ordinary aerobic conditions are resorted to.

To perpetuate the growth transplants should be made weekly by means of a capillary pipette. Trypanosoma Brucei and Lewisi do not require the presence of hemoglobin for their existence.

The characteristic rosette formation of trypanosoma Brucei and Lewisi serves as a means of differentiation.

Since the cultures are pathogenic for rats and guinea-pigs the positive causal relation of the trypanosome to the disease nagana can be demonstrated by Koch's requirements.

After obtaining such excellent results with trypanosoma Brucei this medium seems especially promising for the cultivation of other pathogenic forms.

CHART I

Showing the Per Cent of Positive Results on Various Media

No. of media used	Kind of media	No. of experi-ments	Av. No. of tubes in each experi-ment	Per cent of positive growths
1	Novy & MacNeal blood agar.	6	12	25%
2	Bean and pea blood agar....	6	12	53%
3	Nicolle blood agar.........	6	12	48%
4	Dialyzed dil. blood agar.....	6	12	80%
5	Dialyzed dil. serum agar....	8	10	100%
6	Dialyzed inact. serum agar..	8	8	100%
7	Dialyzed dil. bld. cell agar...	8	14	38%
8	Dialyzed Ascitic fluid agar..	3	6	0%
9	Erdmann's medium........	3	15	0%
10	Veal bld. minus white bld. cells agar................	10	10	100%

A Technic for the Bacteriological Examination of Soils.

H. A. Noyes* and Edwin Voigt.†

For nearly half a century investigators have been developing bacteriological technic. Most of the "standard" methods that have resulted from past investigations are adapted to medical rather than to industrial bacteriology. The results obtained by following the average technic are only "qualitatively quantitative" for the methods used are qualitative.

Only of late has extended research been done in the field of soil bacteriology and consequently there is no standard technic for the bacteriological examination of soils. Judging from recent publications soil bacteriologists are adapting medical methods with varying successes and failures. Of late (1) a move has been made to standardize methods for the bacteriological examination of soils. Methods that are accepted as "standard" will have to be founded on the fundamental principles of physics and chemistry. Soil physics is not completely understood and the fundamental chemical changes going on in the soil have not been worked out so advances in bacteriological methods will of necessity have to be related to the development of soil physics and soil chemistry. The following article is submitted with the hope that it may bring out some applications of physical and chemical technic worthy of consideration by other investigators and may help a little in the standardization of methods of technic. These methods have been successfully followed in the Horticultural Research Chemistry and Bacteriology laboratories of the Purdue Agricultural Experiment Station during the past three years. The technic followed, while not entirely original with the authors of this paper, has greatly facilitated the manipulation of sample, media, and apparatus, without in any way impairing the accuracy of the methods used.

That part of the apparatus which differs from that used in most laboratories is described below.

Sampler for Taking Soil Sample.

For sampling the soil, the bacteriologist's soil sampler is used. This sampler is the result of an attempt on the part of the senior author to devise a piece of apparatus that would overcome the inaccuracies that occur through the employment of the usual methods of sampling. The authors have considerable data which show that differences in the aeration of soils affect the bacterial content and are hence stronger advocates than before, for the sampler. We quote as follows from the published article which deals with the bacteriologist's soil sampler.[2] "The sampler is a brass tube 11 inches

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†Research student.

in length and 2 inches in diameter, open at both ends. One end is sharpened to a cutting edge. This cutting edge is so made that the core of soil is cut out and the compaction of soil that is necessary in order to make room for the sampler takes place outside the tube. The cutting end is fitted with a tight fitting 2 inch brass cap. The uncapped end plugged with cotton makes the sampler complete. This sampler embodies at least four of the principles that a good sampler should have: (1) it is easily sterilized and kept sterile;

Figure I—Dilution Bottle and Mixing Spoon.

(2) it is easy to use; (3) it takes and keeps the soil sample free from contamination; (4) it is durable."

For Mixing the Soil Sample.

For mixing the soil when it is taken from the sampler a two quart graniteware sauce pan and an aluminum spoon, tablespoon size, are used. The aluminum spoon is bent so that it will fit the mouths of the 12 ounce dilution bottles. Figure I.

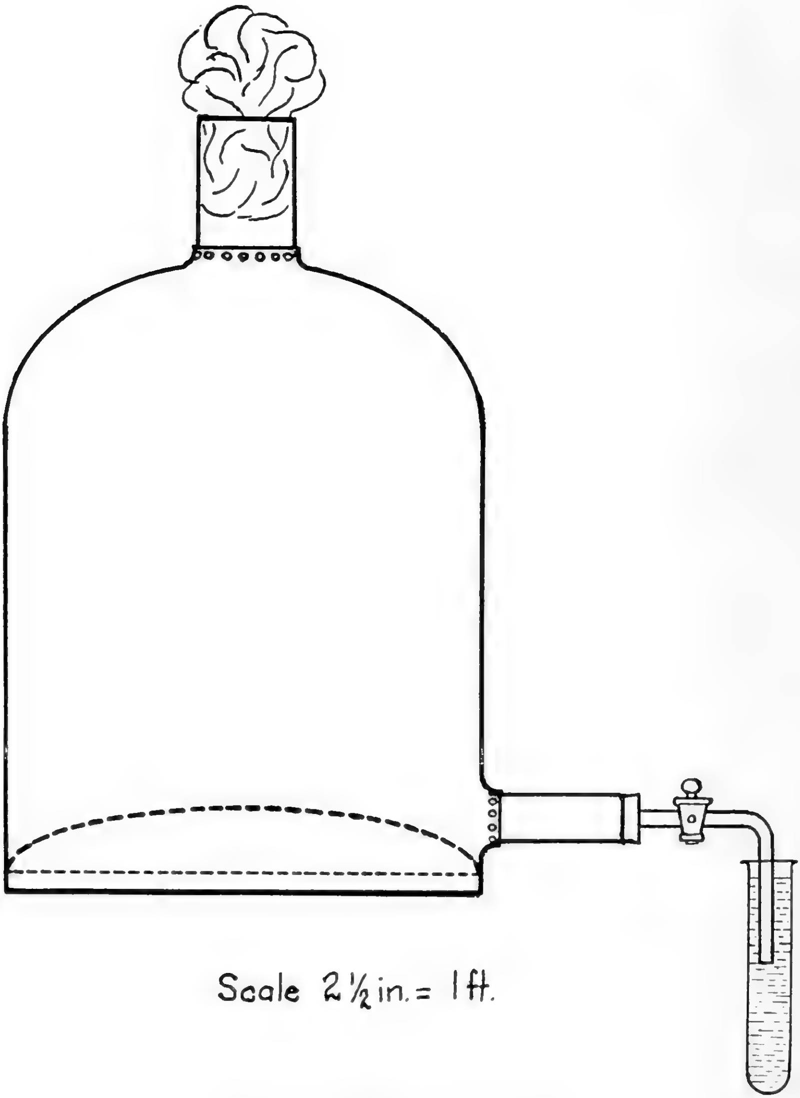

Figure II—Container for sterile water.

Dilution and Test Bottles.

Whitall-Tatum Co's make, (Figure I—regular shape, saltmouth bottles have been found more satisfactory for making dilutions and soil extracts than erlenmeyer flasks. The sizes used are 8, 12 and 16 ounces respectively. The 8 and 12 ounce sizes being used in making dilutions and the 16 ounce size for extracting nitrates. The advantages of these bottles for making dilutions are that they stand sterilization at 200° C, can be compactly piled into the hot air sterilizer, are not as easily broken as flasks, and can be advantageously washed with a bottle brush. (The bottle breakage with us has been about one tenth what the erlenmeyer flask breakage used to be, and the bottles apparently stand sterilization as well.)

Container for Sterilizing and Keeping Sterile Water.

All water is sterilized by boiling on three successive days in an especially constructed copper boiler, lined with tin. Figure II. The boiler is an 8 gallon copper aspirator bottle having a rather large and long neck, allowing first, a large cotton plug (which permits the water to be boiled without blowing out the plug), second, the transmission of enough heat to thoroughly dry the cotton plug after boiling is over. The outlet tube is closed by a rubber stopper, through which passes a tube fitted with a glass stop-cock. The glass tube on the other side of the stop-cock contains a right angle bend. The stop-cock and outlet tube are sterilized by allowing about a pint of boiling water to run out through them each time the water is boiled, and kept sterile by keeping the end of the tube immersed in a test tube of 70 percent alcohol, or 3 per cent hydrogen peroxide.

For Incubation Tests.

One half pint jell glasses with loose fitting lids are used as containers for soil subjected to incubation tests. The jell glass is preferable to either a beaker or tumbler because it has a lid, and is to be preferred to a beaker because the soil can be removed by inverting the jell glass and dropping it with smart slap, on a hard surface.

Pipettes.

The short form volumetric pipettes, Figure III, are used for making dilutions and in taking aliquots for plating. These can be used as accurately as the regular form and apparently have the following advantages for bacteriological work: (1) are easier to handle and wash; (2) can be readily sterilized in large test tubes, as they pack in well and are not as liable to breakage; (3) are easier to fill; and (4) soil emulsions drain out more quickly and completely from them.

Sterilization by Dry Heat.

For hot air sterilization the "Láutenschläger" ovens are quite satisfactory. The large amount of sterile glassware necessary for soil work and the desirability of handling the glassware by the ovenful had led to the supplement-

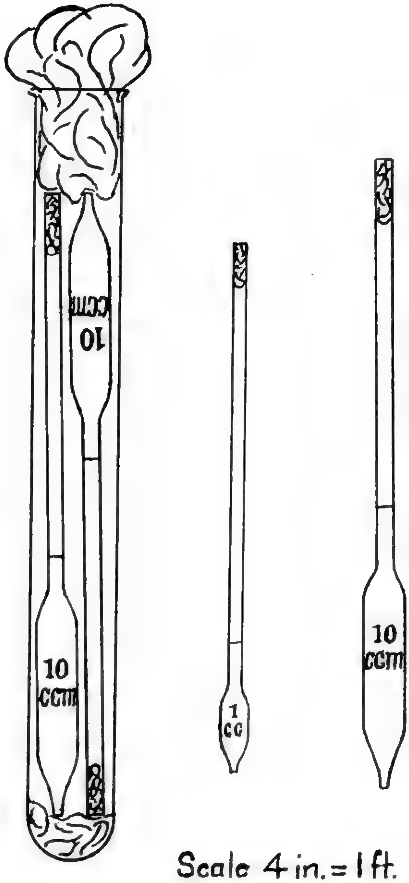

Figure III—Pipettes and pipette case.

ing of the "Láutenschläger" oven by a two burner gas plate and several detachable baking ovens. A square of asbestos is laid over each burner to diffuse the heat, and holes about one insh and a half in diameter are made in the top lining and top of each oven, to allow the moisture formed by the burning gas to escape. It is desirable to have the holes cut in the oven so that one is not exactly above the other. By using the detachable baking ovens apparatus can be sterilized some days previous to the time the samples are taken and an oven with its contents can be set to one side while another ovenful of glassware is sterilized. This simplifies the handling of petri plates and dilution bottles as the ovens can be carried directly to the work table without handling the apparatus and risking chance contamination. This is very important where a large number of petri plates are used at one time.

Autoclave.

The American Sterilizer Company's autoclave has proven in spite of its high initial cost to be very efficient and economical for within one half hour from the time the gas is lit not only eighteen pounds pressure of steam can be generated but one load of material can be given a ten minute sterilization under eighteen pounds pressure of live steam. The automatic valve which regulates the pressure of the steam in the boiler by shutting off or turning on the gas is a feature appreciated by the investigator.

Water Bath

A water bath, is used to cool the agar media to 45°C after it has been melted in the autoclave. The media is then kept in the bath at 40°-42°C until it is poured into the petri dishes.

Absorbent Cotton

By buying in quantity absorbent cotton is as cheap as the bat cotton at retail prices. It is preferable because the fibre is cleaner and better plugs can be made from it.

Mallets.

The mallet for driving the bacteriologist's soil sampler should be of wood and not weigh over three pounds. The light mallet for use in the laboratory weighs about a half a pound and is made from very light wood.

Petri Dishes

Petri dishes 10 centimeters in diameter and 15 millimeters high have been most satisfactory. The top of the dish should not have a rim deep enough to come down to the table when the dish is placed right side up, on a table.

THE TECHNIC

The technic is given as directions for handling ten samples of soil at one time. In addition to the ordinary apparatus such as burners, autoclave, ovens and so forth being ready for use, the following apparatus must be ready for use. No list is made here of the chemical apparatus that is necessary for nitrogen, moisture, nitrates or other chemical determinations that are to be run on each sample.

List of Apparatus Needed Before Plating is Finished

10 Bacteriologist's soil samplers capped, plugged and sterilized.
1 Driving mallet.
1 Driving head.
1 Light wooden mallet.
1 2 quart sauce pan.
1 Aluminum spoon (tablespoon size.)
11 12 ounce plugged and sterile salt mouth bottles.*
55 8 ounce plugged and sterile salt mouth bottles.
10 16 ounce salt mouth bottles with rubber stoppers.
30 One half pint jell glasses (sterile.)
1 Set Balances sensitive to 0.1 gram with a capacity of 400 grams per pan.
8 Liters of sterile water.
11 Rubber stoppers to fit 12 ounce bottles.
72 Test tubes of sterile media.
67 Sterile 10 cc. vol. short form pipettes, plugged and in cases.
24 Sterile 1 cc. vol. short form pipettes plugged and in cases.
1 Sterile 5 cc. pipette plugged and in a test tube case.
72 Sterile 100 millimeter petri dishes.
10 One pint Mason jars with rubbers.
1 200 cc. graduated cylinder, plugged and sterilized.
1 100 cc. graduated cylinder, plugged and sterilized.
2 6-inch Battery jars.

The numbers given are exactly what is needed. More apparatus is always prepared to take care of mishaps or mistakes.

Procedure

Take 10 samplers, remove the caps, rub a piece of paraffin over the outside of each just above the cutting edge (this is so the cap will slip on easily after the sample is taken), and replace the caps on the samplers. The cap and the sampler it fits should be stamped with the same number. Plug the samplers with absorbent cotton, sterilize them in hot air oven, cool and stand in a suitcase. Keep the samples upright.

Plug, with absorbent cotton, the 55 eight ounce bottles, two hundred cc. graduated cylinder and one hundred cc. graduated cylinder, place them in one of the made over baking ovens and sterilize them. Plug the 11 twelve ounce bottles with absorbent cotton, weigh each to the nearest decigram,

*See note at end of article.

mark the weight on the bottle and sterilize in the same manner as the other bottles.

Weigh each of the 30 jell glasses to the nearest decigram and record the weight on the tin lid. As a rule it is advisable to sterilize the jell glasses with dry heat so as to be sure that they are free from any contaminations resulting from previous use or storage.

Plug the stems of the 10 cc. the 5 cc. and the 1 cc. pipettes with absorbent cotton. Prepare 12 inch by 1 inch test tubes by placing a mat of absorbent cotton in the bottom of each. Place the pipettes in the test tubes, plug the test tubes with cotton and sterilize in a hot air sterilizer. (Two ten cc. or four one cc. pipettes are sterilized in one test tube.)

PLATE I.
Ready to Start.

Media is made up and sterilized and distilled water for making dilutions is sterilized in the special boiler. The casein solution for ammonification, the mannite solution for nitrogen fixation and the ammonium sulphate solution for nitrification are made up and sterilized.

The light wooden mallet, a bunsen burner, the two quart saucepan, the aluminum spoon, the sixteen ounce salt mouth bottles, the weighed bottles and jell glasses, the ten one pint mason jars and the balance are arranged on the laboratory table. (Plate I.) The heavy mallet, the driving head, and the samples are taken to the field and the soil samples taken according to directions given in a previous article.[2] Eleven rubber stoppers of such size that they will fit the twelve ounce bottles are put in the inner part of a double boiler, covered with distilled water and the double boiler placed over a bunsen burner.

Handling of Soil Sample

When the samples reached the laboratory they are set out in a row on the laboratory table where the apparatus has already been arranged. The bunsen burner is lighted and the saucepan and aluminum spoon are sterilized by passing them through the free flame several times. The pan is set down on the bench and the spoon placed inside of it. A sampler containing a sample of soil is wiped off with a towel to free it from loose soil on the outisde, the light mallet is sterilized in the free flame and placed in the sterile saucepan. The outside of the sampler is sterilized in the flame. The cap is removed from the sampler, and laid to one side. The sampler is held, with the left hand, over the saucepan and struck with the mallet, the soil falls out into the pan. (We have found this the most efficient way of removing the soil from the sampler unless the soil is frozen.) The soil is now thoroughly mixed with the aluminum spoon.

Place one of the previously weighed twelve ounce bottles on one pan of the balance and then place 50 grams more than the bottle weighs on the other pan. Remove the cotton plug flame the mouth of the bottle, place the bottle on the balance pan and lay the cotton plug top down in the balance pan beside the bottle. By means of the aluminum spoon quickly introduce fifty grams of soil into the bottle, flame, then replace the cotton plug and set the bottle to one side.

Into each of three of the jell glasses weigh out one hundred grams of the soil, for conducting the physiological tests, and set the jell glasses to one side. Weigh out on a paper 50 gms. of the soil and put it in one of the 16 ounce saltmouth bottles. (This is the aliquot for the determination of nitrates present in the field soil.) Put the remainder of the sample in one of the Mason jars and seal the jar. Clean the graniteware pan and aluminum spoon. Usually all the visable soil is removed by wiping with a piece of absorbent cotton. Each of the other samples of soil is handled in the same way. The heat is started under the double boiler containing the rubber stoppers and preparations are made to melt the media and get it in the 40°C water bath. If proper preparations were made the media can be melted and prepared while the dilutions are being made.

Making Bacterial Dilutions

The sterile graduated cylinders and the tank of sterile water are placed on the laboratory table and sterile water drawn off as follows. Remove the test tube of alcohol that is over the outlet to the tank, allow about a pint of water to run out and discard it. Flame the cotton plug of the 200 cc. graduated cylinder, remove it, flame the mouth of the cylinder, and then by means of the graduated cylinder add 200 cc. of the sterile water to each of the 10 twelve ounce bottles to which aliquots of soil were added and to the extra bottle that was prepared for a blank check. In each case the cotton plug and lip of the bottle is flamed just before the bottle is opened for the addition of the water. Now bring up the oven containing the fifty-five eight ounce bottles, take the sterile 100 cc. graduated cylinder, flame the cotton plug, remove it, flame the mouth of the cylinder and by means of the graduated cylinder place 90 cc. of sterile water in each bottle. The cotton plug closing each of the bottles is flamed just before the bottle is filled. The eight ounce bottles are arranged in five rows each eleven bottles long, running lengthwise of the bench.

PLATE II.
Adding of sterile water to soils and dilution bottles.

The bottles containing the water and soil are set out in a row in front of the other bottles, (Plate II). The rubber stoppers that have been steaming in the double boiler are put in the bottles containing soil and water in place of the cotton plugs. Work from left to right always as it is easier and such a system prevents mistakes. The first two of the bottles in the front row are grasped, one in each hand, in such a way that the index finger presses down on the stoppers. The bottles are lifted up from the laboratory table, the hands and arms are turned so that the bottles are upside down, and the bottles are shaken vigorously for fifteen seconds and then placed back on the table. The next two bottles are picked up in the same manner, inverted, shaken for fifteen seconds and then placed back on the table. This is continued until each bottle has been shaken 10 fifteen second periods.

The pipettes, in their test tube sterilizing cases, are brought within easy reach. Commencing at the left end of the front row of bottles proceed as follows: Remove, without having the fingers come in contact with the bulb, a 10 cc. pipette from its test tube case, get the soil and water in the first bottle, (which is a 1-4 dilution of the bacteria in the field soil) thoroughly in motion by shaking and while the mixture is still in motion fill the pipette. Pick up the eight ounce dilution bottle which was directly behind the first bottle taken, flame the cotton plug and remove it. While holding the plug in the hand, blow out the 10 cc. mixture of soil and water from the pipette into the 90 cc. of water, replace the cotton plug, and set the bottle back in place.

PLATE III.
Making Bacterial Dilutions.

The pipette is dropped into a battery jar half full of water as it is hard to clean if the soil is allowed to dry on the glass. The mixture just made is a 1-40 dilution of the bacteria in the field soil. Make the 1-40 bacterial dilutions of the other samples in the same way. The bottle containing the 200 cc. of sterile water is treated exactly as though it contained soil, (Plate III.) The bottles from which the dilutions have been made are put on a tray and carried away.

The bottles containing the 1-40 bacterial dilutions are each shaken for ten seconds as vigorously as it is possible to shake them without wetting the cotton plugs. When all have been shaken start over and shake each bottle again. This is repeated until each bottle has been shaken 10 ten second periods. The procedure followed in making the 1-40 bacterial dilutions is followed in making the 1-400 bacterial dilutions and the bottles containing 1-40 bacterial dilutions are taken away. The 1-400 dilutions of the bacteria in the field soil are shaken, in order, until each bottle has been shaken the 10 ten second periods. Following the same technic we make 1-4,000, 1-40,000 and 1-400,000 bacterial dilutions. The 1-40,000 and 1-400,000 bacterial dilutions are retained for plating while all other dilutions are discarded. The 1-400,000 bacterial dilutions are shaken exactly as though dilution were to be made from them.

PLATE IV.
Ready to pour plates.

PLATING

Thirty-six petri dishes are taken from an oven and spread out on the laboratory table. Care is taken to prevent contamination from the lifting up or sliding of the lids of the dishes. The dishes are arranged in rows of three. All dishes are labeled and numbered, each set of three being numbered to correspond to one of the soil samples. The six dishes in excess of the thirty actually needed for plating one dilution of the bacteria in the ten samples of soil are utilized as follows; three for plating the water that has been run as a check on the technic and three to plate the media alone. This enables the investigator to trace contamination to the water, air, or media, and classify the contamination accordingly. (Plate IV.)

One of the dilution bottles is taken, the cotton plug flamed, a one cc. pipette taken from a test tube case, the bottle shaken, the plug flamed and removed, the pipette inserted and allowed to fill to the mark. The pipette is withdrawn and the cubic centimeter of solution blown out into one of the petri dishes prepared for plating that sample. Using the same technic two more one cubic centimeter aliquots are taken from the same bottle and put in the other two of the triplicate plates prepared. The bottle and the pipettes are put to one side. A tube of media is taken from the 40°C water bath, the plug removed, the mouth of the tube flamed and the media then poured into one of the petri dishes to which the aliquot of solution has been added. The dish is rotated to thoroughly mix the media and solution and to get an even layer all over the dish. In carrying out the above procedure as much care as possible is taken to prevent the plates from being contaminated from outside sources. The other two of the triplicate plates are then poured. Three plates are then made in the same way from each of the other 1-40,000 bacterial dilutions and of the media. The plates are piled in stacks of three and moved to one end of the laboratory table. The remaining thirty-six petri dishes are taken from the oven, laid out on the table, labeled, and platings made from the 1-400,000 bacterial dilutions. These plates are stacked in piles of three. The piles of plates after the agar has hardened are inverted, placed in trays and the trays are set in the 20°C incubating room. The plates are inverted because after they are poured they are less liable to contamination if inverted, and because the formation of spreaders is hindered.

Where a man works slowly or is working alone the 1-400,000 bacterial dilutions are not made until after the 1-40,000 bacterial dilution have been plated.

The jell glasses containing the one hundred gram quantities of field soil are separated into three groups, one of each of the triplicate glasses from one sample of soil being put in each group. To each glass of one set is added five cc. of ammonium sulphate solution for nitrification tests, to each glass of another set ten cc. of mannite solution for nitrogen fixation tests and to each glass of the third set ten cc. of casein solution for ammonification tests. The jell glasses are then incubated in the 20°C incubation room for the proper lengths of time.

To each of the 16 ounce bottles containing the fifty gram aliquots of soil distilled water is added and the nitrates determined. The samples in the Mason jars are analyzed, as soon as time permits, for moisture, nitrogen, and other elements desired. The moisture is necessary to put results on a dry basis and the nitrogen content is needed to base nitrogen fixation results upon.

DISCUSSION

Sterile Apparatus

The technic calls for the sterilization of samplers, of dilution bottles, of the glasses used for incubation tests and all other apparatus. From reports made recently[3] it would seem to some that sterility of apparatus for agricultural bacteriology has been over-emphasized. Some might maintain that the samplers need not be sterile if they are clean and that the contamination in the lower dilutions from clean dilution bottles would be negligible.

As long as clean does not mean the same to all workers and just as long as we will admit that unless apparatus is sterile we do not know just how great or of what kind the contamination is—sterile utensils and glassware should be used for the crudest of tests and are absolutely necessary for investigational and research work.

Sampler

The reasons for using the sampler have already been given. The facts (1) that this apparatus samples as accurately under sod as under clean cultivation; (2) that it does not destroy the cultural practices, and (3) that it may be used with as much accuracy and safety near a tree, shrub, or bush. as in the open field are emphasized.

Field Versus Air Dry Samples

If aliquots for bacteriological analysis are taken from air dry samples a discussion of methods and a technic for sieving or grinding the air dry samples would be in place. Air dry samples cannot properly be used to determine the bacteria present in field soils unless it is proven by careful investigation that changes in moisture, in aeration, and in temperature have no effect on the bacterial content of the soil.

Size of Aliquot of Soil

A small sample of soil is not representative. Soils are not composed of equal sized particles or of particles of the same material. Granting that a given soil contained particles all of the same composition and which were non-porous, the variation in the area of the soil particles of two different chance aliquots might be as much as the area of the particles of one of the aliquots. Add the factor of different kinds of particles to that of variation in size and it is safe to say that no two samples of soil are exactly alike. If the size of the aliquot of soil taken for analysis is decreased beyond a certain point, a small proportion of the larger, rock particles must necessarily account for a larger per cent of the weight and cut down the area of the soil particles in the aliquot.

If air dry samples could be used the aliquot required to be representative would be smaller than that required from a field sample. It has not been proven advisable to use air dry samples and so aliquots of the moist field soil are used. Dr. P. E. Brown (4) takes on one hundred gram aliquots of field soil from which to make bacterial dilutions, while Dr. H. Joel Conn (5) uses one-half gram aliquots of field soil from which to make bacterial dilutions.

The authors of this paper have investigated the amount of soil to use to get representative counts and summarize their results as follows:

(1) When tests were made to determine the amount of soil necessary to get reliable checks in moisture determination on a silty clay soil, taking aliquots from the sample jars as they came from the field, it was found that it took ten gram aliquots to have the duplicates check regularly to one tenth of one per cent. The soil rarely contained particles of stone or foreign matter that could be picked out and no attempts were made to weigh out exact amounts so we were forced to conclude that to get accurate moisture results ten grams of field soil had to be used. This was when the soil contained 12% to 15% of moisture. Having made the above test, and knowing that the bacteria which are present in large numbers, are small, and must be distributed in the sample more or less relatively to the internal surface of and the composition of the sample, the authors are forced to conclude that it would take larger aliquots to get good bacteriological results than it would for good moisture results.

(2) Where the ground is covered with plants and their roots are incorporated in the surface soil, it is evident that a larger aliquot must be taken to represent the soil.

(3) When the soil is frozen it is harder to mix the samples and a large aliquot must be taken to overcome inaccuracies in attempts at mixing.

(4) A large quantity of soil must be chosen so that the same sized aliquots of all normal types of soil can be analyzed accurately. This gives a standard.

(5) Fifty grams of field soil were chosen as the quantity from which to make dilutions for the following reasons. Although smaller than the amount used by Dr. Brown it allows the counts made from duplicate and triplicate aliquots from the same field sample to check as well. The results of an extended investigation on size of aliquot of field soil to use will be published as a separate paper.

Dilution

The chemist makes dilutions of various chemical compounds and mixtures of chemical compounds. To the chemist a specified dilution is a mixture such that all aliquots taken from it by weight or by volume will be of the same composition.

Definite amounts of solids are put in solvents and the resulting clear true solutions are exact dilutions of the substances used providing no chemical reaction takes place. Solutions of acids, bases and salts are diluted with water or some other proper solvent and the amounts of materials in the more dilute true solutions bear definite relations by weight and volume to the amounts in the original more concentrated solutions. Definite amounts of a finely divided or ground material are put with definite amounts of another finely divided or ground material and thoroughly mixed. The resulting mixtures are dilutions of both materials because aliquots of mixture have the same composition and the proportions of the original substances contained, bear definite relations to the concentration of the materials used to make the mixture.

The bacteriologist makes specified dilutions and solutions of media and salts in the same way the chemist does. Further the bacteriologist has to reduce the concentration of the bacteria in all kinds of materials so that an aliquot containing few enough bacteria to be handled with present apparatus and technic can be taken. Water is the usual diluent employed and the concentration of the bacteria has to be reduced whether the substance under examination is a gas, liquid, or solid, whether it is soluble or insoluble, miscible or non-miscible.

When the substance under bacteriological examination is a liquid the report is usually made of number of bacteria per cc when a solid of the number of bacteria per gram. When the materials are such that specified dilutions of them can be made, the bacteriological dilutions are dilutions of both the materials and the bacteria. When the materials are solids or non-miscible the bacteriological dilutions are dilutions of the bacteria only.

Bacteriologically speaking the dilution of bacteria states the number of cubic centimeters of diluent which would contain the number of bacteria in one gram or one cubic centimeter of the original material.

Throughout this paper the phrases dilution of bacteria per gram of field soil and bacterial dilution have been used. Investigators and texts agree fairly well that the bacteria in soil are intimately associated with the moisture in the soil. Explanations of the finding of living bacteria in frozen soil cluster about discussions of whether the films of moisture surrounding the soil particles are really frozen. The bacteria in soil, when dilutions are made, are diluted for they are distributed through a larger volume of water. Dilutions are based wholly on the volume of water added. Fifty grams of soil and 200 cc of water means a 1-4 bacterial dilution of the fifty grams taken. for each gram of soil has four cubic centimeters of water to give up its bacteria to. Subsequent dilutions are based on the volume of the aliquot of the lower dilution taken. The soil that makes up part of the aliquot is considered as water. So little of the field soil is soluble and such a small part of it really gets through to the high bacterial dilutions that the soil in the aliquot is usually ignored.

Basis of Dilutions

The reason that the dilutions are based on 1-4 and not on the 1-2 or 1-10 is that it has been found that on the 1-4 basis the best plates from average soil are secured from either the 1-40,000 or the 1-400,000 bacterial dilutions of the bacteria in the soil. 100 colonies on plates from the 1-40,000 bacterial dilution mean 4 million bacteria per gram of field soil while 100 colonies on plates from the 1-400,000 dilution mean 40 million bacteria per gram of field soil taken. This allows a larger variation in the bacterial content to be handled more satisfactorily with the same number of dilutions and technic than can be handled on the 1-2, 1-200, 1-2,000, etc., or the 1-10, 1-100, 1-1,000, etc. systems of dilution. Calculations are not hard as the number of colonies divided by 25 or 2.5, according to the dilution, gives millions of bacteria per gram of field soil.

Number of Bacterial Dilutions Necessary

Results obtained where the bacterial content is low should be comparable with results obtained where the bacterial content is high, therefore a uniform system for making dilutions is advisable. Suppose the 1-40 bacterial dilution of a gravel should contain few enough bacteria to yield good plates but that it was necessary to make a 1-40,000 bacterial dilution of a sandy soil in order to get as good plates. A 1-40 dilution of the sandy soil should be made in the series of dilutions to have the results comparable for maximum errors occur in the first bacterial dilution made.

Representative aliquots are necessary if results are to approach accuracy. It takes larger aliquots of some solutions and mixtures to have the aliquots represent the solution or material under investigation than it does of others. Using a pipette graduated to .005 of a cubic centimeter, a .05 cc aliquot of a clear, dilute sodium chloride solution would be representative of the sodium chloride present in the solution. A .05 cc aliquot of a turbid solution would not be representative even if taken with the same pipette, for the suspended material would interfere with the composition of the small aliquot and affect the accuracy with which the pipette could be used. In mixtures of soil and water the soil particles vary in size, in shape, and in specific gravity. An aliquot of a soil and water mixture must be rather large to be representative (at all) of the mixture. A soil and water mixture is not homogeneous for the following reasons:

1. It is not a solution.
2. Soil is heavier than water and the particles settle out, even when the mixture is in motion because of differences in size, in shape and in specific gravity.

Errors that occur in aliquoting a soil and water mixture are:

1. Some of the material in suspension is taken as part of the aliquot when an aliquot is drawn from the moving mixture.
2. Solid material drawn as part of the aliquot clings to the walls of the pipettes, and they do not drain accurately as a result.
3. Bacteria are in, or on, the soil particles besides being in suspension so it is practically certain that not all colonies are broken up by the first shakings.

The errors enumerated above can not be entirely eliminated but are cut down when the size of the aliquot taken is increased. As a rule, in every series of bacterial dilutions there are at least two dilutions from which platings are made. One of these dilutions is ten times another, thus, for uniformity and so that results obtained from either higher or lower dilutions of other materials would be more comparable, every higher bacterial dilution should be ten times the one from which it is made. Thus there would naturally be two uniform systems of making dilutions of the bacteria in soil that might reasonably be employed; either 1 cc of the lower bacterial dilution and 9 cc of sterile water to make the next bacterial dilution or 10 cc of the lower bacterial dilution and 90 cc of sterile water to make the next bacterial dilution. It would be necessary in either case to make as many dilutions as ten is a factor of the highest dilution desired.

Many investigators take one cc of the first mixture made up and put it with 99 cc or 199 cc of sterile water, making the resulting bacterial dilution one hundred times, or two hundred times as great at once.

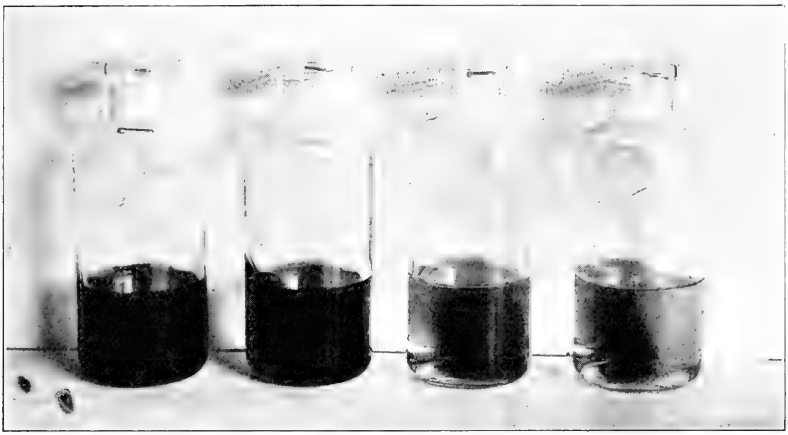

Plate V.

To determine whether a one cc aliquot of a soil and water mixture would be as representative as a ten cc aliquot the following experiments were carried out. Dry and sieved samples were used as counts were not desired. Two acid soils were chosen, No. 1, an acid black sand and No. 2 a very acid peat. 50 grams of each soil were taken in each case, put with 200 cc of water and shaken for five minutes. A one cc portion of each mixture was taken with a one cc pipette while the mixture was still in motion and put with 99 cc of distilled water and shaken. Ten cc aliquots of the original mixtures were taken in the same manner as the one cc aliquots, put with 90 cc of water and shaken. This gave a 1-40, and 1-400 bacterial dilution of each soil. Ten cc aliquots of the 1-40 bacterial dilutions were put with 90 cc of distilled water giving 1-400 bacterial dilutions. Thus two 1-400 bacterial dilutions of each soil were made, one on the 10 cc basis and one on the 1 cc basis. Using 10 cc aliquots of each of these bacterial dilutions and 90 cc of distilled water, 1-4,000 bacterial dilutions were made, and, following the same procedure, 1-40,000 bacterial dilutions were made.

When ammonium hydroxide is added to acid soil containing a large amount of organic matter the solution becomes dark colored in proportion as the soil is acid. One cc portions of strong ammonium hydroxide were added to each of the bacterial dilutions made and it was found that the color produced was darker in each case where the 10 cc aliquots had been taken from the original 1-4 bacterial dilutions first made up. The fact that the amounts of material soluble and insoluble in water which would react with ammonium hydroxide were different in high dilutions made when 10 cc aliquots were taken at the start from what they were when 1 cc aliquots

PLATE VI.

were taken at the start, is conclusive evidence that the results of working the two ways are not the same. Figure V shows the results using soil No. 1. The two bottles at the left are the 1-400 bacterial dilutions while those at the right are the 1-4,000 bacterial dilutions. The left hand bottle in each case shows the result of using 10 cc aliquots from the start. When tested in a colorimeter the depth of color of the solution in the left hand bottle of each set was about 1.5 times that in the corresponding bottle where a 1 cc aliquot was taken at the start.

Figure VI shows the results using soil No. 2 which was much more acid and which contained over seven times as much organic matter. Six of the bacterial dilutions made were photographed, the two at the left being the 1-400, the middle two the 1-4,000, and the two at the right the 1-40,000 bacterial dilutions. The left hand bottle of each set is the one where 10 cc aliquots were used from the start. The colorimeter shows the depth of color in all bottles made from the 1 cc original aliquot to be about 4-5 of the depth where the 10 cc aliquot was taken at the start. Just as small pebbles form a large part of a small aliquot of soil that may be taken for bacteriological analysis and prevent the results from being representative, the variations in the solid material contained in small aliquots of soil and water mixtures cause a large error in high dilution based on these aliquots.

To determine whether the differences in color in the above tests might be due to differences in amount of the original soil carried through as part of the aliquots rather than to representativeness of the aliquots under comparison, the bacterial dilutions of two silty loam soils which happened to be at hand were examined. Ten and one cc aliquots of the 1-4, 1-40, and 1-400 bacterial dilutions were put into tared evaporating dishes, evaporated, dried in the oven at 105°C for two hours, and the residues weighed. The results obtained are given in Table I.

TABLE I.

Weight of soil in 10 cc and 1 cc aliquots of soil and water mixtures made up by technic under discussion.

Soil	Bacterial Dilution 1-4		Bacterial Dilution 1-40		Bacterial Dilution 1-400	
	10 cc	1 cc	10 cc	1 cc	10 cc	1 cc
A	1.139	.098	.092	.003	.004	.000
	1.191	.075	.093	.005	.003	.000
Average...	1.161	.087	.092	.004	.004	.000
B	1.185	.113	.097	.006	.003	.000
	1.246	.103	.090	.006	.004	.000
Average....	1.216	.111	.094	.006	.004	.000

The weight of soil taken in 1 cc from the 1-4 bacterial dilution represents the weight that would be in the 1-400 bacterial dilution providing the bacterial dilution was increased 100 times at once.

The weight of soil taken in the 10 cc aliquot from the 1-40 bacterial dilution represents the weight that would be in the 1-400 bacterial dilution providing the bacterial dilution is increased 10 times at the start.

1 cc aliquots would cause .087 and .111 grams of soil, respectively, to be

present in the 1-400 bacterial dilutions. 10 cc aliquots would cause .092 and .094 grams of soil respectively, to be present in the 1-400 bacterial dilutions. The variation in these figures is not 1.5 to 1.0 nor 1 to .8 and thus would not account for the variation in the ammonium hydroxide tests on the bacterial dilutions made from soils No. 1, and No. 2. As a result of these two tests it is thought that 1 cc is too small an aliquot of a water and soil mixture to be taken as representative.

To determine whether there is more uniformity between triplicate ten cc aliquots from the same bottle than there is between triplicate one cc aliquots from the same bottle, the following experiment was undertaken. All aliquots were taken from the 1-4 bacterial dilutions of the soils used. The acid peat and the acid black sand used were the same soils used in a previous test except that they were oven dried and reground in a mill. The red silty clay is a "freak" soil, so fine that it dusts, and contains a large percentage of soluble matter. The one cc aliquots were taken first and then the ten cc aliquots were taken from the same bottle. The mixture of soil and water was always in motion when aliquots were drawn.

TABLE II.

Uniformity of 10 cc and 1 cc aliquots of 1-4 bacterial dilutions of three soils.

Soil and Aliquot	Weight of soil in aliquot			Av.	Range	Range per. cc taken
	1	2	3			
Acid peat						
1 cc	0.127	0.105	0.119	0.117	0.022	0.022
10 cc	1.412	1.565	1.602	1.526	0.190	0.019
Acid black sand						
1 cc	0.065	0.082	0.065	0.071	0.017	0.017
10 cc	0.749	0.797	0.842	0.796	0.093	0.009
Red silty clay						
1 cc	0.141	0.118	0.144	0.134	0.026	0.026
10 cc	1.669	1.684	1.698	1.684	0.029	0.003

The table shows:

1. That the differences between the results obtained with triplicate 1 cc aliquots and triplicate 10 cc aliquots vary as the type of soil.

2. That the soil in the soil and water mixtures is not accurately aliquoted.

3. That variation between one cc aliquots is so great that the increasing concentration of the soil in the mixture (due to 2) does not regularly increase the amount of soil in each succeeding aliquot.

4. That the increased concentration of the soil in the soil and water mixtures increases the amount of soil taken in succeeding 10 cc aliquots.

5. That per cc of aliquot taken the 10 cc aliquots contain nearer constant amounts of a given soil in spite of 4.

The experiments to this point having shown that a ten cc aliquot is more representative of a soil and water mixture than a 1 cc aliquot the following determinations and calculations were made to find out if, in following regular systems of dilution, the soil making up part of a 10 cc aliquot would cause more or less departure from the bacterial dilution desired than the soil making up part of the 1 cc aliquot would.

In addition to using the determinations of the soil in the 10 cc and 1 cc aliquots already given, the results from five more soils were also secured. All determinations used as the basis of calculations are given in Table III. The soil in the first 10 or 1 cc aliquot taken is used as this would be the aliquot used in making bacterial dilutions.

TABLE III.

Weights of soil taken with 1 cc and 10 cc aliquots of 1-4 bacterial dilutions of soils.

Soil.	Gms. soil 10 cc aliquot	Gms. soil 1 cc aliquot	Percentage soil in 1 cc aliquot is of soil in 10 cc aliquot.
*Acid Peat	1.412	.127	8.99
Peat	0.274	.025	9.12
*Acid Black sand	0.749	.065	8.68
Black sand	0.608	.037	6.09
Black sandy loam	0.208	.016	7.69
Sandy loam	0.621	.045	7.25
Silty loam A	1.139	.098	8.60
Silty loam B	1.185	.113	9.54
Yellow tight sand	0.148	.012	8.11
*Red silty clay	1.669	.141	8.45
Average			8.25

Table IV shows the dilutions that actually would be made if uniform systems of dilution were employed. A 1 cc aliquot would be put in practice, with 9 cc of water and a 10 cc aliquot with 90 cc of water to increase the dilution ten times.

TABLE IV.

Actual bacterial dilutions made with 10 cc and 1 cc aliquots of 1-4 bacterial dilutions of ten soils.

Column headings denote bacterial dilutions desired.

*Samples very finely divided and dry.

1 cc aliquot plus 9 cc water to give next dilution versus 10 cc aliquot plus 90 cc water to give next dilution.

Soil and size of Aliquot.	Bacterial Dilution Desired.	
	1-40	1-400
Acidpeat*		
10 cc	43.72	441.1
1 cc	43.33	433.3
Peat		
10 cc	40.68	407.6
1 cc	40.69	406.9
Acid black sand		
10cc	41.08	412.0
1 cc	40.96	409.6
Black sand		
10 cc	40.88	409.6
1 cc	40.56	405.6
Black sandy loam		
10 cc	40.28	403.2
1 cc	40.24	402.4
Sandy loam		
10 cc	40.92	409.2
1 cc	40.68	406.8
Silty loam A		
10 cc	41.72	418.9
1 cc	41.48	414.8
Silty loam B		
10 cc	41.80	419.7
1 cc	41.28	412.8
Tight yelow sand		
10 cc	40.20	402.0
1 cc	40.16	401.6
Red silty clay		
10 cc	42.56	428.2
1 cc	42.12	421.2
Average 10 c	41.38	415.1
Average 1 c	41.15	411.5
Difference	0.23	4.6

*Specific gravity of peat taken as 1.5 all other soils calculated as having a specific gravity of 2.5.

In the above table the volume of soil taken in the aliquot from the 1-40 bacterial dilution is ignored when 1 cc is taken, and used as one tenth the volume taken from the 1-4 bacterial dilution when a 10 cc aliquot is taken.

The tables present evidence that the 10 cc aliquots should be taken for a chance clump of bacteria in the 1 cc aliquot first taken would cause a much greater error than the differences in bacterial dilutions calculated above.

Table V is based on the same data as Table IV. The only difference being that, as is recommended by some, the one cc aliquot is used to increase the bacterial dilution 100 times at the start.

TABLE V.

Actual Bacterial dilutions made by taking 10 cc and 1cc aliquots of 1-4 bacterial dilution.

Soil	1–40	1–400	1–4,000	1–40,000	1-400,000
Acid Peat					
10 cc.	43.72	441.135	4,411.35	44,113.5	441,135.
1 cc.		436.64	4,366.4	43,664.	436,640.
Difference.		4.495	44.95	449.5	4,495.
Peat					
10 cc.	40.68	407.6136	4,076.136	40,761.36	407,613.
1 cc.		406.72	4,067.2	40,672.	406,720.
Difference.		.8936	8.936	89.36	893.60
Acid Black Sand					
10 cc.	41.08	412.0324	4,120.324	41,203.24	412,032.4
1 cc.		410.56	4,105.6	41,056.	410,560.
Difference.		1.4724	14.724	147.24	1,472.4
Black Sand					
10 cc.	40.88	409.6176	4,096.176	40,961.76	409,617.6
1 cc.		406.0	4,060.	40,600.	406,000.
Difference.		3.6176	36.176	361.76	3,617.6
Black sandy loam					
10 cc.	40.28	403.2028	4,032.028	40,320.28	403,202.8
1 cc.		402.56	4,025.6	40,256.	402,560.
Difference.		.6428	6,428	64.28	642.8
Sandy loam					
10 cc.	40.92	410.0184	4,100.184	41,001.84	410,018.4
1 cc.		407.24	4,072.4	40,724.	407,240.
Difference.		2.7784	27.784	277.84	2,778.4
Silt Loam A					
10 cc.	41.72	418.8688	4,188.688	41,886.88	418,868.8
1 cc.		416.16	4,161.6	41,616.	416,160.
Difference.		2.8088	28.088	280.88	2,808.8

TABLE V.—Continued.

Soil	1–40	1–400	1–4,000	1–40,000	1–400,000
Silt Loam B					
10 cc..........	41.80	419.672	4,196.72	41,967.2	419,672.
1 cc..........		418.68	4,186.8	41,868.	418,680.
Difference...		0.992	9.92	99.2	992.
Tight yellow sand					
10 cc..........	40.20	402.0	4,020.	40,200.	402,000.
1 cc..........		401.92	4,019.2	40,192.	401,920.
Difference...		0.080	0.80	8.0	80.
Red silty clay					
10 cc..........	42.56	428.154	4,281.54	42,815.4	428,154.
1 cc..........		423.28	4,232.8	42,328.	423,280.
Difference...		4.874	48.74	487.4	4,874.
Av. Diff.....		2.265	22.65	226.5	2,265.

This table supports the data given in Table IV. An investigation is under way to determine upon a formula for correcting for the error caused by volume of soil that is taken as part of the aliquot.

The largest error occurs in taking the first aliquot from the 1-4 bacterial dilution first made up. Calculations are given in Table VI of the effect of errors in measuring 10 cc and 1 cc aliquots on 1-10, and 1-400 bacterial dilutions.

TABLE VI.

Effect of errors in measuring on bacterial dilutions.

	Bacterial Dilutions Desired.		
	1–40	1–400	1–4000
Error—minus .01 cc			
10 cc pipette....................	40.04	400.4	4,004.
1 cc pipette....................		404.0	4,040.
Error—minus .02 cc			
10 cc pipette....................	40.07	400.7	4,007.
1 cc pipette....................		408.1	4,081.
Error—minus .03 cc			
10 cc pipette....................	40.11	401.1	4,011.
1 cc pipette....................		412.2	4,122.

TABLE VI—Continued.

	Bacterial Dilutions Desired.		
	1–40	1–400	1–4000
Error—plus .01 cc			
10 cc pipette	39.96	399.6	3,996.
1 cc pipette		396.1	3,961.
Error—plus .02 cc			
10 cc pipette	39.92	399.2	3,992.
1 cc pipette		392.2	3,922.
Error—plus .03 cc			
10 cc pipette	39.88	398.8	3,988.
1 cc pipette		388.5	3,885.

This table shows:

That the errors in measuring which might occur in using pipettes are magnified when made in taking a 1 cc aliquot.

TABLE VI IN COMPARISON TO TABLE V.

(1) Errors of .01 to .02 of a cc that may occur in using a 1 cc pipette cause a larger error in the high bacterial dilutions than the volume of ordinary soil contained in the aliquot does.

(2) That the slightly larger error caused by the volume of ordinary soil in 10 cc aliquots of soil and water mixtures is more than offset by the accuracy with which the ten cc aliquots can be measured.

ADDING WATER TO DILUTION BOTTLES.

The water is not sterilized in the dilution bottles, because:

Water is lost from the dilution bottles if it is sterilized in them, and

The amount lost varies with:

1. The autoclave.
2. The size of the load in the autoclave.
3. The variation in hardness of the cotton plugs in the bottles.
4. The position of the bottle in the autoclave.
5. The surface of liquid exposed and the amount of liquid in the bottle.

The following tests show the results of one sterilization in the autoclave. In putting the water into the eight ounce bottles used in these tests the technic was as follows: Each bottle was weighed to the nearest decigram and 99 gms., or 90 gms., as desired, in excess of the weight of the bottle was placed on the opposite pan of the balance. 99 cc or 90 cc aliquots of distilled water were measured out by means of a 100 cc graduated cylinder and poured into each bottle. In no case was the amount of water poured in more than .35 of a gram away from that desired. Water was taken out or added so that each bottle contained the weight desired.

The bottles were sterilized for 15 minutes under 18 pounds pressure of live steam and then the pressure was reduced at the rate of one pound per minute; the door being opened 35 minutes after it was first closed.

Test 1.

Two eight ounce salt mouth bottles containing 99 grams of water and two containing 90 grams of water.

All four bottles were plugged with absorbent cotton.

The results of this test are given in Table VII.

Table VII.

Bottle No.	Wt. of H_2O put in.	Wt. after sterilization.	Losses in Weight	% Wt. lost.
1	99 gms.	95.9 gms.	3.1 gms.	3.13
2	99 gms.	95.2 gms.	3.8 gms.	3.84
3	90 gms.	86.5 gms.	3.5 gms.	3.89
4	90 gms.	86.9 gms.	3.1 gms.	3.44

Test 2.

Fourteen 8 ounce salt mouth bottles containing 90 grams of water.

Seven were plugged with absorbent cotton and seven were left unplugged. They were set in the autoclave in sets of two. The two at the rear were numbered 1 and 2, and the two nearest the door 13 and 14. Even numbers denote bottles having no plugs. Experiment conducted as Test 1. Results are given in Table VIII.

TABLE VIII.

Bottle No.	Wt. of H_2O put in.	Wt. of H_2O lost.	% of H_2O lost with plug.	% of H_2O lot without plug.
1	90	2.2	2.44	....
2	90	6.3	....	7.00
3	90	3.7	4.11	....
4	90	8.3	....	9.22
5	90	3.0	3.33	....
6	90	8.3	....	9.22
7	90	2.9	3.22	....
8	90	3.7	....	4.11
9	90	3.0	3.33	....
10	90	8.0	....	8.69
11	90	2.4	2.67	....
12	90	7.6	....	8.44
13	90	2.5	2.78	....
14	90	5.1	....	5.67
	Average.......	4.8	3.13	7.51

All of the bottles were left standing on the laboratory table for 24 hours. They were then weighed again. Those with cotton plugs had lost about 1.5 grams on standing, and those with no plugs had lost more.

If sterilization in the autoclave did not change the volume of water in the dilution bottle the practice should be discontinued in soil work as the bottles would have to stand on the laboratory tables for varying lengths of time.

Water could be more accurately added to the dilution bottles with an automatic pipette than it can be with a graduated cylinder. Automatic pipettes that can be easily sterilized and connected directly to the special tank for sterile water are being investigated, but cannot at this time be recommended to graduated cylinders which can be made absolutely sterile.

SHAKING DILUTION BOTTLES

Stress has been laid on the manner of holding and the manner of shaking the soil and water mixtures. The following make it necessary to emphasize shaking.

1. Variations in manner different individuals shake up materials.
2. Variation in the ease with which colonies of bacteria are disintegrated by shaking.
3. Variation in nature of different soils.

Rather than recommend shaking a certain length of time in a specified make of shaking machine the technic of shaking is given in such a way that any accidental variations introduced by different individuals will have little effect on the results.

In investigations with milk and food products large variations in results have been credited to differences in manner of shaking up the samples and bacterial dilutions. Dr. H. W. Conn,[6] found within the last two years that variations occurring between reports from different collaborators on the same sample of milk might be due to variations in the way in which different workers carried out given directions for shaking. The rubber stoppers are put in the first set of bottles so that they may be shaken more vigorously, as it is here that colonies ought to broken up. The number of times specified and the lengths of time given are considered sufficient to overcome variations in carrying out the technic of shaking the bacterial dilutions.

Plating

A one *cc* aliquot of the proper bacterial dilution is put directly into the petri plate before the media is added. This is so that all the bacteria in the aliquot may have a possible chance to develop into colonies. Care should be taken to rotate the dish sufficiently to have the bacteria evenly distributed through the media. It has been our experience to have the bacteria in one cc aliquots evenly distributed throughout the media when the bacteria in 0.1 cc aliquots were clumped together. One *cc* aliquots are advised both to increase the accuracy of aliquoting and to insure more representative aliquots.

Incubator

We do not feel justified in discussing incubators for this laboratory has an inside room over the vaults where the temperature does not vary over four degrees Centigrade in the course of a year.

Reports

Reports are always made of the number of bacteria or the amount of material per gram of dry soil.

Physiological Tests and Media

Three methods of studying the activities of the soil bacteria have been mentioned together with certain solutions for starting these tests. These methods of determining the physiological activities are not necessarily recommended as we have not studied them in great detail or compared them extensively with other methods. They are given to emphasize the advisability of weighing out the aliquots of soil to be used for physiological tests *at the same time the aliquot from which bacterial dilutions are to be made is weighed out.*

The media used in the laboratory has been omitted because the technic is the same whatever the agar media used.

Note. Glass stoppered bottles such as are used in milk laboratories are not used for dilution bottles. They are not even used where rubber stoppers are later on put in the bottles for silt and clay are found to work up around the stoppers and cause them to stick unduly. (This holds true even when the proper stoppers are kept with the bottles they are made for.)

Summary.

(1) All apparatus used should be sterile.

(2) Fresh samples of soil are used for analysis.

(3) A 50 gram aliquot of fresh soil has been found as satisfactory as a 100 gram aliquot. 50 grams of fresh soil is recommended as the standard amount of soil to take.

(4) Dilutions are made of the bacteria and not of the soil.

(5) Fifty grams of fresh soil and 200 cc of sterile water are used as the basis of all dilutions.

(6) Each higher bacterial dilution should be made by taking 10 cc of the lower bacterial dilution and 90 cc of sterile water.

(7) Water should be added to dilution bottles after the water and bottles have been sterilized.

(8) Bacterial dilutions should be shaken long enough so that variations in carrying out the technic of shaking will be eliminated.

(9) A one cc aliquot of the proper dilution is used for plating. This is added direct to the petri dish.

(10) The procedures followed in preparing the apparatus, in mixing the soil sample, in making the bacterial dilutions, and in plating are given in detail.

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Acute Poliomyelitis.

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This subject is deemed worthy of discussion in detail because of the extensive outbreak of Infantile Paralysis in the United States in 1916, especially the eastern part.

In 1840 a detailed description of the symptoms of Infantile Paralysis was published by Heine, an orthopedic surgeon, of Cannstadt, Germany, although previous to this several cases of the disease had been reported. He suggested that the seat of the disease was a serous exudate in the spinal cord.

Medin after studying forty-three cases in the Swedish epidemic in 1887 came to the conclusion that this was an infectious disease because of the accompanying symptoms of fever, headache, gastro-intestinal disturbances, etc. Wickman, who suggested Heine-Medin as the name of the disease, after studying the epidemic of 1905 in Sweden in which over one thousand cases occurred, first called attention to the fact that an abortive form may occur without paralysis or any of the other symptoms. He also noted the fact that the so-called Landry's type was most fatal.

A great many authors describe their results of bacteriological findings, especially in the cerebrospinal fluid. A typical example of the latter is that of Geirsvold who was able to cultivate a gram positive diplococcus on ordinary nutritive media. Upon injection of suspensions of this organism into animals, he was able on several occasions to produce paralysis. His work and that of others who also isolated cocci cannot be taken as authentic because noted investigators like Wickman, Landsteiner, Popper and Römer could not duplicate results of their experiments.

Attempts were made to reproduce similar processes characteristic to poliomyelitis by injecting different micro-organisms such as streptococci, staphylococci directly into the blood current but the results were not satisfactory and in no case were the histological changes similar to those of poliomyelitis. This was also true of Wickman's streptococcus strain which he isolated from the spinal fluid of a poliomyelitis patient and exalted by successive animal passage. Injecting rabbits with the serous exudate in the spinal cord from known positive cases gave absolutely negative results according to Bülow-Hansen and Harbitz.

All such attempts to determine the causative agent were unsatisfactory until Landsteiner and Popper while studying the epidemic in Vienna in 1908, were able to reproduce the disease with typical clinical symptoms and pathological findings by injecting monkeys with spinal cord from cases of poliomyelitis. From these successful experiments conclusions were made which showed that Poliomyelitis is not as we were heretofore lead to believe caused by different kinds of micro-organisms, but by a specific virus which can not be demonstrated by the ordinary bacteriological methods. This work gave impetus to a host of experiments upon monkeys and made it possible for the previously mentioned authors and Flexner, and Lewis, and Levaditi to carry out successive animal passages. These experiments also demonstrated that the virus was filterable and resistent toward glycerin and in these respects resembled the virus of Rabies.

Uniformly negative results are obtained when mice, rats, guinea-pigs, cats, dogs, sheep, goats, pigs, horses, calves, chickens, and doves are injected. Of the different species of monkeys used for this work the *macac cynomolgus* seems to be the most susceptible. This is especially true of young, half-grown animals. The symptoms of infected monkeys are essentially the same as those of the human type of the disease. According to the experiments conducted by Flexner and Lewis the inoculation is followed by a symptomless incubation period which may be from two to forty-six days, usually one or two weeks in duration. This latter is largely dependent upon the size and virulence of the test dose. The incubation period is followed by premonitory symptoms which consist of nervousness, shaking of the head and of the extremities, general weakness, spasmodic condition, and possibly unconsciousness, followed in a comparatively short time, from a few hours to one or two days, by the characteristic paresis and crippling. Paralysis of the hind quarters, seldom front, follows and in sever cases the muscles of the trunk, neck, and back are affected and the animals die with disturbed breathing. The disease is much more fatal for monkeys, seventy-six per cent, than for humans, five to twenty per cent. Flexnor and Lewis noticed that some of the monkeys after intraperitoneal or subcutaneous injection of the suspected material developed no paralysis but showed marked signs of drowsiness, weakening, and diarrhea. However, if fresh clean monkeys were injected with spinal cord suspensions which were obtained from these latter cases, they would become infected with the typical type of the disease. From analogy, in all probability we have the same occurring in humans; also it is quite probable that monkeys may suffer from the abortive type as man does.

By injecting youny rabbits of a certain species with enormous doses Marks was able to infect and to pass the virus successfully from rabbit to rabbit. Marks also produced typical infection in monkeys by injecting the latter with the virus which had undergone successive rabbit passage.

The infected rabbits died between the eighth and tenth days and just before death showed symptoms of weakness and cramps. However, characteristic pathological changes were not found on post-mortem. Therefore, that rabbits are susceptible to the virus, although not developing the characteristic symptoms, can be demonstrated by injecting the rabbit strain into monkeys, the latter develop the characteristics of the disease.

As previously stated the presence of the virus in suspensions made from spinal cord and its filterability was first positively demonstrated by Landsteiner and Popper and soon after by Flexnor and Lewis. The virus passed readily through Pasteur-Chamberland, Berkefeld, and Pukall filters, although the virulence is decreased after such treatment, as is noted by a longer incubation period. In this connection it would be interesting to know if the virus could be made to pass through collodium sacs. The rabic virus which resembles the poliomyelitis virus in some respects can be filtered through collodium.

A temperature of 50° C. to 55° C. for one-half hour will destroy the virus, whereas it will retain its virulence for several days at room temperature, 22° C. to 25° C. Freezing does not injure the virus but on the contrary it seems that at a temperature of minus ten or minus fifteen degrees Centigrade the virulence is best preserved, as it is retained for months under these conditions.

The virus of Poliomyelitis i. resistant to glycerin. Therefore, in order to conserve its virulence it is advisable to keep it in 33% to 50% glycerin in the ice-box. In this condition it will survive for more than six months. The virulence of the virus remains after drying over caustic sodium or potassium for twenty or thirty days. It is destroyed by the ordinary disinfectants.

Although the characteristics of the virus of Poliomyelitis were fairly well worked out, they were not free from objection until its presence was demonstrated by microscopic and cultural methods. Cultivation experiments were undertaken by Flexnor and Lewis, and Levaditi. They noticed that when serum bouillon was inoculated with filtered virus and incubated at 37½°C. for fifteen days that a slight cloudiness developed and that if a small amount of this cloudy fluid was transferred to a similar medium cloudiness appeared in these tubes. However, Römer by using the same medium could not duplicate these results. The latter investigator also obtained negative results by placing collodium sacs containing suspensions of the infecting material in the intraperitoneal cavity of animals. New attempts were pursued by Flexnor and Noguchi and positive results were obtained in 1913 by using a medium similar to that used by Noguchi in cultivating the spirochaete of syphilis. The medium used consists of ascitic fluid, sterile fresh tissue, usually kidney of a rabbit, although brain tissue may also be used. Oxygen must be excluded and is mechanically accomplished by paraffin oil. The technique employed is as follows; about 15 cc of ascitic fluid and a piece of sterile fresh kidney obtained from a rabbit is placed in a sterile tube. This is inoculated with a physiological salt emulsion of brain. The tubes are incubated at 37° C. and are not disturbed for seven to twelve days. Tubes revealing the presence of growth in a few days are discarded because of contamination. A faint opalescence should, however, appear just around the tissue in about five days. Cultures were also obtained using a solid medium which was prepared in a similar manner as above plus 2% agar. The opalescence also just appears in the immediate vicinity of the tissue and then gradually disseminates throughout the medium. This condition soon gives rise to macroscopically visible, grayish colored colonies. These colonies may obtain the size of ⅓ millimeter in diameter. In the cultivation of the virus of Poliomyelitis ascitic fluid, fresh sterile tissue, anaerobic conditions, and 37° C. are essential. Examination of these colonies under the dark-field microscope revealed the presence of small globular bodies which are often in pairs or small groups. The forms described by Flexnor and Noguchi are .15 to .3 microns in diameter and are similar to the bodies found by Noguchi in spinal cord obtained from cases of Poliomyelitis. Similar bodies were observed by these investigators and others by examining Berkefield filterates of brain and spinal cord emulsions. The bodies stain with the polychrome dyes, and Löffler's flagella and Gram's method is applicable.

Infection of monkeys was obtained by injecting with the fifth, sixth, and even the twentieth generation. From the infections thus produced true poliomyelitis symptoms develop and the virus can be recultivated from such culture infected animals, thus positively demonstrating the casual relationship of this organism to the disease. However, the virulence of the organism is not well retained. Considerable difficulty is met with in inoculating monkeys with material from human source. Several times monkeys were inoculated with original human material without effect; likewise passage of the virus from monkey to monkey failed. Levaditi calls attention to the fact that the virus from sporadic cases is less virulent than the epidemic form. Flexnor by continuous animal passage obtained a so-called "Fixed-virus" which would infect in a dilution of .001 cc.

Because of the similarity between Rabies and Infantile paralysis it would seem possible that "negri-like" bodies might be found. Bonhoff reports finding small round or oval bodies having a diameter of about 2 microns, although the size varies considerably in the nucleus of the neuroglia cells. According to Bonhoff these bodies are specific for Poliomyelitis.

The disease may present different clinical pictures, depending upon the different parts of the central nervous system that may be attacked. The disease, therefore, may be divided into several forms according to the parts affected which are as follows: 1, the spinal; 2, the ascending or descending Landry's type; 3, the bulbar, pontine, and midbrain; 4, cerebral; 5, the cerebellar (ataxic); 6, neuritic; 7, meningitic; and 8, abortive forms.

Excluding the latter type because of lack of definite data, the spinal form is most common. The symptoms of the disease may be of great variety. Clean-cut cases will usually occur suddenly, often with fever (102–103.5° F.), general weakness, gastro-intestinal trouble, vomiting, and severe headache and pains in the neck, spine and extremities.

Flexnor, Lewis, Levaditi, Landsteiner, Leiner and Wiesner observed that one attack of the disease usually brings about a condition of active immunity and the insusceptibility thus conferred includes the various forms of the disease. This has been demonstrated in monkeys and similar conclusions were made by observations upon humans. Blood taken from monkeys or persons who have recovered from poliomyelitis when brought in contact with virulent virus has the power of rendering the latter inert, whereas the blood from normal animals has no effect.

Because of the similarity in some respects of the virus of poliomyelitis and rabies it was suggested and hoped that methods which are used to immunize against the latter could likewise be used against poliomyelitis. The Högyes antirabic method which is to inject with sub-lethal doses and gradually increase until lethal doses are used, has been attempted and has afforded monkeys protection and immune bodies have been demonstrated in their blood. The method however, is not applicable because in some instances immunity was not obtained and unexpected paralysis resulted. Levaditi and Landsteiner were able in some cases to produce immunity by repeatedly injecting suspensions of the spinal cord as per Pasteur method. The same condition of uncertainty followed when the virus containing material was heated to 55°-60° C. or treated with chemicals—phenol and formalin. Animals injected with immune serum plus virus according to Flexnor and Lewis do not become immune. Immunity experiments show that the poliomyelitis and rabies virus are not similar not only because of the above facts but also because animals immunized against Rabies are susceptible to the virus of poliomyelitis.

It was hoped that animals might be temporarily protected, rendered passively immune, by transferring the blood from immune persons or monkeys to healthy ones. It was found that this could be actually done but the artificial immunity was only of very short duration as well as somewhat uncertain and therefore this method is not practical from the prophylactic standpoint.

Flexnor and Lewis, and others, have obtained favorable results by repeated intra-spinal injections of immune serum into infected monkeys. This method is not practical because of the source and the very limited amount of immune serum. Anti-rabic serum showed no germicidal or protective action against the virus of infantile paralysis.

Attempts at serum diagnosis by the complement-fixation test have in general proven unsuccessful. Römer and Joseph; Gay and Luccas were not able to demonstrate conplement-fixation substances in the serous spinal fluid or in the blood of persons or monkeys affected with the disease.

What can be said of serum treatment in general holds true for chemicals Hexamethylenamin is according to experiments performed on monkeys, sometimes effective if used very early in the course of the disease.

Apparently the best treatment to prevent paralysis is total rest.

Recently a peculiar polymorphous streptococcus and its etiologic relation to poliomyelitis was described by E. C. Rosenow, Towne and Wheeler. Ascites media containing sterile tissue was used in the cultivation of this organism and pure cultures were obtained from throats, tonsils, abscesses in tonsils and from the central nervous system in cases of poliomyelitis. Flexnor and Noguchi consider these cocci as contamination. Guinea-pigs, rabbits, dogs, cats, and monkeys after receiving intravenous or intracerebral injections of this pleomorphous organism became paralyzed and developed lesions in the central nervous system.

The serum of horses immunized with suspensions of this organism has specific antibodies, agglutinins and complement-deviating substances.

This serum, according to Rosenow, seems to have protective and curative power against the virus of poliomyelitis.

Nuzum and Herzog also describe an organism similar to the one isolated by Rosenow.

There have been several theories advanced as to the mode in which the virus of Poliomyelitis is spread. Our attention was called to this through the great opportunity of studying the epidemics occurring in Sweden, Norway, Germany, Austria, France, England, United States, Russia, Switzerland, Italy, Spain, Holland, Australia, Cuba, and in an island in the South Sea. The largest is that which is occurring at the present time in the United States, especially the eastern part, with some 20,000 cases involved up to September 30, 1916. There were 9,029 in New York City alone. In 1910 8,700; 1909, 2,300; 1907, 2,900 cases; and in Sweden in 1911 3,800, in 1905, 1,000 cases occurred.

Some of the most discussed theories as to the manner in which Poliomyelitis is spread are: (1) Contagious; (2) Insect-borne; (3) Dust-borne; (4) Alimentary infection. Wickman while investigating the Swedish epidemic in 1905, noticing the occurrence of sporadic cases, epidemic groups, and the abortive form, came to the conclusion that Poliomyelitis is a contagious disease and is transmitted not only by contact with sick individuals but by so-called healthy "carriers" and by persons having the abortive type of the disease. Kling and Levaditi came to the same conclusions while studying the epidemic in Sweden in 1911. Flexnor and Lewis expound the theory that the infection occurs by way of the mucous membrane of the nose and mouth and leaves the body in a like manner. These investigators were able to demonstrate the presence of the virus of poliomyelitis on the mucous membrane of the nose of monkeys which had been infected by an intracranial inoculation. Vice versa, they could infect monkeys by applying the virus on the unbroken mucous membrane of the nose. These experimentors also were able to demonstrate that the secretions of the mouth, nose, throat, and feces were virulent both from the sick and the diseased. During the extensive epidemic in Sweden in 1911, Kling, Wernstadt, and Pettersson not only came to the same conclusions but were able to demonstrate that in some instances the secretions of healthy people were infective. Monkeys can be infected therefore, not only with material from abortive cases where no symptoms present themselves but also with secretions from some healthy persons. The experimental demonstration of the presence of the virus in the secretions of the nose and mouth shows the contagious character of the disease and how it may be spread in the immediate neighborhood of the infected one.

Flexnor, Clark, and Frazer have apparently positively demonstrated the part of the healthy "carrier" by infecting a monkey with washings of the mucous membrane of a parent of a child who was suffering from the disease. The question arises; are adults relatively immune because they have had the disease in a mild form in childhood. Likewise, this may explain the occurrence of few cases of the disease in densely inhabited localities.

Osgood and Lucas experimentally demonstrated the presence of the virus on the mucous membrane of a monkey five and one-half months after apparent recovery, They also proved its presence in a chronic "carrier" in man. Kling, Pettersson, and Wernstadt corroborated these latter findings.

In humans as well as in monkeys stomach and intestinal symptoms often occur previous to paralysis. Medin, Wickman, Krause, and Richardson, because of these symptoms, were lead to believe that there were other avenues of entrance for the virus than through the air passages of the nose and throat. However, Römer and Joseph called attention to the fact that monkeys which were injected intracrainally develop gastro-intestinal symptoms.

The virus is widely disseminated in the body. It is constantly found in the central nervous system and cerebro-spinal fluid, mucous membrane of nose and throat, mesentery glands, lymph nodes, intestines and it has been found in the general circulating blood and internal organs.

Poliomyelitis has a seasonal prevalence which does not correspond to that of diseases spread by secretions or excretions of the nose and mouth. Its seasonal prevalence is during summer and fall and because of this fact it was thought that the disease was insect-borne. Experiments directed along these lines by Flexnor and Clark showed that flies which were allowed to come in contact with infected spinal cord could carry the virus at least for 48 hours. Flies that were caught in sick rooms according to Kling, Pettersson, and Wernstadt could not produce infection. Howard and Clark were able to experimentally produce the disease by injecting filtrates made from bed-bugs seven days after they were permitted to suck the blood from infected monkeys. However, transmission by the bite of bedbugs, mosquitoes, and lice proved uniformally negative. Rosenau and Brues were able to successfully transmit the virus from monkey to monkey by the bite of the stable fly (*Stomaxys calcitrans*). They believe this fly is the intermediate host. Kling and Levaditi seem to have positively proven that the disease is not insect-borne. They had occasion to allow flies, bedbugs, and mosquitoes to feed upon infected material and in no case were they able to produce the disease by injecting emulsions of them into monkeys. Also, in opposition to this view, is the fact that in order to infect a monkey from the blood of a monkey suffering from the disease Flexnor and Lewis had to take twenty cubic centimeters; with two cubic centimeters they failed. Leiner and Wiesner made six attempts using defibrinated monkey blood taken after the appearance of paresis and one from the blood of a paralyzed child. Only in one case (from a monkey) did the infection succeed. This, of course, argues against the possibility of infection by any blood-sucking insect.

Because of the gastro-intestinal symptoms the possibility of it being carried by foodstuffs and milk is apparent. No outbreak of Poliomyelitis has been associated with milk, water, or any article of diet. Landsteiner and Levaditi have shown that milk and water which were inoculated with the virus remained infective for a month. Kling and Levaditi could not, however demonstcate the presence of the virus in milk or water used by families that were suffering from the disease. Breast nursed children also suffer from Poliomyelitis.

Infantile paralysis is considered by some to be a dust-borne disease and this is very probable when we recall the fact that the virus is resistent to drying. The best evidences of this are the very interesting experiments of Neustäder and Thro who succeeded in infecting monkeys by means of filtered extracts of dust collected from rooms in which patients had poliomyelitis. This experiment demonstrates the presence of the virus in the dust of the sick-room.

It was also suggested that poliomyelitis may be spread by some of the lower animals for it was noticed that domestic animals (horses, dogs, pigs, chickens) suffer from nervous diseases during poliomyelitis epidemics. In the cases reported we are not sure that rabies was excluded. In as much that the lower animals except the monkey and certain species of rabbits cannot be infected with the virus it is strong evidence against the theory of transmission by such animals. Flexnor, Lewis, Clark and Richardson could not by experimental methods transmit the affection suffered by the domestic animals and in all probability there is no connection between these diseases.

The manner in which the disease makes its appearance seems rather uncertain. Consequently specific methods of prophylaxis are difficult. In the present state of our knowledge the only thing that can be done is to fight the disease from every possible avenue of infection.

The patient should be isolated and other members of the family should be kept under quarantine for four to eight weeks. Above all children from such families must not be allowed to go to school. It may be advisable to close the latter and other places of assembly for children during epidemics.

Persons who have been directly exposed to poliomyelitis should be kept under observation for a period of two weeks.

Traveling in or out of infected areas especially children should not be permitted and unnecessary contact with persons known to have come from infected regions should be avoided.

Secretions and excretions of the nose and intestines of patients should be carefully disinfected. Local application of disinfectants may be applied to the nose and mouth regents.

Children should not kiss or be kissed by other persons during the prevalence of the disease.

Remnants of food, dishes, toys, books, towels, bed linen, etc., which have been in the room should be properly cared for.

Cats, dogs, or other pets must not be allowed in the sick room.

All cases should be reported to the health authorities. Houses should be placarded. Patients should be screened in and the breeding places of flies destroyed as far as possible. Suspicious cases should also be reported.

Dust on the streets should be allayed as well as in the sick room.

Sick rooms should be disinfected not only by gaseous fumigation but they should be given a thorough mechanical cleansing.

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The Cultivation of Trypanosomes in Vivo.

H. C. Travelbee.

Practically all of the common laboratory animals are susceptible to trypanosomal infection. For the following reasons white rats and guinea pigs are the ones most frequently used; (a) they require but little space, (b) they are easily kept, and (c) in them the infection runs an acute or sub-chronic course. It is essential to know at all times the status of the infection and the condition of the animal, and there are certain routine procedures which are followed in making the observations on the culture. These routine procedures as carried out in the laboratories at Purdue University will be described more or less in detail.

The infection is transferred from animal to animal by the hypodermatic injection of infected blood. The injections may be made subcutaneously or intraperitoneally. The former method is usually used when it is desired to have the course of the infection proceed slowly; and only small quantities of blood are injected for that reason. The intraperitoneal method is used when it is desired that the climax of the infection come quickly. In this case larger quantities of the virulent blood are injected.

To transfer the infected blood a small hypodermatic needle is used, which has been boiled for ten minutes in a saturated solution of borax, and then rinsed thoroly with a sterile physiological salt solution. About 0.5 cc. of the sterile salt solution is then drawn up into the syringe. A drop of the virulent blood is then drawn up and mixed with the salt solution in the barrel of the syringe, and all or any fraction of it is injected into the animal, as it has been shown that a single trypanosome when injected will cause a typical infection.

Methods of Obtaining the Virulent Blood.

Rats are bled from the tip of the tail and Guinea pigs from the ear. The rats are kept in large battery jars which have weighted wire covers. The cover is held slightly to one side and the rat's tail is drawn thru the opening thus made until the rump is snugly against the edge of the jar and the rim of the cover. The tail is taken in the left hand, the left forearm holding the cover in place, and with a sharp pair of sterile scissors a bit is cut cleanly from the end of the tail. It is important that this cut be made cleanly, for if the tail is lacerated or if any shreds of tissue remain, the blood will run back among the stubby hairs which cover the tail and will not form a drop on the end of it. This drop which collects is drawn into the syringe, mixed with the salt solution and injected. In the case of the guinea pig the ear is held between the thumb and forefinger of the left hand. A clean cut is made in the edge of the ear and the drop of blood which forms is taken into the syringe in the same manner as the drop from the rat's tail.

When a rat is to be injected intraperitoneally, the skin on the back of the neck or shoulders is seized with a pair of self-locking rat forceps. The tail and hind legs are pulled well down and held in the left hand, along with the forceps. The needle, held in the right hand, is inserted thru the skin and muscular wall in the median portion of the abdomen and the desired amount of the contents of the syringe injected. In making a subcutaneous injection the rat is held in the same manner, the needle being inserted just thru the skin in the thoracic region. Guinea pigs do not offer the vicious resistance to this treatment which is characteristic of rats, and consequently it is not necessary to handle them with forceps. When making a subcutaneous injection it is advisable to lift the point of the needle slightly after it has been inserted, in order to determine definitely that it has not entered the muscular tissue.

Beginning with the next day or the second day after an animal is injected, daily or bi-daily examinations of its blood are made. A drop of blood is obtained in the manner described above, but instead of being taken into a syringe, is touched to a clean glass slide and immediately covered with a clean coverglass. The cover-glass is pressed down until a layer of blood of about the thickness of one red blood corpuscle remains under it. Care is taken not to push the coverglass sidewise as this causes rapid plasmolysis of the red cells. This "fresh preparation" of the blood is examined under the 4mm. objective with a No. 10 ocular and 160 mm. tube length, and the number of trypanosomes per field is counted and recorded.

The following method of keeping the records of the animals and cultures has proven most satisfactory. The inoculated animals are kept in battery jars or small wire cages which are marked with gummed labels bearing the following information: the name of the organism, the number of the animal, the page in the note-book on which its record can be found, the date of inoculation and any mark that may be necessary to properly identify the animal in question. The latter item is only used when two or more animals are kept in the same jar or cage. For example:

Typanosoma
Brucei.
8p2
L
2-1-17

This label shows that this animal was inoculated with Trypanosoma Brucei on February 1, and that it is number eight on page two of the notebook. The 'L' indicates a notch cut in the left ear to distinguish it from another animal in the same cage. On page two, the following record of this animal is to be found:

6. Blk. and Wht. G. pig. ¼ ear drop from 5p2. Sub cut. inj.

1-2-17

1-5-17—0.5 per drop.
1-8-17—1-100 pf.
1-13-17—2 pf.
1-15-17—5 pf ¼ ear drop to 7p2.
1-17-17—10 pf.
1-20-17—0 pf.

	1-24-17—5 pf. 1-27-17—100 pf. 1-31-17—200 pf. 2-1-17—Dead.*
7. Brindle G. pig. ¼ ear drop from 6p2. Sub cut. inj. 1-15-17	1-17-17—0 pf. 1-20-17—0 pf. 1-22-17—1 per drop. 1-24-17—5 pf. 1-27-17—5 pf. 1-29-17—10 pf. 1-31-17—1 pf. 2-1-17—2 pf ½ ear drop to 8p2. 2-3-17—15 pf. 2-6-17—65 pf. 2-7-17—Dead.*
8. Yellow G. pig. ½ ear drop from 7p2. Sub cut. inj. 2-1-17	2-3-17—0 pf. 2-6-17—1 per drop. 2-7-17—1 pf. 2-10-17—5 pf. 2-14-17—1-50 pf ½ eardrop to 9p2. 2-16-17—3 pf. 2-18-17—8 pf. 2-19-17—75 pf 2 drops to 1p4. 2-20-17—Dead.*

Note:
Blk.—Black.
Wht.—White.
pf—per field.
Sub cut. inj.—Subcutaneous injection.

When the animal dies its label is crossed off and its record is marked with a large asterisk in the lower right hand corner. If any other disposition is made of the animal it is so noted in its record.

A careful observation of this record will show how the pedigree of a culture may be traced, and how it is possible to know at all times the condition of the infected animal.

*Behrens: Journal of Infectious Diseases, Vol. 15, No. 1, pp. 24-62.

Plants New or Rare to Indiana. VII.

Chas. C. Deam.

All species reported in this paper are new to Indiana, unless mention is made to the contrary. Specimens of the species reported are deposited in my herbarium under the numbers given. The Equisetum and Isoetes were determined by L. S. Hopkins; the Gramineae by Agnes Chase; the Carices by K. K. Mackenzie; the Juncus by H. H. Bartlett; the Rubus and Viola by Ezra Brainerd; the Chamaesyce by C. F. Millspaugh; the determination of the remainder was made or checked at the Gray Herbarium.

Equisetum hyemale var. *intermedium* A. A. Eaton.

Lake County, July 28, 1907. No. 2,349. Border of a slough near Pine.

Isoetes Braunii Durieu.

Crawford County, October 12, 1916. No. 22,385. In a small pond on the north side of the road about one mile east of Pilot Knob hill. The pond is usually filled with water, but was dry when the specimen was taken, which was at an unusually dry time. It was associated with young plants of Eleocharis from which it was not easily distinguished. The specimens were determined by L. S. Hospkins, and his notes are given.

Number of plants examined, 3.
Number of leaves per plant, 10, 10, 10, 11, 16, 16, 16, 17.
Average number of leaves per plant, 13.
Length of leaves up to 20cm.; average about 12 cm.
Color of leaves, green.
Peripheral bundles none. Stomata abundant. Trunk distinctly bilobed.
Macrospores fairly uniform in size and shape, 486 to 504 microns.
Microspores 24, 26, 28 microns.

The plants were so covered with mud that it was impossible to get clean macrospores for measurement. The fruiting leaves, i. e. the ones of this season's growth have been pretty well detached from the parent plants while the leaves retained are those which will bear the next season's fruit. Nevertheless I feel pretty sure the determination is correct. It was from the detached leaves that the spores were secured for measurement.

Isoetes foveolata A. A. Eaton.

Harrison County, June 25, 1916. No. 20,467. Found in a low place in a woods four miles south and one mile east of Palymra. The colony was about three feet wide and twenty-five feet long; and was located in an old wagon road through the woods. The plants formed a carpet of green. In wet seasons the water would course over the colony, and the place was only moist at this time which was a rather dry time. The nearby trees were Liquidamber;

Acer rubum and *Quercus palustris*. The only herbaceous plants noted were *Isnardia palustris* and *Samolus floribundus*. The determination was made by L. S. Hopkins, and his notes are given.

Number of plants examined, 3.
Number of leaves, 31, 46, 49; average number, 42.
Average length of leaves, about 20cm.; longest leaf, 28cm.
Color, reddish or olive green.

Peripheral bundles, none. Stomata, a few near the tips of the leaves; not plentiful.

Trunk bilobed in one: the other two look as if the plants had been pulled in two and only half of each plant collected, or as if they might have been attached to a stone or root.

Macrospores, 450, 468, 486, 522 and 540 microns.
Microspores, 20, 22, 24, 26, 28, 20, 32, microns.
The preceding are actual measurements.

Sparganium diversifolium Graebner.

Allen County, October 1, 1916. No. 22,109. In a small branch which empties into Cedar Creek about ten miles northeast of Fort Wayne. Newton County, August 30, 1916. No. 21,497. In a dredged ditch four and a half miles north and two miles west of Morocco. Noble County, Sept. 14, 1916. No. 21,883. In a slough on the south side of a black and white oak ridge about one mile south of Indian Village. Warren County, August 31, 1916. No. 21,643. In shallow water in Kate's Pond about one and a half miles northwest of Independence.

Sagittaria cuneata Sheldon.

Howard County, September 2, 1916. No. 21,663. On the boggy shore of Wild Cat Creek three miles east of Kokomo. Lagrange County, August 20, 1916. No. 20,968. Boggy border of Pigeon River three miles east of Mongo. Whitley County, September 11, 1916. No. 21,713. In a mucky Salix swamp on the south side of Blue River Lake.

Sagittaria longirostra (M. Micheli) J. G. Smith.

Vigo County, October 5, 1916. No. 22,193. Low muddy border of the north end of the Greenfield bayou about ten miles northwest of Pimento.

Lophotocarpus calycinus (Engelm.) J. G. Smith.

Posey County, October 8, 1916. No. 22,278. In a small pond in a field on the east side of the New Harmony and Mt. Vernon Road about three miles south of New Harmony. No. 22,291 in Pitcher's pond which is about six miles northwest of Mt. Vernon.

Echinodorus radicans (Nutt.) Engelm.

Posey County, October 8, 1916. No. 22,303. In a low place in Pitcher's pond about six miles northwest of Mt. Vernon.

Paspalum circulare Nash.

Clark County, September 6, 1910. No. 7,538. Roadside through the Forest Reserve near the Medsger bottoms. Jefferson County, September 9, 1915. No. 18,846. Roadside ditch four miles north of Madison. Posey County, September 20, 1911. No. 10,155. Roadside and adjoining meadow about three miles west of Hovey Lake.

Paspalum repens Berg. (*Paspalum mucronatum* Muhl.)

Schneck reported this species as occuring in the Lower Wabash bottoms. The following are definite localities: Gibson County, October 7, 1916. No. 22,247. Low border of a pond, bordering the Patoka River about three miles southwest of Patoka. Knox County, October 6, 1916. No. 22,201. In a low woods, bordering the west end of Dan's pond. Associated with *Eclipta alba; Phyllanthus caroliniensis* and *Homalocenchrus virginicus.* Posey County, October 8, 1916. No. 22,309. Low wooded border of Pitcher's pond which is about six miles northwest of Mt. Vernon.

Alopecurus geniculatus L.

Gibson County, May 27, 1899. Specimen taken by Dr. J. Schneck in a low sandy meadow near Lyle's Station. Greene County, May 26, 1912. No. 10,660. Common in a low place in a fallow field three-fourths miles east of Bushrod.

Stipa avenacea L.

Lagrange County, July 9, 1916. No. 20,709. Frequent in an open black and white oak woods on the south side of Pigeon River one mile east of Mongo.

Aristida purpurascens Poir.

Newton County, Aug. 30, 1916. No. 21,463. In very sandy soil along the roadside, bordering a black and white oak clearing three and a half miles south of Thayer. This species is given by Troop in his "Grasses of Indiana," but no definite locality is given.

Leptochloa floribunda Doell.

Posey County, October 8, 1916. No. 22,293. In the dried up mud basin of Pitcher's pond which is about six miles northwest of Mt. Vernon.

Cyperus dentatus var. *ctenostachys* Fernald.

Starke County, September 1, 1914. No. 15,164. On the low border of the southeast side of Bass Lake.

Scirpus smithii var. *setosus* Fern.

Noble County, September 13, 1916. No. 21,851. On the low sandy border of the south side of Bear Lake. Associated here with *Juncus canadensis; Drosera longifolia; Bidens trichosperma,* etc.

Carex tonsa (Fernald) Bicknell.

Porter County, May 25, 1913. No. 12,959. On a dry open wooded dune half mile north of the Mineral Springs stop on the South Shore Traction line. Taken again in 1916 in the same county on the top of a wooded dune just east of Mud Lake. My No. 20,177.

Carex trisperma Dewey.

Kosciusko County, June 5, 1912. No. 10,923. Growing in deep sphagnum in a tamarack swamp about one mile south of Leesburg. Taken again in the same swamp on July 23, 1908. No. 5,095.

Commelina augustifolia Michx.

Knox County, July 8, 1915. No. 17,087. In the Knox sand in a cut along the railroad about four miles south of Vincennes. Associated with *Cyperus filiculmis; Bouteloua curtipendula; Stylosanthes biflora hispidissima; Petalostemum purpureum; Asclepias verticillata;* etc. Marshall County, August 19, 1915. No. 17,944. On the high sand hill on the southwest side of Lake Maxinkuckee. Associated with *Monarda punctata; Cycoloma atriplicifolia; Polygonum tenue; Rosa humilis; Rhus arbuscula* Greene; etc. Newton County, August 30, 1916. No. 21,511. Growing in almost pure sand in a roadside cut, four and a half miles north and one and a half miles west of Morocco. Porter County, August 25, 1916. No. 21,165. At the base of a wooded dune about two and a half miles northwest of Porter.

Commelina longicaulis, Jacq.

Gibson County, August 29, 1915. No. 18,328. In sandy soil in a cultivated field on the Gordon Hills six miles west of Patoka. I do not regard this as a migrant since I have specimens from other parts of the same county and from Posey County that match this specimen, but somewhat too immature to have well developed seed.

Juncus tenuis var. *anthelatus* Wiegand.

Clark County, June 30, 1910. No. 6,889. In an open ditch on the Forest Reserve. DuBois County, July 6, 1912. No. 11,625. In a roadside ditch half mile north of Birdseye. Jefferson County, June 21, 1915. No. 16,266. Roadside one mile west of Clifty Falls. Knox County, July 7, 1915. No. 16,940. Low place along the roadside six miles north of Decker. Perry County, July 4, 1912. No. 11,515. Roadside ditch six miles west of Derby. Spencer County, June 28, 1915. No. 16,594. Roadside two miles south of Fulda. Washington County, June 29, 1916. No. 20,581. In very dry sterile soil on a Quercus Prinus ridge about twelve miles north of Salem.

Sisyrinchium albidum Raf.

Allen County, June 27, 1914. No. 14,358. In sandy soil in the clearing on the Godfrey Reserve just south of Ft. Wayne. Cass County, May 7, 1916. No. 19,366. In dry sandy soil in an open black and white oak woods on the south side of Lake Cicott. Gibson County, June 10, 1913. No. 13,289.

In a dry sandy woods four miles southwest of Owensville. Jasper County, May 8, 1916. No. 19,424. In very sandy soil on a low hill along the right of way of the Penna Ry. about two miles east of Goodland. Associated with *Ranunculus fascicularis; Viola pedatifida;* etc. Lagrange County, June 5, 1915. No. 15,982. In very sandy soil in a low black and white oak clearing just north of Pigeon River and about half a mile west of the Steuben County line. Flowers white. Abundant here and albino plants not infrequent. Frequent in similar habitats throughout the county. Laporte County, June 1, 1916. No. 19,957. In a prairie habitat along the railroad a half mile east of Wanatah. Associated with *Hypoxis hirsuta; Phlox pilosa;* etc. Common here as well as *Phlox pilosa*, and albino forms of both species frequent. Starke County, June 1, 1916. No. 19,925. In sandy soil in an open black and white oak woods one fourth mile southeast of the southeast side of Bass Lake.

Silene dichotoma Ehrh.

Switzerland County, June 19, 1915. No. 16,170. In poor soil on a hill along the Bennington Road four miles north of Vevay. Abundant here.

Cheirinia inconspicua (S. Wats.) Britt.

Marshall County, May 30, 1913. Collected in Plymouth along the railroad by E. L. Greene during a wait to change cars. This illustrates the ceaseless activity of this peer of botanists.

Rubus Baileyanus Britton.

This species was reported in Coulter's Catalogue, but recent studies of the genus Rubus have given a different meaning to many of the species of the genus. The following records are given to set forth the known range of the species in our area. The names of the counties and the number of the specimens are given only. Allen County, No. 20,229. Bartholomew County, No. 20,608. Clark County, No. 20,336. Crawford County, No. 20, 431. Elkhart County, No. 19,949. Harrison County, No. 20,499. Lagrange County, No. 18,884 and 19,887. Marshall County, No. 19,935. Starke County, No. 19,963. Steuben County, No. 20,226.

Rubus betulifolius Small.

Pike County, July 7, 1915. No. 16,967. In a beech woods one mile east of Union. Posey County, July 5, 1915. No. 16,850. In sandy soil along the roadside one mile south of Cynthiana.

Rubus Enslenii Tratt.

Starke County, June 1, 1916. No. 19,932. Low sandy border of the southeast side of Bass Lake.

Rubus floridus Tratt.

Harrison County, June 26, 1916. No. 20,518. In rather moist soil along the roadside one and a half miles west and three-fifths of a mile south of Elizabeth.

Rubus frondosus Bigel.

Crawford County, Nos. 20,389 and 20,400. Harrison County, No. 20,509. Jackson County, No. 20,605. Noble County, No. 20,085. Starke County, No. 19,923. Steuben County, No. 20,211.

Rubus allegheniensis x recurvans.

Allen County, No. 19,871. DeKalb County, No. 20,235. Elkhart County, No. 19,948. Franklin County, No. 20,283. Lake County, No. 20,088.

Rubus argutus x recurvans.

Porter County, No. 20,032. Wayne County, No. 20,249.

Acalypha ostryæfolia Riddell.

Clark County, September 29, 1909. No. 5,474. In a catalpa planting on the Forest Reserve. Harrison County, October 14, 1916. No. 22,457. In a potato field along the Ohio River about one mile west of Locust Point. Posey County, September 28, 1910. No. 7,676. In a cultivated field about three miles south of New Harmony. Collected in 1916 in the same county in a corn field about three miles east of Mt. Vernon.

Chamaesyce Lansingii Millspaugh.

Randolph County, September 13, 1914. No. 15,447. Bank of the Salamonie River south of Redkey. Tipton County, August 2, 1913, by Mrs. Chas. C. Deam. No. 13,897. Right of way of the Lake Erie Ry. about one mile west of Goldsmith.

Lechea Leggettii Britton and Hollick.

Allen County, August 2, 1914. No. 14,515. Locally abundant in sandy soil in the clearing on the Godfrey Reserve just south of Ft. Wayne. Newton County. August 30, 1916. No. 21,395. In sandy soil in a black and white oak woods, just west of Thayer. Starke County, September 1, 1914. No. 15,161. In rather moist sandy soil in a black and white oak woods on the southeast side of Bass Lake.

Viola hirsutula Brainerd.

Clark County, June 29, 1916. No. 20, 567. On a wooded slope bordering the road about two miles west of Bennettsville. Associated with *Quercus velutina and Pinus virginiana.* A hybrid of this species was found at the same place.

Viola pratincola Greene.

Lake County, May 9, 1916. No. 19,473. In a low woods bordering the Kankakee River one mile south of Schneider. Associated with *Quercus palustris; Quercus bicolor; Acer saccharinum*; etc. Porter County, June 3, 1916. No. 20,050. On the moist wooded bank of the Calumet River, just north of the Gary School property.

Viola cucullata x sagittata.

Lagrange County, May 31, 1916. No. 19,894. In a dry place in a tamarack swamp bordering Pigeon River one mile east of Mongo.

Viola hirsutula x papilionacea.

Brown County, May 18, 1913. No. 12,822. In moist soil at the base of a wooded ravine one mile east of Helmsburg.

Viola papilionacea x pedatifida.

Jasper County, May 8, 1916. No. 19,418. In rather moist soil on the right of way of the Penna Ry. about two miles east of Goodland.

Viola triloba var. *dilatata* (Ell.) Brainerd.

Harrison County, June 26, 1916. No. 20,519. In a beech woods two miles south of New Middletown. *Cimicifuga racemosa* which is infrequent in Indiana was abundant at this place.

Rhexia mariana L.

Spencer County, June 30, 1915. No. 16,654. Abundant in sandy soil along the road leading to the residence of Floyd Thurman about two miles west of Grand View.

Ludwigia sphaerocarpa Ell.

Porter County, August 26, 1916. No. 21,191. In a sedge marsh between wooded dunes a short distance east of Mud Lake. Newton County, August 30, 1916. No. 21,425. In a ditch through the marsh just west of Thayer. Starke County, August 22, 1916. No. 21,066. Low border of the northwest side of Bass Lake.

Pyrola asarifolia incarnata (Fisch.) Fernald.

Steuben County, June 14, 1916. No. 20,203. In a tamarack swamp on the southwest side of Tamarack Lake about four miles southeast of Orland.

Apocynum medium Greene.

Clarke County, June 29, 1916. No. 20,571. Near the base of a wooded slope in a thick beech and oak woods about one mile northwest of St. Joe.

Convolvulus fraterniflorus Mack and Bush.

Knox County, July 8, 1915. No. 17,059A. Low wooded border of Claypole pond.

Mentha longifolia mollississima Borkh.

Noble County, July 9, 1916. No. 20,722. Abundant along the sandy roadside on the Lindsay Farm about one-fourth mile north of Wolf Lake.

Ruellia parviflora (Nees.) Britton.

Crawford County, September 4, 1915. No. 18,584. Wooded slope of Dry Run about one mile northeast of Leavenworth.

Galium labradoricum Wiegand.

Lagrange County, July 9, 1916. No. 20,688. Growing in sphagnum in a wet opening in a tamarack marsh along Pigeon River one mile east of Mongo. Associated with *Sarracenia; Calopogon; Triglochin maritima; Eriophorum viridi-carinatum; Pogonia ophioglossoides;* etc. Porter County, June 3, 1916. No. 20,044. In a tamarack swamp about two and a half miles northwest of Porter.

Kuhnia corymbosum Ell.

Lagrange County, August 29, 1914. No. 14,940. Common in very sandy soil along a roadside about one mile east of Howe.

Antennaria occidentalis Greene.

Cass County, May 7, 1916. No. 19,363. Abundant in dry sandy soil in the Davis cemetery about two and a half miles west of Cicott. In the Midland Naturalist Vol. 2:89:1911, E. L. Greene refers to a specimen of this species in the National Herbarium, which was collected by Dr. W. S. Moffatt in Lake County on May 29, 1879.

Iva ciliata Willd.

Posey County, October 9, 1916. No. 22,316. Roadside along the Wabash River near "Bone Bank," about thirteen miles southwest of Mt. Vernon.

Rudbeckia Sullivantii Boynton and Beadle.

Decatur County, August 13, 1911. No. 9,551. Collected by Mrs. Chas. C. Deam on the wooded and boggy bank of Flat Rock River about one-half a mile above St. Paul. Huntington County, September 18, 1916. No. 22,042. On the boggy wooded bank of the Salamonie River about four miles north of Warren. Kosciusko County, September 16, 1916. No. 21,968. Moist sandy shore of the east side of Little Chapman Lake. Marion County, August 24, 1914. No. 14,069. Boggy slope in a woods bordering White River, about eight miles north of Indianapolis. Parke County, September 2, 1911. No. 9,904. Moist rocky wooded slope of Sugar Creek at Turkey Run.

Sonchus arvensis L.

Wells County, August 7, 1916. No. 20,842. In the alley back of Lee Mart's residence in Bluffton. There was quite a colony of it, which indicated that it had persisted for several years. When I informed Mr. Martz that it was a new weed, he at once set to work to exterminate it.

Cloisterium Moniliferum

F. M. Andrews.

Specimens of *Closterium moniliferum* were centrifuged by simply placing a quantity of the plants in a small amount of water in the glass cylinders. A large number of the specimens were easily obtained by filtering a considerable volume of water containing the plants through filterpaper. As the specimens lie in different positions the centrifugal force acted in a great many directions on these unicellular plants. The contents was therefore thrown sometimes to one end, at other times to the side or diagonally in the cell according to the direction the centrifugal force had acted.

A centrifugal force of 1207 g. acting for 1 minute is enough to displace the contents of the cell of *Closterium moniliferum*. The contents are displaced all along the walls almost to the centrifugal end of the cell, while in the center it remains in a string-like mass about two-thirds the length of the cell The chlorophyll, as well as the gypsum particles, which latter showed the Brownian movement actively, were also displaced. A complete return of the cell contents took place at 22° C. in 3 days. Movement of the protoplasm can be clearly seen in *Closterium moniliferum* in the normal condition. As soon as the centrifugal machine could be stopped and the specimens examined, which was about two minutes, there could be seen an exceedingly rapid movement of the protoplasm in all directions. Part of the contents was forced very compactly into the centrifugal end of the cell. The movement was not visible before centrifuging, but was observable immediately after. There was shown a very beautiful arrangement of transparent polygonal protoplasmic plates so placed as to resemble a honeycomb. This same phenomenon I have observed in the cells of seeds of *Phaseolus multiflorus* when they had been allowed to germinate and were then centrifuged.

The cells were rarely killed by centrifuging and by the displacement of their contents. Unless accidentally killed the contents always returned sooner or later to its original position. This process began by a spreading out on all sides of the centrifuged mass. This at first was very slow, but gradually became more rapid. By the end of the first day at 22° C. only about one-tenth of the area of the cell, from which the contents had been displaced, had returned. On the second day about one-third of the displaced area was recovered and, as stated before, the contents had returned to all parts of the cell by the end of the third day. The contents as they spread out were not of the usual density but gradually became so as its return progressed. The return of the contents was materially assisted in its redistribution by the rapid streaming movements of the protoplasm above referred to. The gypsum crystals also eventually returned to their former position in the cell although they, like some other parts of the cell contents, were carried for a while in all directions by the moving protoplasm. When the movable contents was compactly thrown to one end of the cell, it could be ascertained that it equalled about one-seventh of the volume of the cell. When the contents were thrown to one side of the cell its redistribution was somewhat more rapid owing to the fact that there was a much greater surface over which redistribution could take place. The average time for redistribution of the contents of a larger number of specimens at 22° C. when their contents was centrifuged to one side was two days.

After the contents had returned, I centrifuged the same specimens of *Closterium moniliferum* again using 1207 g. as before. The contents were displaced as expected. One of the tubes of specimens I placed in the light and the other was put in the dark. The contents returned in all the specimens as before. In the case of those specimens in the light, however, the contents returned completely in three days at 22° C. The specimens which were placed in the dark required a considerably longer time, as complete redistribution of their contents only occurred in five days. As the contents returned to their normal position in the cell in the light after a second centrifuging in the same length of time as before, the activity of the cells did not seem to have been diminished. The cells did not seem to have been injured by such treatment. The influence of the light promoted a more rapid return of the contents and darkness had a somewhat retarding effect, as might be supposed.

The movements of *Closterium moniliferum* were not stopped by low centrifugal force as shown both before and after centrifuging.

An Aecium on Red Clover, *Trifolium pratense L.*

Geo. N. Hoffer.

The aecia of *Nigredo fallens (Desmaz.) Arthur* are reported in the North American Flora, Vol. 7, Part 3, 1912, as being uncertain. The rust *Nigredo trifolii (Hedw.f.) Arthur* is unknown on red clover.

Kern, 1911, calls attention to the fact that the common rust on red clover had long been ascribed to *Uromyces trifolii (Hedw.) Lev.* He mentions however, that Liro in 1906 pointed out that the rust of white clover, *T. repens*, differs from that of the red clover both in structure and habit. Kern distinguishes *Uromyces fallens (Desm.) Kern* growing on *Trifolium incarnatum L.*, *T. medium L.*, and *T. pratense L.* from *Uromyces trifolii (Hedw.) Lev.* which grows on *T. incarnatum L.*, *T. hybridum L.* and *T. repens L.*, but not on *T. pratense L.*, by the fact that the urediniospores of *Uromyces fallens* have scattered the germ pores.

In the same paper Kern suggests, however, that he believes that the red clover rust is heteroecious. There seems to be but a single uncertain report of an aecial stage on red clover. The further fact that a number of similar rusts of legumes are known to be heteroecious led him to suggest that the alternate host possibly belonged to some euphorbiaceous host of the group to which *Euphorbia commutata* belongs.

The writer has found aceia on the stems and leaves of the red clover. It was impossible to grow aeciaspores on any red clover plants and be certain that they gave rise to uredinia because of the lack of proper controls. The evidence is circumstantial that they are the aecia of *Uromyces fallens*.

The aecia were found on May 23, 1915. They developed on leaves of a plant which had all the appearances of *Trifolium pratense L.*, but the plant was not in flower. Because of the difficulty in determining the host species, the plant was dug up and transferred to the writer's garden. The plant thrived.

During the following two weeks a number of other leaves bore aecia. Several of these leaves were left on the plant to note the effect of the fungus upon them.

Later in July, the plant blossomed and its identity determined. Three heads formed and developed during the summer. These were taken and form part of the collection.

Dr. J. C. Arthur, of the Purdue University Agricultural Experiment Station, has given the writer his estimate of some previous collections of aecia supposedly on red clover. None of these collections sent to him had blossoms with them and because of similarity in the leaves of the various species of clover they were not absolutely authentic.

One of the above referred-to collections made by Mr. J. Dearness, at

London, Ontario, on May 20, 1911, corresponds closely with mine. All of the other collections of leaves bearing aecia are undoubtedly *Uromyces trifolii* on related species of clover.

Pathology.

The striking feature of the leaves bearing aecia is that they blacken and wilt in a very short time. The mycelium causes rapid necrosis. It is for this reason that the writer believes that the collection of the aecial stage of this rust is difficult.

During the latter part of the summer the plant was badly rusted and bore urediniaspores of *Uromyces fallens* continuously. The plant died during the following winter.

Kern, F. D. Phytopathology 1; 1, 1911.
Liro, J. Ivan (J. I. Lindroth—F. D. Kern) in Acta Soc. pro Fauna et Flora Fennica, 29; 15. 1906.

Additions to the List of Plant Diseases of Economic Importance in Indiana.[1]

Geo. A. Osner.

The following list of plant diseases represents collections and observations made by the writer and other members of the staff of the Department of Botany of the Agricultural Experiment Station at various times during the summer, in connection with other work. With these have been included collections made by students in the Department of Biology of Purdue University under the direction of Prof. G. N. Hoffer to whom thanks are due for his hearty co-operation.

The past season was extremely dry and hot during the mid summer months, thus reducing materially the damage due to fungus and bacterial diseases. However, in spite of this dry weather, several plant diseases, new to Indiana, were discovered that were causing very material loss to the crops concerned. These losses are mentioned in the proper place in the following list.

It is hoped to add to this list from year to year until a more or less complete survey of the important plant diseases of this state shall have been obtained. Specimens of the plant diseases listed are retained in the herbarium of the Department of Botany, Agricultural Experiment Station, of Purdue University where they are available for examination by any one interested. Unless otherwise stated, the collections were made by the writer.

APPLE, (*Pyrus Malus* L.)

Leaf Spot.

Coniothyrium pirinum Shel. Scott, White, July, 1916; Tippecanoe, Sept., 1916; Boone, July, 1916 (P. S. Lowe). This disease was quite common during the past season.

Coryneum foliicolum Fckl. Boone, August, 1916 (P. S. Lowe). This fungus was found accompanying *Coniothyrium pirinum* Shel. and *Phyllosticta pirina* Sacc. (See also under pear.)

Illosporium malifoliorum Shel. Jefferson, Sept., 1916 (E. Coppess).

Phyllosticta pirina Sacc. Boone, July, 1916 (P. S. Lowe); Wayne, August, 1916 (R. E. Wilson). This fungus frequently accompanies *Sphaeropsis Malorum* Pk. and *Coniothyrium pirinum* Shel.

BEAN, (*Phaseolus vulgaris* L.)

Blight.

Bacterium Phaseoli E. F. Sm. Marshall, August, 1916; Pulaski, Tippecanoe, Sept., 1916; Sullivan, July, 1916 (J. C. Summers); Boone, August, 1916 (P. S. Lowe). This disease caused quite severe loss in northern Indiana during the past season.

1. This list is supplementary to "A List of Plant Diseases of Economic Importance in Indiana" by F. J. Pipal. Ind. Acad. Sci. Proc. 1915.

BLACKBERRY, (*Rubus allegheniensis* Por.)

Leaf Spot.

Cercospora Rubi Sacc. Tippecanoe, Sept., 1916 (J. C. Summers).

CARNATION, (*Dianthus caryophyllus* L.)

Stem rot.

Corticium vagum B. & C. Tippecanoe, Sept., 1916 (C. C. Rees). This disease was observed in one of the greenhouses belonging to Purdue University. (See under celery and potato for additional notes on this fungus).

CARROT, (*Daucus carota* L.)

Leaf blight.

Cercospora Apii var. *Carotae* Pass. Marshall, Sept., 1916; Tippecanoe, Sept., 1915 (H. S. Jackson).

Macrosporium Carotae E. & L. Marshall, Sept., 1915. This disease was quite abundant in 1915.

CELERY, (*Apium graveolens* L.)

Stem rot.

Corticium vagum B.& C. Elkhart, Oct., 1916. This disease caused heavy loss on muck farms during the past season to the celery growers around Goshen, Ind. The disease was favored by the cold, wet weather of late spring and early summer. (See also under carnation and potato).

CHERRY, (*Prunus* sp.)

Shot hole.

Cercospora circumscissa Sacc. Marshall, Sept., 1916.

CITRON, (*Citrus Medica* var. *genuina* Eng.)

Anthracnose.

Colletotrichum Lagenarium (Pass.) E. & H. Marshall, Sept., 1916. The vines were almost entirely killed in some cases. (See also under gourd and pomegranite melon).

CLOVER, RED (*Trifolium pratense* L.)

Leaf spot.

Pseudopeziza Trifolii (Bernh.) Fckl. Marshall, June, 1916.

CLOVER, WHITE (*Trifolium repens* L.)

Slime mold.

Physarum cinereum (Batsch) Pers. Lagrange, July, 1915 (B. M. Reed). The leaves of the white clover were so completely covered by the plasmodium and sporangia of this slime mold that they were much injured, or in some cases completely killed. This trouble has been reported previously on blue grass.[2]

COWPEA, (*Vigna sinensis* [L.] Endl.)

Leaf spot.

Amerosporium oeconomicum E. & T. Sullivan, June, 1916 (J. C. Summers).

Phyllosticta phaseolina Sacc. Tippecanoe, October, 1916 (J. C. Summers).

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2. Pipal, F. J. Ind. Acad. Sci. Proc. 1915.

CUCUMBER, (*Cucumis sativus* L.)

Leaf spot.

Cercospora Cucurbitae E. & E. Marshall, St. Joseph, Sept., 1916. This disease was found in a number of fields but was not of great economic importance as it produced only an occasional spot on the leaves. (See also under gourd, muskmelon and squash).

CURRANT, RED (*Ribes vulgare* Lam.)

Leaf spot.

Cercospora angulata Wint. Tippecanoe, Sept., 1916 (J. C. Summers).

DILL, (*Anethum graveolens* L.)

Phoma disease.

Phoma Anethi Sacc. Marshall, Sept., 1915. Every plant was severely diseased in a field near Plymouth, Ind.

EGG PLANT, (*Solanum melongena* L.)

Leaf spot.

Phyllosticta hortorum Speg. Marshall, August, 1916.

GINSENG, (*Panax quinquefolium* L.)

Alternaria blight.

Alternaria panax Whet. Green, July, 1911 (D. W. Solliday).

GOURD, (*Cucurbita Pepo* L. and *Lagenaria vulgaris* Ser.)

Leaf spot.

Cercospora Cucurbitae E. & E. Marshall, Sept., 1916. (See also under cucumber, muskmelon and squash).

Anthracnose.

Colletotrichum Lagenarium (Pass.) E. & H. Marshall, August, 1916. Around Plymouth, Ind., this disease was very severe on both leaves and fruit during the past season. This fungus was also collected at Plymouth, August, 1916, on the following hosts: Chinese watermelon (*Benincasa Cerifera* Savi), mango melon (*Cucumis Melo* var. *Chito* Naud.), balsam apple (*Momordica Balsamina* L.), and balsam pear (*Momordica Charantia* L.) See also under citron and pomegranite melon). This disease has been reported previously on cucumber, muskmelon and watermelon.[3]

HOLLYHOCK, (*Althea rosea* Cav.)

Leaf spot.

Cercospora kellermani Bub. Boone, August, 1916 (P. S. Lowe.)

HORSERADISH, (*Radicula amoracia* L.) (Rob.)

Leaf spot.

Macrosporium herculeum E. & M. Marshall, August, 1916. This disease was quite severe last season.

LIMA BEAN, (*Phaseolus lunatus* var. *macrocarpus* Benth.)

Blight.

Bacterium Phaseoli E. & F. Sm. Marshall, Starke, Sept., 1916. This disease almost ruined the crop in some gardens near Plymouth, Ind., last year. (See also under bean.)

3. Pipal, F. J. Ind. Acad. Sci. Proc. 1915.

MILLET, (*Setaria Italica* [L.] Beauv.)

Leaf spot.

Piricularia grisea (Cke.) Sacc. Marshall, August, 1916; Laporte, Sept., 1916. This disease was very severe in some fields during the past season.

MUSKMELON, (*Cucumis Melo* L.)

Leaf spot.

Cercospora Cucurbitae E. & E. Starke, Sept., 1916. (See also under cucumber, gourd and squash).

Mosaic.

Cause not known, Marshall, July, 1916. This disease has been reported previously on cucumber.[4]

OATS, (*Avena sativa* L.)

Leaf spot.

Helminthosporium Avenae Ei. Marshall, June, 1916. This disease was quite common in oat fields last summer.

ONION, (*Allium Cepa* L.)

Scab.

Vermicularia circinans Berk. Jefferson, April, 1916 (J. B. Demaree).

ORCHARD GRASS, (*Dactylis glomerata* L.)

Ergot.

Claviceps microcephala (Wal.) Tul. Tippecanoe, July, 1916. (See also under timothy).

Leaf spot.

Scolecotrichum graminis Fckl. Marshall, June, 1916; Tippecanoe, July, 1916. This disease has been reported previously on timothy, blue grass and *Poa nemoralis*.[5]

PEAR, (*Pyrus communis* L.)

Leaf spot.

Coryneum foliicolum Fckl. Tippecanoe, Sept., 1916 (J. C. Summers). (See also under apple).

PEPPER, (*Capsicum annuum* L.)

Mosaic.

Cause not known. Marshall, Sept., 1916. Specimens of this disease were also collected on pokeweed (*Phytolacca decendra* L.), Marshall, July, 1916. This disease has been reported previously on tomato.[6]

PLUM, (*Prunus* sp.)

Bacterial leaf spot.

Bacterium Pruni E. F. Sm. Marshall, June, 1916; Carroll, Sept., 1916 (G. N. Hoffer). This disease has been reported previously on the peach.[7]

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4. Pipal, F. J. Ind. Acad. Sci. Proc. 1915.
5. Underwood, L. M. Ind. Acad. Sci. Proc. 1893:48.
Pipal, F. J. Ibid 1915.
6. Pipal, F. J. Ind. Acad. Sci. Proc. 1915.
7. Pipal, F. J. Ind. Acad. Sci. Proc. 1915.

POMEGRANITE MELON, (*Cucumis Melo* var. *Dudaim* Naud.)

Angular leaf spot.

Bacterium lacrymans Sm. & Bry. Marshall, August, 1916. This disease has been reported previously on cucumber.[8]

Anthracnose.

Colletotrichum Lagenarium (Pass.) E. & H. Marshall, August, 1916. This disease was severe on fruit, stems and leaves last season. (See also under citron and gourd).

POTATO, (*Solanum tuberosum* L.)

Russett scab.

Corticium vagum B. & C. Tippecanoe, April, 1916; Marshall, Sept., 1916; Jefferson, April, 1916 (J. B. Demaree). (See also under carnation and celery).

RASPBERRY, (*Rubus* sp.)

Anthracnose.

Gloeosporium naviculisporum Ston. Boone, August, 1916 (P. S. Lowe). This disease may be readily distinguished from the ordinary anthracnose caused by *Gloeosporium venetum* Speg. by the fact that the acervuli are scattered indefinitely over the stem or leaf, rather than being confined to definite spots.

RED TOP, (*Agrostis alba* var. *vulgaris* [With.] Thurb.)

Leaf spot.

Scolecotrichum graminis Fckl. Marshall, June, 1916. (See also under orchard grass).

ROSE, (*Rosa* spp.)

Spotting.

Pilobolus Oedipus Mont. Tippecanoe, May, 1916. This fungus has been found causing more or less damage to roses in greenhouses around Lafayette, Ind. While not parasitic upon roses, the spore heads of the fungus are shot up on to the leaves and flowers, in some cases covering them thickly with black specks and decreasing the value of the flowers.

Leaf spot.

Phyllosticta Rosae Desm. Boone, August, 1916 (P. S. Lowe), on cultivated roses.

Cercospora rosicola Pass. Tippecanoe, Sept., 1916 (J. C. Summers), on *Rosa nitida* Willd. While the fungus was collected only on the wild rose, it is known to cause a disease of cultivated roses as well.

SALSIFY, (*Tragopogon porrifolius* L.)

White rust.

Albugo Tragopogonis (D. C.) S. Gray, Clay, June, 1916 (W. B. Gillespie). This disease has been reported previously on *Ambrosia artemissifolia*.[9]

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8. Pipal, F. J. Ind. Acad. Sci. Proc. 1915.
9. Wilson, G. W. Ind. Acad. Sci. Proc. 1907:82.

SQUASH, (*Cucurbita* spp.)

Leaf spot.

Cercospora Cucurbitae E. & E. Marshall, Sept., 1916; Boone, Sept., 1916 (P. S. Lowe). (See also under cucumber, muskmelon and gourd).

Septoria Cucurbitacearum Sacc. Starke, Sept., 1916, on *Cucurbita maxima* Duch. This disease was abundant in one truck garden.

STRAWBERRY, (*Fragaria* sp.)

Leaf spot.

Marsonia Potentillae var. *Fragariae* Sacc. Lake, July, 1916.

SWEET CLOVER, WHITE (*Melilotus alba* Desr.)

Leaf spot.

Ascochyta caulicola Lau. Tippecanoe, May, 1916 (H. S. Jackson).

Cercospora Davisii E.& E. Tippecanoe, July, 1916.

TIMOTHY, (*Phleum pratense* L.)

Ergot.

Claviceps microcephala (Wal.) Tul. Marshall, August, 1916. (See also under orchard grass).

VETCH, (*Vicia villosa* Roth.)

Leaf spot.

Ascochyta Pisi Lib. Marshall, June, 1916. This disease has been reported previously on peas.[10]

WATERMELON, (*Citrullus vulgaris* Schrad.)

Leaf Spot.

Cercospora citrullina Cke. Marshall, August, 1916.

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10. Pipal, F. J. Ind. Acad. Sci. Proc. 1915.

A Study of the Relations Between Plant Growth and Combined Nitrogen in Winona Lake.†

Thurman B. Rice.

Objective. The purpose of the investigation as it was first conceived was to determine the effect of combined nitrogen content of the water upon the luxuriance of plant growth. As the work progressed, however, a considerable mass of data accumulated pertaining to the effect of the vegetation upon the nitrogen content of the water, and so the scope of the work was broadened to include this phase of the subject.

Preliminary Work. Work was begun in July, 1915, by making an accurate map of the lake, and by making a close study of the entire littoral region in order to determine the most fruitful points of attack. The entire shoreline was sounded at close intervals to a depth of five meters, this being found to be the limit of plant growth. The Lake was under constant observation from July, 1915, to September, 1916. During this time observations of some kind were taken nearly every day except while the lake was covered with ice.

Analyses. Analyses were begun in October and continued until August. In all, 135 analyses were made. About half of the analyses were complete for combined nitrogen, the others being for nitrates and nitrites only. Standard methods of water analysis were used (Mason, '12 and Olsen, '08.)*

Samples were taken from clear unfiltered water just below the surface unless otherwise stated. The bottle used to carry samples were thoroughly cleaned and was sealed immediately after being filled. Analysis was begun as soon as the laboratory was reached, on the average about thirty minutes after the sample was taken.

A map of the lake with analysis stations is presented as Fig. 1.

Description of the Stations from which analyses were made.

A Weedy, numerous confervoid algae, muddy sediment bottom.
B Weeds scanty, but dense close by, sediment bottom. 4m deep.
C Clear water, near center of the lake, deepest place, 21m deep.
D Weedy, many algae, muddy sediment bottom.
E and G Very weedy, water much contaminated, 1m deep.

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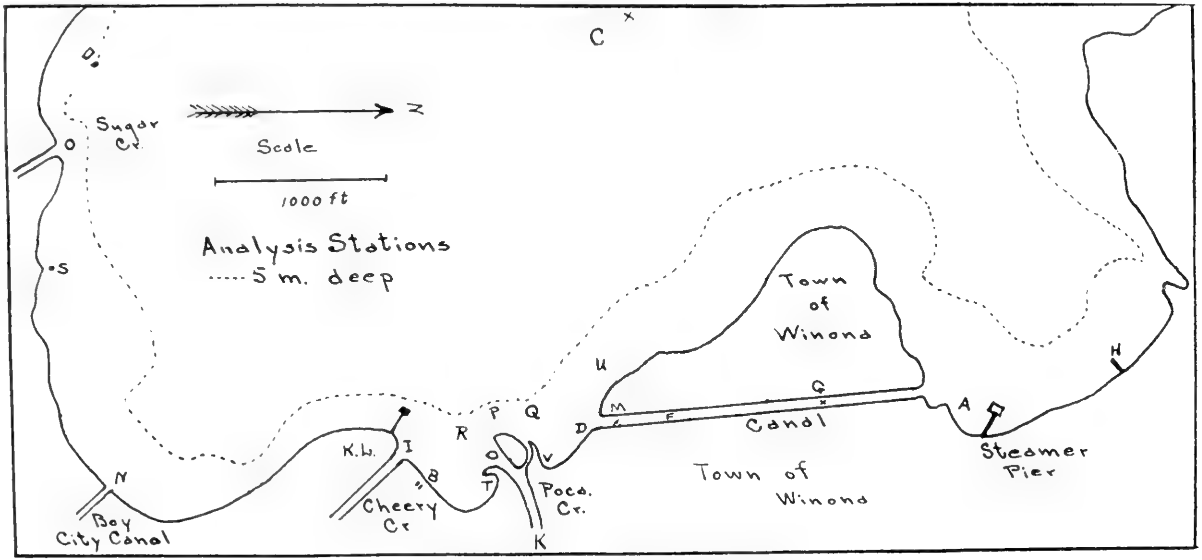
†Contribution of the Zoology Department of Indiana University No. 156. The problem was suggested by Dr. Will Scott under whose direction the work was carried out.

*Mason, Examination of Water, 1912: Wiley and Sons.

Olsen, Quant. Chem. Anal. 1908, Van Nostrand. An error of one decimal place in the computation of nitrites as given in the 1908 edition (corrected in 1915 edition) was detected and computations were made accordingly.



Map showing location of the Stations.

I Few weeds at mouth but the creek was choked with weeds, the discharge of the creek is small. No sewers empty into the creek.

K The main inlet of the lake. Water usually clear but much contaminated by discharge from septic tanks.

M Weedy, many algae and seed plants. 1m deep.

N No weeds at mouth but the canal was choked with them. Flow very scanty.

O Second largest inlet. Water clear but carrying some silt.

P Dense Potamogeton field. 3-4m deep.

Q Dense Potamogeton field. 2-3m deep.

T Extremely dense vegetation. Water Shallow.

S Peaty bottom. Described in detail below.

R Dense field of *Potamogeton*. 2-3 m deep.

U Weeds sparce. Sewers empty not far away.

V Weeds very dense, especially filamentous algae.

PART 1. THE EFFECT OF THE VEGETATION UPON THE NITROGEN CONTENT.

A In the Pelagic Region.

Description of Analysis Station. At the deepest place in the lake (21M) a barrel was anchored, and from this place the samples were taken. The position of this station is indicated by the letter C upon the map.

*Discussion of the graphs.** The analyses taken in the late autumn showed a low nitrogen content due to the fact that the plants growing in the lake had assimilated a large amount of nitrogen during the summer previous. The following March showed a rise of everything except the nitrite which was practically absent. From March until May the four nitrogen compounds—nitrates, nitrites, free ammonia, and albuminoid estimated as ammonia—increased, reaching a maximum in late May.

(1) Nitrogen increased during winter and early spring due to the surplus of affluents and decay over effluent and fixation by plants.

(2) Nitrogen fell during the time the plant growth was rapidly increasing and profuse (after about June 10-15.)

(3) Storms mixed the lake by bringing into the body of the lake the more concentrated water of the bays. Note data taken just after the lake was rough; June 21, 29, July 13, 22.

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*In all of the graphs showing a time element the horizontal spaces represent days unless the graph is interrupted. The date and the number of the analysis are shown just below the base line. The amounts of the different compounds are represented by the vertical spaces. These values are uniform throughout. In the cases of nitrate, total ammonia and total nitrogen .1 part of nitrogen per million or .1 milligram of nitrogen per liter is taken as the unit. In case of nitrite, however, .01 parts of nitrogen per million is taken as the unit. This was done in order to throw the nitrite graph within comparable distance to the other graphs. This change in scale must be kept in mind.

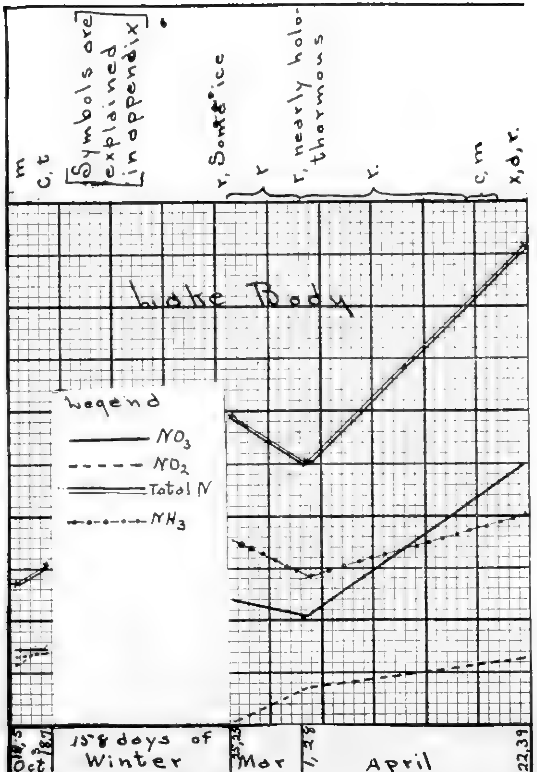

Symbols are explained in appendix
Lake Body
Legend
NO_3
NO_2
Total N
NH_3
158 days of Winter
Oct
Mar
April

Fig.—2

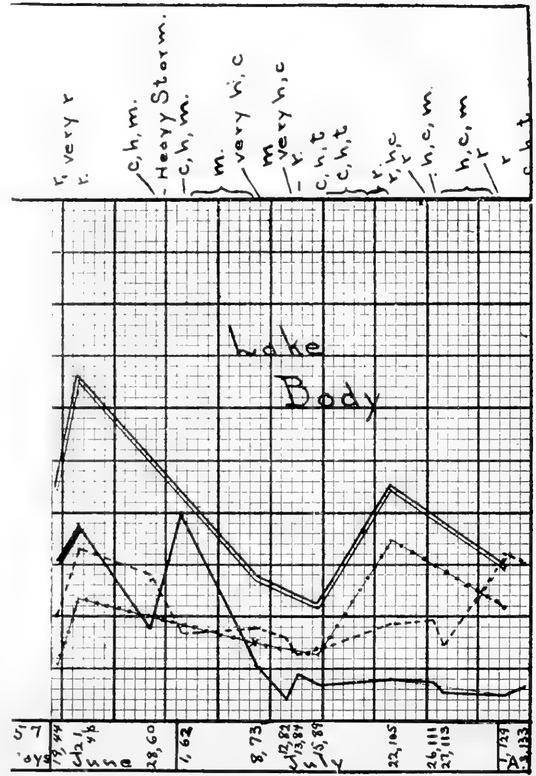

Heavy Storm.
Lake Body
June

Fig.—3

(4) Note the practical absence of nitrate at the end of winter, and also note the general shape of the nitrite curve.

(5) Nitrate gradually rose, and then rapidly fell after the plants began to increase.

The reason for the increase during the winter is of course the fact that the factors tending to increase the content; i. e. the nitrogen content of the in ets, the release of nitrogen to simpler forms by decay, and the nitrogen compounds washed from the air by rain and snow, over-balanced the factors tending to reduce the content, such as loss from the outlet and nitrogen assimilation by plants. The very low nitrite content at the end of winter indicates that the disposal of this form over-balanced its production, at a time when pro duction was slow due to the fact that the cold weather inhibited bacterial action. When the warm weather of spring came, the bacterial action was resumed and the nitrites were again produced faster than they were used.

About the first of June, the phanerogams began to increase rapidly and by the end of July had reached the maximum. This growth although limited to the littoral region clearly affected the pelagic region as is shown by the fact that the results obtained from the open lake were comparable to those obtained where plants grew, except of course the less striking results were found in the open lake, since it acted as a reservoir. It was noticed particularly that the nitrate decreased and came to practically equilibrium at a low level at the time that plant growth was at its maximum.

The Effect of Stratification. Vertical series were run from Station C, the deepest place in the lake. It was found that the lower part of the lake contained more n trogen than the upper. This general fact was noted by Birge and Juday, 1911* in investigations on Lakes Garvin and Mendota, but in other respects my results differed from theirs, due perhaps to differences in the lakes.

The graph showing the nitrogen content at different levels (Fig. 4) does not represent a single series, but is the average of two or three analyses for each depth.

This graph offers a partial explanation of the rise of nitrogen content during the winter, since the water mixes from top to bottom during that time due to the holothermous condition, and the water of the bottom being more concentrated causes the surface content to rise. This is insufficient, however, to account for all of the increase since the winter and spring content at the surface is much higher than that at the bottom later in the season at least. Before the spring statification began, the content must have been practically uniform from top to bottom, and the fall to the conditions found when the vertical series was run was probably due to the settling of the albuminoid, and the utilization of nitrates by plants, at least these two were the com-

*Birge and Juday, Wisconsin Geological and Natural History Survey, 1911.

pounds which showed the greater part of the decrease. It was also true that the content of the surface of the pelagic region continued to rise in the spring after the stratification had begun (See Figs. 2 and 3). So it would seem that winter mixing is not the only, and perhaps not the main factor in causing the increased nitrogen concentration. A considerable part of the albuminoid increase in winter and spring is doubtless due to the sediment of the bottom being stirred up, the lake being much rougher in spring than in summer.

Interesting questions outside the scope of this paper are suggested by the relation of the various compounds to the thermocline (Fig 4). It may be said

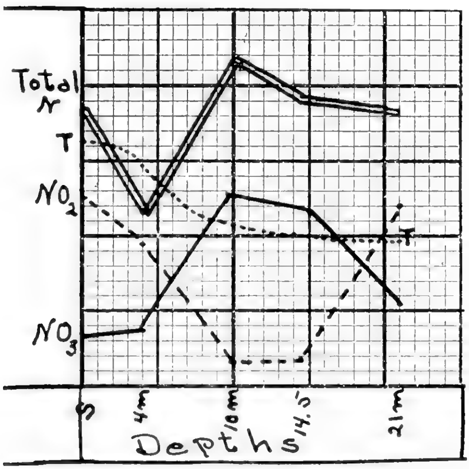


Fig.—4 (See Table 2) Vertical Series taken rt Station C.

The dotted line marked T—T is the thermocline.
One space represents, 5° F.

here, however, that shortage of oxygen near the bottom probably accounts for the behaivor of the nitrate and nitrite. Determinations of dissolved oxygen made at various times by Dr. Will Scott show an average of about 1.5 cc per liter for the water of the bottom of the lake during the summer.

B. Littoral Regions Where Plant Growth was Open Enough to Allow Free Circulation of Currents Set up by the Wind.

As might be expected these regions showed close similarity to the pelagic region. The water mixed freely with that of the open lake, and local variations were slight.

A region of this nature was that along the shore of the island made by the canal. This region was close to the town and received a considerable amount of sewage, but supported only a moderate plant growth. The region gave upon analysis a content quite close to that of the open lake, as can be seen by comparison of stations C and U in Figs. 1, 5. Station U had a sparse growth of various Potamogetons. Its location is shown on the map.

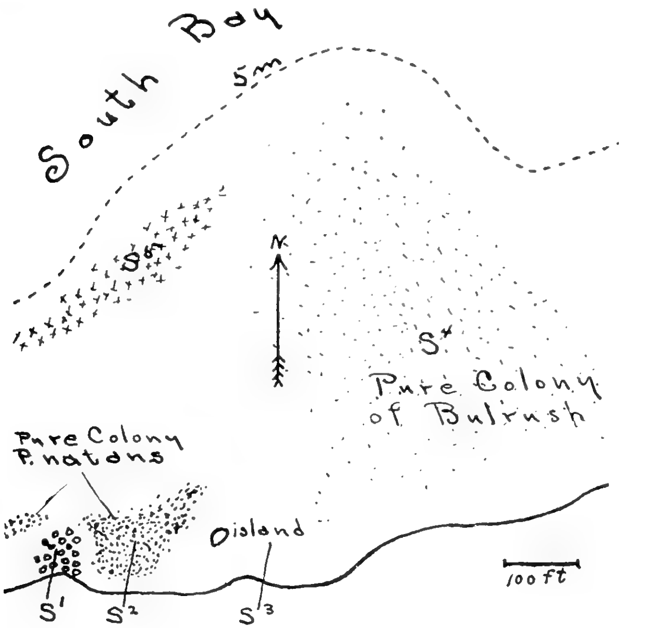


Fig. 5—Map af Stations in South Bay.

Five stations in South Bay were intermediate between this condition and the next, and it was found that the contents of the five stations were nearly identical at any given date, although the stations were very diverse as to plant growth.

The map (Fig. 5) shows the relations of the stations which are also described in the list giving the characteristics of the stations. The general region is indicated on the map of the lake (Fig. 1) by the letter S.

There was a distinct and fairly constant relation between the stations as shown by the analyses but no opportunity was afforded for an accumulation of any form of nitrogen due to the fact that the currents kept the region mixed. See figure 14 for graphs for these stations.

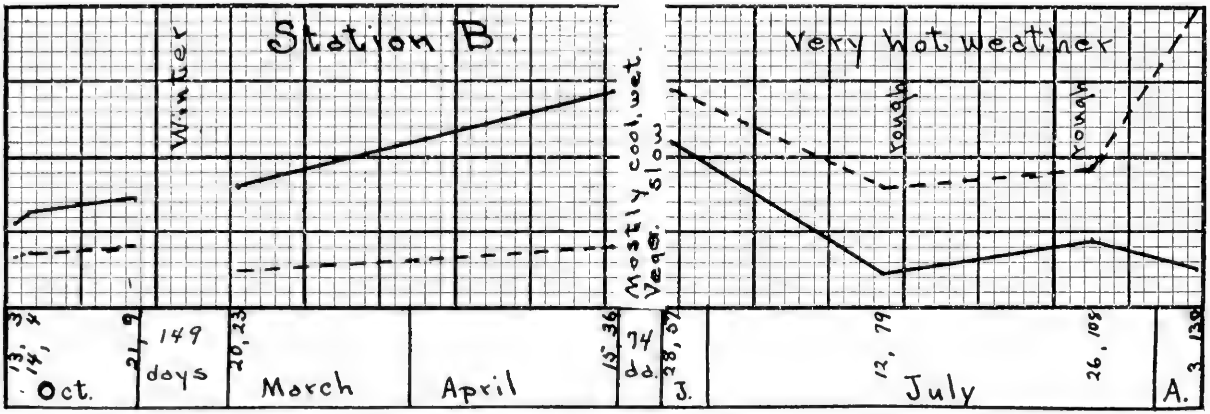


Fig. 2—Station B. (See Table 4 for Data)

The significance of the curves is discussed in the text.
The graphs shown in this figure are very typical of the conditions existingin regions of moderate density near the shore.

C. Littoral Regions Where Phanerogams Grew so Dense that the Circulation of the Wind Driven Currents was Inhibited or Wholly Prevented.

(*a*) *Regions of Dense Growth.*

Stations A, B, R, P and Q answered to this description and from them the following data were taken. They are readily located on the map (Fig. 1).

Nitrate Behavior. In these stations nitrate fell very rapidly during the last of June and the first few days of July. All stations agreed in this respect, as is shown by Fig. 7, which also shows the five graphs from the South Bay stations. After July 5, the nitrate content seemed to have come to a state of equilibrium and was produced and used at about the same rate. The explanation of the nitrate curve is rather simple. The bacteria increased very rapidly during the warm days of spring and produced a great surplus of nitrate before the plants got fairly started. Then the plants being supplied with abundance of plant food and bright sunshine grew apace and succeeded in cutting down the surplus of nitrate and early in July established nitrate equilibrium at a rather low level.

Nitrite Behavior. The nitrite content fell gradually until about July 5, remained low until July 19 after which it gradually rose until the last analyses were made (Aug. 3). The explanation of the first part of the nitrite curve is no doubt similar to that for the nitrate of the same time. Then during the following period of low content, photosynthesis was extremely active due to the bright sun and warm weather.

This resulted in a supersaturation of free oxygen in the water, as was evidenced by the fact that bubbles of oxygen were seen over the surface of the plants. The then existing conditions would facilitate the passage of nitrites into nitrates as will be further discussed under the conditions existing in regions of extremely dense plant growth.

Following this period the reproductive processes predominated over the vegetative and hence the amount of free oxygen produced by photosynthesis was reduced and the amount used for respiration was increased with the end result that the amount of free oxygen in the water considerably lessened. At this time the nitrites began to increase due to the fact that less was being converted into nitrate. This result was noted in all of the stations considered in this division, and was also noted in the five stations in South Bay and in the lake body itself indicating that the process was general rather than local.

Confirmatory evidence of the above explanation is found in the fact that during the latter part of July and the whole of August, the vegetation was much paler than earlier in the season, and the plants were mainly engaged in producing flowers and fruit, rather than vegetative growth. Katabolic processes using free oxygen probably predominated over anabolic processes producing free oxygen.

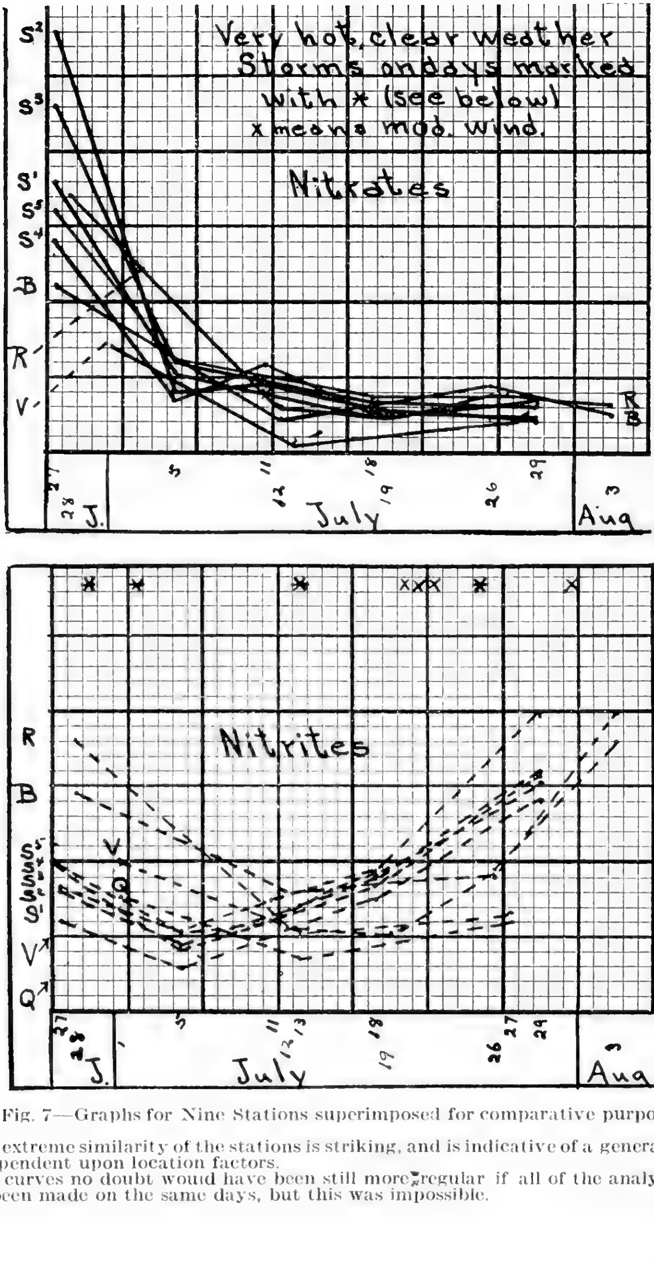


Fig. 7—Graphs for Nine Stations superimposed for comparative purposes.

The extreme similarity of the stations is striking, and is indicative of a general procees not dependent upon location factors.

The curves no doubt woud have been still more regular if all of the analyses could have oeen made on the same days, but this was impossible.

(*b*) *Regions of Extremely Dense Vegetation.*

In the two regions of this description the vegetation was so extremely dense that a boat could be pushed through only with great difficulty. Great stagnation existed in both places. The water in station T at the place where the samples were taken was .3M deep. The station was well protected as its location on the map will show. The water in the other station of this description, the canal, was about 1M deep.

The plant growth consisted mainly of various pondweeds, *Potamogetons;* waterpest, *Elodea canadensis;* duckweed, *Spriodela polyrhiza;* eel grass, *Vallisneria spiralis; Naias flexilis;* filamentous and confervoid algae and phyto-plankton. The algae predominated in the canal while the phanerogams constituted the main bulk of the plants in station T.

Nitrate Behavior. In each case the stations showed a rapid fall in nitrate and then remained low, in fact extremely low, throughout the remainder of the season. The reason for the fall in content is apparent in the light of the great drain that such a dense vegetation would make upon the nitrate in solution. In this connection, it should be remembered that the water could circulate very little due to the resistance offered by the mat of plants. The water in this station was also quite shallow, as before stated, and hence could hold no great store.

Nitrite Behavior. The behavior of the nitrite in these stations is peculiar but very significant. As has been stated before, the nitrite was very low at the end of winter as the ice was going off. It then gradually rose until April 20 at which time it began to show a rapid rise, due no doubt to the fact that while at that time the higher plants has been unable to get a start, the bacteria on the other hand had flourished inordinately. Toward the latter part of June the phanerogams began to flourish and much free oxygen was produced as a by-product of photosynthesis. The effect of this was to oxidize the nitrite, and hence the precipitous fall of nitrite from June 24 to July 12.

The conditions in these regions remained more uniform than in regions of less plant growth, due I think, to the fact that large amounts of algae and phytoplancton were found in these regions and this tended to keep the vegetative processes in the ascendency, which was not the case in the regions of less density. The temperature of the water was high, due to the fact that there was little interchange with other regions, and to the fact that the water was shallow (100° F was frequently reached and temperatures as high as 106° F were observed). The presence of so much free oxygen, a high temperature, a high bacterial count, and a nitrate content which remains low, due to the constant drain upon it, results in the oxidation of the nitrites almost as soon as they are formed.

Two Points of Interest outside the scope of this paper to be noted at this point are:

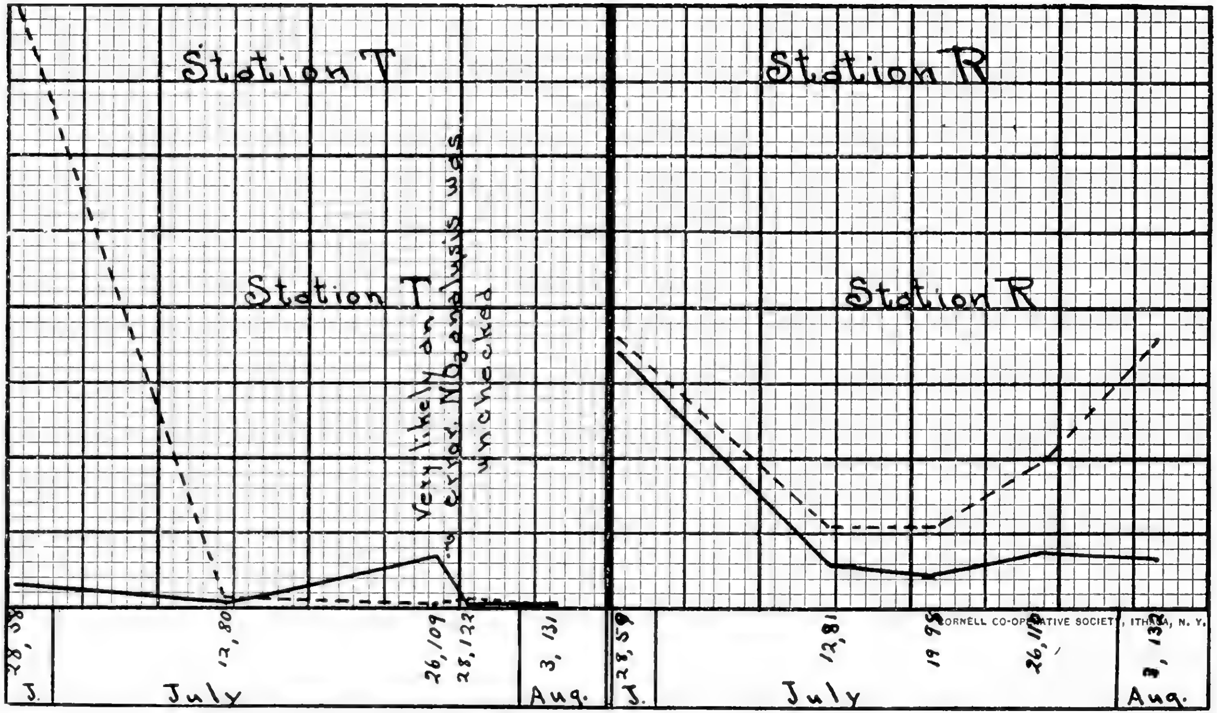


Fig. 8—(See Table 4 for Data)

For comparative purposes an extremely dense station (T) is set beside a moderately dense station (Station R). It is quite likely that the analysis for Station T taken July 26 is too high. The analysis was not checked, which is unfortunate. Compare Station T with Canal Station in Fig. 9. Compare Station R with Fig. 6 and 7.

The curves for Station T and R are very typical for the kind of regions they represent. Note that in the less dense region the nitrates and nitrites do not fall so low and that there is a distinct rise in the nitrite after the period of maximum vegetative growth; i.e. when the plants were chiefly engaged in producing flowers and fruit.

First, in regions of very dense or even of fairly dense vegetation where great contamination exists, a chemical determination of nitrates or nitrites as an indicator of pollution in making a sanitary water analysis is absolutely worthless in itself.

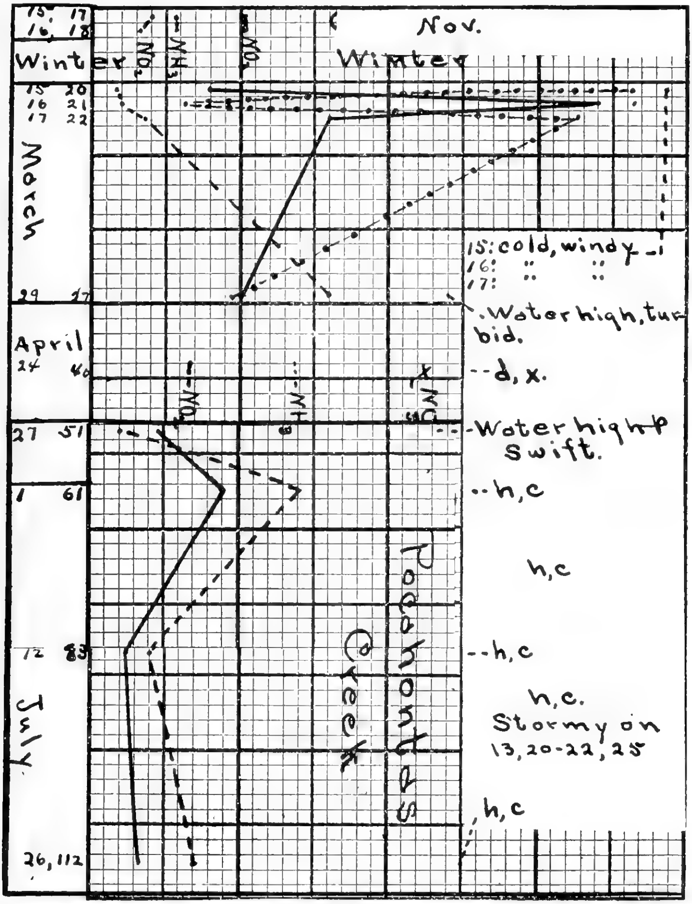


Fig. 9—See Table 7 for Data

(1) The nitrite and nitrate curves are extremely regular.

(2) Compare with Station T of Plate 5. These two are the only regions of extremely dense vegetation.

(3) Note the effect of the windy weather of April 17. At this time the turbid, very much contaminated water of Entrance Bay was brought in.

(4) Absence of data covering hiatus of 60 days is very unfortunate.

Second, we have a possible explanation of the fact that a diurnal variation of the free oxygen dissolved in the water of densely vegetated regions has not been found to be as great or as constant as was predicted on theoretical grounds. It would seem that during active photosynthesis the water would contain much more free oxygen than in the early morning after several hours of respiration by plants and animals in the water. But in case the free oxygen combined to a considerable extent with the nitrites to produce nitrates as seems indicated by the results obtained in these observations, such a large variation would be prevented.

Concerning the Ammonia Content. Not much account was taken of the ammonia content, either as free ammonia or as albuminoid since no great effect of the profuse plant growth could be noted upon it. Perhaps very active photosynthesis would indirectly hasten its oxidation to simpler forms due to the free oxygen produced. It seems clear from the results obtained that the ammonia acts merely as a reservoir from which nitrites and later nitrates are derived. It should also be remembered that aside from the ammonia in solution there is always the large amount in the ooze at the bottom. This would serve as a storehouse for the production of all of the compounds under discussion, and would be extremely difficult of estimation. There is no doubt that the bacterial action which results in higher oxidized forms would be more active in the ooze than in the water. It was noticed that the ammonia analyses showed great variation, and judging from the fact that large amounts were found after a rough period and smaller amounts after a calm, there seems to be no doubt that the variation is due to the water being more or less stirred up at one time than another. It was impossible from the number of analyses taken to arrive at any definite conclusions concerning the ammonia, and since *it acts merely as a storehouse, at all times well supplied* it seems quite unessential that further attention should be given to it in this part of the paper.

Part II. The Effect of the Nitrogen Content Upon Plant Growth.

Attention is called to the map of Winona Lake (Fig. 10) in which the regions of plant growth are stippled in proportion to the degree of density. Special care was taken to get the correct proportions but in spite of this the shading must be regarded as only approximate. Several conditions contributed to the difficulty of representing on paper the amount of vegetation. The following complicating factors may be mentioned; seasonal variations; the impossibility of making accurate quantitative measurements of plant growth per unit area; the great diversity of the growth as to species; the variations in level at which the plants were found; and finally the difficulty in judging the degree of shading required to represent a given condition.

It is at once apparent from a study of the map that the regions of densest plant growth are contiguous to the town of Winona Lake which is situate upon and drains into the north two-thirds of the east shore of the lake.

A statement of the drainage conditions of this town will be instructive at this place. Practically every house in the town has connection to the sewer system. These pipes pass to a large number of septic tanks which in turn discharge into the lake within the limits of the line on the map. A very large tank discharges into Pocanhontas Creek and its intermittent discharge is

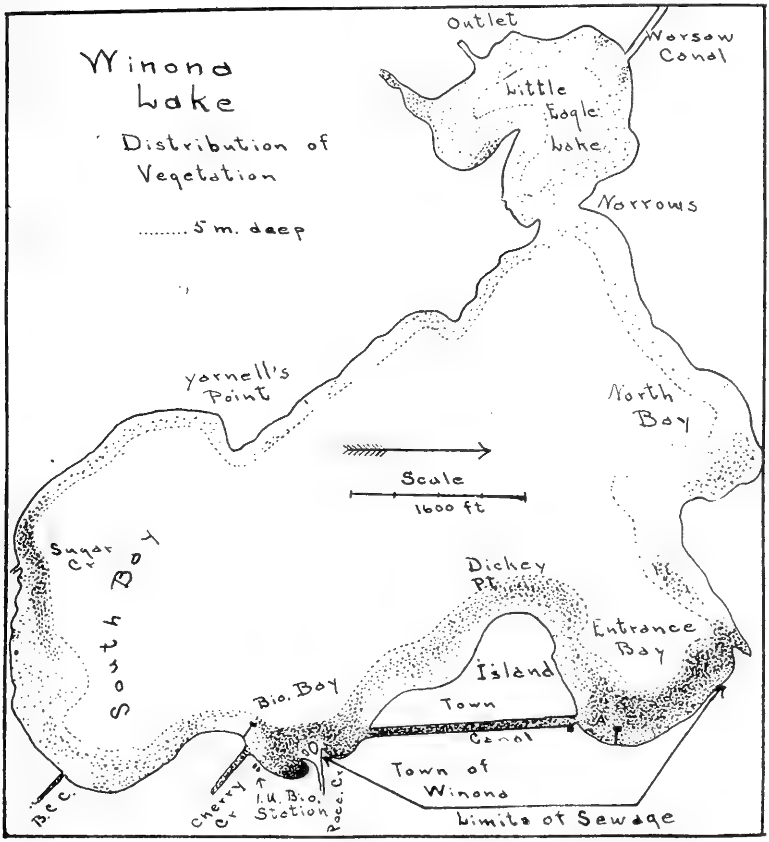


Fig. 10—Map showing distribution of Plant Growth.

responsible for the great variation in the analyses of the samples taken from the station near the mouth of the creek. (Fig. 11) Relatively few tanks discharge along the shore of the island made by the canal. During the summer the town of Winona Lake has a large population, and the sewage is very considerable in amount. The regions near the town showed a higher nitrogen content as a look at the data will show. The ease with which the albuminoid was broken up by the permanganate-alkali solution used in the analyses strongly indicated that the greater part of the albuminoid was of animal rather than vegetable origin. The broad conclusion can hardly be escaped; the large amount of available plant food resulting from proximity to the town is largely responsible for the very abundant plant growth; i. e. the determining factor is the chemical composition, particularly the nitrogen content of the water. Specific statements are not so apparent.

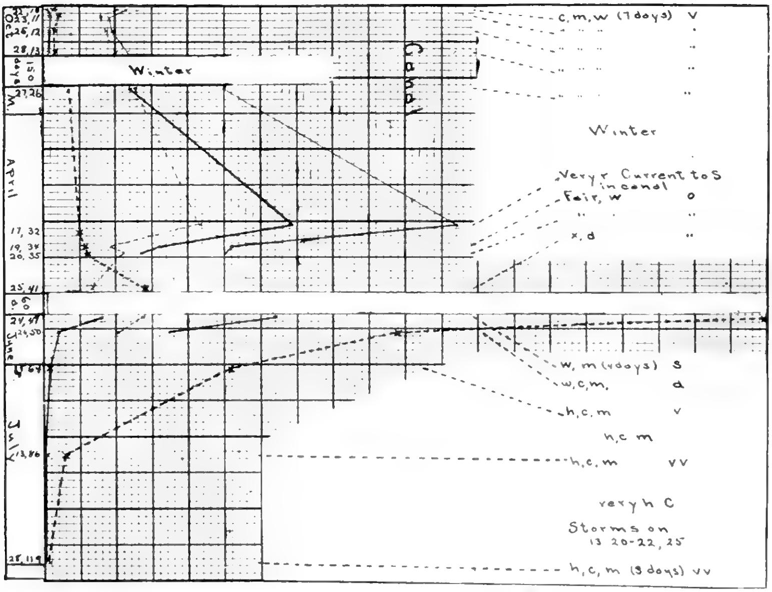


Fig. 11.—Pocahontas Creek, the main inlet of the Lake. (See Table 8.)

(1) Note the extreme fluctuation during March. This was due to the intermittent discharge of a large septic tank up the course of the creek, and also to the alternate freezes and thaws, thus influencing the drainage of surface water from a number of farm lots and pig sties above.
(2) Total nitrogen was high.

Note first that in all stations whether of dense or very dense plant growth the nitrate was the only one of the four compounds under consideration that was consistently affected. In every graph the nitrate line fell coincident with abundant plant growth. This was to be expected since the nitrate is the form in which the nitrogen is assimilated by the plant. Other forms were merely feeders of nitrogen to the nitrate form.

But note the extremely small amount of nitrate required to support a rapidly growing and later very dense vegetation as shown by the following analyses:

No.	Station	Parts per million of		
		NO_3	NO_2	Sum
80	T	.025*	.006*	.031
122	T	.0275*	.006*	.0235
131	T	.02*	.0015*	.0215
86	F	.02*	.03*	.05
119	F	.01*	.011*	.021

Note also that the next lower form of combined nitrogen was likewise extremely low. Yet these stations contained the very densest vegetation to be found in the entire lake. Analyses at different depths show that the nitrogen content was practically the same from top to bottom in these stations. Hence samples taken from near the surface were trustworthy. The following two vertical series show this clearly.

No.	Station	Depth	Parts per million of		
			NO_3	NO_2	Sum
98	R	Surface	.24*	.055*	.295
99	R	.15M deep	.40*	.09*	.49
100	R	1.0M deep	.40*	.085*	.485
101	R	1.5M deep	.32*	.075*	.41
102	R	1.8M (bottom)	.29*	.075*	.355
119	F	Surface	.0125*	.007*	.0195
118	F	.4M deep	.01*	.011*	.021
120	F	.8M (bottom)	.02*	.012*	.032

From the fact that the regions of greatest plant growth are the regions of lowest content of available nitrogen it would seem that nitrogen content of itself can not be a determining factor of great importance. This rather radical statement is to be tempered somewhat in consideration of the fact that most of the increase of plant growth was made before the nitrate went so low. A look at the data will show, however, that some increase was made after July 1, when nitrate was .09* parts per million and a

*After an analysis indicates that the analysis was carefully checked.

great increase was made after June 26 when the nitrate was .20* parts per million. At both of these times, however, the nitrite was very high and no doubt nitrate was being formed very rapidly by conversion of nitrites into nitrates. In fact the data indicate such a process most definitely. In one case I found (Station T; July 12, Fig. 8) a rapid increase of plants while both nitrates and nitrites were low (Nitrate .025* and Nitrite .006 parts per million.) If this last case could be considered representative it would mean that preformed nitrate or nitrite content is not a determining factor in plant growth, but one analysis, checked though it was, is too slender a basis for so broad a statement. It does, however, serve to emphasize the probability that the nitrogen supply in so far as it is a determinant acts not as a preformed, static condition, but as a dynamic process whereby the complex molecules of albuminoid are converted to constantly simpler and higher oxidized forms available for plant assimilation.

It might be thought that plants absorb considerable nitrate from the sediment of the bottom. Several considerations make this improbable:

(1) Although no analyses of the sediment were made, it is unlikely it contained a very large amount of nitrate. The analyses taken of samples very near the bottom show even a lower concentration at that place. Then too, diffusion would tend to remove the soluble form from the sediment.

(2) The lower part of the stem of plants like *Potamogetons* and *Elodea*, which were most abundant has very little physiological function, but serves merely as a holdfast.

(3) It is difficult to understand how a plant stem of small diameter would be able to transport a highly soluble and readily dialyzed substance through a space filled with water in which a low tension of the same substance exists, without losing it to the surrounding medium.

(4) In these same regions of densest growth floating plants were especially abundant (Algae and Spirodela predominating). These plants of course had no direct connection with the bottom.

After consideration of the above facts it seems very unlikely that the content of the sediment has any appreciable effect upon the plant growth except as ft affects the composition of the water about the plants.

Summary: The following facts are indicated by the data:

(1) The growth of plants greatly reduces the amounts of nitrates and nitrites in regions where currents are inhibited, and to a less extent in all regions of the lake. This reduction became marked in this lake about the first of July.

(2) The contents of all the compounds under consideration rose during the winter with the exception of the nitrite which fell almost to zero.

(3) Nitrate and nitrite rose very rapidly in the months of April and May and first few days in June. This was no doubt due to the bacteria getting started before the plants and so building up a surplus of these forms.

(4) In regions of extremely dense vegetation the nitrate and nitrite were reduced to an extremely low figure after the latter part of July.

(5) The nitrate supply for the growing plants need not be preformed, provided there is a supply of the more complex compounds upon which bacteria may work and so produce the simpler forms required for plant assimilation.

(6) The albuminoid and ammonia content of the water serves as a storehouse from which the simpler forms are made by oxidation processes. The sediment of the bottom serves in the same way. Stirring of the water produces great variations in the content of the albuminoid and ammonia.

(7) Plants may flourish in water containing an extremely small amount of nitrate and nitrite, provided the conditions for producting these forms are present.

(8) Sewage discharge into the lake was favorable to plant growth. It is likely that the availability of the nitrogen in this discharge was the main determining factor.

Appendix.

The following pages contain a number of graphs which are of interest only to those who are especially interested in the subject. The data from which all of the graphs in the paper were made are included in this portion.

For the sake of brevity various arbitrary symbols were used in making the graphs and in recording the data. The following key will render them intelligible.

Condition of the Sky—
- c—clear.
- d—dark, cloudy.

Condition of the surface of the Lake—
- m—calm, smooth, mirror.
- t—ripples.
- r—rough.

Temperature conditions—
- h—hot.
- w—warm.
- n—moderate.
- x—cool.
- z—cold.

Amount of Vegetation—
- vv—extremely dense.
- v—dense.
- a—abundant.
- s—sparce.
- o—none.

When the above symbols are enclosed in parenthesis () they indicate that the conditions represented existed just previous to the time of taking the sample. In case a number is enclosed in the parenthesis it means that the represented conditions have existed for that many days.

Illustration of the use of the symbols:

Cmh(10)vv means clear, calm, hot, at the time and for the ten days just preceding, very dense vegetation.

Ctn(dxr)o means clear, ripples, moderate temperature, at the time sample was taken and that the period preceding was dark, cool, and the lake rough; no vegetation found in that particular station.

The following arbitrary signs are used in recording the data also.

* after an analysis means it was checked for accuracy.

??? means that an analysis was doubtful and hence rejected.

– – – means that no attempt was made to determine the amount of the particular compound in question.

The nitrite for Station F is very similar to that for Station T (Fig. 8.)

Also as in Fig. 13, the region of greatest plant growth was the region of lowest nitrate content.

Vegetation was rapidly increasing during the time covered.

(1) Note the great difference in nitrite at different dates in the case of Station T.

(2) In each case the region of greatest plant growth is the region of lowest nitrate content.

(3) Nitrate estimate in analysis 109 is probably an error, being too high. Analysis 109 was one of the very few of the last one hundred analyses which was unchecked for accuracy.

(4) The amount of vegetation increases rapidly from June 28 to July 26.

(5) In the following three graphs the horizontal spaces have no time significance. The grouping is entirely arbitrary and merely a matter of convenience.

(1) Note that altho the graph for nitrite is nearly straight, in every case save that for July 5 it describes a very much flattened out letter M. This seems more than accident, and considering the slight differences is surprising. Note too that an error of .015 parts per million would be all that was necessary to spoil the figure even in that case (July 5).

(2) Note that the nitrites gradually ascend in relation to the nitrates.

(3) The points indicated in (1) and (2) indicate that a definite relation exists between the stations and that these relations remained quite constant even while the group relations changed as time progressed.

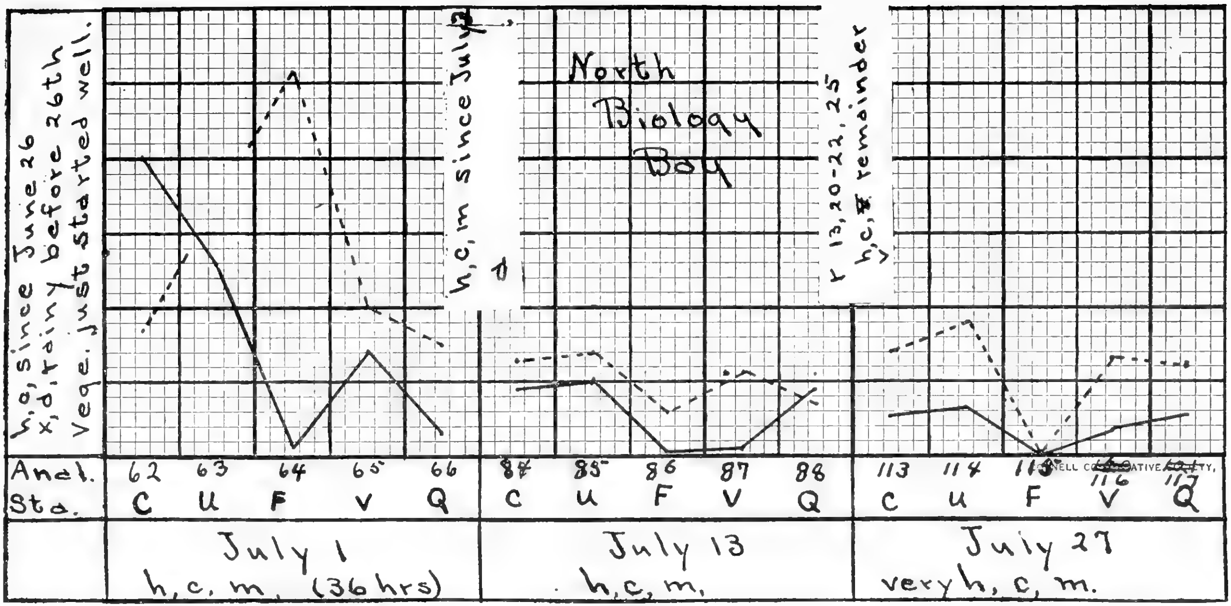


Fig. 12. North Biology Bay.

(Data for Station C given in Table 1; for Station F in Table 7; and for Stations U, V, and Q in Table 5.)

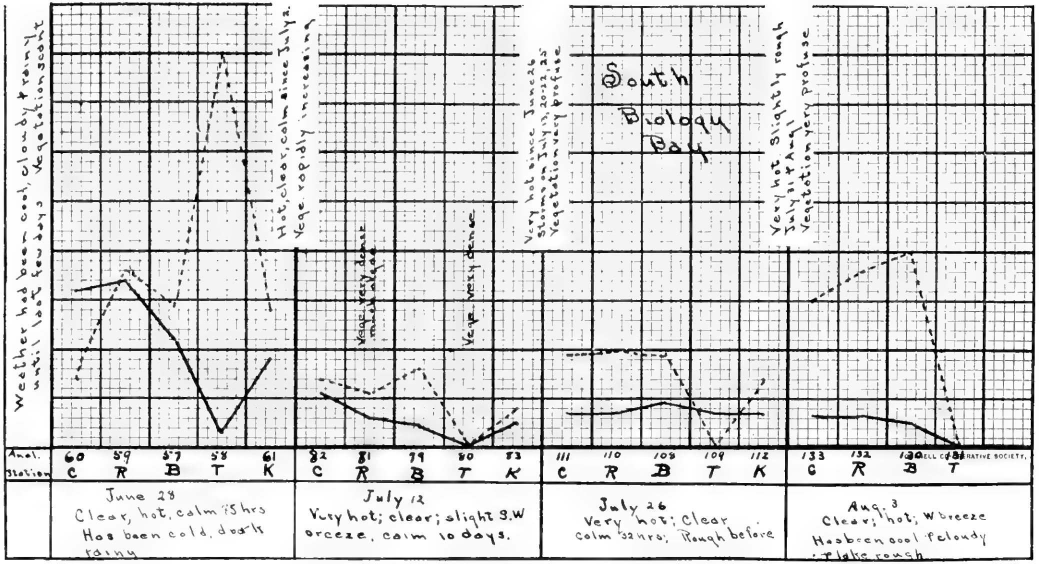
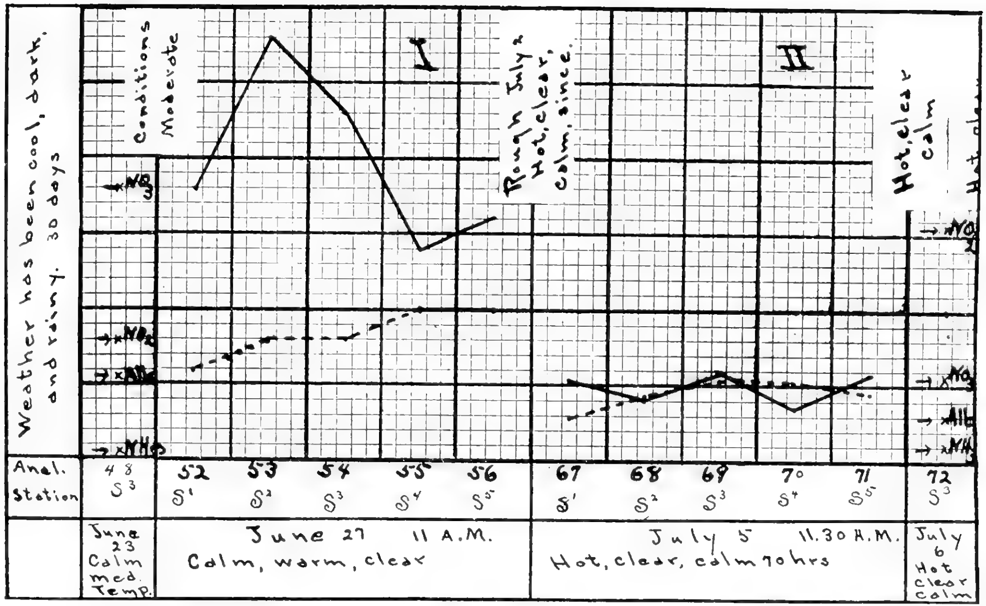


Fig. 13.—South Biology Bay



Weather has been cool, dark, and rainy. 30 days
Conditions Moderate
I
Rough July 2 Hot, clear, calm, since.
II
Hot, clear calm
Anal. Station
48 S3
52 S1
53 S2
54 S3
55 S4
56 S5
67 S1
68 S2
69 S3
70 S4
71 S5
72 S3
June 23 Calm med. Temp.
June 27 11 A.M.
Calm, warm, clear
July 5 11.30 A.M.
Hot, clear, calm 70 hrs
July 6 Hot clear calm

Fig. 14.

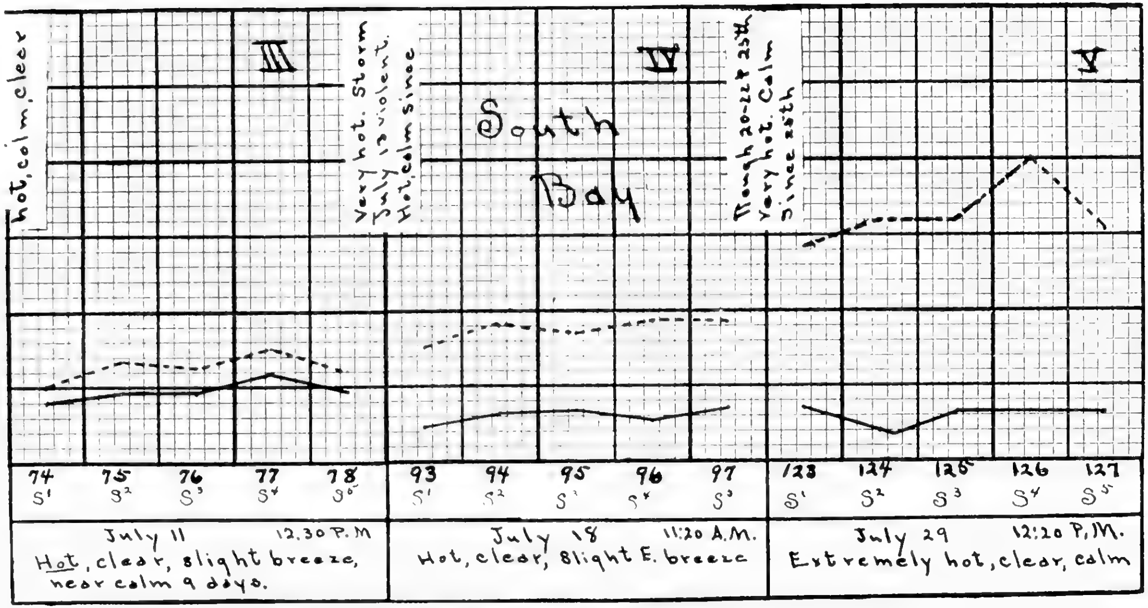


Fig. 15.—South Bay (See Table 3.)

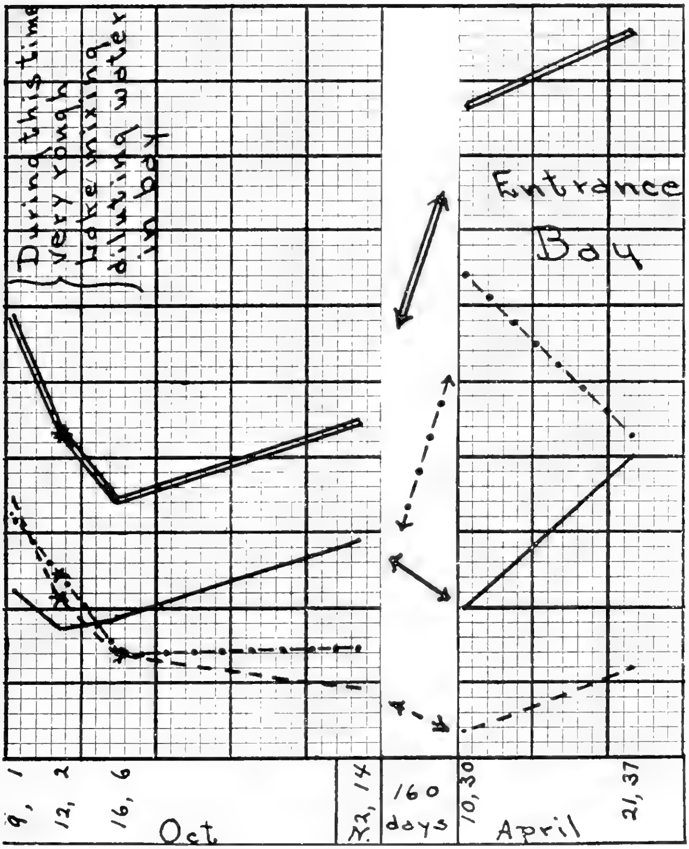


Fig. 16.
Entrance Bay—(See Table 8.)

The total nitrogen content greatly increased due to the large increase of albuminoid over winter.

TABLE 1.—(See Figs. 2 and 3.)

Samples taken from the lake body at the deepest place.

Data represented in Figures 2 and 3.

No.	Sta.	Date	Remarks	NO_3	NO_2	Sum.	Free NH_3	Alb. NH_3	Total NH_3	Total N (combined)
5	C	10–15	cm(wr)o	.72	.066	.786	???	???	.59	1.376
7	C	10–18	cto	.72	.07	.79	.076	.676	.752	1.542
25	C	3–25	rx-some ice	1.20	.004	1.204	.01	1.76	1.77	2.974
28	C	4–1	r(4)o	1.04	.036	1.976	.034	1.396	1.43	2.506
39	C	4–22	dxr(r)o	2.50	.064	2.56	1.0*	.987*	2.007	4.571
44	C	6–19	r o	1.55	.10*	1.65	???	???	.554	.204
46	C	6–21	r(r)o	1.90*	.165	2.065	....	....	1.194	3.259
60	C	6–28	cmh(3)o	1.60*	.07*	1.67	....	....	....	....
62	C	7–1	cmh(1)o	2.00*	.085	2.085	....	....	....	....
73	C	7–8	cth o	.51*	.09*	.60	....	....	....	....
82	C	7–12	cth(10)	.55*	.07*	.62	....	....	....	....
84	C	7–13	cmh(11)	.45*	.065*	.515	....	....	....	....
89	C	7–15	cth(r)o	.35*	.07*	.42	....	....	....	....
105	C	7–22	crh(3)o	.40*	.094*	.494	.145	1.60	1.745	2.239
111	C	7–26	cmh(1)o	.36*	.096*	.456	....	....	....	....
113	C	7–27	cmh(2)o	.28*	.072*	.352	....	....	....	....
129	C	8–1	r(r)o	.24*	.16*	.40	....	....	....	....
133	C	8–3	crh o	.32*	.02*	.34	....	....	....	....

TABLE 2. (See Fig. 4.)

Data from which Vertical Series Graphs were made.

No.	Date	Depth in Meters	NO_3	NO_2	Total Nitrogen
89	7–15	Surface	.35*	.07*	???
105	7–22	Surface.	.40*	.094*	2.239
129	8–1	Surface.	.24*	.16*	1.485
133	8–3	Surface.	.32*	.18*	....
	Average	Surface.	.33	.126	1.85
90	7–15	4	.50*	.07*	???
106	7–22	4	.32*	.105*	1.022
134	8–3	4	.28*	.11*	1.31
	Average	4	.37	.95	.16
91	6–15	10	1.30*	.008	???
107	7–22	10	1.20*	.022*	2.147
135	8–3	10	1.32*	.02*	2.16
	Average	10	1.27	.017	2.15
92	7–15	14.5	1.00*	.014*	1.849
104	7–21	14.5	1.36*	.025*	2.015
	Average	14.5	1.18	.0195	1.932
103	7–21	21	.44	.14*	1.695
128	8–1	21	.60*	.10*	2.105
	Average	21	.53*	.12	1.849

TABLE 3.

Samples taken from South Bay.

Data represented in Figures 14 and 15.

No.	Sta.	Date	Remarks	OO_3	NO_2	Sum.	Free NH_3	Alb. NH_3	Total NH_3	Total N (combined)
48	S3	6–23	dnm(3)o	1.80*	.08*	1.88	.036	.549	.584	2.464
52	S1	6–27	cmw(3)a	1.80*	.06*	1.86*	....	....	....	....
53	S2	6–27	cmw(3)a	2.80*	.08*	2.88	....	....	....	....
54	S3	6–27	cmw(3)o	2.30*	.08*	2.38	....	....	....	....
55	S4	6–27	cmw(3)s	1.40*	.10*	1.50	....	....	....	....
56	S5	6–27	cmw(3)a	1.60*	.10*	1.70	....	....	....	....
67	S1	7–5	cmh(3)a	.51*	.029*	.539	....	....	....	....
68	S2	7–5	cmh(3)a	.40*	.043*	.443	....	....	....	....
69	S3	7–5	cmh(3)o	.56*	.054*	.614	....	....	....	....
70	S4	7–5	cmh(3)s	.355*	.051*	.406	....	....	....	....
71	S5	7–5	cmh(3)a	.56*	.045*	.605	....	....	....	....
72	S3	7–6	cmh(4)o	.55*	.155*	.705	.10	.298	.398	1.103
74	S1	7–11	cth(m9)a	.40*	.05*	.45	....	....	....	....
75	S2	7–11	cth(m9)a	.46*	.068*	.528	....	....	....	....
76	S3	7–11	cth(m9)o	.45*	.063*	.513	....	....	....	....
77	S4	7–11	cth(m9)s	.58*	.075*	.655	....	....	....	....
78	S5	7–11	cth(m9)a	.84*	.06*	.54	....	....	....	....
93	S1	7–18	cth(4)a	.24*	.076*	.316	....	....	....	....
94	S2	7–18	cth(4)a	.32*	.09*	.41	....	....	....	....
95	S3	7–18	cth(4)o	.34*	.085	.425	....	....	....	....
96	S4	7–18	cth(4)s	.28*	.094*	.374	....	....	....	....
97	S5	7–18	cth(4)a	.36*	.094*	.454	....	....	....	....
123	S1	7–29	cmh(4)a	.36*	.144*	.504	....	....	....	....
124	S2	7–29	cmh(4)a	.20*	.16*	.36*	....	....	....	....
125	S3	7–29	cmh(4)o	.32*	.16*	.48	....	....	....	....
126	S4	7–29	cmh(4)s	.32*	.20*	.52	....	....	....	....
127	S5	7–29	cmh(4)a	.32*	.152*	.472	....	....	....	....

TABLE 4.—(See Figures 6, 7 8 and 13.)

Samples taken in South Biology Bay.

No.	Sta.	Date	Remarks	NO_3	NO_2	Sum.	Free NH_3	Alb. NH_3	Total NH_3	Total N (combined)
3	B	10–13	cm(r)s	.56	.034	.594	.18	.8	.86	1.454
4	B	10–14	r(cm)s	.64	.036	.676	....	....	....	....
9	B	10–21	m(m)s	.72	.04	.76	.09	.712	.802	1.562
23	B	3–20	ice on lake body	.80	024	.824	.05	.65	.70	1.524
36	B	4–15	cr(r)o	1.44	.05	1.49	.04	.585	.625	2.115
45	P	6–20	cm a	.75	.05	.80	.068	.97	1.038	1.838
57	B	6–28	cmh(3)s	1.10*	.144*	1.244	....	....	....	....
58	T	6–28	cmh(3)v	.15*	.40*	.55	....	....	....	....
59	R	6–28	cmh(3)a	1.70*	.18*	1.88	....	....	....	....
79	B	7–12	cmh(10)s	.22*	.08*	.30	....	....	....	....
80	T	7–12	cmh(10)vv	.025*	.06*	.031	....	....	....	....
81	R	7–12	cmh(10)a	.30*	.055*	.355	....	....	....	....
98	R	7–19	cmh(6)a	.24*	.055*	.295	....	....	....	....
108	B	7–26	cmh(1)s	.46*	.094*	.554	....	....	....	....
109	T	7–26	cmh(1)vv	.35(?)	.004*	.354	....	....	....	....
110	R	7–26	cmh(1)a	.36*	.10*	.46	....	....	....	....
122	T	7–28	cmh(3)vv	.0275*	.006*	.0235	....	....	....	....
130	B	8–3	chr s	.24*	.20*	.44	....	....	....	....
131	T	8–3	chr vv	.02*	.0015*	.0215	....	....	....	....
132	R	8–3	chr a	.32*	.18*	.50	....	....	....	....

TABLE 5.—(See Fig. 12.)

Samples taken in North Biology Bay

No.	Sta.	Date	Remarks	NO_3	NO_2	Sum.
63	U	7–1	cmh(1)s	1.30*	???	???
65	V	7–1	cmh(1)v	.70*	.10*	.80
66	Q	7–1	cmh(1)a	.175*	.075	.250
85	U	7–3	cmh(11)s	.50*	.07	.57
87	V	7–13	cmh(11)v	.055*	.056*	.111
88	Q	7–13	cmh(11)a	.45*	.034*	.484
114	U	7–27	cmh(2)s	.32*	.09*	.41
116	V	7–27	cmh(2)v	.18*	.65*	.245
117	Q	7–27	cmh(2)a	.28*	.06*	.34

TABLE 6.—(See Fig. 16.)

Samples taken in Entrance Bay.

No.	Sta.	Date	Remarks	NO_3	NO_2	Sum.	Free NH_3	Alb. NH_3	Total NH_3	Total N (Combined)
1	A	10-19	cms	1.12	.172	1.292	.64	1.02	1.66	2.952
2	A	10-12	cm(r)s	.88	.108	.988	.48	.78	1.26	2.268
6	A	10-16	cm(r)s	.96	.072	1.032	.104	.584	.688	1.73
14	H	11-2	xr(cmw)s	1.44	.048	1.488	.052	.68	.732	2.22
30	A	4-10	rp	1.00	.016	1.016	.09	3.14	3.23	4.246
37	A	4-21	dxto	2.00	.06	2.06	.86	2.60	2.686	4.746

TABLE 7.—(See Figure 9.)

Samples taken from the Canal between 11th and 12th Streets.

10	F	10-22	cmw(7)vv	.05	.016	.066	.05	.994	1.044	1.11
11	G	10-23	cmw(8)vv	.09	.022	.112	.106	.70	.806	.918
12	G	10-25	cmw(10)vv	.08	.013	.093	.096	.782	.878	.971
13	F	10-28	cmw(13)vv	.08	.016	.96	.052	1.024	1.076	1.172
26	M	3-27	r(r)o	1.20	.036	1.236	.47	.794	1.264	2.50
32	F	4-17	r(r)o	3.48*	.05	3.53	???	???	2.19	5.72
34	G	4-19	cm o	1.60	.056	1.656	???	???	.95	2.606
35	F	4-20	c o	1.36	.06	1.42	???	???	1.106	2.526
41	G	4-25	dx(dx)o	???	???	???	.16	.492	.66	....
49	G	6-24	wm(3)s	.80*	1.0**	1.80	.05	1.432	1.482	3.282
50	G	6-26	cm a	.20*	.49*	.69	.51	.518	1.028	1.718
64	F	7-1	cmh(1)v	.09*	.257*	.347	....	....	....	....
86	F	7-13	cmh(11)v	.02*	.03*	.05	....	....	....	....
119	F	7-28	cmh(3)vv	.01*	.011*	.021	....	....	....	....

TABLE 8.—(See Figure 11.)

Samples taken from Pocahontas Creek. (Main Inlet.)

17	K	11-15	rx(rx)o	1.00	.04	1.04	.106	.48	.586	1.626
18	K	11-16	rx(rx)o	1.00	.032	1.032	.166	.414	.58	1.612
20	K	3-15	rx(rx)o	.80	.018	.818	.14	3.50	3.64	4.458
21	K	3-16	rx(rx)o	3.36*	.02	3.38	.10	.52	.62	4.00
22	K	3-17	rx(rx)o	1.60	.036	1.636	.034	2.94	2.974	3.916
40	K	4-24	dx o	2.25	.068	2.318	.04	1.34	1.39	3.648
51	K	6-27	rain o	.49	.02	.51	.062	.70	.762	1.272
61	K	6-28	cmh(3)o	.90*	.14*	1.04	....	....	....	....
83	K	7-12	cmh(10)o	.25*	.04*	.29	....	....	....	....
112	K	7-26	cmh(1)o	.34*	.07*	.41	....	....	....	....

Compare with sample taken at mouth of Sugar Creek.

42	O	4-26	dx(dx)o	.48	03	.51	.004	.40	.404	.914

A Remarkable Case of Fasciation in Oenothera Biennis.

Paul Weatherwax

Near the middle of last July a student brought into one of the laboratories of the Botany Department of Indiana University a specimen of *Oenothera biennis* L., the stem of which was fasciated to such a remarkable degree that it is considered worthy of mention here.

The height of the plant was about 1.5 meters, which is probably a little more than the average for the plant in the vicinity of Bloomington; but the width and thickness of the stem were very much out of proportion to the height and to each other. Near the ground it was 5 cm. wide and 2 cm.

thick, but at the height of a meter, it was 21 cm. wide and only 5 to 8 mm. thick.

The upper part of the stem, for 15 or 20 cm., was divided into three thin flat branches, one of these being still further divided at the tip; and, near the base, there were three small, slender branches which were normal in appearance. (See the figure.)

The whole plant had a perfectly healthy appearance. The stem was densely covered with leaves, those near the edge being like the average for the species, and those farther away from the edges being much smaller than normal.

Covering the tips of the thin flat branches at the top of the plant, were a large number of flower buds—probably more than a thousand. Among these were several flowers and a few young fruits.

Since fasciation has, in some cases, proved a very profitable characteristic for experimental work, it would be interesting to test the hereditary qualities of such a phenomenal plant, but its seeds were not mature, and the roots are, of course, not expected to live for another flowering season. A search will be made for similar plants in the same locality next year.

A Variation in Plantago Lanceolata.

Paul Weatherwax.

A variant form of *Plantago lanceolata* L. has been under observation by the writer for somewhat more than a year and offers an opportunity for further interesting work. A preliminary report will be given here for the

Fig. 1—Plantago lanceolata L. Normal plant at the left; the variation at the right.

purpose of finding out whether or not the peculiarity has been observed elsewhere.

The original plant was found near the Indiana University waterworks reservoir, north of Bloomington, in June, 1915. It was immediately transplanted to the University Campus, and, although flowers were present at the time, no seeds were matured that year. In October the root was separated into four parts and transferred to the greenhouse. During the winter the plants grew well, but no flowers were produced until the regular flowering time for the species, the plants having been transplanted outside in the meantime. Then many inflorescences appeared, and several seeds matured during the summer and fall.

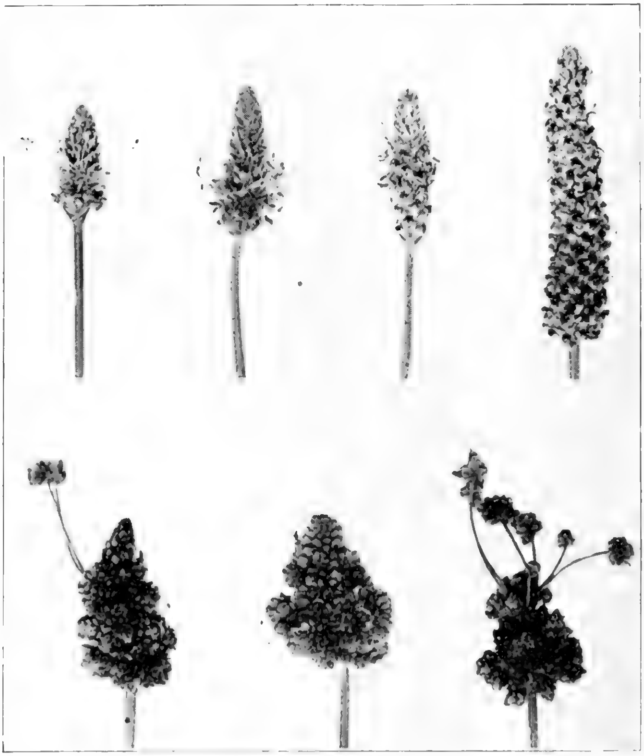


Fig. 2—Inflorescences. Above, normal inflorescences of different ages; below, compound inflorescences of the abnormal form.

Throughout the period of observation, the striking feature has been the shape and structure of the flower cluster. The normal inflorescence of the species is a spike; that is, the flowers are sessile on a single common axis; but in this plant the inflorescence is made up of a number of short, conical spikes arranged in a conical aggregation around the end of the scape as a central axis. In many instances the stalks of these spikes are considerably elongated. (See the figures for a comparison of the variation with the type form.)

The details of the flower have not yet been examined thoroughly, but it seems that only a few of them function; and, of these, a great many do not have normal stamens. No other plant of the genus was allowed to grow within a radius of 250 feet from this one during the past summer, and it is very probable that self-pollination was the only means of seed production. The small number of seeds produced—only 10 to 20 in an inflorescence—may be correlated with the scarcity of pollen.

In some ways the abnormality resembles those caused by insect or fungous diseases in some other plants, but no organism has been found in this case, and there is no good evidence of the presence of a parasite in the tissue of any part of the plant. Moreover, if a parasite is present, it has remained with the plant through a variety of conditions of environment, and is not known to have been transmitted to any other plant of the species. This possibility as to the cause of the peculiarity will be investigated later if no positive results are obtained from the investigations now in progress.

Some of the seeds have been planted, and a fair per cent of them have germinated. If the peculiarity reappears in the next generation, it will furnish good reason for treating this plant as a definite specimen of mutation. The roots of the old plant have again been divided and transplanted and give promise of at least another season's growth.

The writer has observed the same variation in this species on two other occasions, but on the first of these the significance of the peculiarity was not realized, and no thorough examination was made. In the other instance the plant was examined carefully, and it was found that only a few inflorescences were abnormal. The spikes of *Plantago Rugellii* Dcne. often show a similar tendency by being more or less branched, especially when growing in rich soil and well supplied with moisture. But the variation here described does not seem to be in any way connected with soil or moisture conditions; and every one of the 500 or more inflorescences produced during the past summer has consistently shown this peculiarity.

Weed Seeds in the Soil.

F. J. Pipal.

In spite of the continued fight the farmer is waging against weeds he finds that these tramps of the vegetable kingdom manage to keep his farm well stocked with their seed and are able to produce abundant crops of their kind every season.

Most weeds produce a great abundance of seed. Single, rather large specimens of crabgrass and foxtail, our two commonest weed-grasses, will produce about 100,000 seeds each. Purslane, pigweeds, speedwell, and Canada fleabane will even exceed this number. Individual plants of many other species of common weeds produce seeds ranging high in thousands. It is readily seen that at this rate of seed production it is not necessary for very many plants to reach maturity in order to keep the soil well seeded.

Blatchley stated, in his Indiana Weed Book, that "Those weeds which are most common and successful in cultivated fields are in general those which by reason of a quick growth are enabled to produce and ripen an enormous number of seeds."

Aside from being able to seed the ground abundantly most of the weed species have also provided their seeds with excellent protective coverings against loss of vitality when unfavorable conditions prevent their germination. Species of Rumex, Plantago, Polygonum, Amaranthus, Chaetochloa, and the Mustard family especially are well known for their ability to remain viable for many years while buried deep in the soil. Seeds of the members of the mustard family owe their longevity, in part, it is claimed, to the great preserving power of the oil which they contain.

Professor Beall[1] found by actual tests that "Shepherd's Purse, Mustards, Purslane, Pigeon-grass, Pigweeds, Peppergrass, Mayweed, Evening Primrose, Smartweed, Narrow-leaved Dock, two Chickweeds, survive when buried in the soil thirty years at least. . . ."

J. S. Grennell,[2] commenting upon the wonderful vitality of mustard seed, made the following statement: "We have known of a piece of ground that had not been ploughed for thirty years at least, which, after the first ploughing in spring, was yellow with the charlock. . . ." Mr. Grennell also stated that "A blackish earth was found beneath an old building known to have existed over two hundred years; when this earth was spread abroad, a quantity of marigold came up all over it, although it had never been seen in that place."

It does not seem possible that the seed of this particular weed would retain its vitality for two hundred year., but such evidently was Mr. Grennel's observation.

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[1] Michigan Agricultural Experiment Station Bulletin No. 260, p. 105.
[2] Report on Agriculture of Massachusetts, 1861, p. 106.

Farmers often report that certain weeds, as red sorrel and white top, for example, spring up in the meadows in great abundance, although they had not been seen there for several years. The story of wheat turning into cheat is no doubt familiar to all. Some farmers also think they have reasons to believe that timothy will turn into red top, cultivated oats into wild oats, and that weeds come up sometimes spontaneously. The followers of such beliefs have evidently not yet realized that the seeds of many weeds may lie dormant in the soil and retain their vitality for many years, and start into growth whenever a favorable opportunity presents itself. The sudden disappearance from the field of some weeds can sometimes be accounted for in a similar way.

As regards the number of viable weed seeds found in the soil several investigations have been made in the past, and some very interesting findings have been reported.

The First Annual Report of the New York (Geneva) Agricultural Experiment Station contains a statement that "On June 22 a single square foot of soil in the garden, which had been plowed and harrowed in the spring, contained 356 growing plants, comprising seven distinct species, not counting clovers and grasses."

Professor Prentiss,[3] of New York, who investigated seven samples of soil taken from different sites and types reported the following results:

A sample taken beside a brook, where the soil had been washed and deposited, contained viable weed seeds at the rate of 13,000,000 per acre.

Another sample taken from a garden also contained weed seeds at the rate of 13,000,000 per acre.

Samples from a compost heap and potting soil produced viable weed seeds at the rate of 34,000,000 and 23,000,000 per acre, respectively.

Muck soil yielded only about 1,000,000 seeds per acre.

A strip of recently plowed sod produced weeds during the season at the rate of 175,000 per acre. Another strip of old sod ground, but cultivated for two or three seasons, produced 80,000 weeds to the acre during the same season.

Dr. Arthur,[4] reported the following results from his investigations at the New York (Geneva) Experiment Station:

8,826 weeds, comprising 45 species, were picked from a strip, covering one-twentieth of an acre, of old pasture land plowed in the spring. Almost one-half of this number was Canada thistle, and over one-fourth foxtail. Another strip of the same size but which had been cultivated during the preceding four years, produced 4,095 weeds, comprising 37 species. Almost one-half of the number was fox-tail.

Two other plots, each one-twentieth of an acre in size, yielded as follows: The first plot which had been cultivated in the spring and cropped the

[3] Transactions of the New York Agricultural Society, 1883-1886, pp. 298-299.
[4] New York (Geneva) Agricultural Experiment Station Annual Reports 1885, pp. 262-265; 1886, pp. 281-283; 1887, pp. 356-363.

preceding season brought forth, during the growing season, 12,068 specimens of weeds, including 28 species; two-thirds of the total was foxtail. The second strip, turned over from an old meadow and adjoining a roadside, produced 38,432 weeds, including 39 species; crabgrass and purslane numbered over one-half of the total.

In another series of similar investigations Arthur secured four samples of soil, two in December and two in April, and placed them in the greenhouse. Plants growing out of these samples were pulled and counted every month for one year.

The following is the record of the number of weeds produced:

A. A square foot of soil, three inches deep, taken in December from a plot which had clean cultivation, produced 29 specimens of grass and 60 specimens of other species of weeds.

B. A square foot of soil, three inches deep, taken in December from a plot which was allowed to run to weeds the previous season, produced 35 specimens of grass and 349 specimens of other weeds.

C. A square foot of soil, one and one-half inches deep, taken in April from the same plot as A, produced 81 specimens of grass and 57 specimens of other weeds.

D. A square foot of soil, one and one-half inches deep, taken in April from the same plot as B, produced 271 specimens of grass and 378 specimens of other weeds.

Bulletin 3, of the Department of Agriculture and Immigration, Winnipeg, Canada, contains the following reference to weeds: "Their seeds are found in all soils, and experiments have been made which show that ordinary garden soil contains 1,300,000 such seeds to the acre."

Hitchcock and Clothier,[5] at the Kansas Agricultural Experiment Station, removed and recorded weed seedlings, for five consecutive seasons, from two plots, of ten square feet, located on poor soil, with the following results:

One plot produced 37,639 weeds, including 79 species, and the other plot produced 70,825 weeds. Purslane, water hemp (Acnida sp.), buffalo bur, stink-grass (Eragrostis major), and Crab-grass were the most common species.

H. S. Fawcett, of the Ames College, Iowa, picked 187,884 weeds, on June 2, on one square rod of garden soil. On another plot, of the same size but which had received more cultivation, he counted 50,736 weeds. Foxtail, Pennsylvania smartweed, Canada fleabane, hedge mustard, and common goosefoot were the most common species.

Another interesting determination was made on the Buzuluk Experimental Field, in Russia, by Bazhanov.[6] He found 3,000 seeds per one square meter of seed bed, two inches deep, or 34,000,000 seeds per one hectar (13,760,000 per acre), and 160,000,000 per hectar (64,750,000 per acre),

[5] Kansas Agricultural Experiment Station Bulletin No. 80, pp. 124-128.

[6] Bulletin Appl. Botany VIII, pp. 276-293. 1915. Extract in Botanisches Centralblatt, Band 129, No. 20, pp. 525-526.

but eight inches deep. The total number of weeds observed on this field included 107 species.

The writer made investigations, during the past five years, along similar lines. In addition to ascertaining the number of viable weed seeds in the different samples of soil used, it was also the intention to learn what difference there was in this respect, between soils carefully tended and those receiving poor cultivation. Still another object was to learn at what depth most of the seeds are usually found, and also what species are most prevalent.

Samples of soils were secured from various sites, during the months of November and December, and placed in boxes or pots in the greenhouse. When the growing weeds were large enough to allow definite determination of the species they were pulled and recorded. This process was continued until all viable seeds had germinated. The soil was stirred occasionally or repotted to hasten germination. All samples were kept for a considerable period after the last specimens of weeds were removed to make sure that all viable seeds had opportunity and time to grow.

In each of the following five samples a square foot of soil was taken to a depth of six inches and separated into the upper and the lower three-inch layers. These samples were secured from the following sites:

1. A rye field, which prior to this time had been repeatedly planted to corn for several years, the crops having been rather poorly tended. (Two samples.)
2. An old abandoned orchard, used to some extent for gardening purposes.
3. An experimental plot on Purdue Farm, used mostly for corn, cow-peas and soy beans. This ground was carefully tended.
4. A garden patch. well tended until midsummer, then allowed to run to weeds.
5. A blue-grass sod, in an old permanent pasture.
6. In addition to the above a cubic foot sample was taken from site No. 1 (the rye field), and separated into the successive inch layers, each layer being potted separately.

The first specimens of weeds were picked, in each case, about a month after the soil samples were potted and placed in the greenhouse. The pulling process was continued, about two months apart, for nearly two years.

Table 1, on the following page, shows the number of plants of each species that grew from the upper and the lower three-inch layers of the various soil samples.

The figures in the table indicate that the grass-weeds are usually the most common intruders in the gardens and fields. This is especially true of crab-grass, which undoubtedly is the most common and persistent grass-weed in the state.

The comparatively large numbers of peppergrass, shepherd's purse, and carpetweed, found in the garden, justify the title of "social weeds," frequently applied to these particular species. They do not seem to be able

TABLE 1.

Number of weed seeds found in the upper and lower three-inch layers of a square foot of soil.

NAME OF WEED.	Location of Soil Sample.											
	Rye Field				Orchard		Purdue Field		Garden		Sod	
	First 3″	Second 3″	First 3″	Second 3″	First 3″	Second 3″	First 3″	Second 3″	First 3″	Second 3″	First 3″	Second 3″
Syntherisma sanguinale	93	49	62	27	64	51	30	30	46	31	...	...
Echinochloa Crus-galli	12	13	...	...	...	...	...	...	...	...	...	...
Chaetochloa glauca	7	1	2	2	33	14	7	5	...	...	...	...
Panicum capillare	3	...	...	...	...	...	...	...	...	2	...	...
Muhlenbergia sp.	2	...	...	...	...	...	...	...	...	...	...	...
Eragrostis sp.	1	...	31	19	21	24	1	4	10	5	...	...
Poa pratensis	...	...	...	...	...	...	...	...	...	...	5	...
Ranunculus sp.	8	16	...	...	...	...	...	...	...	...	...	...
Mollugo verticillata	5	8	32	20	6	21	10	4	100	26	...	...
Amaranthus retroflexus	13	...	14	5	8	20	4	...	1	1	...	...
Convolvulus sepium	1	9	10	...	...	26	3	10	...	...	...	...
Xanthium sp.	5	...	...	...	...	...	...	...	...	...	...	...
Portulacca oleracea	3	2	3	5	2	6	...	...	5	15	...	...
Leptilon canadense	4	...	...	4	2	2	...	...	...	...	1	...
Trifolium sp.	3	...	1	...	...	1	...	...	...	...	...	1
Polygonum sp.	1	2	...	...	...	...	...	...	...	...	...	...
Oxalis stricta	...	3	...	...	8	4	...	3	3	...	3	...
Veronica sp.	1	2	2	...	4	9	1	3	6	19	...	...
Lepidium virginicum	2	...	5	1	33	9	3	...	152	35	1	3
Acalypha virginica	1	1	...	...	...	...	...	...	...	...	...	...
Bursa pastoris	1	1	...	1	1	3	...	...	21	43	...	...

Ambrosia artemisaefolia		1										
Alsine media	1				3	1						
Cerastium sp.											1	
Taraxacum sp.			1	1	1					1		1
Amaranthus graecizans			1			2		3				
Chenopodium album			2									
Rumex sp.				1	3							
Erigeron annuus			1		9	7						
Plantago major					1	2	1		1			
Lactuca scariola												
Euphorbia sp.							2	1	1	1		
Solanum melongena									1			
Solanum nigrum										12	3	1
Undetermined	1	10				2						
Total	168	118	167	86	199	204	62	64	347	191	14	8
Calculated per acre	7,318,080	5,140,080	7,274,520	3,746,160	8,668,440	8,886,240	2,700,720	2,787,840	15,115,320	8,319,960	609,840	348,480
Calculated per acre for 6″ layer	12,458,160		11,020,680		17,554,680		5,488,560		23,433,280		958,320	

TABLE 2.

Number of weed seeds found in the successive inch layers of a cubic foot of soil. Sample No. 6.

NAME OF WEED.	Number of the Layer.												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Syntherisma sanguinale	36	22	35	19	16	14	14	9	9	16	6	2	198
Echinochloa Crus-galli	2	6	4	5	5	3		2	2	1			30
Chaetochloa glauca	3	3	1			1	1				1		10
Panicum capillare	3												3
Eragrostis sp	1								1				2
Muhlenbergia sp			3										3
Poa pratensis										1			1
Carex sp											1		1
Amaranthus retrodexus	10	3											13
Xanthium sp	3	1	1										5
Lepidium virginicum	2				1								3
Leptilon canadensis	3	1											4
Trifolium sp	1	1	1		1		1			1		1	7
Polygonum sp	1			1		1				2	1		6
Convolvulus sepium	1			2	2	5							10
Acalypha virginica	1					1							2
Veronica sp	1					2							3
Ranunculus sp	1		7	1	4	11							24
Mollugo verticillata	1		4	3	2	3	1						14

Alsine media	1												1
Portulacea oleracea	1	2		1	1				2				7
Bursa pastoris			1			1							2
Ambrosia artemisaefolia				1				1					2
Oxalis stricta				1	2		6	4	2	4	4	1	24
Cerastium sp.					1								1
Physalis sp.								2	1	1			4
Chenopodium album									1	1			2
Undetermined	1					10							11
Total	73	39	57	34	35	52	23	18	18	27	13	4	393
Calculated per acre	3,179,880	1,698,840	2,482,920	1,481,040	1,524,600	2,265,120	1,001,880	784,080	784,080	1,176,120	566,280	174,240	17,119 080

TABLE 3.

Number of weed seeds calculated per acre.

Reported by	Site or kind of soil	No. of seeds per acre	Remarks
Exp. Station, Geneva, New York	Garden	15,507,360	Picked in June.
Prentiss	Overflow land	13,000,000	
Prentiss	Garden	13,000,000	
Prentiss	Compost	34,000,000	Total depth of soil layer not reported.
Prentiss	Potting soil	23,000,000	
Prentiss	Muck	1,000,000	
Prentiss	Plowed sod	175,000	
Arthur	Plowed pasture	176,520	Growth of current season.
Arthur	Cultivated field	81,900	Growth of current season.
Arthur	Cultivated field	241,360	Growth of current season.
Arthur	Plowed meadow	769,640	Growth of current season.
Arthur	Cultivated field	3,876,840	Total layer of soil 3 inches deep.
Arthur	Neglected field	16,727,040	Total layer of soil 3 inches deep.
Arthur	Cultivated field	6,011,280	Total layer of soil 1½ inches deep.
Arthur	Neglected field	28,270,440	Total layer of soil 1½ inches deep.
Dept. of Agric., Winipeg, Canada	Garden	1,300,000	Current season's growth.
Hitchcock and Clothier	Poor fallow ground	32,791,097	Average of five year's current growth.
Hitchcock and Clothier	Poor fallow ground	61,702,740	Average of five year's current growth.
Fawcett	Garden well tended	8,117,760	Picked in June.
Fawcett	Garden poorly tended	30,061,440	Picked in June.
Bazhanov	Cultivated field	13,760,000	Total layer of soil two inches deep.
Bazhanov	Cultivated field	64,750,000	Total layer of soil eight inches deep.
Pipal	Poorly tended field	12,458,160	Total layer of soil six inches deep.
Pipal	Poorly tended field	11,020,680	Total layer of soil six inches deep.
Pipal	Well tended field	5,488,560	Total layer of soil six inches deep.
Pipal	Permanent pasture	958,320	Total layer of soil six inches deep.
Pipal	Poorly tended garden	23,435,280	Total layer of soil six inches deep.
Pipal	Abandoned orchard	17,554,680	Total layer of soil six inches deep.
Pipal	Poorly tended field	17,075,520	Total layer of soil twelve inches deep.

to hold their own, however, especially the first two, in the open fields where competition is more severe.

The difference in the number of viable seeds found on well tended ground (Purdue plot) and neglected land is very pronounced, showing clearly the value of frequent and thorough cultivation in the control of weeds. Better cultivation of the fields and regular mowing of weeds on fallow and waste land would considerably reduce the ten million dollar loss, which is occasioned yearly in Indiana by the numerous weed pests.

The permanent sod contained, as shown in the table, a comparatively small number of viable weed seeds per square foot.

The second table shows the species and the number of weed seeds contained in the separate inch layers of sample number 6. The figures indicate that the largest number of weed seeds occurs in the surface layer. A large majority of the total number of seeds are contained in the first six inches of the soil layer. This latter fact indicates the depth at which the land in question was usually plowed. Beyond this depth the number of viable seeds is considerably reduced, leaving only four seeds in the twelfth inch, in this particular case, as compared with fifty-two in the sixth inch. At a greater depth than twelve inches the number of weed seeds, found on upland soil, is doubtless very small. On overflow land, however, it is quite likely that many viable seeds are found at considerable depths.

The third table summarizes the total number of weed seeds, calculated per acre, as reported by the investigators mentioned in this paper.

A brief reference to this work has been made in the twenty-eighth Annual Report of the Purdue University Agricultural Experiment Station, pp. 31-32.

The Effect of Hydrogen Peroxide in Preventing the Smut of Wheat and Oats.

F. J. Pipal.

In order to determine the efficiency of hydrogen peroxide in preventing the stinking smut of wheat and the loose smut of oats, a series of field tests were made on Purdue Farm, during the seasons of 1913-1914 and 1914-1915.

Nineteen lots of winter seed wheat (Egyptian Red) and nineteen of seed oats (Great Dakota), used in these tests, were mixed with spores of Tilletia foetans and Ustilago Avenae, respectively, to insure abundant infections. They were loosely wrapped in cheese cloth packets and soaked in the variously proportioned solutions of hydrogen peroxide as shown in the accompanying tables. In addition to the above samples two lots of wheat and two of oats were treated with formaldehyde solution, to compare the effect of the latter with that of hydrogen peroxide. Two checks were left in the wheat and one in the oat tests.

All treated samples were dried, at least partially, immediately after soaking, and then sown in the field. The amount of treated grain was sufficient, in each case, to seed about 300 square feet of ground. When the grain headed out, careful counts were made to determine the per cent. of smut on each plat.

The results of the first season's treatment, recorded in table 1, indicate that the weaker solutions of hydrogen peroxide increase the infection of the stinking smut of wheat to a considerable extent. In all cases, except two, where the treating solution ranged in the proportion of hydrogen peroxide to water from 1 to 100 to 1 to 25, the per cent. of smut was higher than the average of the two check plats. The average per cent. of smut of the first twelve treated plats was 18.5, as compared with 16.0 per cent. of the untreated plats. The stronger solutions and pure hydrogen peroxide effected a considerable decrease in the amount of smut but in no case was it eliminated entirely.

Further tests, made in the season of 1914-1915, in which the time of soaking was prolonged to five hours, similar negative results were obtained. The plats on which seed wheat was treated with 1 to 100, 1 to 75, 1 to 50, and 1 to 25 hydrogen peroxide solutions produced 14.6 per cent. of smutted heads, as compared with 12.1 per cent. on the check plat. No stronger solutions were used in these tests than those indicated above. The object of these trials was to use solutions of such proportions as could be employed within reasonable cost limits, in actual farm practice, in case they proved effective against the smut disease.

Table 2 shows the results of the treatment of oats in the season of 1914. The effect of hydrogen peroxide in these tests was positive in every case. Although smut was eliminated entirely only in one case (plat 19), there was a considerable reduction of it on practically every plat, especially where the seed was treated with stronger solutions (plats 13 to 19). According to the tabulated results the average per cent. of smut on nineteen plats treated with hydrogen peroxide solution was 4.9, and 11.0 per cent. on the check plat.

The tests made in the season of 1915, in which only four different strengths of solution (1 to 100, 1 to 75, 1 to 50, 1 to 25) were used and the time of soaking was increased to five hours, showed practically the same results as the tests of the preceding season. Although the percentage of smut in this crop was only two per cent., the effect of the hydrogen peroxide treatment was quite apparent in all but one case. While the plat treated with 1 to 100 solution produced two per cent. of smutted stalks the other pl.ats showed almost a uniform decrease in the amount of smut from two per cent. to six-tenths of one per cent.

In summarizing the results of these tests it may be stated that weaker solutions of hydrogen peroxide, varying in proportion from 1 to 100 to 1 to 25, not only had no effect in preventing the stinking smut of wheat but even seemed to stimulate its development and considerably increase its quantity in the crop. Stronger solutions, however, varying in strength from 1 to 15 to pure hydrogen peroxide, had perceptibly decreased the amount of wheat smut, the pure solution reducing it from sixteen per cent. to three and one-tenth per cent. In the case of oats, however, there was a gradual reduction of the smut disease in most cases, and a complete elimination of it when seed oats were soaked thirty minutes in full strength hydrogen peroxide.

The five-hour period of soaking the seed apparently had no more preventative effect on the development of smut then the one-hour period. The one-hour period was more effective in most cases than the thirty-minute period; and the latter produced better results than the fifteen-minute period.

Hydrogen peroxide had no retarding but rather stimulating effect on the germination of both wheat and oats.

Inasmuch as only pure hydrogen peroxide will materially reduce the stinking smut of wheat and entirely eliminate the smut of oats, as indicated by the results of these tests, the high cost of the treatment makes its practical application prohibitive. Formaldehyde furnishes not only a more effective but also the cheapest seed grain disinfectant.

All hydrogen peroxide used in this work was furnished by the Commercial Company, Clearing, Illinois, at whose suggestion the tests were made.

A brief reference to this work has been made in the twenty-seventh and the twenty-eighth Annual Reports (pp. 32-33, and p. 30, respectively) of the Purdue University Agricultural Experiment Station.

TABLE 1.

Treatment of seed wheat with solutions of hydrogen peroxide and formaldehyde.

Plat	Treatment		
	Parts of Peroxide to water	Time of soaking Minutes	Plants smutted Per cent.
1	1 to 100	15	23.3
2	1 to 100	30	13.0
3	1 to 100	60	13.5
4	1 to 60	15	21.3
5	1 to 60	30	18.3
6	1 to 60	60	18.6
7	1 to 40	15	20.3
8	1 to 40	30	19.1
9	1 to 40	60	16.5
10	1 to 25	15	21.3
11	1 to 25	30	20.0
12	1 to 25	60	17.5
13	1 to 15	15	14.5
14	1 to 15	30	14.4
15	1 to 15	60	8.6
16	1 to 10	15	7.7
17	1 to 10	30	6.9
18	Pure hydrogen peroxide.	15	5.4
19	Pure hydrogen peroxide.	30	3.1
20	Sprinkled with 1 to 30 formaldehyde solution.	....	.0
21	Sprinkled with 1 to 50 formaldehyde solution.	....	.0
22	Check—soaked in pure water 30 minutes.	....	17.0
23	Check—dry.	....	15.0

TABLE 2.

Treatment of seed oats with solutions of hydrogen peroxide and formaldehyde.

Plat	Treatment		
	Parts of peroxide to water	Time of soaking Minutes	Plants smutted Per cent.
1	1 to 100	15	9.2
2	1 to 100	30	9.8
3	1 to 100	60	6.0
4	1 to 60	15	9.4
5	1 to 60	30	9.8
6	1 to 60	60	4.0
7	1 to 40	15	7.5
8	1 to 40	30	3.1
9	1 to 40	60	3.6
10	1 to 25	15	7.0
11	1 to 25	30	7.0
12	1 to 25	60	4.9
13	1 to 15	15	4.0
14	1 to 15	30	3.5
15	1 to 15	60	3.9
16	1 to 10	15	1.7
17	1 to 10	30	.8
18	Pure hydrogen peroxide.	15	.9
19	Pure hydrogen peroxide.	30	.0
20	Sprinkled with 1 to 30 formaldehyde solution.	....	.0
21	Sprinkled with 1 to 50 formaldehyde solution.	....	.0
22	Check—dry.	....	11.0

Rusts of Hamilton and Marion Counties, Indiana. II

Guy West Wilson.

Since the publication of the catalogue of the *Uredinales* of this region, (Proceedings for 1905, pp. 177-182), further field work has resulted in the addition of some very interesting and important species to the list as well as extending our knowledge of others. In the former list and in the present paper those rusts which were collected in certain restricted areas are designated by an asterisk. For the sake of uniformity the same nomenclature is used altho some important changes have been made since the publication of the first paper.

12. *Caeomurus perigynus* (Halst.) Kuntze.

The material on *Carex utriculata* which was so recorded from Hamilton County has since been made the type of a new species, *Uromyces valens*, Kern, = *Nigredo valens* (Kern), Arthur. So far this species is known only from Indiana. Its aecial stage is unknown.

14. *Caeomurus Polygoni* (Pers.) Kuntze.

*On *Polygonum erectum*, L. Hamilton.

Usually very abundant on *Polygonum aviculare* L.

The present season this host was apparently free from the rust while *P. erectum* was severely infected.

40. *Coleosporium Campanulae* (Pers.) Lev.

*On *Campanula americana*, L. Hamilton.

This species was first noted in August, 1907, when it was rather rare. The present season it has been very abundant, causing partial defoliation of the host.

41. *Dicaeoma Phlei-pratense* (Erik.)

*On *Phleum pratense* L. Hamilton, Marion.

In August, 1910, this rust was noted as wide spread and fairly abundant on the timothy of roadsides and waste places, apparently not causing damage to the crop. During the present season it has been very abundant, causing serious damage in some meadows. In some cases the yield was reduced over fifty per cent over sufficient area to make a noticeable reduction in the total yield of the meadow.

42. *Dicaeoma Malvaceearum* (Bert.) Kuntze.

*On *Althea rossa* L. Hamilton.

During late June of the present season a very old bed of hollyhocks was noted as seriously infected. Later several widely scattered beds were noted as being so severely infected as to cause complete defoliation before blooming was completed. This is certainly to be ranked as one of our injurious species. The source of introduction was not determined, but the distribution and severity in attack would suggest that the rust had been with us for a number of years. However, an inquiry addressed to Dr. Arthur brought the reply that the earliest Indiana record for this rust was June, 1915. We have not seen it on any native Malvaceae.

The Ethyl-Sulphuric Acid Reaction.

P. N. Evans.

Since the time of Williamson's classical work on etherification published in 1850, the reactions between ethyl alcohol and sulphuric acid have been familiar to chemists although not thoroughly understood. There are three important reactions, leading respectively to ethyl-sulphuric acid, ethyl ether, and ethylene, and represented by the equations:

$$C_2H_5OH + H_2SO_4 = \rightarrow C_2H_5HSO_4 + H_2O \qquad (A)$$
$$2C_2H_5OH = \rightarrow C_2H_5OC_2H_5 + H_2O \qquad (B)$$
$$C_2H_5OH = \rightarrow C_2H_4 + H_2O \qquad (C)$$

In the last two reactions the sulphuric acid acts as a dehydrating agent. Other reactions of less importance are known, leading to ethyl sulphate, isethionic acid, and ethionic acid, respectively, in accordance with the equations:

$$2C_2H_5OH + H_2SO_4 = \rightarrow (C_2H_5)_2SO_4 + H_2O \qquad (D)$$
$$C_2H_5OH + H_2SO_4 = \rightarrow CH_2OH.CH_2SO_2OH + H_2O \qquad (E)$$
$$C_2H_5OH + 2H_2SO_4 = \rightarrow CH_2HSO_4.CH_2SO_2OH + 2H_2O \qquad (F)$$

No attempt is made to show the intermediate steps in the formation of the products mentioned.

The reactions depend on temperature and on the proportions of substances present. That leading to ethyl-sulphuric acid occurs at ordinary as well as higher temperatures, the others only inappreciably at ordinary temperatures.

In the writer's laboratory the first three reactions have been the subject of investigation. The formation of ether was examined as to its completeness and limitations by Miss Lena M. Sutton and the results were presented in outline to this Academy (Proceedings 1910), and published in full in the Journal of the American Chemical Society (1913, *35*, 794). The same reaction is being made the subject of further study at present as to the nature and quantities of the by-products. The formation of ethylene is also at present under investigation as to its temperature limitations, speed, and side-reactions. The ethyl-sulphuric acid reaction was last year made the subject of examination by Mr. J. M. Albertson, Assistant in Chemistry, as a thesis for the Master of Science degree, and the results are here presented in oultine.

Plan of the Work.

It will be seen from equation (A) that in the formation of ethyl-sulphuric acid one of the two acid hydrogens of the sulphuric acid is replaced by the ethyl group and neutralized, so that just half of the original acidity disappears when the reaction is complete. The degree of completeness of the reaction at any time can therefore be measured by titration of the reaction mixture with standard alkali, if there are no complications due to other reactions. This was the method followed, and methyl orange was used as the indicator. Regarding complications due to other reactions, it might be feared that dilution of the mixture before titration might reverse the reaction appreciably before the neutral point was reached, and the significance of the titration results be thus impaired. Also, disappearance of acidity might be due in appreciable measure to the reactions shown in equations (D), (E) and (F).

To determine the first point, titrations were made at various time intervals after dilution, and it was found unexpectedly that no increase in acidity occurred even in twenty-four hours. This was surprising, considering the rapidity of the reaction in the other direction (as will be shown), and the fact that the conditions of equilibrium reached were found to be approximately equivalent to half completeness in the original direction. There is apparently some marked auto-catalytic effect involved.

The essential correctness of the assumption that the completeness of the ethyl-sulphuric acid reaction was really measured by the titration was confirmed by actually isolating the product in the form of its potassium salt, as follows: To the mixture was added calcium carbonate as long as effervescence resulted, converting both the ethyl-sulphuric acid and the unchanged sulphuric acid into their calcium salts; the calcium sulphate was then filtered out and washed, and to the filtrate containing calcium ethyl-sulphate potassium carbonate solution was added until the precipitation of calcium carbonate was just complete; the filtrate from this was evaporated to dryness, and the potassium ethyl-sulphate weighed. The yield corresponded in one case to a 57 per cent completeness of reaction as compared with 59 per cent by the titration method for the same conditions; in another case the yield indicated a completeness of 60.9 per cent, and the titration one of 60.0 per cent.

To determine the speed and completeness of the original reaction, as shown by equation (A), the procedure was as follows: Equal molecular quantities of absolute alcohol and pure sulphuric acid were mixed, with precautions as to cooling to prevent a rise in temperature above that for which data were sought; it was found practicable to obtain satisfactory results at temperatures ranging from 20 to 140° C. The mixture was kept in a bath of water or sulphuric acid maintained at a constant temperature; duplicate samples were withdrawn at intervals, diluted with water, and titrated with standard sodium hydroxide.

Results.

The results obtained may be briefly stated as follows: The completeness of the reaction ranged from 58 per cent at 20° to a maximum of 60.4 per cent at 50°, and to 42.6 per cent at 140°, as calculated from the titrations, being almost constant, at 58 to 60.4 per cent, from 30° to 90°.

The time necessary for the establishment of equilibrium varied from 2.5 hours at 20° to less than 10 minutes at 70°; observations could not be completed in less than 5 minutes. This speed of reaction proves unnecessary and even undesirable the much longer time and higher temperature generally recommended for the preparation of ethyl-sulphuric acid and its salts.

Above 70° there was found to be after the first 10 minutes a very slow but steady increase of acidity with lapse of time, probably due to the formation of ether, the odor of which was observed, according to the equation

$$C_2H_5HSO_4 + C_2H_5OH \rightarrow C_2H_5OC_2H_5 + H_2SO_4 \quad (G)$$

It is evident that there would be a doubling of the acidity of the ethyl-sulphuric acid, or a return to the acidity of the original sulphuric acid, if the formation of ether were complete. To determine how rapidly this proceeded, the usual mixture of alcohol and sulphuric acid was kept at 140°; the titrations ranged from 15.2 cc alkali at the end of 5 minutes to 23.0 cc at the end of an hour. The original acidity would have corresponded to 19.7 cc if there had been no change in volume, but loss of ether would increase the concentration of other substances, so the increase in acidity was due in part to this loss of ether. The odor of ether was observed at as low a temperature as 70°, though the ether reaction is generally thought to begin at much higher temperatures—about 130°.

When the original mixture of alcohol and sulphuric acid was allowed to stand at room temperature for a considerable time, after the rapid decrease in acidity due to the formation of ethyl-sulphuric acid, practically reaching equilibrium in 2.5 hours, there was a very slow further decrease in acidity, the titration figure changing from 13.9 to 13.8 cc in 2 days, 13.6 cc in 7 days, 13.4 cc in 2 weeks, and 13.3 cc in 3 weeks. This was probably due to the formation of ethyl sulphate according to equation (D), or possibly that of isethionic acid or ethionic acid by reactions (E) and (F). This point might well receive further attention.

ELECTROMOTIVE FORCE MEASUREMENTS OF THE SYSTEM. H_2—Pt—0.1 M (HCl+KCl)—Hg_2Cl_2—Hg.

N. Edward Loomis.

For several years there has been great uncertainty in regard to the relative dissociations of O.1 M HCl and O.1 M KCl. It has been shown that the conductivity method indicates too high a degree of dissociation for hydrochloric acid because of increase in the mobility of the hydrogen ion with increasing concentration. Most authors in recent years have assumed that at 25° both solutions are 86% dissociated in accordance with the recommendation of Lewis and Sargent in 1909[1]. Since 1912, however, Lewis has questioned his earlier view and the matter has again been left in doubt.

The writer has attempted to secure information upon the relative dissociations of 0.1 M HCl and O.1 M KCl by studying the electromotive force of the system:

H_2—Pt—0.1 M (HCl+KCl)—Hg_2Cl_2—Hg

It is obvious that if 0.1 M HCl is dissociated to the same extent as O.1 M KCl then the electromotive force of the system

H_2—Pt—0.1 M HCl '' 0.1 M KCl—Hg_2Cl_2—Hg (2)

should be the same as that of

H_2—Pt—0.1 M HCl—Hg_2Cl_2—Hg

since the potential of the calomel electrode is a function only of the chlorine ion concentration of the surrounding solution.

Within the limits of experimental error this has been shown to be the case in an article recently published by the writer.[3] The best measurements of the electromotive force of the system

H_2—Pt—0.1 M HCl '' 0.1 M KCl—Hg_2Cl_2—Hg

at 25° give a value of 0.3988 or slightly greater depending upon the value of the contact potential used in the calculations. The mean of twenty-eight measurements of the system

H_2—Pt—0.1 M HCl—Hg_2Cl_2—Hg

gave 0.3988±0.0002. It is seen that the electromotive force of the two systems is identical within the limits of our knowledge of the contact potential of 0.1 M HCl—0.1 M KCl, and consequently 0.1 M HCl and 0.1 M KCl appear to be equally dissociated.

If 0.1 M HCl and 0.1 M KCl are equally dissociated then according to the isohydric principle it should be possible to mix the solutions in any proportion without changing the degree of dissociation of either. Consequently the potential of a calomel electrode surrounded by any mixture of 0.1 M HCl and 0.1 M KCl should be the same as that of a 0.1 M KCl calomel

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1 J. Am. Chem. Soc *31*, 363, (1909).
2 The symbol ('') indicates that the contact potential has been eliminated.
3 J. Am. Chem. Soc. *38*, 2310, (1916).

electrode or that of a 0.1 M HCl calomel electrode. Therefore any variations in the potential of

H_2—Pt—0.1 M (HCl+KCl)—Hg_2Cl_2—Hg

with change in the relative amounts of HCl and KCl would be due to the change in the potential of the hydrogen electrode, caused by the change in the hydrogen ion concentration. The change in hydrogen ion concentration corresponding to any change in the potential of the hydrogen electrode can be readily calculated and it is therefore possible to compare the experimentally determined hydrogen ion concentrations with those calculated on the isohydric principle. Agreement would further confirm the equal dissociation of the two solutions. Disagreement would indicate either a discrepancy in the degrees of dissociation or a failure in the application of the isohydric principle.

So far mixtures of the composition

0.08 M HCl+0.02 M KCl
0.05 M HCl+0.05 M KCl
0.03 M HCl+0.07 M KCl
0.01 M HCl+0.09 M KCl

have been studied and rough agreement between the calculated and experimental values is obtained. Variations of the order of 1% have not yet been explained and the study is being continued in order to account for these variations. At present it is thought that probably the variations are due to changes in the potential of the calomel electrodes upon standing, such as have been noted with 0.1 M HCl calomel electrodes.

Development of Chemical Science in Indiana.

J. H. Ransom

This paper was read before the Indiana Section of the American Chemical Society, Oct. 8, 1916. By request it was submitted to the Indiana Academy of Science.

Indiana is this year celebrating the one hundreth anniversary of her entrance into the sisterhood of States. Almost weekly in the various counties, pageants are being held in which local and state history is being enacted depicting the earlier life of the state and the gradually changing conditions that have led up to the modern social, religious and educational environment.

It seems not unfitting at this time, and in this presence, to call attention to some of the more scientific phases of the development of this commonwealth to the end that we may see more clearly the struggles through which, and, may I add, by which, some measure of success has been attained; and know better the meanderings of the stream upon which our barques are being urged to the haven of still larger accomplishment.

It is my purpose, therefore, in the few moments at my disposal, to bring before you in review, not the development of the whole scientific thought of the State, interesting as that might be if I were capable of doing it, but some of those things which are more closely related to the science of chemistry. However, in the early history of Indiana science the different branches were not as clearly differentiated as now, and chemistry and its practical applications were closely associated and entwined with both physics and geology, so the influence of the chemist is not always clear.

The soil and climate of Indiana are peculiarly well adapted to agricultural pursuits. Therefore it is not wonderful that, when the two great streams of immigration, from the northeast and southeast, met upon the soil of the state it should be found that a very large proportion were young men and women of humble parentage with little or no eduation and without financial standing. They came here to force from the great forests and from the rich virgin soil hidden under them that which would supply them with better homes than they had known in the east, and with better educational outlook for their children than they possessed. Consequently it is to be expected that the early history of the state would be free from any hint of scientific thought, or of the applications of science to the affairs of life. The New Harmony settlement may seem to contradict this statement; for in the settlement were men of scientific standing. Later these men and their successors exerted great scientific influence. But in the earlier years their influence was along socialistic and religious lines. Not until after the adoption of the constitution of 1850, and the provision therein for an adequate support of the public school system, does there seem to have been any attempt by the state to apply scientific knowledge in assisting the people.

Soon after the adoption of this constitution the legislature established the department of Geology and appointed David Dale Owen to the office of state geologist. Mr. Owen was the son of Robert Owen one time owner of New Harmony. He had done work for Kentucky and other states; was a brilliant man and had a thorough knowledge of the geology of the Mississippi valley. A younger brother was appointed his assistant and the two undertook a preliminary geologic survey of the state. Among other things they investigated the soils in different parts of the state, comparing the chemical analyses of the virgin soils, as well as the subsoils, with those which had become poor from croppings. Thus they laid the foundation for the great fertilizer industry of the state, and began to educate the farmers to the idea that plant food, once removed with the crop, must be returned to the soil if the latter is to retain its original strength. In transmitting his report of the analyses of these soils Robert Peter, a chemist from Lexington, Ky., wrote as follows: "Chemical study of the soil and of plants and animals, has demonstrated that certain elements, necessary to vegetable and animal development, are gradually consumed from the soil in the crop. * * * The mineral constituents * * * are found in relatively small proportion and must be carefully husbanded and restored to the soil in order to maintain constant fertility. Such a process * * * would be the perfection of agriculture. And such a system is perfectly practicable in an agricultural community where the chemical nature of the soils, of manures and of vegetable and animal products have been studied and understood. The path of improvement, therefore lies in this direction, and it is the duty of our enterprising farmers to prepare themselves to improve it, by the scientific study of their profession; and of states and communities liberally to aid progress in this pathway." He then concludes as follows: "The fundamental study in this relation is that of the chemical nature of the soil; a study which is yet in its infancy, but which may be matured by judicious patronage into a branch of science of extensive utility." Such a message, from such a source, must have carried conviction to many a farmer whose soil gave poorer returns with each succeeding year. And its influence, consciously or unconsciously, must have persisted even to the present.

The Owens also began a study of the coal regions of the state, marking their boundaries in the counties where coal was to be found. To some extent they classified the coals on the basis of their best use and compared them with coals from other sources. They pointed out beds of paying iron ore and the quarries of limestone with which to flux it, and thus started the iron industry of the state. This, as now known, is not large in comparison with the present sources of supply, but at that time it was a most important addition to the resources of the commonwealth. From their knowledge of the geology of this and adjoining states these men were able to tell the people what other valuable minerals might lie beneath the surface in paying quantities and what ones, if found at all, would be only in small pockets brought in by glacial action.

The state geologist died while in office and the brother, after writing and publishing a comprehensive annual report, was appointed to succeed to the office. The chemical and geologic work done before 1860 laid the foundation for future work in the development of the varied industries of the state. But small appropriations and poor equipment made possible only a beginning in spite of the earnest endeavors of these most conscientious, gifted and scientific men. The civil war period produced an hiatus in the work which was first resumed in 1869 under the efficient management of state geologist, E. T. Cox, and his assistants. Under the leadership of Governor Conrad Baker the powers and purposes of the office of the state geologist had been enlarged, and provision made for building and equipping a chemical laboratory. The first year was largely occupied in building this laboratory as an addition to the east side of the state house; but when completed it was said to be one of the best equipped laboratories in the west. In his first report Mr. Cox says, "I trust soon to be able to commence a series of elaborate investigations of the iron-smelting ores, iron ores and fluxes used in the blast furnaces of Indiana, that will, it is confidently believed, prove of great utility to the iron masters, and materially advance the manufacturing interests of the state." And he goes on to say that a large portion of his time had been spent in receiving visitors and imparting geological information to capitalists from many parts of the country, who were desirous of investing money in the various branches of manufacture within the state.

Mr. Cox, who, was not only a great geologist, but a great advertiser of the state resources, extended the scope of analytical chemical work to include hydraulic cement clays, pottery clays and glass sands; and he so greatly advertised the work accomplished that in the ten years of the occupancy of the office probably millions of dollars were invested in Indiana industries. In the first annual report there is a full page illustration of a blast furnace in operation. In the 1872 report there is long descriptive letter, written by Hugh Hartman, of the then new Bessemer process of steel manufacture. The next year the same gentleman has a description of the industries represented at the Vienna exposition. In 1871 he writes "chemistry as a science was almost unknown in its practical applications fifteen or twenty years ago; now it is the only foundation upon which even practice can grow. Chemistry is at the bottom of modern iron production." Infinitely truer is it today. Not only in the iron industry, but in a thousand others it is the foundation for financial success.

The study of glass sands led to the erection of a number of glass factories which, later, were stimulated by the discovery of natural gas in the state. These became, and for years remained one of the larger industries of the state. In this and following administrations analyses of the clays of the state opened the field for the cement industry which, in both the southern and northern sections has become so important an addition to our economic wealth. It is probably true that the analytical work done under the direction of Mr. Cox was the beginning of the earlier, if not the more recent, prosperity for which the state has long been noted. From the standpoint of the industries and wealth the twenty years following the civil war were crucial in this state.

In this connection I cannot refrain from mentioning still more recent work which is of great moment to the people of the state. I refer to the notable work of Harvey W. Wiley, a pioneer chemist of the state, who, by his interest in the welfare of the people, awoke the nation, as well as the state, to the importance of the pure food question, and who is the author and defender of many of the pure food laws of the country. Through his interest in agriculture and his work and writings on the chemical side of this field of work he has stimulated practical research and added much to the health and prosperity of the nation. No less splendid and important has been the work of another man who, in his earlier years, was a chemist in the employ of the state in the department of Geology. I am thinking of our neighbor, Dr. J. N. Hurty, and his work on sanitation and preventive medicine. His work is also nation wide, and he has brought honor and, what is more important to us, an increased measure of health to those who are living now and who will live here in the ages to come. Both of these men rank equally with the Owen brothers, Cox and others in the work they have done for our commonwealth.

There is another phase of the subject about which I wish to speak briefly. It has reference to the development of chemistry in the higher educational institutions of the state. Like the more material industries education started rather tardily. The common school system was begun in 1824; but for lack of financial support was not well organized until 1852; and only in 1865 was its normal development certain. In the meantime small colleges were springing up like mushrooms, but, being under the care of some church or denomination without much financial support, their development was slow and precarious. It must be said, however, that in comparison with their size and educational advantages, their influence was very great. Many of them have survived and are today among the strongest agencies for development in the state. In their curricula they patterned after Harvard, Yale and Princeton, but, unlike these institutions they had no well defined functions and no permanent standing. As late as December, 1878, President Tuttle, of Wabash College, in comparing the eastern colleges with the western said, "There the college is a well defined thing, and a greatly prized thing. Here the college is so indefinite a thing that it means many things which are not very similar. Not a dog wags his tail against Yale or Princeton, but who is there here but feels at liberty to cast a stone at the college, whatever its pretensions? Our rights are questioned and our methods denounced."

Dr. Tuttle, whom some of us remember with great reverence as "The grand old man" was, at that time, in the zenith of his power and influence in the state. By education he was a pure classicist, and for sixteen years he had been president and educational director of one of the classical colleges of the state. One of the things which caused him to speak despairingly, as quoted above, was the fact that in the educational air there were floating the germs of a new education; an education which he thought would, if allowed to propagate, poison if not kill the real education so dear to his heart. He lived to see the new education well established and to value it at its true value. But in the address from which I have quoted he proceeds, among other things, to frame an argument in favor of the continuance of classical education in the colleges and to denounce the newer ideas of a practical or scientific education. This was less than forty years ago and during the period that the Owen brothers and Cox were doing such important work for the state. I speak of this only to point out that in such an atmosphere and against such leadership chemistry, with the other sciences, waged its battle —often a losing one—for equal rights.

In the development of the sciences many of the arguments advanced by the classicists proved to be well founded, many of the weaknesses predicted by them came true. The standard of education was lowered; the quality of scholarship was poorer; men of little mental ability and less character passed through the college courses; mechanical work took the place of mental effort; the experimenter replaced the thinker. In 1880 John M. Coulter, in discussing the place of science in colleges, and in pleading for a higher standard in it, said, "The so-called scientific course * * * seems to have been originated to supply a long felt want, viz., a short cut through college, thus gaining in time and eliminating the heavy studies. If the man had neither brains enough nor an inclination to graduate from the classical course in four years he entered the scientific course and graduated in three." Yet in the face of this poor beginning the scientific courses rapidly became stronger and, under the influence of such men as Jordan, Coulter, Noyes, and others were made to approach the classical courses in content and in mental requirement.

The influence of these men in raising the standard of scientific education until it approached that of the classical was partly through the students who, after graduation, went into the high schools of the state as teachers, and there created an interest in science among the pupils. These in turn demanded a scientific education when they entered the college walls. Partly their influence was exerted through the college association of the state. This was an organization composed of the presidents of the colleges in the state together with a few professors selected from the colleges. In their annual meetings formal papers were read covering this phase of education, as well as others, and thorough discussion was had of the arguments advanced in the papers. From some of these papers and discussions I have quoted. A third influence, which is still powerful, was the Indiana Academy of Science which was founded in 1885. Here the professors from the different colleges presented a resume of the scientific work which was being done; and in the earlier years at least, students were encouraged to study some problem in the junior and senior years and present the results of their work at the meetings. In some ways it is unfortunate that this method of stimulating interest and efficiency in things scientific is being superceded by the more prosaic method of formal instruction. A roster of the membership of the Academy contains names of men and women of which any state might well be proud: Presidents of universities, experts in government work, scientific educators in many fields and of a national reputation; and research men who were and still are at the head of their respective fields of investigation. Still a fourth influence tending to the strengthening of chemical training in the colleges during the eighties and late seventies was that many graduates of our colleges went to European universities for their graduate work and became enthusiastic in research. Later they returned to the colleges where their enthusiasm diffused itself through the student body.

To obtain a clear idea of the changing attitude towards the science of chemistry one has only to study the catalogues of the colleges of the state and observe the changes which the curricula have undergone through the years. Only a few of these stretching back through the earlier decades was I able to consult. It would be interesting to have a detailed comparison of all of them between 1840 and 1890. But with only a few exceptions those that were consulted followed along the same lines, and it is reasonable to suppose that others followed in nearly the same path. To make the comparison more striking it is only necessary to recall that in most of the colleges of Indiana today four years of chemistry may be taken, the time per week varying from six to sixteen or more hours.

Before 1885 it is safe to say that, in most of the colleges chemistry was one of several subjects taught by one professor. Often this subject was not the one which the instructor was best fitted to teach. It must be said, however, that often such a man made up in interest and enthusiasm what he lacked in technical knowledge. Quite commonly there were no laboratories; or if there were they were equipped with apparatus for only the most rudimentary study of the subject. It is said that some courses were completed without the performance of a single experiment either by the student or the instructor.

In 1857, under Professor Hovey, Wabash college required two terms of chemistry in the senior year. Two years later one of the few books of refference mentioned in the catalogue is Webster's dictionary. In 1867 a scientific course was established. In this course no Greek was required but, in its place, somewhat more work in science and modern languages was allowed. For some years this course was under the ban of the faculty and those who chose it were considered to be less meritorious and able men. In 1877 a year of work was given to the science men—two terms in the sophomore year and one in the senior. By 1888 two years could be taken, and these by juniors and seniors.. This represented the maximum possible.

In 1879 Asbury college (Depauw later) gave two terms only of chemistry. In 1882 a chair of chemistry and physiology was created. In 1886 a student could take two terms as freshman, two as junior and three as a senior. In 1891 three or even four years might be taken.

In 1878, at Butler college, H. Jamison was professor of chemistry, toxicology and children's diseases. Chemistry was given from one to three terms in different courses and was taught by Professor Thrasher, professor of mathematics and astronomy, and by D. S. Jordan, Professor of natural history. In 1887 there was one year of chemistry for all students; and in 1890–92 it was required in junior year and elective in the senior. At the State Normal in 1885 one term was given, in 1892 one term each of general chemistry, organic and qualitive analysis.

At Rose Polytechnic Institute a professor of chemistry was selected in 1882, Chas. A. Cotton. In the inaugural address he states that chemistry includes laboratory practice. The course was four hours of chemistry and physics in the sophomore year and one hour in the senior year. In 1884 it is stated that chemistry is largely conducted by dictation exercises in the laboratory. The work was given in the last three years. In this year a division of practical chemistry was made. Fifty lectures and recitations were given to the freshmen, and "an improved course in reading." A new laboratory was provided, consisting of four rooms; one each for qualitative and quantitative analysis, a balance room and an office. After this year chemistry could be taken in all four years. The statistics for Indiana University were not available.

At Purdue, under the leadership of Professor Wiley, a school of chemistry was established about 1874, in which three or even four years of chemistry could be taken. The first term of the first year was given over to illustrated lectures on the subject. Beyond this term chemistry was elective. But those who elected it were given much time in the laboratory. The fourth year was designed to teach chemical technology, metallurgy and didactic chemistry. For a number of years no one elected the fourth year and the laboratory was not equipped for its teaching. The degree of Bachelor of Chemistry was given for three years of chemistry, and of Doctor of Chemistry for completing the four years course. In 1876 there were five lectures a week for the first two years. In the first year there were five hours of laboratory work; in the second ten and in the third year six to eight hours per day were required for laboratory alone. In 1883 the school of chemistry had been discontinued and a smaller amount of work in chemistry offered. In 1887, under Dr. Nef, the work was clearly divided into lectures, recitations and laboratory practice with the practical applications of chemistry made prominent. For a number of years before this the work seems to have been confined to the junior and senior years; but in 1891 the work could again be taken in the sophomore year with some extra elective work allowed.

The method and kind of instruction were also themes of discussion and matters of development. When the courses were short and equipment meager the teaching was largely by means of the text book, the professor, perhaps, performing some of the simpler experiments by way of illustrations. Later the extreme opposite method was used, only laboratory work being thought of value. In 1881 a discussion was had by the College Association in which very decided views were promulgated. Professor John L. Campbell read a paper in which he advocated, for physics, a combination of lecture, recitation and laboratory work. Professor Wiley took the extreme view that, for chemistry, laboratory work was the all important thing; that the first day in the laboratory should be research, as should be every day following. He said nothing should be told the student; neither should he read anything. He was to go into the laboratory and discover things which, to him at least, were entirely new; investigate nature. While a number agreed with Wiley the consensus of opinion seem to be that Professor Campbell's method was preferable. This may give some idea of the confusion of thought that was in the air relative to the place of chemistry in those transition years between the pure classical education and the new science. Quite rapidly, however, the chemical courses became standardized and took their places beside the classical, equal in extent, almost equal in content. Each received something from the other. The scientist came to understand that education is to make men as well as chemists, and the classical man learned that there is a human and practical side to all education.

While chemistry and the other pure sciences are fairly well standardized as means of educational development it is probable that the practical applications of chemistry can be better worked out so as to be used in a better way as an instrument in the development of the student. On the contrary some of the more practical applications of science as taught in our colleges, such as agriculture and home economics, are about at the stage of development of chemistry thirty or forty years ago. And they are lowering the general standard of scientific education now in the same way that chemistry lowered the standard in the earlier stages of its development, and somewhat for the same reason. Their methods of attacking problems presented are not sufficiently mental, thorough and developing. Instead of using the practical things, with which they must deal, to develop educational qualities in the student, the forms of education are being used to teach some practical things which, in themselves, are of little educational value. The two methods are not identical and cannot be superimposed.

A roster of the men who were most conspicuous in the transition period of which I have spoken may not be out of place. In addition to the brothers Owen and E. T. Cox, State Geologists, there may be mentioned T. C. VanNuys, head of the Department of Chemistry, Indiana University; H. W. Wiley, Professor of Chemistry, Purdue, State Chemist of Indiana, head of the Bureau of Chemistry, U. S. Department of Agriculture. President of the American Chemical Society; P. S. Baker, Professor of Chemistry, DePauw; J. U. Nef, Professor of Chemistry, Purdue, head of the Department of Chemistry, University of Chicago; W. A. Noyes, Professor of Chemistry, Rose

Polytechnic Institute, head of the Division of Chemistry, Bureau of Standards, head of the Department of Chemistry, University of Illinois, editor of the American Chemical Journal; R. B. Warder, Professor of Chemistry, Purdue; W. E. Stone, Professor of Chemistry and President, Purdue; Alexander Smith, Professor of Chemistry at Wabash and in the University of Chicago, Administrative Head of the Department of Chemistry, Columbia University, President of the American Chemical Society. There may have been, and probably were, others of whom I do not know or of whose work I am not able to judge correctly. Certainly there are many others who, in a somewhat less conspicuous way, exerted an equal or even greater influence in shaping chemical thought during the thirty years following the civil war.

In this brief paper I have tried to point out—especially to the younger chemists—some of the recruiting stations, and some of the battle fields upon which chemical freedom in Indiana was won. The wars of yesterday have but given strength and wisdom for the struggle tomorrow. These struggles will not be against classicism or ignorance or superstition or the indifference and opposition of the state. Its war now is and will be to establish correct standards for the air we breathe; for the water we drink; for the food we eat, for the medicines we need; for the drinks we enjoy; for the fuels we burn and the minerals we mine; for the chemicals we manufacture; for the soil we till, and for the dyes with which we beautify the world. The borders of chemical science must be enlarged. Youth must be taught the value of truth; of the sacredness of natural law, and of the power of the mind trained to habits of exact thought and logical deduction. In co-operation with the classics and the other sciences, pure and applied, our science must attempt to unfold the highest qualities of man—his intellectual, moral and religious nature.

Rate of Humification of Green Manure.

R. H. Carr

Since the use of green manures is becoming a more common aid in maintaining the fertility of the soil, many questions have arisen regarding the availability of the plant food they contain as compared with that of foods in artificial manures, farm manures, etc. Another question concerns the possible acidity of the soil produced by fermentation of manures turned under when in a very green condition. The writer first became interested in the acidity side of green manures on noting the different results in crop yield in two parts of a 14 acre clover field. About one half of the field had been plowed when the crop was green. The inner half had been plowed after the crop had been left to ripen for seed. Then the whole field was put in wheat. The wheat and clover were a failure on the outer half, but the inner half produced 22 bushels to the acre and also a good stand of clover was secured. Several years passed before a good stand of clover on the outer part of the field was obtained. Hence it was thought the soil had been soured by the large amount of green manure turned under. A number of writers comment on the possiblity of souring the soil by the use of green manures. In circular 10 of Iowa Experiment Station is found the following statement regarding green manures:

"In its (organic matter) decomposition, acids may be produced in considerable amounts and the soil becomes acid or sour in reaction."

Object of Experiment

The object of this experiment was first, to determine the rate of decomposition as measured by the rate of humification and growth of crops, second, to determine the amount of acid formed when different green manures decompose.

Plan Followed

Clay soil that was very deficient in organic matter, or humus hungry, was chosen for the experiment. The soil was placed in boxes holding approximately a cubic foot and was mixed with different green or dry manures as follows:

Box 1, green cow pea stalks 3,000 grams, chopped up, well mixed with soil.

Box 2, green cow pea stalks 3,000 grams, layer in middle of box, soil above and below.

Box 3, green cow pea stalks 3,000 grams, layer in middle of box lined with 100 grams $CaCo_3$.

Box 4, green alfalfa 2,250 grams, layer in middle of box and 100 grams $ca\ CO_3$ and soil.

Box 5, green alfalfa 2,250 grams layer not limed plus soil.

Box 6, green alfalfa 2,250 grams, chopped and mixed with soil.

Box 7, green sweet clover 2,650 grams, layer, plus 100 grams $CaCO_3$ and soil.
Box 8, green sweet clover 2,650 grams, layer, not limed, soil.
Box 9, green sweet clover 2,650 grams, chopped and mixed with soil.
Box 10, green oats straw 2,368 grams, layer, plus 100 grams $CaCO_3$ and soil.
Box 11, green oats straw 2,368 grams, layer, not limed, and soil.
Box 12, green oats straw 2,368 grams, chopped and mixed with soil.
Box 13, cowpeas 450 grams stalk *dried*, layer and soil.
Box 14, alfalfa 450 grams, stalks *dried*, layer and soil.
Box 15, sweet clover 450 grams, stalks *dried*, layer and soil.
Box 16, oat straw 450 grams, stalks *dried*, layer and soil.
Box 17, soil only.

All the boxes contained the same weight of soil and green or dry manures (reduced to dry bases 450 grams). They were buried Oct. 5 in a trench out doors so that the tops of the boxes came just a little above the level of the ground and six inches apart. It was thought the moisture conditions could be kept more constant in this way.

Farm Management of Green Manure

In applying the green manures by the different methods, it was aimed to imitate the following farm practices:

1. Turning under a heavy roll of green material.
2. Discing the green mass before plowing.
3. Allowing the material to dry before plowing it under.
4. Applying 5 tons of ground limestone per acre.

Humus Determinations

The percentage of humus was determined, by the Smith method, when the green materials were mixed and at varying intervals, with the following results:

Oct. 5, 1915		Dec. 16	Feb. 25	Mar. 18	
When just mixed					
Cow peas	0.63%	0.75% limed	0.75%	0.65%	
		0.84% unlimed	0.83%	0.66%	dried 0.58%
Alfalfa	0.67%	0.64% limed	0.66%	0.77%	
		0.57% unlimed	0.62%	0.65%	dried 0.64%
Sweet clover	0.40%	0.84% limed	0.62%	0.58%	
		0.77% unlimed	0.78%	0.71%	0.75%
Oats	0.46%	1.09% limed	0.92%	0.81%	
		0.87% unlimed	0.65%	0.80%	0.86%
Check	0.42%	0.41%	0.43%	0.42%	

Vegetative Tests

On May 16th corn was planted in each of the boxes and Oct. 1st the corn was harvested and the boxes sowed with rye. The following table gives relative growth and yield:

		Corn, height 6–27–15	Corn and Stock yield, wt. when cut	Rye yield
Cow peas	disced	16.5 inches	403 grams	....
	rolled under	26.5 inches	487	....
	dried	22.5 inches	300	....
	limed	24 inches	497	....
Average.......		22.4 inches	421.8	....
Alfalfa	disced	19.5 inches	368	....
	rolled under	21.5 inches	499	....
	dried	27.5 inches	435	....
	limed	23.5 inches	518	....
Average		23 inches	455	....
Sweet clover	disced	21 inches	297	....
	rolled under	21.5 inches	413	....
	dried	26.5 inches	400	....
	limed	24 inches	550	....
Average		23 inches	415	....
Oats	disced	29 inches	518	....
	rolled under	31.5 inches	485	....
	dried	29.5 inches	292	....
	limed	28.0 inches	533	....
Average		29.5 inches	457	....
Check		15 inches	160	....

Acidity Developed

In order to determine to what extent the fermenting of green material causes acidity, tests, by the Veitch method, were run at various intervals, with the following results:

Pounds of Limestone Needed Per Acre

		Oct.	Dec.	April
Cowpeas	disced	4,050	4,950	4,575
	rolled under	4,050	5,175	4,300
	dried	4,050	4,050	4,050
Alfalfa	disced	4,050	4,500	4,900
	rolled under	4,050	4,900	4,550
	dried	4,050	4,050	4,200
Sweet clover	disced	4,050	5,500	4,550
	rolled under	4,050	5,500	5,500
	dried	4,050	4,050	4,050
Oats	disced	4,050	4,550	4,250
	rolled under	4,050	4,900	4,550
	dried	4,050	4,050	4,200
Check		4,050	4,025	4,075

The limestone requirement was also determined by the KNO_3 method. This method showed much less limestone needed per acre than the Veitch method, but the percentage of increase in acidity was much the same by both methods.

Conclusions

1. The alfalfa boxes did not increase appreciately in humus, whereas the oats boxes doubled their humus contents in two months. The sweet clover was next in humus increase, followed by cow peas.
2. All green manures showed rapid humification. There was no increase in percentage of humus in any of the boxes after 2 months.
3. The boxes in which green manure was disced showed poorest progress in growth of corn.

4. The rapid growth and high yield of corn in oat boxes may be accounted for partly by their high humus contents.

5. There was an increase in acidity of the soil wherever the *green* manure was added, the acidity being less for the disced than the undisced. The dried manures showed no appreciable increase of acid.

6. The high yield of corn in all limed boxes may be accounted for partly by limestone neutralizing acidity produced and partly by the more favorable condition for bacterial action and humus increase.

7. Rolling under of green manures was more effective in corn production than either disking or drying.

Indiana Soils Containing an Excess of Soluble Salts.

S. D. Conner

The usual procedure when making a laboratory examination of an Indiana soil is to test for a probable deficiency of lime, organic matter or plant food elements. There are, however, some soils from the humid section that have too much rather than too little plant food and soluble salts. The bulk of such soils are peat, muck or black sand soils that were formed in poorly drained sections. The only clay or loam soils in humid regions which have excess soluble salts are very local in area and are formed by artificial rather than natural causes.

The black soils high in soluble salts are of two general types. One type contains relatively small amounts of soluble salts of a highly toxic nature. An example of this type is the acid black sand of the Wanatah experiment field where the soluble matter is largely aluminum nitrate, a salt very toxic to the roots of agricultural crops. Results of experiments on this soil are published in Bulletin 170, Purdue Agricultural Experiment Station.

Another type of the black soils under discussion contains relatively small amounts of toxic salts but very high concentration of salts of low toxicity. One such soil was sent to the Experiment Station laboratory from Starke County. The samples were taken from an onion field on muck soil in September, 1913. Where the onions were dying the soil contained .44% nitrates and 1.2% soluble salts. Where the onions were doing well the soil contained .10% nitrates and only .45% soluble salts. Another case where soluble salts seemed to be the cause of injury to onions was reported from muck soil in Noble County in July, 1916. Samples taken from the part of the field where the onions were dying contained .50% nitrates and 1.12% soluble salts, while the soil from the part of the field where the onions were still good contained .17% nitrates and .57% soluble salts.

Quite a number of cases have been reported where both onions and corn on muck soil seemed to be failing or were entirely destroyed because of a high concentration of soluble salts. Analysis of water extracts of such soils show that the soluble salt is composed largely of calcium and nitric acid. The occurrence of this salt in such soil is not hard to explain as the soils contain large amount of nitrogenous organic matter and calcium. During the warm weather of summer nitrification is very active and calcium nitrate is formed in great quantities. As the soil moisture evaporates this salt together with any other soluble matter is carried to the surface and deposited in such quantities that the salts act in the same manner as the alkali salts in Western soils. Calcium nitrate is an excellent fertilizer for thin lands but in these soils it is a positive detriment. While calcium nitrate is perhaps one of the main factors in producing crop injury, it is not the only one. Given a mixture of salts of varying degrees of toxicity and mixed in different proportions it is, of course, impossible to say just what causes the injury.

Areas containing excess soluble salts in Indiana clay or loam soils have been found only where refuse matter has been dumped or in locations where old stables stood. A farmer near Warren reported a spot in a field where crops had failed for five years on the site of an old stable. Samples of soil were taken at various depths and analyzed. The soil at 0 to 6 inches had .1% nitrates, .85% water soluble potash and 2.54% total soluble matter. At a depth of 24 to 30 inches there was .012% nitrates, .44% water soluble potash and 1.33% total soluble salts, the trouble in this case being without doubt caused by an excess of potash and other soluble salts. This and similar cases illustrate very well just how extensive the leaching of manure may be, and how important it is to prevent such loss by providing concrete or some other kind of water-tight floor in the stable. The soil on this spot to a depth of at least 30 inches had a fertilizer value equal to manure five years after the stable had been removed.

The Description and Stratigraphic Relationships of Fossil Plants From the Lower Pennsylvanian Rocks of Indiana.

T. F. Jackson

The outcrop of the Lower Pennsylvanian rocks in Indiana extends in a belt of varying width in an east-of-south direction from Warren County on the north to the Ohio river in Perry and Crawford counties on the south. The outcrop in a few places is almost twenty miles in width although the usual width is very much less. For the most part the rocks of this area are made up of a series that vary greatly in lithologic characteristics both horizontally and vertically. In places the formation consists of a massive sandstone ranging in texture from rather coarse conglomerate to the fine-grained Hindostan whetrock of Orange county. In other localities interbedded sandstones and shales make up the formation. Locally coal beds occur and in a few places iron ore is found at or near the base of the series. The series lies unconformably on Mississippian limestone, shale or sandstone. The great similarity of the Upper Mississipian (Chester) shales and sandstones to the shales and sandstones of the Lower Pennsylvanian has made the separation of those two systems a difficult matter, especially when stratigraphic evidence alone has been employed. This series of rocks is overlain by the shales, sandstones or limestones of the Allegheny formation. Ashley[1] considered that the boundary between the Pottsville and Allegheny series in Parke county is found to come between the two Minshall coals, apparently about the top of the limestones between the two coals.

The series of rocks briefly described in the foregoing paragraph is the "Millstone grit" of the early geologists and the "Conglomerate" and "Conglomorate sandstones" referred to in the earlier State Reports. Hopkins in his report on "The Carboniferous Sandstones of Western Indiana,"[2] proposed the term "Mansfield Sandstone" for the series. Later Ashley placed the series in what he designated "Division I." He retained the term "Mansfield sandstone" for the massive bed or beds of sandstone that occur locally in the series.[3] As the fossils obtained from these rocks show that the rocks are of the Pottsville age there is no good reason why that name should not be applied as suggested by Ashley.[4]

The Pennsylvanian rocks that occur within the area included in the Bloomington Quadrangle represent in part the Pottsville or Ashley's "Division

1 33rd An. Rep. Ind. Dept. Geol. and Nat. Res. p. 58, 1908.
2 20th An. Rep. Ind. Dep. Geol. and Nat. Res. 1895.
3 23rd An. Rep. Ind. Dep. Geol. and Nat. Res. p. 95, 1896.
4 33rd An. Rep. Ind. Dep. Geol. and Nat. Res. p. 58, 1908.

I." Geographically they occupy a position somewhat south of the center of the eastern outcrop of the Pennsylvanian in Indiana. The stratigraphy of these rocks within the Quadrangle has already been published.[5]

The fossil plants collected in the Bloomington Quadrangle were obtained principally from two localities: (1) From a shale bed about one fourth mile southeast of the Yoho School, in the northwest quarter of section 8, T. 7 N, R 2 W; and (2) From a ferrugineous sandstone layer along the east side of the road, about one fourth of a mile southeast of Cincinnati, in section 27, T 7 N, R 3 W. A provisional list of fossils from those localities has previously been published.[6] A more critical study of a better collection from the former locality has slightly modified and increased the number of species of the provisional list.

The fossil plants found at the Yoho school locality are as follows:

Sphenophyllum cuneifolium (Stb.) Zeiller.
Sphenophyllum tenue D. W.
Lepidodendron yohoense n. sp.
Lepidodendron obovatum Sternb.
Lepidodendron clypeatum Lx.
Sphenopteris inequilateralis Lx.
Sphenopteris communis Lx.
Mariopteris decipiens Lx.
Mariopteris muricata Schloth.
Pecopteris plumosa Artis.
Pecopteris sp. indet.
Pseudopecopteris cf. macilenta L. and H.
Pseudopecopteris dimorpha Lesq.
Neuropteris cf. Elrodi Lx.
Neutropteris Jenneyi D. W.
Alethopteris grandifolia Newb.
Alethopteris Evansi Lx.
Alethopteris sp. indet.
Callipteridium cf. tracyanum Lx. MMS.
Callipteridium sp. indet.
Odontopteris Newberryi Lx.
Cordaites Robbii Dn.
Cardiocarpon annulatum Newb.
Cardiocarpon pachytestum Lx.
Cardiocarpon rugosum n. sp.
Cardiocarpon ovoideum n. sp.
Cardiocarpon sp. indet.
Trigonocarpum cf. Schultzianum Goepp. and Berg.
Rhabdocarpon sp. indet.

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[5] 39th An. Rep. Ind. Dep. Geol. and Nat. Res. pp. 223–229, 1914. The Geologic map of the Quadrangle is given in the same volume.
[6] Proc. Ind. Acad. Sci. pp. 395–398. 1914.

While a few of those plants have a rather extensive vertical range, by far the greater number of them are plants that are confined to the Pottsville, among which may be mentioned *Sphenophyllum cuneifolium*, *S. tenue*, *Sphenenopteris inequilateralis*, *S. communis*, *Mariopteris decipiens*, *M. muricata*, *Neuropteris Elrodi*, *Alethopteris Evansii*, *A. grandifolia*, *Odontopteris Newberryi*, *Cardiocarpon annulatum*, *and C. pachytestum*, forms that are characteristic of the upper part of the Middle Pottsville of the type section or of horizons in Ohio (Sharon coal?), Tennessee (Sewanee coal), Arkansas ("the coal bearing shales"), and West Virginia (Sewell) that are approximately of the same age.[7] From the evidence of the fossils it would appear that the Pennsylvanian as represented in the Yoho School locality would fall somewhere in the upper part of the middle Pottsville.

Plants found at the Cincinnati locality are as follows:

Calamites Suckowi Brongn.
Lepidodendron clypeatum Lx.
Cardiocarpon bicuspidatum? (Sternb.) Newb.
Trigonicarpum ovatum n. sp.
Trigonocarpum hexagonale n. sp.
Trigonocarpum hexacostatum n. sp.

Definite correlation cannot be drawn from the meager flora from this locality. *C. Suckowi* and *L. clypeatum* have an extensive vertical range and the range of the three new species of Trigonocarpum is not known. *G. bicuspidatum* would indicate an age somewhat near that of the Yoho School locality.

The Clay City Quadrangle includes parts of Owen, Clay and Putnam counties. The fossil plants obtained from this Quadrangle were all found in the northeastern quarter of the Quadrangle and immediate vicinity. Plants were obtained from the following localities: (1) From a "black jack" layer over a thin coal in the creek bank, near the section line between sections 18 and 19, T 11 N, R 5 W, about one half mile east of Bowling Green; (2) From shales overlying the Lower Block Coal in a drift mine in a ravine, on the east side of the road, two miles north of the Roadman School, in the southwest corner of section 1, T 12 N, R 6 W; (3) From a sandstone overlying the horizon of the Lower Block Coal, in the creek about one fourth mile north of Liberty School, in the north central part of section 31, T 12 N, R 5 W; (4) From the fire clay under the Upper Block Coal, in the creek bank, about one fourth mile northwest of Asherville, in section 15, T 12 N, R 6 W; (5) From hard sandy shales over the Lower Block Coal at Schroepferman's mine, in the east part of section 4, T 12 N, R 6 W; (6) From shales over the Upper Block Coal at Baird's mine, in the east part of section 5, T 12 N, R 6 W; (7) From a plant-bearing sandstone in the Pennsylvanian, about one

[7] 20th An. Rep. U. S. G. S. Part II, pp. 816–817, 1900.

and one-half miles southwest of Reelsville. The fossils from the three last mentioned localities are too fragmentary to be of much value.

The following species of plants were found at the Bowling Green locality:

Lepidodendron obovatum? Sternb.
Lepidodendon aculeatum Sternb.
Alethopteris Serlii (Brongn.) Goepp.
Sigillaria elegans? Sternb.
Cordiates Robbii Dn. Daws.
Cardiocarpon bicuspidatum? (Sternb.) Newb.
Cardiocarpon cf. circulare Lx.

These fossils were obtained from "Coal A" of Cox. This coal rises rapidly to the eastward and unites with "Coal B" of Cox[8] about fifty yards up the creek. Both coals are overlain by massive sandstones. Detailed stratigraphic work has not yet been completed in that part of the Quadrangle so that the relation of those two coals to the two Block Coals farther west is not definitely known. It is interesting, however, that the fossils from the Lower Block Coal at the Roadman School locality represent almost exactly the same flora, which is given below:

Lepidodendron obovatum Sternb.
Lepidodendron aculeatum Sternb.
Althopteris Serlii (Brongn.) Goepp.
Sigillaria elegans? Sternb.
Cordaites Robii Dn.
Cardiocarpon bicuspidatum (Sternb.) Newb.
Cardiocarpon subcirculare n. sp.

The following species were found in the Liberty School locality.

Calamites Suckowi Brongn.
Sphenophyllum cuneifolium (Sternb.) Zeiller.
Pseudopecopteris obtusiloba (Brongn.) Lx.
Cardiocarpon annulatum Newb.
Pecopteris sp. indet.

The above named plants are also from a horizon representing Ashley's[9] Coal I and "Coal A" (or "Coal B") of Cox.[10] From somewhat detailed field work this horizon is believed to be the same, or very nearly the same, as that of the Lower Block Coal.

The plants from the shales overlying the Lower Block Coal at Schroepferman's mine were insufficient to cast much light on the age of that horizon.

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[8] Cox, E. T., 1st. Rep. Geol. Surv. Ind. p. 24, 1869.
[9] Ashley, Geo. H., 23rd An. Rep. Ind. Dep. Geol. and Nat. Res., 1898.
[10] Cox, E. T., 1st. Geol. Surv. Ind., 1869. See also the map accompanying the 7th Am. Rep. Geol. Sur. Ind., 1876.

The fossils from the horizon of the Lower Block Coal at Bowling Green, Roadman School and Liberty School localities, although insufficient for definite correlation with the Pottsville in the type locality, very likely represent a horizon somewhere in the lower half of the Upper Pottsville.

The plants from the Asherville locality, with a single exception, are from the fire clay under the Upper Block Coal, and are as follows:

Sphenophyllum cuneifolium (Sternb.) Zeiller.
Lepidodendron obovatum Sternb.
Lepidodendron aculeatum Sternb.
Pecopteris cf. abbreviata Brongn.
Cardiocarpon obtusum n. sp.
Cardiocarpon cordatum n. sp.
Cardiocarpon communis n. sp.
Cardiocarpon irregulare n. sp.
Cardiocarpon cuneatum n. sp.
Cardiocarpon gracile n. sp.

Of the above species *Sphenophyllum cuneifolium* is the only plant that has much value as a horizon marker. This species was represented by the rigid, coarse veined variety, characteristic of the upper Pottsville[11] and was obtained from a thin layer of ferrugineous concretions just above the Upper Block Coal.

Only three species of plants were found in the shales overlying the Upper Block Coal at Baird's mine, the following forms being represented:

Cordaites Robbii? Dn.
Cordaianthus sp. indet.
Cardiocarpon acuminatum n. sp.

These forms are of very little value in determining the age of the horizon from which they were obtained.

The few fragments of plants from the Reelsville locality are insufficient for correlating that horizon with the Pottsville of other localities.

[11] White, D., 20th An. Rep. U. S. G. S. Part II. p. 899, 1900.

Notes on the Previously Known Species and Descriptions of New Species from the Lower Pennsylvanian Rocks of Indiana.

EQUISETALES.

Genus *Calamites* Suckow.
Calamites Suckowi Brongn

Plate VIII, fig. 8.

1828. *Calamites Suckowi*, Brongniart, Hist. veg. foss., p. 124, pl. XIV, fig. 6; pl. XV, figs. 1–6; pl. XVI.
1886. *Calamites Suckowi* Brongn. Zeiller, Bassin houil. de Valenc., Atlas, Pl. LV, fig. 1. Text (1888), pp. 333–338.
1914. *Calamites Suckowi* Brongn. Stopes, M. C., The "Fern Ledges" Carboniferous Flora of St. John, New Brunswick. Memoir 41, Canadian Geol. Survey, Pl. II, pp. 15–16.

The specimens in hand seem to agree closely with forms previously assigned to this species. The form figured is from the Liberty School locality and seems to have ribs a little less in width than the forms from New Brunswick[1] and Europe.[2] Representatives of this species were also found at the Cincinnati locality.

SPHENOPHYLLALES

Genus *Sphenophyllum* Brongniart
Sphenophyllum tenue D. W.

Plate I, Fig. 1

1900. *Spenophyllum tenue* White, David, The Stratigraphic Succession of the Fossil Flora of the Southern Anthracite Coal Field, Pennsylvania, U. S. G. S., 20th Ann. Rep. Part II, pp. 900–901, Pl. CXCI, Figs. 6–7.

The stems, so far as could be determined, were rather slender and moderately well ribbed. The leaves were eight millimeters to one centimeter in width and about one and one-half centimeters in length, crenulate-denticulate, broadly cuneate, usually slightly rounded at the apex, semi-translucent, with slender, elongated bases. The single primary nerve is prominent for some distance upwards from the base, forks four to six times at a narrow angle, thus providing a nervule for each tooth.

The specimens in hand seem to agree rather closely with the forms described from the type locality.[3] They appear to differ somewhat in that the leaves are a little shorter in the narrow basal part, are slightly more cuneate, and have heavier lamina. The latter difference can well be due to the large

[1] Stopes' paper above cited.
[2] Zeiller's works above cited.
[3] White, cited above.

amount of iron present and not to a difference in structure. This species was not abundant, single, detached leaves usually being found. A whorl of five leaves is shown in Plate I, Fig. 1. Locality: Yoho School.

Sphenophyllum cuneifolium (Sternb.) Zeiller.
Pl. I, figs, 2, 3, 6; Pl. II, fig. 3.

1823. *Rotularia cunefolium* (Sternb.) Versuch, Fasc. 2, p. 33, Pl. XXVI, Figs. 4a, 4b.
1886. *Sphenophyllum cuneifolium* (Sternb.) Zeiller, Fl. foss. Bas. houill. Valencienne, Atlas, Pl. LXIII, Figs. 1, 3, 6, 7, 9, Text, (1888), p. 414.
1899. *Sphenophyllum cuneifolium* (Sternb.) Zeill. White, David, Fossil Flora of the Lower Coal Measures of Missouri. U. S. G. S. Mon. 37, pp. 174–177.
1900. *Sphenophyllum cuneifolium* (Sternb.) White, David, The Strat. Succ. Foss. Flora S. Anthracite Coal Field, Pa. U. S. G. S. 20th Ann. Rep. Part 2, pp. 889-890.
1908. *Sphenophyllum cuneifolium* (Sternb.) Zeill. Sellards, E. H. Foss. Plants Upper Pal. of Kans. Univ. Geol. Surv. Kans., Vol. IX, p. 426, Pl. LII, Fig. 4,

This species was represented by two forms: (1) a form in which the leaves are deeply dissected and (2) a form in which the leaves are not dissected. The former type of leaf is narrow, with elongated, sharp teeth. The bifurcation of the nerves occurs near the base. In pl. I, fig. 3 and in pl. II, fig. 3, are shown leaves of this type. In the latter figure the dissection extends almost to the base of the leaf. The other type of leaf is seven to ten mm. in length and two mm. in width, slender, elongated and a little less cuneate than the European form. The nervation arises from two nerves which fork once near the base, either or both again dividing near the middle of the leaf and sending veins to the four elongated, sharply-pointed teeth.

Localities: Both types of leaf are common in the Yoho School locality. The dissected variety only was found in the Liberty School locality. The form with the leaves not dissected was found in concretions above the Upper Block Coal at Asherville.

LYCOPODALES

Genus *Lepidodendron* Sternburg.
Lepidodendron Yohoense n. sp.

Pl. V. Fig. 6

Bolsters comparatively large, broadly lanceolate in shape, marked by fine transerse wrinkles throughout their entire length; elongated and acuminate in opposite directions at the ends; separated by a prominent ridge marked by fine transerse wrinkles; inside scar a little above the center, rhomboidal, transersely elongated and slightly rounded above; vascular scar and parichnos prominent in lower part of scar; ligular pit obsure; appendages rather large and prominent.

This tree appears to belong to a group of *Lepidodendra* with nominally transersely wrinkled bolsters to which belong *L. Brittsii* and *L. Wortheni* and possibly *L. Choctawense.* It differs from those species in that the wrinkles appear to be more pronounced, the subjacent lateral appendages are present, the bolsters are more sharply pointed and the leaf scars are proportionally smaller.

Locality: Yoho School. Rather common.

Lepidodendron obovatum Sternb.

Plate VII. fig. 7; Pl. VIII, figs. 1, 6; Pl. IX, fig. 15.

1820. *Lepidodendron oboratum* Sternburg, Ess. Fl. monde prim., I, fasc. 1, pp. 21–25, pl. VI, fig. 1; Pl. VIII, fig. 1a, 1b; fasc. 4, p. x. Renault, Cours. bot. foss., II, p. 13, pl. VI, fig. 5.

1879. *Lepidodendron dichotomum.* Lx. (non Sternb.), Coal Flora, Atlas, pl. LXIV, fig. 3, text, pp. 384–385.

1886. *Lepidodendron obovatum* Sternburg. Zeiller, Bassin houiller de Valencien. Atlas, pl. LXVI, figs. 1a. 8, text (1888), pp. 442–446.

The majority of the forms assigned to this species were in a poor state of preservation, being in most instances considerably distorted or decorticated. The plant shown in pl. VI, fig. 17, is possibly a better representation of the species than those from other localities.

Localities: Yoho School, Bowling Green, Roadman School and Asherville.

Lepidodendron clypeatum Lx.

Pl. V, fig. 7; pl. VI, fig. 15.

1854. *Lepidodendron clypeatum* Lesquereux, Jour. Bost. Soc. Nat. Hist., Vol. VI, p. 429.

1879. *Lepidodendron clypeatum* Lx., Coal Flora, Atlas, p. 12, pl. LXIV, figs. 16, 16a, 16b; text. Vol. II (1880), p. 380.

1899. *Lepidodendron clypeatum* Lx., White, D., Fossil Flora of the Lower Coal Measures of Missouri, U. S. G. S. Monograph Vol. 37, p. 201.

This species was common in both the Yoho School and Cincinnati localities. The form figured from the former locality has bolsters with sides more nearly equilateral than the Pennsylvania plants described and figured by Lesquereux. The appendages are also a little larger than in the Pennsylvania forms. The form of the bolsters of the plant shown in Pl. VI, fig. 15, more closely resembles the Pennsylvania forms. The latter specimen is a sandstone mold; consequently the characteristic markings of the species are more or less obliterated.

Localities: Yoho School, Cincinnati.

Lepidodendron aculeatum Sternb.

Plate VIII, Fig. 2; Pl. IX, fig. 14.

1820. *Lepidodendron aculeatum* Sternburg, Ess. fl. Monde Prim., I, Fasc. 1, pp. 21–25; pl. VI, fig. 2.

1880. *Lepidodendron aculeatum* Sternburg, Lesquereux, Coal Flora, Atlas (1879), Plate LXIV, Fig. 1. Text, pp. 371–372.

1886. *Lepidodendron aculeatum* Sternburg, Zeiller, Bassin houiller de Valenciennes. Atlas, Plate LXV, Figs. 1–7. Text (1888) pp. 435–441.

This species closely agrees with the European forms figured and described by Zeiller. The fine, longitudinal wrinkles on the ridges separating the bolsters are however not figured as appearing on the European forms. The bolsters are a little wider than those figured by Lesquereux from Pennsylvania.[4]

Locality: Lower Block Coal east of Bowling Green, Asherville and north of the Roadman school. A form doubtfully referred to this species was also found in the Yoho School locality.

Genus *Sigillaria* Sternburg

Sigillaria elegans? Sternburg

Pl. VII, Fig. 8; Pl. VIII, Fig. 7.

The extremely poor state of preservation of these plants makes their determination uncertain. The form shown in pl. VII, fig. 8, appears to possess some of the characteristics of *S. tassellata*. The unusual length of the parichnos in the form shown in pl. VIII, fig. 7, may be due to the conditions of fossilization.

Localities: The species figured in pl. VIII, fig. 7, is from the Roadman school; the form shown in pl. VII, fig. 8, is from Bowling Green.

[4] Coal Flora, Atlas, pl. LXIV, fig. 1.

FILICALES AND PTERIDOSPERMALES

Genus *Sphenopteris* Brongniart

Sphenopteris communis Lx.

Pl. I, Figs. 4, 5 and 7.

1884. *Sphenopteris communis* Lesquereux, Coal Flora, Vol. III, p. 762, pl. CIV, figs. 1, 1a.

The fossils referred to this species agree closely with the forms described by Lesquereux as *S. communis*. This specimen is interesting in that it is fertile. Figs. 5 and 7 show the reduced lamina and small, quadrivalvate, cupular fructifications, probably belonging to the genus *Zeilleria*, attached to the ends of the principal nerves. Those details are better indicated in the enlarged text figure.

Fig 1. Part of fruiting frond of Sphenopteris communis (x3½)

Sphenopteris cf. *inequilateralis* Lx.

Pl. II, figs. 6, 7.

A few fragments of a plant comparable with *S. inequilateralis* were found in the Yoho School district. Those fragments agree rather closely with

Arkansas fossils described and figured by Lesquereux. A slight difference is noted, however, in that the pinnules are a little more deeply lobed and more blunt than in Lesquereux's figures.[5]

Locality: Yoho School.

Genus *Mariopteris* Zeiller

Mariopteris muricata Schlotheim

Pl. II. Fig. 2.

1880. *Pseudopecopteris muricata* Brongn. Lesquereux, Coal Flora, Vol. I, p. 203, pl. XXXVII, fig. 2.

1886. *Mariopteris muricata* (Schlotheim). Zeiller, Bassin houiller de Valenciennes. Description de la Flora Fossile. Atlas, pl. XX, fig. 1–4; pl. XXI, fig. 1; pl. XXII, figs. 1, 2; pl. XXIII, fig. 1; Text, (1888) p. 173.

The plant shown in pl. II, fig. 2, agrees very closely with the European form figured by Zeiller[6] as *M. muricata* Sch. var. *hirta* Stur.

Locality: Yoho School.

Mariopteris decipiens Lx.

Pl. IV, fig. 7; Pl. V, fig. 4.

1860. *Sphenopteris dilatata* Lesquereux, 2nd. Rept. Geol. Surv. Ark. pp. 310–315, pl. II, figs. 3, 3a.

1879. *Pseudopecopteris decipiens* Lesquereux, Coal Flora, Atlas, Pl. LII, figs. 9?, 10, 10a, text (1880), p. 214.

1895. *Mariopteris (Pseudopecopteris) decipiens* Lx. White, David, Flora of the Outlying Carboniferous Coal Basins of Southwestern Missouri, Bul. 98, U. S. G. S., p. 47, pl. I, figs. 5-8, 5a; pl. II, figs. 1-3, 3a.

This species was represented principally by detached pinules. Those fragmentary specimens have pinules that differ slightly in shape from the Missouri forms in that they are more restricted at the base and have a greater number of lobes. They closely resemble the Arkansas[7] forms figured by Lesquereux. The form shown in Pl. IV, fig. 7, is close to the Pennsylvania forms.[8]

Locality: Yoho School.

Coal Flora, Vol. III, Pl. 765, p. CIII, figs. 4–5a.

[6] Basin Houiller de Valenciennes, Flore Fossile, Atlas, pl. XX, fig. 4.

[7] 2nd Geol. Surv. Ark., Pl. II. figs. 3, 3a.

[8] Coal Flora, p. 214, Atlas, pl. LII, figs. 9? 10, 10a.

Genus *Pseudopecopteris* Lesquereux

Pseudopecopteris obtusiloba (Brongn.) Lx.

Plate IX, figs. 2 and 7.

1829. *Sphenopteris obtusiloba* Brongniart, Hist. Veg. Foss., p. 201, pl. LIII, fig. 2.
1884. *Pseudopecopteris obtusiloba* (Brongn.) Lesquereux, Coal Flora, Vol. III, p. 753.
1886. *Sphenopteris obtusiloba* Brongn. Zeiller, Fl. Foss. houill. Valenc. Atlas, pl. III, figs. 1–4; pl. IV, fig. 1; pl. V, figs. 1–2, text (1888), p. 65.
1893. *Sphenopteris (Pseudopecopteris) obtusiloba* Brongn. D. White, Bull. U. S. G. S., No. 98, p. 52.
1899. *Sphenopteris obtusiloba* (Brongn). Lx. D. White, Mon. U. S. G. S., Vol. 37, p. 24, pl. VII, Figs, 1–3; Pl. VIII.

This plant occurred in a hard, porous sandstone. the cementing material of which was principally silica, with a very small per cent of iron; consequently the diagnostic details of the fossils were not well preserved. The plants shown in figs. 2 and 7 agree closely with *P. obtusiloba* from Missouri.[9]

Locality: Liberty School.

Pseudopecopteris cf. *dimorpha* Lx.

Pl. II, figs. 1b?, 4? and 5.

The plant shown in fig. 5, pl. II, is very close to the plant described by Lesquereux as *Pseudopecopteris dimorpha.* Figs. 1b and 4 may represent *P. macilenta*,[10] the material being so fragmentary that determination is uncertain.

Locality: Yoho School.

Genus *Pecopteris* Brongniart

Pecopteris plumosa Artis

Pl. IV, figs. 3, 5 and 6.

1825. *Filicites plumosa.* Artis, Antediluvian Phytology, p. 17, pl. XVII.
1828. *Pecopteris plumosa* Brongniart, Hist. veg. foss., p. 348., pl. CXXI, CXXII.
1871. *Pecopteris (Aspidites?) serrulata* Hartt in Dawson, Foss. Devon. Upp. Silur, Canada, Geol. Surv. Rep., p. 55, pl. XVIII, figs. 207–209.
1888. *Pecopteris (Dactylotheca) dentata* Brongn. Zeiller, Flor. Foss. houill. Valenc., p. 6, Atlas, (1886) pl. XXVI-XXVIII.
1914. *Pecopteris plumosa* Artis. Stopes, M. C., Memoir 41, Geol. Surv. Canada, p. 44, pl. XII, figs. 27, 28, 29, and text fig. 7.

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[9] U. S. G. S. Mon. Vol. 37, p. 24; Bull. U. S. G. S. No. 98, p. 52.
[10] Coal Flora, Vol. III, p. 750. pl. CXVIII, figs. 4, 4a.

The specimens representing this species appear to be the same as the Canadian form, *P. serrulata* of Hartt,[11] and Zeiller's European form, *P. dantata*. There seems also to be no essential difference between the plants studied and the forms described and figured by Brongniart as P. plumosa.

Locality: Yoho School.

Pecopteris sp.

Pl. II, fig. 8.

Detached pinnae of a rather delicate Pecopterid plant comparable with *P. Miltoni* were found at the Yoho School locality. The diagnostic features of those fossils are too obscure for definite determination.

Pecopteris cf. *abbreviata* Brongn.

Pl. IX, figs. 11, 12 and 13?.

A few poorly preserved fragmentary plants are doubtfully referred to this species. The shape and size of the pinnules agree rather closely with forms figured by Zeiller.[12]

Locality: Fire clay under the Upper Block Coal, Asherville.

Undermined *Pecopteris* Species

A few imperfectly preserved, fragmentary Pecopterid forms are figured in plates VI, IX and X. Fig. 13, pl. VI, represents a plant from the Reelsville locality; fig. 1, pl. IX, a plant from the Liberty school locality; figs. 5 and 6, pl. IX, are of fossils from Schroepferman's mine; fig. 2, pl. X, is a plant from the fire clay under the Upper Block Coal, Asherville.

Genus *Neuropteris* Brongniart.

Neuropteris Elrodi Lx.

Pl. V, fig. 2.

1879. *Neuropteris Elrodi* Lesquereux, Coal Flora, Atlas, pl. XII, fig. 4' text (1880), p. 107.

1883. *Neuropteris Elrodi* Lx. 13th, Ann. Rep. Geol. and Nat. Hist. Ind., p. 52, pl. X, fig. 3.

1900. *Neuropteris Elrodi* Lx. White, David, U. S. G. S., 20th Ann. Rept. Part II, p. 782.

The fossils referred to this species closely agree in all essential characteristics with plants from the shales of the Whetstone beds of Indiana.

Locality: Yoho School.

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[11] See Stropes' discussion of this species in Memoir 41, Geol. Surv. Canada, pp. 45–46.

[12] Flore Fossile, Atlas, pl. XXIV.

Neuropteris sp.

Pl. III, fig. 4; pl. IV, fig. 1; pl. V, figs. 1 and 3.

Numerous detached cyclopterid pinnules of *Neuropteris Sp.* were found at the Yoho School locality. As none of these pinnules were found in actual connections with the parent plant their determination is uncertain. The form shown in pl. V, figs. 1 and 3, bears a rather close resemblance to the cyclopterid pinnules of *N. Jenneyi* D. W.[13]

Detached pinnules of two other undetermined species of *Pecopteris* are shown in plate IX, fig. 4, and pl. X, fig. 1. The former is from the Asherville locality and the latter is from Schroepferman's mine.

Genus *Alethopteris* Sternburg

Alethopteris grandifolia Newb.

Pl. II, fig. 9, pl. III, fig. 6, Pl. V. fig. 5.

1873. *Alethopteris grandifolia.* Newberry, Geol. Surv. Ohio. Vol. I, Part II, p. 384, pl. XLVIII, figs. 1, 1a and 2.

1900. *Alethopteris grandifolia* Newb. White, D., U. S. G. S., 20th. Ann. Rep. Pt. II, p. 886.

The fragmentary forms in hand representing this species seem to differ in no essential characteristic from the forms described from Ohio except that they are much smaller.

Locality: Yoho School.

Alethopteris sp.

Plate III, figs. 1, 2.

Only two fragments of this form were found. It is very probable that this is an undescribed species but the material is insufficient for determination and description.

Locality: Yoho School.

Alethopteris Evansii Lx.

Plate III, fig. 3.

1884. *Alethopteris Evansii.* Lx., Coal Flora, Vol. III, p. 834.

1900. *Alethopteris Evansii* Lx. White, D., U. S. G. S., 20th Ann. Rep. Part II, p. 887, pl. CXCII, figs. 7, 7a, 8, 8a.

The forms representing this species agreed closely with the forms from the Pottsville region of Pennsylvania. The finely punctuate and rugose nature of the lamina is not well shown in the figure.

Locality: This species was abundant at the Yoho School locality.

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[13] Bul. 98, U. S. G. S., Pl. II, fig. 10.

Alethopteris Serlii (Brongn). Goepp.

Pl. VII, figs. 1, 2 and 3

1828. *Pecopteris Serlii.* Brongniart, Histoire des Vegetaux Fossilis, p. 292, pl. LXXXV.
1880. *Alethopteris Serlii.* Brongn. Lx., Coal Flora, Vol. I, p. 176; Atlas (1879) pl. XXIX, figs. 1–5.
1900. *Alethopteris Serlii* (Brongn.) Goepp. White, D., U. S. G. S., 20th Ann. Rep. pl. II, p. 782.

The few fragmentary representatives of this species seem to differ slightly from the normal type in that the pinules are somewhat closer together. There is a very close agreement in the shape of the pinules and in the nervation with the Pennsylvania form described by Lesquereux.

Localities: Bowling Green, and Roadman School.

Genus *Callipteridium* Weiss

Callipteridium sp.

Pl. III, fig. 5; pl. IV, figs. 2, 4.

The plants shown in pl. III, fig. 5, and in pl. IV, figs. 2 and 4 are close to a form described by Lesquereux in MMS. as *C. Tracyanum.*[14]

Locality: Yoho School.

Callipteridium sp.

Pl. III, fig. 7.

This species is closely related to *Callipteridium* cf. *Tracyanum* but has more fleshy pinnules, a less prominent midrib and a greater number of nerves. The material at hand is not sufficient for definite determination.

Locality: Yoho School.

Genus *Odontopteris* Brongniart

Odontopteris Newberri Lx.

Pl. I, fig. 8; Pl. II, fig. 1a.

1873. *Odontopteris neuropteroides* Newberry, Geol. Surv. Ohio, Paleontology, Vol. I, p. 381, pl. 47, figs. 1–3.
1880. *Odontopteris Newberryi* Lesquereux, Coal Flora, Vol. I., p. 127.

The plant shown in plate I, fig. 8, agrees closely in all essential characteristics with the Ohio forms described by Newberry. The form shown in pl. II, fig. 1a, is doubtfully referred to *O. Newberryi.* It may represent a closely related species.

Locality: Yoho School.

[14] Private communication from David White.

Genus *Trigonocarpum* Brongniart

Trigonocarpum ovatum n. sp.

Pl. VI, figs. 6a, 6b.

Nutlet oval, slightly truncate at base, pointed at apex, broadly oval to nearly round in cross section, 6–7 mm. in diameter, 12–13 mm. long, marked from base to apex by three prominent ribs at an equal distance apart, base marked by a round depression 3 mm. in diameter.

Locality: Cincinnati.

Trigonocarpum sp.

Four other Trigonocarpum forms are shown in Pl. VI, figs. 9a–9b, 10, 11 and 12. Those forms were so imperfectly preserved that their determination was too doubtful to be of value. The forms shown in figs. 9a-9b and 10 have three ribs; and the forms shown in figs. 11 and 12 are hexagonal in cross section.

Locality: Cincinnati.

Trigonocarpum cf. *Schultzianum* Goep. and Berg.

Plate VI, fig. 7.

This species, although somewhat smaller, appears to agree closely with Kansas forms described by Sellards.[15]

Locality: Yoho School.

Trigonocarpum hexagonale n. sp.

Plate VI, figs. 5a, 5b.

Nut ovoid in outline, pointed at apex, much truncated at base, about 1.5 centimeters long, 8 mm. in diameter, hexagonal in cross section, with six prominent ridges from base to summit; base marked by round depression 3 mm. in diameter and by 6 faint lines extending from the depression to the six angles formed by the six sides.

Locality: Cincinnati.

Trigonocarpum hexacostatum n. sp.

Plate VI, figs. 4a–4b.

Nutlet broadly oval in outline, wedge shaped at apex, truncated at base, hexagonal in cross section, 5 mm. in diameter, 7 mm. long, marked by six rather prominent ridges from base to summit; base 3 mm. in diameter, marked by a small depression and six rather faint lines from the depression to angles of the hexagonal base.

Locality: Cincinnati.

[15] Sellards, E. H., Univ. Geol. Surve. Ks., Vol. IX, p. 428, Pl. LII, fig. 1; Pl. LVIII, fig. 3, 1908.

Cordaianthus sp.

Pl. IX, fig. 8.

A plant probably belonging to the genus *Cordaianthus* was found in the shales overlying the Upper Block Coal at Baird's mine. The specimen was so poorly preserved that specific determination was uncertain.

GYMNOSPERMS

Cordaitales

Genus *Cordaites* Unger

Cordaites Robbii Daw

Pl. VII, fig. 9.

1861. *Cordaites Robbii.* Dawson, Canad. Nat., Vol. 6, p. 168.
1886–1888. *Cordaites brassifolius* Sternb. Zeiller, Bassin Houiller de Valenciennes, p. 625, pl. XCII, figs. 1–6.
1900. *Cordaites Robbii* Daw. White, Foss. Flora Pottsville Form., p. 903.
1914. *Cordaites Robbii* Daw. Stopes, The "Fern Ledges" Carb. Flora of St. John, New Brunswick, p. 82, pl. XIX, fig. 50, and text fig. 16.

The specimen illustrated in pl. VII, fig. 9, is from Bowling Green. It seems to agree closely with forms previously described as *C. brassifolius*.[16] It is also close to, if not the same as *C. communis* although the nervation is more regular than in the Missouri[17] forms of that species. It is very likely the same form described by Stopes as occuring in the Pennsylvanian of New Brunswick.[18] The very fine veins alternating with the coarser ones are not well shown in the figure. They are apparent, however, in a small area near the end of the arrow.

Localities: Yoho School, Bowling Green, Roadman School and Bird's mine (?). The species was common in the two first named locaiitles.

Genus *Cardiocarpon* Brongniart

Cardiocarpon annulatum Newb.

Plate V, fig. 10; Plate VIII, fig. 4.

——.? *Cardiocarpon annulatum.* Newberry. Ann. Sc. of Clevel., 1. c.
1873. *Cardiocarpon annulatum* Newb. Geol. Surv. Ohio, Vol. I, p. 374, pl. 43, Figs. 8–8a.
1879. *Cardiocarpus annulatus.* Lesquereux, Coal Flora, Atlas, Pl. LXXXV, Figs. 36, 37, text (1880), p. 564.

Examples of this species from the Yoko School locality seem to agree in all respects with the forms described by Newberry from the shale over Coal

[16] Comparé figures in Zeiller's works listed in above Synonomy.
[17] See discussion of this species in White's paper above cited.
[18] See Memoir of Stopes above cited.

No. 1 at Youngstown, Ohio.[19] A form shown in Pl. VIII, fig. 4, from the Liberty School locality is doubtfully referred to this species.

Locality: A few specimens were found at the Yoho School and Liberty School localities.

Cardiocarpon pachytestum. Lx.

Plate V, fig. 9.

1879. *Cardiocarpus pachytesta.* Lx. Coal Flora, Part II, p. 565.
1884. *Cardiocarpus pachytesta.* Lx. Coal Flora, Part III, p. 809, pl. CIX, figs. 13, 15.

The examples of this species agree closely with the type forms included by Lesquereux in his later description of the species.[20] A slight difference is noted in that the base of the nucleous does not appear to "continue downward in a narrowly lanceolate acuminate appendage or axis of a pedicel." This, however, may be due to the imperfect preservation of the specimens in hand rather than a difference in structure.

Locality: Yoho School.

Cardiocarpon acuminatum n. sp.

Plate IX, fig. 9.

Fruit about 7 mm. wide, 9 mm. long, oval in outline; nucleus 4 mm. wide, 5 mm. long, truncate at base and acutely pointed at apex; wings of uniform width of about 1.5 mm., conforming to the shape of the nucleus, prolonged, narrowed and close together at the apex.

This form very likely belongs to a group of small, wide-winged Cardiocarpon forms represented by *C. late-alatum.*[21]

Locality: Baird's Coal Mine.

Cardiocarpon irregulare n. sp.

Plate X, figs. 7, 8a, 9 and 12.

Fruit cordate to broadly oval in outline, about 5 mm. wide and 6.5 mm. long; nucleus ovate, acutely pointed above, truncate with small depression at base; wings about .5 mm. in width at base and increasing to about 1 mm. in width at the apex and there emarginate.

This species varies somewhat in shape, in size and in the width of the wings at the base. The cordate shape is shown in figs. 7 and 9, pl. X, and the more rounded form in figs. 8a and 12, pl. X.

Locality: Very numerous in the fire clay under the Upper Block Coal at Asherville.

[19] Geol. Sur. Ohio, Pal., vol. 1, p. 374, 1873.
[20] Coal. Flora, III, p. 809, 1884.
[21] Coal Flora, Vol. II, p. 568, Pl. LXXXV, figs. 46, 47.

Cardiocarpon cuneatum n. sp.

Plate X, figs. 4, 6.

Fruit about 1.2 centimeters long and 1 centimeter wide, the greatest width a little below the middle, narrowly cordate; nucleous ovate to nearly round, elongated and pointed above, slightly flattened or depressed at base and marked by a line extending downward from the micropyle nearly to the base; wings about 1 mm. in width at base and increasing to about 2 mm. in width at apex, slightly marginate.

The smaller size, more acute nucleus, and emarginate wings distinguish this species from *C. minus*,[22] a form which it closely resembles.

Locality: Fire clay under the Upper Block Coal, Asherville.

Cardiocarpon gracile n. sp.

Plate X, fig. 5.

Seed broadly oval in outline, slightly truncate at base, about 9 mm. long and 7 mm. in width, the greatest width a little below the center; nucleus oval, slightly truncate at base, wedge shaped at apex; with line extending downward from micropyle to near the center; wings less than 1 mm. wide at base, increasing to about 1.5 mm. at apex; very slightly emarginate.

This species is doubtless closely related to *C. cuneatum*. It differs from it principally in being smaller in size and in having a less sharply pointed nucleus.

Locality: Same as *C. cuneatum*.

Cardiocarpon cordatum n. sp.

Plate X, fig. 10.

Fruit ovate in outline, about 7.5 mm. long, 6 mm. wide, the greatest width a little below the center; nucleus cordate in outline, pointed above, marked by line extending from apex to depression in truncated base; wings about .5 mm. wide at base and about 1.5 mm. wide near the apex; very faintly emarginate.

This species differs from *C. gracile* in its smaller size and in that its nucleus is more sharply pointed at the apex and more truncate at the base. It may be distinguished brom *C. irregulare* by its larger size, wider wings and nucleus not marked by a vertical line. A poorly preserved specimen shown in Pl. IX, fig. 10, is doubtfully referred to this species.

Locality: Fire clay under the Upper Block Coal, Asherville.

Cardiocarpon commune n. sp.

Plate X, figs. 11 and 15

Fruit very broadly oval to nearly round in outline, 6 mm. wide and 7 mm. long; nucleus oval; wedge-shaped above, flattened below and marked

[22] Geol. Surv. Ohio, Vol. I, Part II, p. 372, pl. 43, fig. 4, 1873.

by a faint line from micropyle to base; wings of uniform width of about 1 mm., slightly emarginate.

The uniform width of the wings and more rounded outline distinguish this species from *C. cordatum*, *C. irregulare* and *C. obtusum*. It is smaller than *C. acutum* and the wings are not narrowed and extended as in that species.

Locality: Fire clay under the Upper Block Coal, Asherville.

Cardiocarpon biscuspidatum (Sternb.) Newb.

Plate VII, figs. 4 and 6; Pl. VIII, fig. 3.

1873. *Cardiocarpon bicuspidatum* Sternb. Newberry, Rep. Geol. Surv. Ohio, Vol. I, part II, p. 373, pl. 43, figs. 9, 9a.

The form shown in pl. VII, fig. 6 seems to agree closely with the Ohio forms described by Newberry. The specimen shown in pl. VII, fig. 4 is somewhat smaller and the margin is narrower than in the Ohio forms. Nuclei of forms doubtfully referred to this species are shown in pl. VI, figs. 8a, 8b.

Localities: Cincinnati, Bowling Green and Roadman School.

Cardicarpon cf. *circulare* Lx.

Plate VII, fig. 5.

The poor state of preservation of this specimen makes its determination a matter of uncertainty. It appears to be closely related to the form described by Lesquereux[23] as *C. circulare*. The wings are slightly more narrowed at the base and less truncate at the apex than in *C. circulare*.

Locality: Bowling Green.

Cardiocarpon subcirculare n. sp.

Plate VIII, fig. 5.

Fruit nearly round; about 1.1 centimeters wide, 1.2 centimeters long; nucleus round, 9 mm. in diameter, acutely pointed above, slightly truncated at the base; wings about 1 mm. in width at the base and a little greater at the top; wings rounded on the side next the micropyle, extended, pointed and close together above.

This form is related to *C. bicuspidatum* but is smaller and more rounded. It also differs from that species in that the nucleus and wings are more sharply pointed and prolonged above.

Locality: Roadman School.

Cardiocarpon sp.

Plate V, Fig. 8.

Fruit oval, somewhat truncate above, about 2.5 centimeters in width and 3.5 centimeters in length; wings about 8 mm. in width, slightly emargin-

[23] Coal Flora, Vol. III, p. 812, pl. CX, fig. 10.

ate above and a little rounded at the apex of the nucleus; nucleus rather narrowly oval, pointed above and marked by three comparatively large longitudinal ridges; basal part of fruit destroyed so that its exact nature cannot be determined.

This fruit appears to belong to a group of large, broad-winged seeds represented by *C. Girtyi*,[24] *C. Newberryi*, *C. Baileyi* and[25] *C. annulatum*. It is likely an undescribed species but owing to its poor state of preservation it is not thought admissible to describe it as such.

Locality: A single form was found at the Yoho School locality.

Cardiocarpon rugosum n. sp.

Pl. VI, Fig. 1.

Fruit slightly oval to nearly round, 21 mm. long, 19 mm. wide, the greatest width a little below the center; wings of uniform width of 2.5 mm. except at the top where the width is about 3 mm; wings close together at apex of nucleus, with small emargination above; nucleus nearly round, a little pointed at top, small depression at base which marks the attachment of pedicle; surface of nucleus finely rugose.

This species is rather close to *C. annulatum* but is smaller and has narrower wings more nearly equal in width. It is also close to *C. ovoideum*, but is larger, has wings of a more uniform width, and the nucleus is less acute above.

Locality: Yoho School.

Cardiocarpon ovoideum n. sp.

Pl. VI, fig. 2.

Fruit of moderate size, slightly oval, 17–18 mm. long, 16–17 mm. wide; nucleus almost round, extending upward, pointed at the top, slightly truncate or depressed at the base; wing blunt, rounded and much emarginate at apex, and slightly rounded on either side of the micropyle, near which it forms a border 3 mm. wide, narrowing downward toward the base where it is about 1.5 mm. in width; point of attachment of the pedicle faintly marked by a rounded depression at the base of the nucleus.

This species is probably related to *C. ovatum* and *C. conglobatum*[27] both of which have been reported from the Pennsylvanian of Arkansas. It differs from the former in that it is larger, more rounded and is more emarginate and does not have wings of equal width.

Locality: Yoho School.

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[24] Rep. Geol. Surv. Ohio, Vol. I, part II, p. 373, pl. 43, figs. 9, 9a.
For a discussion of apparently related forms see White's paper on the Stratigraphic Succession of the Fossil Flora of the Pottsville Formation in the Southern Anthracite Coal Fields of Pennsylvania, 20th An. Rep. U. S. G. S. Part II, p. 907.

[25] Stopes, M. C., Memoir 41, Geol. Surv. Canad., 1914, "The Fern Ledges" Carboniferous Flora of St. John, N. B., p. 92, Text fig. 21.

[26] Geol. Surv. Ohio, Vol. I, p. 374, pl. 43, figs. 8–8a.

[27] Coal Flora, III, p. 810, Pl. Cix., fig. 9,, 1884.

Cardiocarpon obtusum n. sp.

Plate X, figs. 13, 14.

Fruit small, oval or ovate-rectangular, 8.5 to 9 mm. long, 5.5 to 6 mm. wide; wings rounded and slightly emarginate at apex, about 2 mm. wide at micropyle, rather rapidly narrowing downward to less than 1 mm. in width a little below the middle of the altitude, then prolonged and dilated into a concave basal lobe 2 to 2.5 mm. wide, extending downward about 1.5 mm.; nucleus ovate, sharply acuminate at apex, marked by a small depression at the slightly truncate base, and a faint line extending from the micropyle downward a short distance.

The much greater extension of the wings at the apex and the basal dilation distinguish this species from *C. irregulare*,[28] a form which it closely resembles.

Locality: Numerous in the fire clay under the Upper Block Coal at Asherville.

Rhabdocarpon sp.

Plate VI, fig. 3.

Several representatives of this species were found but all of them were so poorly preserved that specific determination was a matter of uncertainty.

Locality: Yoho School.

[28] Idem. p. 810, Pl. Cix, fig. 11.

PLATE I.

1.	*Sphenophyllum tenue* D. W	X1	p. 410
2.	*Spenophyllum cuneifolium* (Sternb.) Zeiller		p. 411
3.	*S. cuneifolium* (Sternb.) Zeiller	X1	p. 411
4.	*Sphenopteris communis* Lx.	X1	p. 414
5.	*Sphenopteris* cf. *communis* Lx. *Zeilleria sp.* attached		p. 414
6.	*Sphenophyllum cuneifolium* (Sternb.) Zeiller	X1	p. 411
7.	*Sphenopteris* cf. *communis* Lx. *Zeilleria sp.* attached		p. 414
8.	*Odontopteris Newberryi* Lx.	X1.	p. 419

All of the above specimens are from the Yoho School locality.

PLATE II.

1a.	*Odontopteris Newberryi* Lx.	X1	p. 419
1b.	*Pseudopecopteris* cf. *macilenta* L. and H.	X1	p. 416
2.	*Mariopteris muricata* Schloth.	X1	p. 415
3.	*Sphenophyllum cuneifolium* (Sternb.) Zeiller	X1	p. 411
4.	*Pseudopecopteris* cf. *macilenta* L. and H.	X1	p. 416
5.	*Pseudopecopteris* cf. *dimorpha* Lx.	X1	p. 416
6.	*Sphenopteris inequilateralis* Lx.	X1½	p. 414
7.	*Sphenopteris inequilateralis* Lx.	X1½	p. 414
8.	*Pecopteris sp.*	X1	p. 417
9.	*Alethopteris grandifolia* Newb.	X1	p. 418

All the above species are from the Yoho School locality.

PLATE III.

1.	*Alethopteris* sp. indet.	X1	p. 418
2.	*Alethopteris* sp. indet.	X1	p. 418
3.	*Alethopteris Evansii* Lx.	X1	p. 418
4.	*Neuropteris* sp.	X1	p. 418
5.	*Callipteridium* sp.	X1	p. 419
6.	*Alethopteris grandifolia* Newb.	X1	p. 418
7.	*Callipteridium* sp. a.	X1	p. 419

All of the above species are from the Yoho School locality.

PLATE IV.

1.	*Neuropteris* sp.	X1	p. 418
2.	*Callipteridium* sp.	X1	p. 419
3.	*Pecopteris plumosa* Artis	X1	p. 416
4.	*Callipteridium* sp.	X1	p. 419
5.	*Pecopteris plumosa* Artis.	X1	p. 416
6.	*Pecopteris plumosa* Artis.	X1	p. 416
7.	*Mariopteris decipiens* Lx.	X1	p. 415

All of the above species are from the Yoho School locality.

PLATE V.

1.	Cyclopterid leaf of *Neuropteris* sp.	X1	p. 418
2.	*Neuropteris Elrodi* Lx.	X1	p. 417
3.	*Neuropteris* sp.	X1	p. 418
4.	*Mariopteris decipiens* Lx.	X1½	p. 415
5.	*Alethopteris* sp.	X1	p. 418
6.	*Lepidodendron yohoense* n. sp.	X1	p. 411
7.	*Lepidodendron clypeatum* Lx.	X1	p. 412
8.	*Cardiocarpon* sp. indet	X1	p. 424
9.	*Cardiocarpon pachytestum* Lx.	X1	p. 422
10.	*Cardiocarpon annulatum* Newb.	X1	p. 421

All of the above species are from the Yoho School locality.

PLATE VI

1.	*Cardiocarpon rugosum* n. sp.	X1	p. 425
2.	*Cardiocarpon ovaloidum* n. sp.	X1	p. 425
3.	*Rhabdocarpon* sp.	X1	p. 426
4a–4b.	*Trigonocarpum hexacostatum* n. sp.	X1	p. 420
5a–5b.	*Trigonocarpum hexagonale* n. sp.	X1	p. 420
6a–6b.	*Trigonocarpum ovatum* n. sp.	X1	p. 420
7.	*Trigonocarpum* cf. *schultzianum* Goepp. and Berg.	X1	p. 420
8a–8b.	Nuclei of *Cardiocarpon bicuspidatum?* (Sternb.) Newb.	X1	p. 424
9a–9b.	*Trigonocarpum* sp.	X1	p. 420
10, 11 and 12.	*Trigonocarpum* sp.	X1	p. 420

13. *Pecopteris* sp. .... X1 p. 417
14. Indet. sp. .... X1 p. 417
15. *Lepidodendron clypeatum* Lx. .... X1 p. 412
16. *Sphenopteris* sp. indet. .... X1 p. 409
17. *Lepidodendron obovatum?* Sternb. .... X1 p. 412

Nos. 1, 2, 3, and 7 are from the Yoho School locality; Nos. 4, 5, 6, 8, 9, 10, 11, 12, and 15 are from Cincinnati; Nos. 13, 14 and 16 are fron Reelsville locality; No. 17 is from Bowling Green.

PLATE VII

1, 2, and 3. *Alethopteris Serlii* Brongn. .... X1 p. 419
4. *Cardiocarpon bicuspidatum?* (Sternb.) Newb. .... X1 p. 424
5. *Cardiocarpon* cf. *circulare* Lx. .... X1 p. 424
6. *Cariocarpon bicuspidatum* (Sternb.) Newb. .... X1 p. 424
7. *Lepidodendron obovatum?* Sternb. .... X1 p. 412
8. *Sigillaria elegans?* Sternb. .... X1 p. 413
9. *Cordiates Robbii* Daw. .... X1 p. 420

All of the above species are from the Bowling Green locality.

PLATE VIII

1. *Lepidodendron obovatum?* Sternb .... X1 p. 412
2. *Lepidodendron aculeatum* Sternb. .... X1 p. 413
3. *Cardiocarpon bicuspidatum* (Sternb.) Newb. .... X1 p. 424
4. *Cardiocarpon annulatum?* Newb. .... X1 p. 421
5. *Cardiocarpon subcirculare* n. sp. .... X1 p. 424
6. *Lepidodendron obovatum?* Sternb. .... X1 p. 412
7. *Sigillaria elegans?* Sternb. .... X1 p. 413
8. *Calamites Suckowi* Brongn. .... X1 p. 410

Nos. 1, 2, 3, 5, 6, and 7 are from the Roadman nehool locality. Nos. 4 and 8 ,are from the Liberty School locality.

PLATE IX.

1. *Pecopteris* sp. .... X1 p. 417
2. *Pseudopecopteris obtusiloba* (Brongn., Lx. .... X1 p. 416
3. *Taeniopteris* sp. .... X1 p.
4. *Neuropteris* sp. .... X1 p. 418
5, 6. *Pecopteris* sp. .... X1 p. 417
7. *Pseudopecopteris obtusiloba* (Brongn.) Lx. .... X1 p. 416
8. *Cordaianthus* sp. .... X1 p. 421
9. *Cardiocarpon acuminatum* n. sp. .... X1 p. 422
10. *Cardiocarpon cordatum?* n. sp. .... X1 p. 423
11, 12 and 13. *Pecopteris* cf. *abbreviata* Brongn. .... X1 p. 417
14. *Lepidodendron aculeatum?* Sternb. .... X1 p. 413
15. *Lepidodendron obovatum?* Sternb. .... X1 p. 412

Nos. 1, 2, 3, and 7 are from the Liberty School locality; Nos. 4, 5 and 6 are from Schroepferman's mine; Nos. 8, 9 and 10 are from Baird's mine; Nos. 11, 12, 13, 14 and 15 are from the fire clay under the Upper Block Coal at Asherville.

PLATE X.

1. *Neuropteris* sp. .... X1 p. 418
2. *Pecopteris* sp. .... X1 p. 417
3. *Sphenophyllum cuneifolium* (Sternb.) Zeiller. .... X1 p. 411
4. *Cardiocarpon cuneatum* n. sp. .... X1 p. 423
5. *Cardiocarpon gracile* n. sp. .... X1 p. 423
6. *Cardiocarpon cuneatum* n. sp. .... X1 p. 423
7, 8a, 9 and 12. *Cardiocarpon irregulare*, n sp. .... X1 p. 422
10. *Cardiocarpon cordatum* n. sp. .... X1 p. 423
11, 15. *Cardiocarpon commune* n. sp. .... X1 p. 423
13, 14. *Cardiocarpon obtusum* n. sp. .... X1 p. 426

All of the above species are from Asherville.

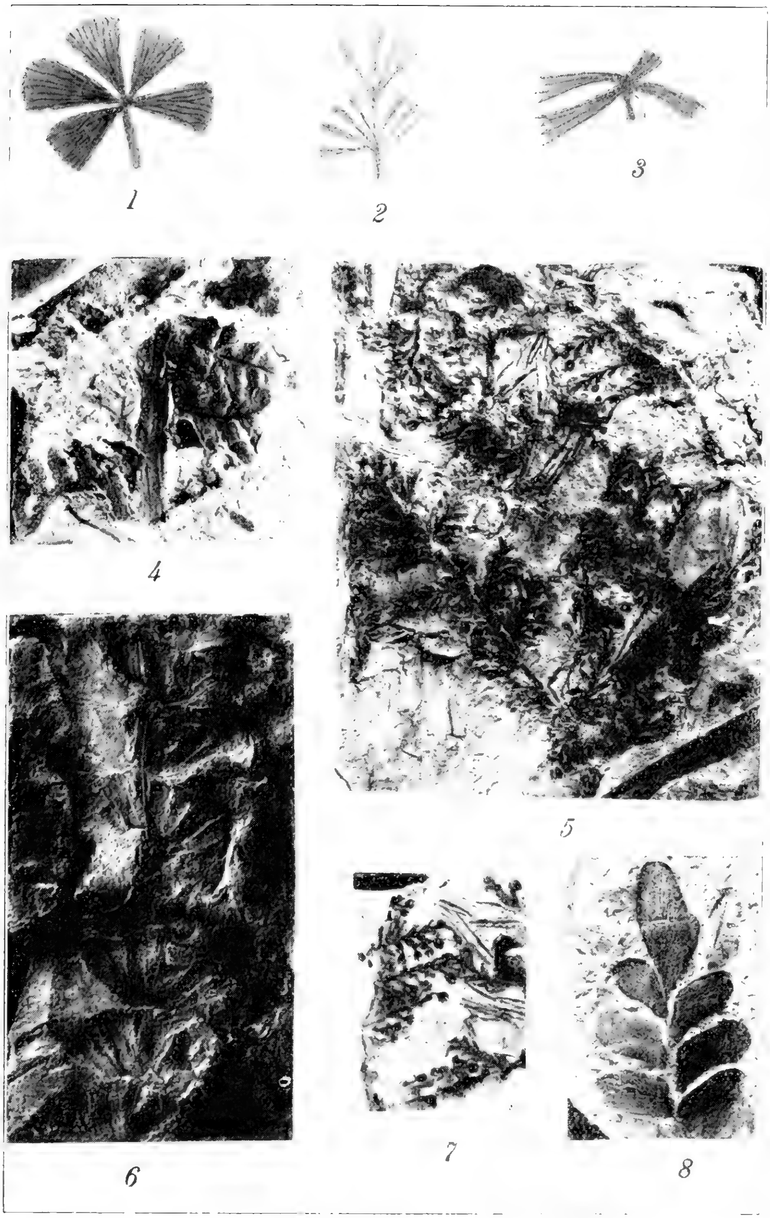


PLATE I

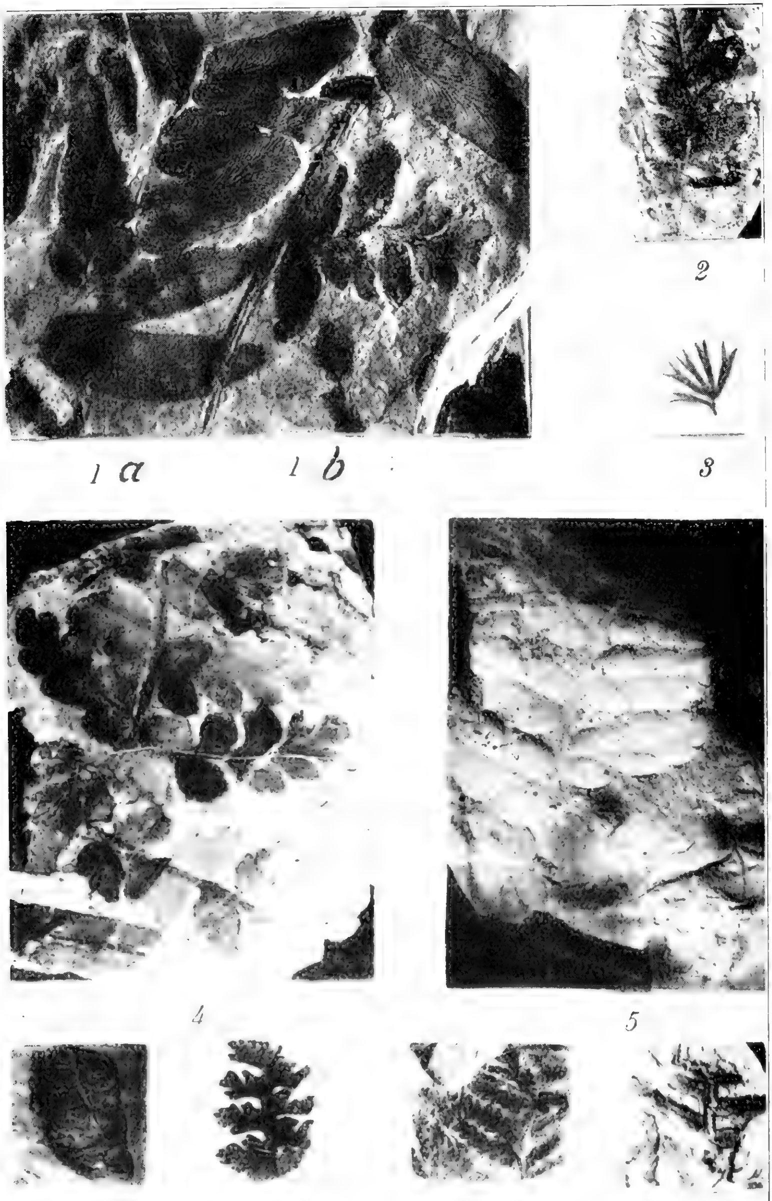


PLATE II

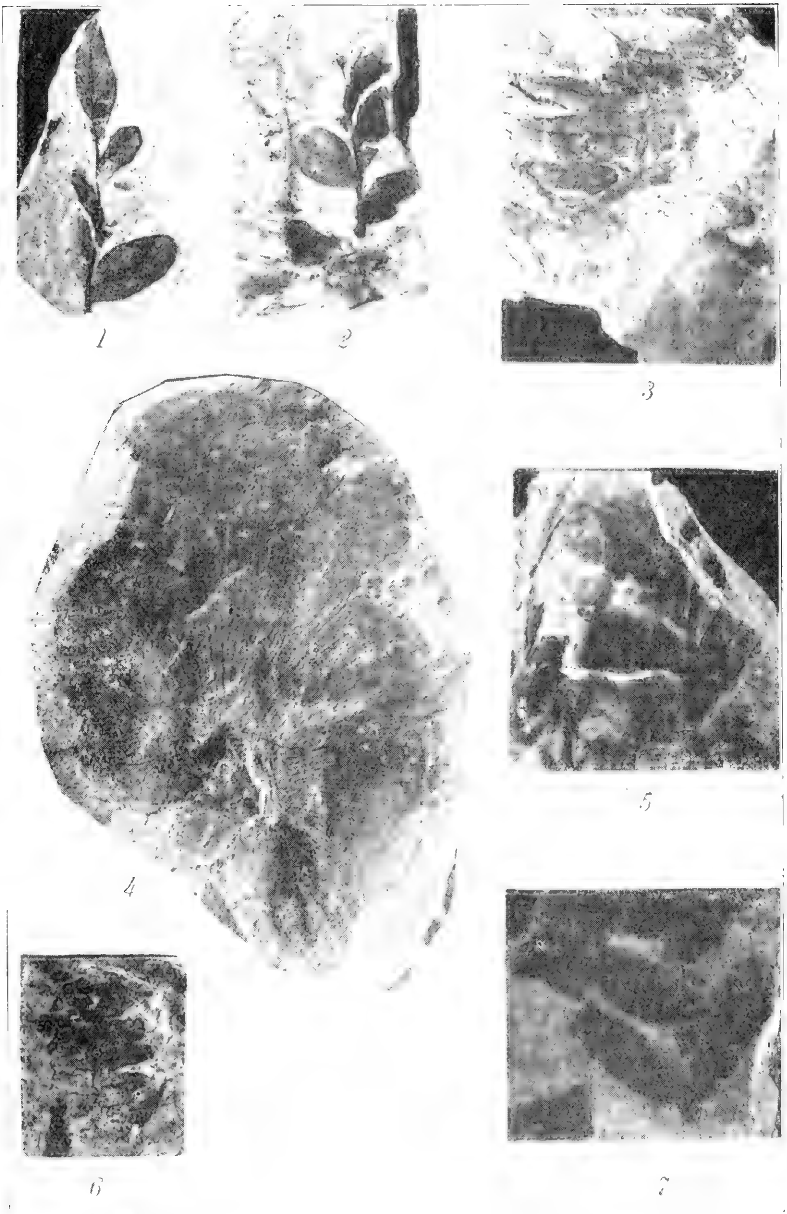


PLATE III

PLATE IV

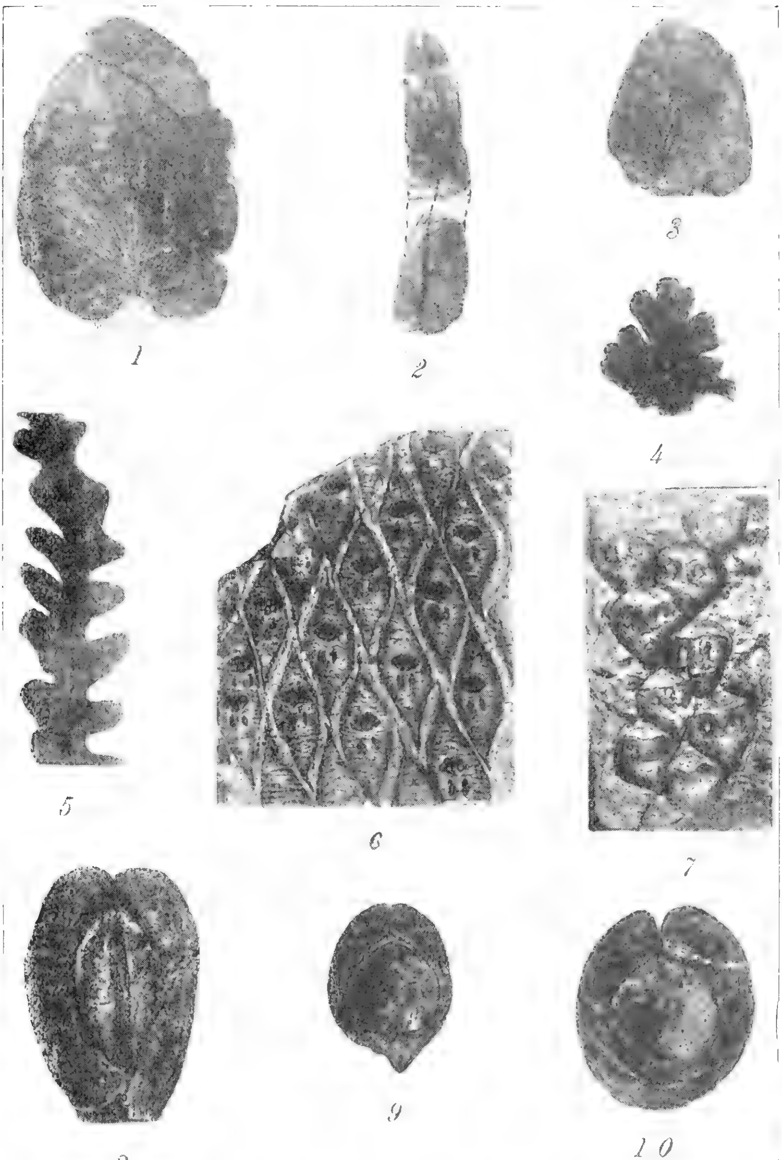
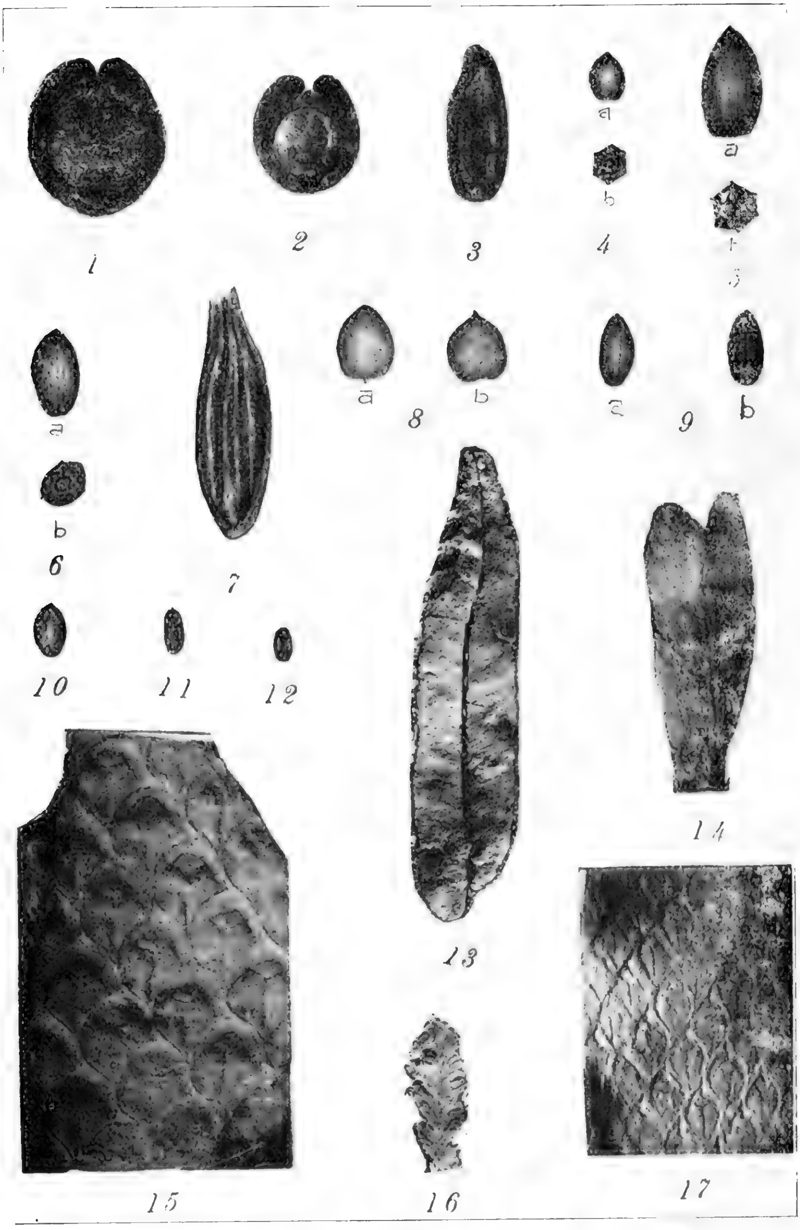


PLATE V



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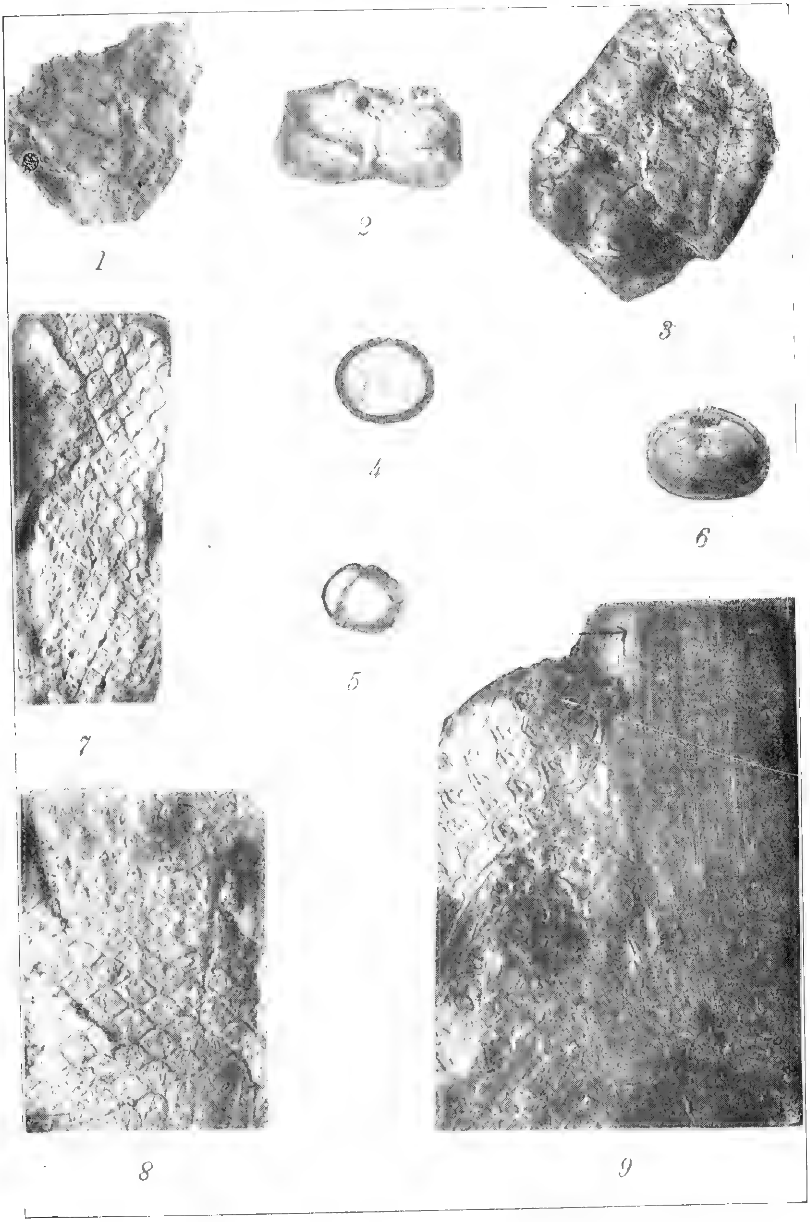


PLATE VII

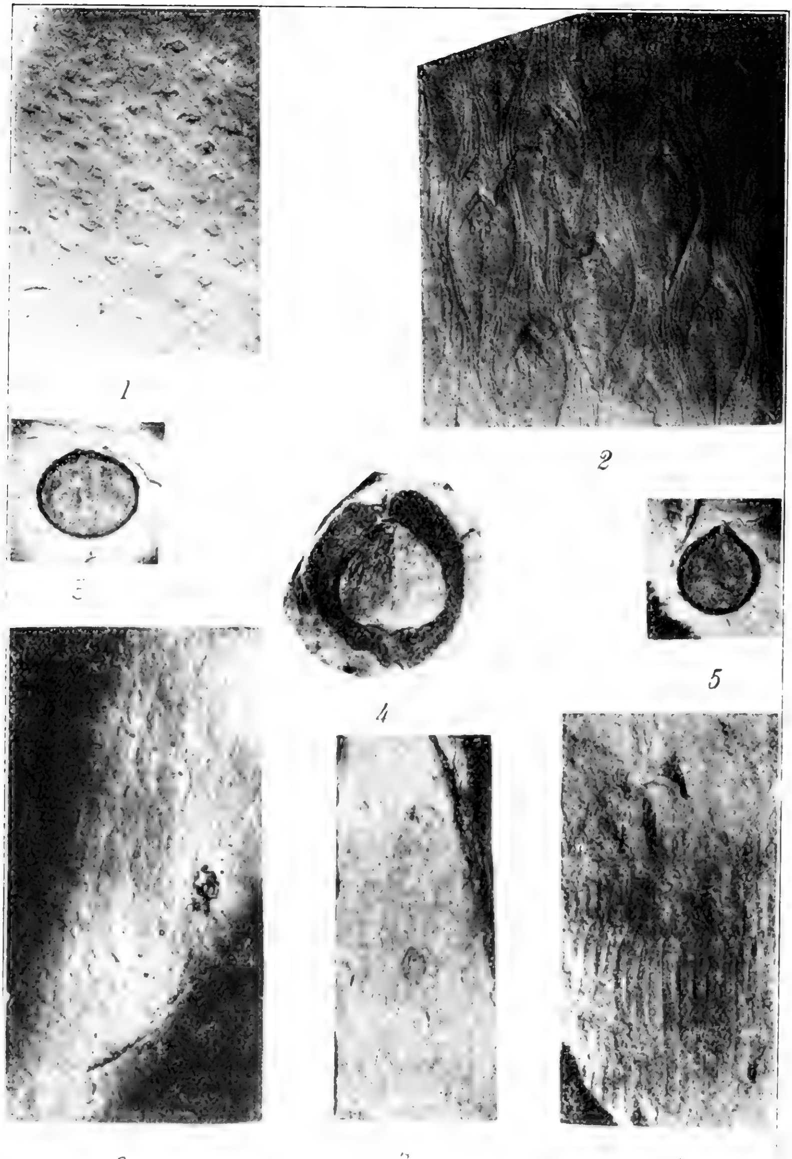


PLATE VIII

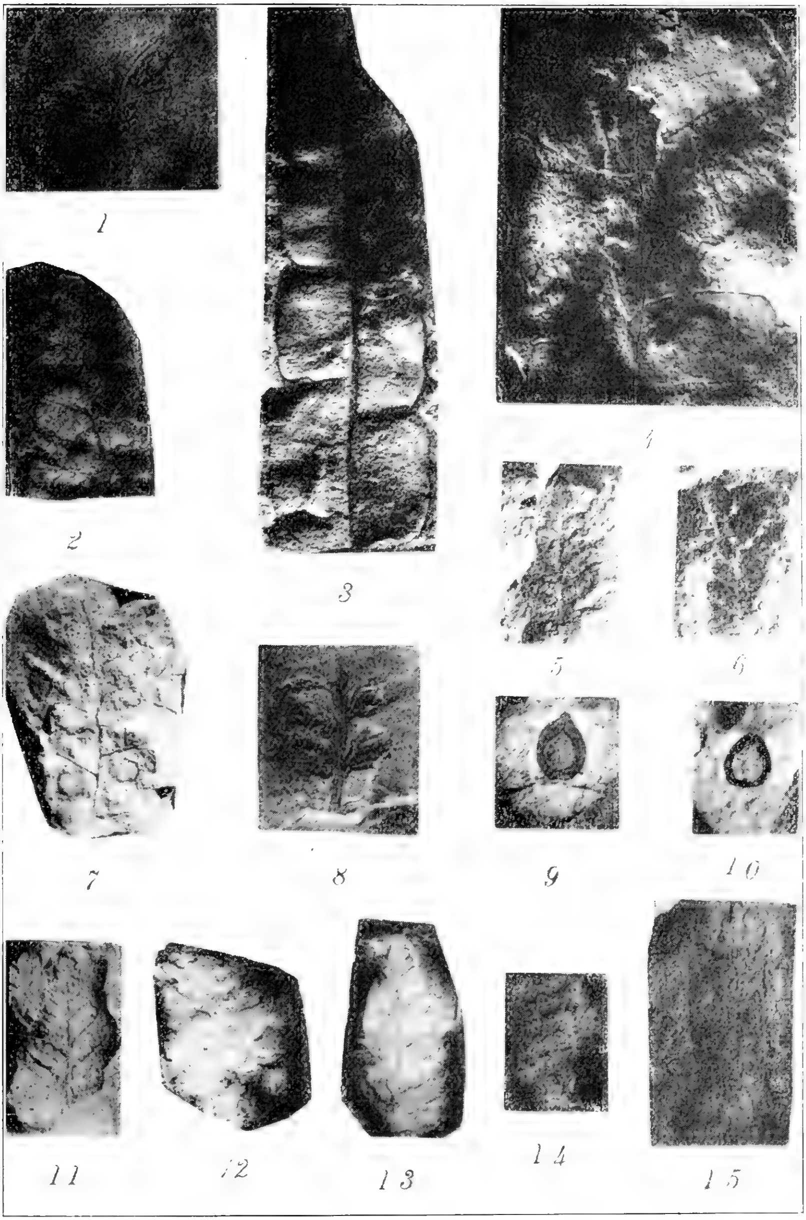


PLATE IX

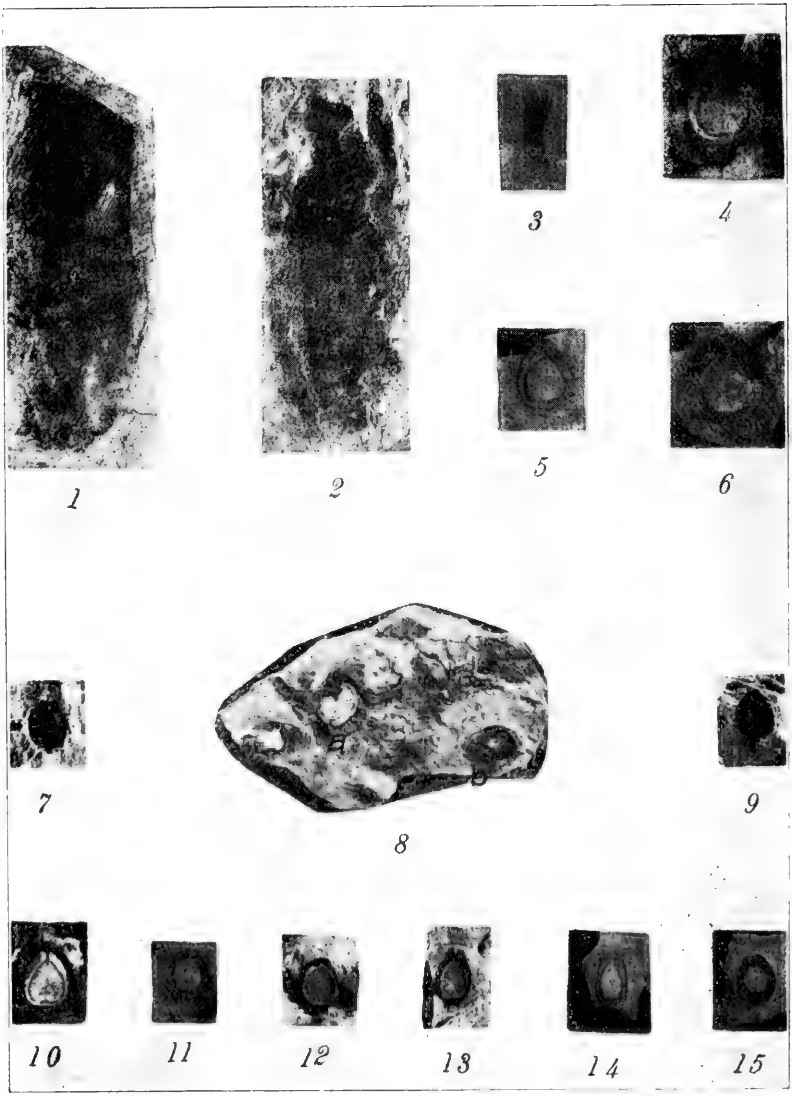
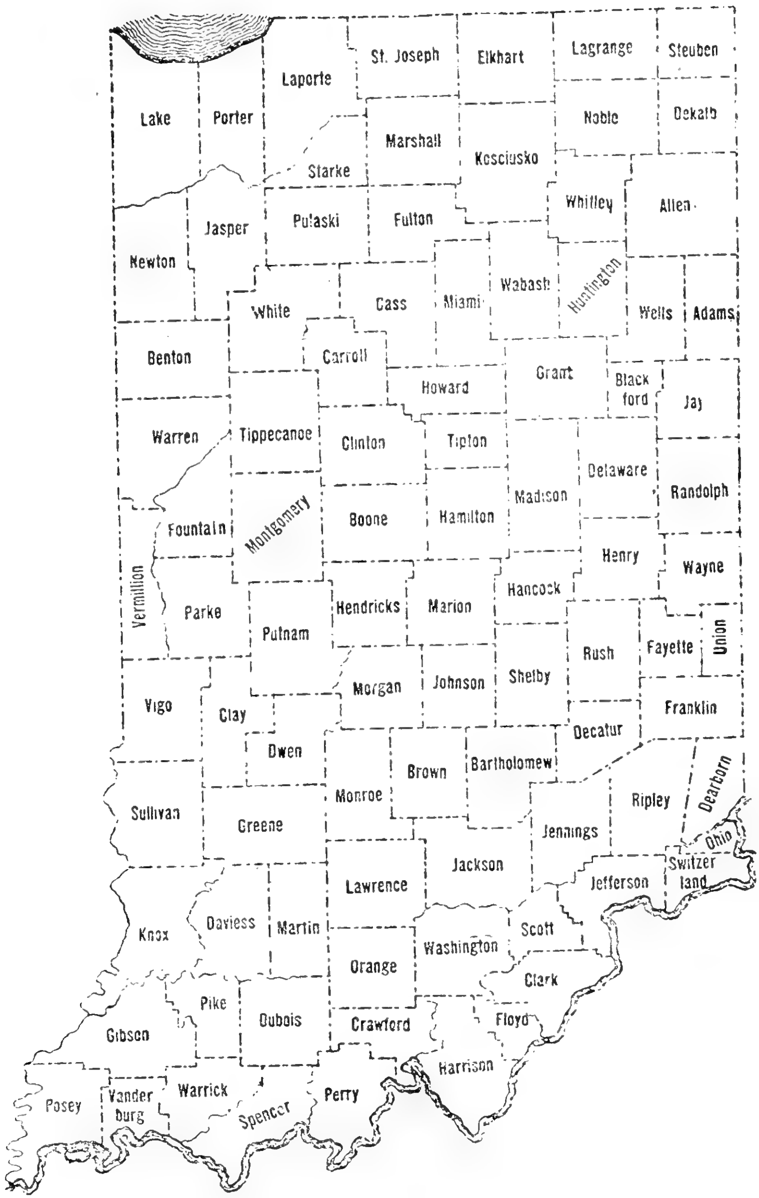


PLATE X



MAP OF INDIANA SHOWING LOCATION OF COUNTIES.

On the Poincare Transformation.

Tobias Dantzig.

1. *Introductory.*

In a memior entitled "Sur un Theoreme de Geometrie" (Rendiconti del Circolo Matematico di patermo, Vol. 33, 1912, P. 375-407) the late Henri Poincare has considered a certain type of transformations of fundamental value in Celestial Mechanics. Without giving a proof he has announced there a general property of all such transformations. The proposition has since been taken up by George D. Birkhoff who in his paper "Proof of Poincare's Geometric theorem" Transaction of the American Mathematical Society, Vol. 14, 1913) has given the theorem a general demonstration. His proof lacks, however, simplicity and directness.

In my article entitled "Demonstration directe du dernier theoreme de Henri Poincare" which appeared in the February issue of the "Bulletin des Sciences Mathematiques et Astronomiques." I gave an elementary, genetic proof of the proposition. I wish to reproduce here the main features of my demonstration as well as to bring out in greater detail some points which were left incomplete in the said paper.

2. *Poincare's Theorem.*

Slightly generalized* the theorem can be stated thus:

Let T be a transformation operating in a plane and having the following properties:

(*a*) *It is continuous and one-to-one in the ring formed by two closed curves contours (C) and (c) of which (c) is entirely within (C). (Fig. 1.)*

(*b*) *It leaves the two contours (C) and (c) invariant.*

(*c*) *It moves any point M on (C) into a point M in the positive sense of rotation, while the points m on (c) advance in the opposite sense.*

(*d*) *It takes every point P within the ring (Cc) into a point P also within the ring.*

(*e*) *It conserves areas.*

Under these considerations there are within the ring (Cc) at least two points I and J which are left invariant by T.

3. *Notations.*

Choose at random within (c) (Fig. 1) a point O, and a half-line OX, for pole and polar axis respectively, and let

$$(1)\begin{cases}\bar{r} = f(r, \Theta)\\ \bar{\Theta} = g(r, \Theta)\end{cases}$$

be the polar equations of the transformation. r, Θ; $\bar{r}$, $\bar{\Theta}$ are the co-ordinates of any point P and its image $\bar{P}$, while f and g are functions which by hypothesis are continuous and single valued within the ring (Cc) and on its boundaries. The same is true of the quantity

(2) $Z = \bar{\Theta} - \Theta = (r, \Theta)$

which measures in value and sign the angle $PO\bar{P}$. I shall call Z the *deviation* for the point P. The following are properties of this function which immediately follow from the hypothesis.

The deviation is positive for any point of the inner contour (c), negative for any point of the outer contour. (Hypothesis c.)

On any ray OM there exists at least one point D for which the deviation is zero. Such a point is shifted by the transformation radially only i. e. D and $\bar{D}$ are collinear with O.

4. *The locus of zero deviation.*

The locus of all points D within the ring for which the deviation vanishes has for equation

(3) $z = (r, \Theta) = 0$

I shall denote this locus by (D). The transformation exercises on this locus a central effect shifting every point D on it along the ray OD. It follows, therefore, that

If E is a multiple point of order p on (D), $\bar{E}$ is a multiple point of the same order on ($\bar{D}$), and E and $\bar{E}$ are collinear with O.

If a ray 1 touches (D) in A it will also touch ($\bar{D}$) in $\bar{A}$, and the contact is of the same order.

If (D) possesses within (Cc) a cl sed branch (u) enclosed between two rays 1 and 1^1 the image ($\bar{u}$) is also closed and is contained in the same angle.

All these properties are immediate consequences of the hypothesis and definitions.

5. *The Principal Branch.*

Lemma A. The locus of zero deviation has within the ring (Cc) at least one closed branch (d) completely surrounding the inner boundary.

Indeed, if we regard (3) as the equation in semipolar co-ordinates of a surface S, the cylinders parallel to Oz and built on (C) and (c), will meet S in two curves (Γ) and (γ) of which Γ is entirely below the plane Π while γ is entirely above. The portion of the surface contained between the two cylinders is continuous and single sheeted. S therefore, will be cut by Π in at least one closed branch completely surrounding (c). But the complete section of S by Π is the locus (D), which proves the lemma.

The branch (d) may have multiple points, but if (E) be such a loop on (d), the image ($\bar{d}$) will possess a similar loop ($\bar{E}$). The elimination of loops on (d) will have, therefore, the effect of eliminating the loops on ($\bar{d}$). It is, therefore, legitimate to assume that (d), is a *simple* contour, as well as its image ($\bar{d}$).

I shall call the curve (d) deprived of all loops the *principal* branch of the locus (D). If (D) possesses more than one such branch, the one "closest" to the inner boundary may be selected for the principal branch.

6. A Particular Case

I will say that a closed contour (K) is *everywhere convex* if any ray thru O meets it in one and only one point (Fig. 1). If a contour (K) is not everywhere convex, it is clear that there exist rays which touch it. By drawing all these tangent rays it is possible to divide the contour into "convex" and "concave" arcs and there is a finite number of these arcs. (Fig. 2).

It is evident from the foregoing considerations that if the principal branch is everywhere convex, this is also true of its image ($\bar{d}$). In the general case by drawing the tangent rays we simultaneously divide both (d) and ($\bar{d}$) into convex and concave arcs.

These preliminaries being established, the proof of the theorem is immediate in the case *when the principal branch of the zero deviation curve is everywhere convex.* Indeed (d) and ($\bar{d}$) must in this case have at least two real intersections, for otherwise d would be either entirely within ($\bar{d}$) or entirely without. In either case, the area of the ring (d, c) could not equal that of the ring ($\bar{d}$, c) contrary to the hypothesis of conservation of areas. If now I is a point common to (d) and ($\bar{d}$), its image $\bar{I}$ coincides with I, and the proposition is proved.

The method used here to prove that (d) and ($\bar{d}$) intersect in at least two points, applies to the general case and discloses this fundamental fact: *If the point I is situated on a convex arc of the principal branch it is certainly an invariant point.* If, however, the point I is on a concave arc it may not be an invariant point, as for instance the point C in Fig. 2. The problem, therefore, reduces to showing that *at least one convex arc of the branch (d) meets its image*

7. The Auxiliary Contour.

I shall call an arc of zero deviation a *normal* arc if it is possible to go from one extremity of the arc to the other without changing the sense of rotation. A segment of a ray thru O is *normal* if it is possible to go from one extremity to the other without changing the sign of the deviation. A contour consisting of normal arcs and segments, I shall call a *normal contour.*

Lemma B. It is always possible to construct within the ring (Cc) a closed normal contour (K) completely surrounding the boundary (c) and everywhere convex.

I commence by drawing all the rays tangent to the zero deviation curve both in its principal and secondary branches. The locus (D) as well as its image ($\bar{D}$) is thus divided in a certain number of convex and concave arcs (Figs. 2 and 3). Any one of these tangent rays I_1 touches (D) in A_1 and crosses it besides in a number of points B_1, B'_1;........Let $\bar{a}_1 = B_1A_2$ be a normal arc of the principal branch the rotation being in the negative sense. Take for second "leg" of the normal contour the segment $A_2B_2 = S_2$ directed inward and in which B_2 is the first point of zero deviation encountered. B_2 may be a point on the principal branch (Fig. 2) or on the secondary branch (Fig. 3). Selecting then for third leg the normal arc $a_2 = B_2A_3$ and continuing in this manner we shall finish by returning to the point B_1, after having described a closed contour (K) everywhere convex and consisting of normal arcs and segments only. This contour is shown in the figures by the heavy lines; its image by heavy dotted lines.

3. *Proof of Poincare's Theorem.*

If $\bar{a}_1$ is the image of the normal arc a_1 it is clear that $\bar{a}_1$ cannot intersect (K) in any other part of it but the corresponding arc a_1, for a_1 and $\bar{a}_1$ are contained between the same two rays l_1 and $l_1 = 1$. On the other hand if $\bar{S}_k$ is the image of the segment S_k, then $\bar{S}_k$ will have no other points in common with the contour (K) than the point B_k.

From these remarks the proof of the theorem follows without difficulty. For if we assume that there are no invariant points, no arc $\bar{a}_1$ would have any points in common with the corresponding arc $\bar{a}_1$. The contour (K) would, therefore, be either entirely within or entirely without its image ($\bar{K}$) and in either case the area of the ring (Kc) could not equal that of ring ($\bar{K}$c) contrary to the hypothesis of conservation of areas.

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*In the above mentioned article Poincare states the theorem in the case of concentric circles. Birkhoff also considers this case, although he remarks at the end of his article that the theorem could be extended to the case of any two convex contours with the aid of a conformal transformation. This has never been very clear to me.

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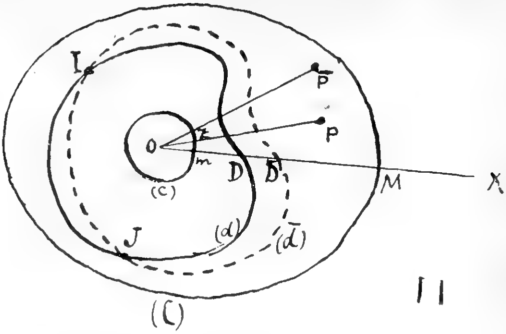


Fig 1.

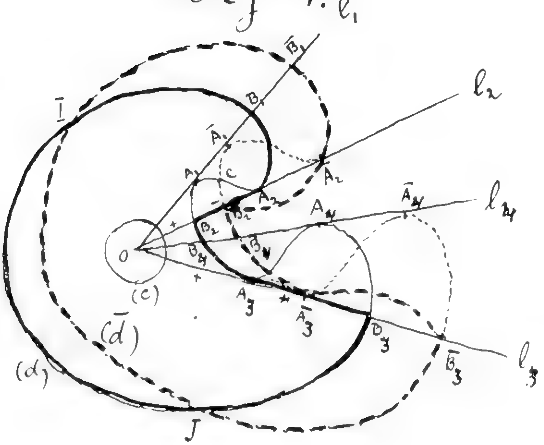


Fig 2

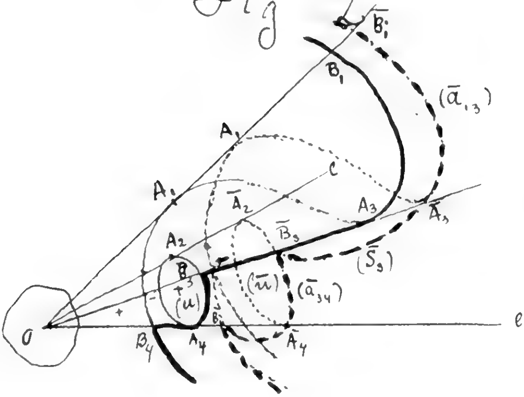


Fig 3

WHAT MIGHT HAVE BEEN.

C. A. WALDO.

In this review of a century of scientific achievements in Indiana isn't it worth while to take a few minutes to rejoice that some things through the help of the Indiana Academy of Science have been frosted in the bud? We remember the conclusion to the parody on Maud Muller

> "If of all sad words of tongue or pen
> The saddest is 'It might have been,
> Sadder yet by far to see
> What is and hadn't ought to be.'"

In the early spring of 1899 vague rumors reached Indiana University and Purdue that some sort of mathematical legislation was pending at Indianapolis. It was evident, however, that the state solons there assembled thought themselves well equipped to attack the problems, whatever they might be, with wisdom and justice for they made no appeal for help to their two state supported fountains of erudition.

As the session of the legislature was drawing toward its close it chanced to be the duty of the writer to visit the State Capitol and make sure that the Academy appropriation was cared for. When admitted to the floor of the House, imagine his surprise when he discovered that he was in the midst of a debate upon a piece of mathematical legislation. An ex-teacher from the eastern part of the state was saying; "The case is perfectly simple. If we pass this bill which establishes a new and correct value for ñ, "the author offers to our state without cost the use of his discovery and its free publication in our school text books, while everyone else must pay him a royalty." The roll was then called and the bill passed its third and final reading in the lower house. A member then showed the writer a copy of the bill just passed and asked him if he would like an introduction to the learned doctor, its author. He declined the courtesy with thanks remarking that he was acquainted with as many crazy people as he cared to know.

That evening the senators were properly coached and shortly thereafter as it came to its final reading in the upper house they threw out with much merriment the epoch making discovery of the Wise Man from the Pocket.

This remarkable bill establishing a new value of ñ had thus passed five readings and it then needed but one more favorable reception in the Senate to secure for itself the inscription "Enacted by the State of Indiana."

And what was this new and correct value of ñ ? The jargon of the text of the bill is difficult to understand. But the nearest the writer could come to the rational interpretation of its meaning was this: At the outset it gave 4 as the true value of ñ while towards the end it gave 3.2 (three and two-tenths as the final truth) for which mankind waited in suspense until the fortunate appearance of the learned doctor. But the state did not father this monstrosity and it was probably the Indiana Academy of Science alone which prevented it. If this deduction is correct then that one act of prevention was worth more to Indiana, jealous of her fair fame as she is, than all she ever contributed or can contribute to the publication of the proceedings of her Academy of Science.

Field Notes on the Distribution and Life Habits of the Tiger Beetles (Cicindelidae) of Indiana

William M. Goldsmith

INTRODUCTION

In the summer of 1915 I began to collect material for the preparation of a paper on the comparative cytological study of the Cicindelidæ. From the outstart I was confronted with difficulty in obtaining the desired specimens. This necessitated a close investigation in many different parts of the state. While making these collections, incidental observations on the distribution and various life habits became so fascinating that this line of field study was extended throughout the western and north central part of the state. (See map.)

SURVEY BY COUNTIES

Pike and Gibson Counties. The first daily collections were made from Aug. 25 to Sept. 10, 1915, at a number of points in Pike and Gibson counties, especially in the vicinity of Petersburg and Oakland City.

Cicindela vulgaris, the most abundant species in these counties, were more or less colonized in definite localities, usually with certain barren spots as centers. For example, vast numbers swarmed the college athletic field at Oakland City, and the county fair grounds at Petersburg. Radiating from these points as centers, the number of beetles decreased in proportion to the distance and environment. After leaving one of these barren centers, one might travel three or four miles without observing a single beetle.

Only one specimen, a mature female, of *C. formosa generoso*, was captured. This was found on a dusty road in Gibson county, September 15, 1915. Very close search was made for other specimens but of no avail. Since this is a double brooded species, I am unable to explain why this female should be mature at this late date.

In the latter part of August, 1915, two specimens of *C. purpures* were collected along the road-side, in western Pike county.

Three visits to the above mentioned counties, during the spring of 1916, revealed about the same distribution. The beetles, however, were less abundant than in the preceeding fall.

Daily observations were made again from Sept. 5 to 15, 1916 with especial regard to the lowland regions. A few *C. vulgaris* were found in company with vast numbers of *C. repanda* along the banks of the south fork of Potoka river, and other small streams.

A few solitary specimens of C. *punctulata* were found on the upland fields and roadsides.

Dubois County. May 1, 1916, collections were made in the vicinity of Huntingburg. The race track at the county fair grounds proved to be a choice feeding and breeding spot for *C. repanda.* The track had been covered with straw to prevent washing. On one side was a steep clay bank, while on the other ran a small stream. The latter furnished a good feeding place for the beetles in dry weather. At the time of collecting, however, the ground was extremely wet and large numbers were to be seen sunning on the banks. Others were feeding on the small insects and worms found in the straw.

Observations were made through the lowland districts near town but no beetles were seen. Then the hill land was studied, with interesting results. After collecting a few *vulgaris* and one *ancocisconensis* in a red clay wheatfield, a point was reached where the public road had been cut through a ridge, leaving the banks on either side about fifteen feet high. A strong wind directed hundred of *C. vulgaris* into this retreat, where they would settle on the warm banks. They were so abundant that they could be captured with perfect ease by swinging the net through the air.

Perry County and neighboring parts of Kentucky. Observations were made in the vicinity of Rome, Tobinsport, Cannelton, Tell City, and Troy, Indiana, and Cloverport, and Hawesville, Kentucky. A rather critical study of the sand bars and banks on either side of the Ohio river was made at intervals from Rome, Indiana, to Hawesville, Kentucky, with a view of ascertaining whether or not this stream affected the distribution of Indiana and Kentucky Cicindelidæ. In this comparative study only one species. *C. repanda,* was found. This, however, was very abundant. In the two different surveys made of this region during the months of May and June, 1916, no indications were found of the river's acting as a barrier. The same species and apparently the same brood that was found on the Indiana side, was found at adjacent points in Kentucky. Indications were that these beetles sometimes fly across the river, as many were watched for at least half the distance, when they disappeared from sight.

The next observations were made over the red clay hilly region of this county from Troy to Bristow, a distance of about thirteen miles. *C. purpurea* and *C. sexguttata* and *C. vulgaris* were found abundantly in damp ravines but rarely in upland regions.

Spencer County. In the latter part of May, 1916, two different collections were made in the locality of Lincoln City. It so happened that each visit was made during extremely wet weather and thus little data were obtained. A single specimen of C. *sexguttata* was found on a concrete walk, also a number of *C. vulgaris* were collected along the muddy roadways and on barren spots in clay pasture fields. These were very sluggish and easily captured, indicating that they had been forced from their hiding places either by the ex cessive rain or by hunger.

Orange County. Four collections were made in this county, with West Baden and French Lick as centers. The dates were as follows—September 10, 1915, May 6, May 30, and September 14, 1916. On May 6, 1916 (after collecting a few solitary specimens of *C. sexguttata* and *C. repanda* from among the hills and valleys), a very productive colony *C. sexguttata* was discovered. The gravel beds along the stream and the limestone rocks projecting from the water, seemed to be the most satisfactory feeding, sunning and mating places. The gravel banks, overlaid with sandy loam, were found to be the winter homes. Here many places were noted where the burrows were so numerous that they honey-combed the bank.

Since *C. sexguttata* were found to be more abundant in Orange county than in any other field in the state, a special trip (May 30, 1916) was made for the purpose of making a detailed study of the feeding habits of this species. An old damp, woodland roadway proved to be the most satisfactory place for this study. By lying in the dense shade, while observing the specimens in the sun, I was enabled to get within two or three feet of them without disturbing them. The wet roadway abounded in small winged ants, small red and large black ants, gnats, flies, medium sized spiders, and various kinds of worms. All of these were attacked with equal violence. However, in case of the larger and more active prey, the beetles would make a sudden retreat if met by a counter attack. They usually made one dauntless charge. and when repulsed gave up in fear. A few second attacks on large black ants were noted, and in practically every instance the prey returned the assault and chased his enemy some distance.

The observations made on the egg laying habits corroborate those of Shelford on *C. purpurea*, "she holds the anterior part of the body as high as possible and, extending the posterior part of the abdomen (ovipositer), she digs a vertical hole with the gonapophyses of the adbomen, from 7 to 9 mm. in depth. She tries the soil by making holes without laying any eggs. About fifty eggs are laid, singly and large end uppermost in such uncovered holes by one female."

C. punctulata was the only species found during the September visits.

Knox and Vigo Counties. A survey of the river and hill regions at Vincennes, and a similar survey at Terre Haute were made in the month of August, with practically the same results. In each locality *C. repanda* swarmed the sand bars and barren river banks, while only a few scattered specimens of *C. punctulata* were found in the upland corn, wheat and pasture fields. The latter were more abundant along a private cattle driveway near Terre Haute, where they were attracted by dung maggots.

Sullivan County. After making a close search through the hilly districts about Sullivan, a large number of *C. repanda* was observed along the banks of a brook which flowed through a meadow. On one small sand bar they were feeding upon small red ants.

Colony after colony of these ants were devoured by a certain group of beetles. At one time, twenty-seven of these greedy ant-eaters were counted on a sloping sand bank in a spot about six feet square. One case was observed where two hungry beetles devoured a whole colony of ants. Each would take every other ant that appeared at the mouth of the hole. In case one was unsuccessful in his catch, he would chase his prey some distance, while in the meantime his partner would do his utmost to devour every ant that appeared. The average rate of consumption for twelve minutes was an ant for each beetle every ninety-five seconds. When no more ants would appear one *repanda* destroyed the mound and dug half the length of his body into the ground in quest of more food.

One solitary *C. punctulata* was found in an old pasture field.

Monroe County. Field observations of the Cicindelidæ in the vicinity of Indiana University were made in the spring and fall of 1915 and 1916.

C. ancocisconensis was the only species found colonized in this county. This colony inhabited the steep banks, made by the Jordan river cutting through a hill, about a quarter of a mile east of the University. The banks are about ten feet high and the burrows were found in the soil at the summit. This position was especially advantageous, as there were large stones both on top of the hill and also in the cut, which sheltered the larvae and adults from the cold, and served as brooding places for small ants—tiger beetles' favorite food—and other prey.

During the early spring days when the ground was cold and wet, the beetles spent most of their time sunning and feeding on the stones and barren spots at the top of the hill. However, as the warm days of spring approached they inhabited the moist central regions of the banks, while later when all the ravine was dry except along the bed of the Jordan, they were found only at the base of the cut.

In the fall when even the stream was dry, practically all the new brood were found near the edge of a pond, about two hundred feet further down the ravine, where the food was more abundant. The majority of this colony disappeared in late June. The imagoes emerged in August.

During the dry weather one specimen of *sexguttata* was found feeding with the above colony. Single specimens of *sexguttata* were also found on the university campus, along flat, rocky ravines, and more frequently on the clay hills near the University water works. The latest specimens of this single brooded species were collected in late June.

Punctulata were ofttimes found on the campus along the beaten paths, and also in the fields about Bloomington. The single brooded fall species was found as late as the first of November.

A few specimens of *vulgaris* and also of *purpurea* were collected in this county.

Putnam County. In June, 1916, a number of *C. repanda* were collected from the sand bars of a creek, about one mile north of Greencastle. Although no highland species were found in this locality, one specimen of *sexguttata* was found in the spring collections of Depauw University students. The

University also had a few *vulgaris* and one *punctulata* which, supposedly, had been collected near Greencastle.

Vermillion, Fountain and Montgomery Counties. In April, 1916, observations were made at various points along the Wabash river, between Vermillion and Fountain counties. In every case *C. repanda* were found in abundance in cornfields, over which a deep layer of white sand had been deposited by the over-flow of the river. This condition was especially noticeable at the entrance to the river bridge opposite Perrysville.

C. ancocisconensis were quite abundant along Cole Creek east of Newtown. The banks which were about four feet high and overlaid with black sandy soil, were penetrated at various angles by numerous burrows. Large groups of adults were feeding along the edge of the overhanging turf or enjoying the sunshine along the banks. Others were copulating and depositing eggs.

Although two days were spent in Fountain and Montgomery counties, in the neighborhood of Mellott, Newtown and Linden, searching for other species, no data were obtained.

Carroll and Cass Counties. A comparative study of the old brood of *C. repanda* along the Wabash river at Delphi (in June), and the emerging brood at the junction of the Eel and Wabash rivers at Logansport (Aug. 22), showed greater abundance of the latter under similar conditions. The former spent their time in mating, depositing egs and collecting food, while the latter were very unsocial and seemed to have no object in view other than obtaining food.

No *C. punctulata* were found in these counties during June. In August, however, they were collected from every field visited. During a four hour trip out to Clymers, they were observed in the following surroundings:—in a cattle lot, in a wheat stubble field, among the scattered straw near an old straw stack, in a meadow feeding under the grass at the edge of a pathway, in a clover field, in a field of growing corn, and in newly plowed ground. They were never found colonized but scattered here and there among the vegetation.

Miami County. Near Chile, special attention was given to a certain wide valley, with steep bluffs on either side, through which ran a winding, shallow stream. *C. repanda* swarmed the small sand bars and rocky edges of the creek.

The feeding habits of about thirty individuals were studied on a sandy plot about five feet square. It was mid-August and the temperature was about 100 degrees in the shade. When undisturbed the beetles spent their time feeding in the shade under the grass surrounding the barren spot. At the least provocation they would rush from the shady places into the barren spot where they were free to take flight if necessary. Repeated observations show that such behavior is common with a number of species which are said to inhabit barren places. However, they really spend the greater part of their unmolested time among the vegetation where the food is most abundant, and rush to the barren places only upon the approach of the observer.

One *C. ancocisconensis* was found with these *repanda*. No other specimens were found throughout the county.

Upon the bluffs and in level upland fields several *C. punctulata* were observed. At points where the banks were sloping the two species were frequently found feeding together, but when flushed each took flight in the direction of his own habitat, namely, the *repanda* to the damp lowlands and the *punctulata* to the upland fields.

Kosciusko County. June 19, 1916, was devoted to a close survey of the B. and O. railroad cut one mile east of Milford Junction. From the base of the cut flowed a number of small springs, which had washed sediment from the bank and thus formed a sand clay marsh between the bank and the railroad. At a number of points there was sufficient water to form small pools along the track. This gave, within two hundred feet, the following varied environment, wheat and pasture lands, turf overhanging a ten feet perpendicular clay bank contiguous with an eroded sand clay bank, level sand clay beds bordering upon the marsh, water pools and lastly the railroad track.

Three species of Cicindelidæ were found in abundance under these conditions, and when disturbed each responded to the natural environmental impulse of the species. *C. repanda* would take flight toward the railroad track and light on the ties over the water, or on the barren spots at the edge of the marsh. *C. sexguttata* would fly in the opposite direction to the top of the cut, or passing on into the fields beyond, while *C. ancocisconensis* would usually alight on the sloping banks.

The Cicindelidæ are comparatively scarce in central Kosciusko county, due no doubt, to the unfavorable physcial conditions of the land. The borders of the lakes and waterways are either marshy fields or rolling hillsides covered with dense vegetation, presenting unfavorable breeding places.

With the exception of *C. punctulata*, the specimens from this county were collected here and there and not found in large colonies. This was also the case in many other counties. A few scattering specimens of *sexguttata*. *repanda* and *ancocisconensis* were found in June and early July, after which they disappeared. The new brood of the last two species appeared in late July, about the time of the coming of the single brooded *punctulata*.

C. punctulata became abundant in dry pathways and open fields by the first of August. They were especially numerous in sandy potato patches, where they were attracted by the smaller of the potato beetle larvae. They were ofttimes seen on the leaves of the potato plant enjoying their tender food. This is the only species that I have observed securing its food from, or even perching upon, vegetation of any kind.

August 19, 1916, was spent in studying the life habits of a formerly selected colony of *C. punctulata*. These inhabited a semi-barren spot in an old pasture field, near Winona Lake. In addition to collecting food, the females were depositing eggs, while the males busied themselves in finding receptive mates, or in attacking their opponents. The ground was so hard and dry, that the females were unable to penetrate it with the ovipositor, and thus since they could not construct the usual cell, they were compelled to deposit their eggs in small cracks and other unfavorable places. All this time they were continually annoyed by the males attempting copulation. In one instance a male forced a female to submission by clasping her between the pro-and mesothorax with his powerful mandibles. After copulating about five minutes, he remained in position over thirty minutes without seeming to disturb the female in her feeding and egg laying habits.

The food of this colony consisted of small ants and worms which were collected under the vegetation. The feeding habits here were comparatively the same as those noted with the *repanda* near Chile.

Elkhart County. The afternoon of June the 9th was spent east and southeast of Elkhart. The only Cicindelidæ found was a large colony of *repanda* in a gravel pit, southeast of town. The environmental conditions were especially advantageous to both larvae and adults. The high banks were covered with sandy loam and turf favorable for larval growth and adult hibernation. The banks also gave protection from the cold while the various insects attracted to the water at the bottom of the pit, furnished an abundance of food.

On account of the small feeding area in comparison to the number of Cicindelidæ, close observation of the beetles while feeding was possible. Ants, small beetles, flies and worms seemed preferable. One *repanda* continued to cling to a large green worm until after he was caught in the net and transferred to a collecting bottle.

Observations were made near Goshen, at the mouth of Rock Run Creek, but since *repanda* was the only species found, no new data were obtained.

St. Joseph County. On June 10, 1916, a careful survey was made along the St. Joseph River between Spring Brook Park and South Bend, and also through the uplands on the opposite side of the river from the city. Here again only *repanda* were collected. On account of the dense vegetation along the river banks, the beetles were confined in small colonies to the sandy deltas of the small inlets. At these points, however, they were very abundant and easily captured.

Laporte County. Collections were made June 11, 1916, in late afternoon around Pine Lake and among nearby hills, However, only a few specimens of *repanda* were secured from the sandy lake shores.

SUMMARY

One or more Cicindelidæ collecting trips were made in the twenty-one counties indicated on the map, and specimens were received from a number of other points.

C. repanda are by far the most abundant of all lowland species, if not the most numerous of all Indiana Cicindelidæ. They swarm the lake shores, river banks, sand bars and deltas in Indiana from early spring until late fall with the exception of a few weeks in July and August. They are found not only along the larger waterways but appear in great abundance in gravel or sand pits or in any other natural or artificial depression, containing water and surrounded by barren banks. They may be collected in almost any number along small ditches through lowland pasture fields.

Observations indicate that the *C punctulata* are more numerous throughout the state than all other upland species combined. This is a single brooded species and does not appear until the latter part of July (perhaps earlier in southern Indiana). They have a greater diversity of habitat than any of the observed Cicindelidæ. Although they were usually found in fields among the vegetation, they did not seem to object to a home in the woods, on sloping grounds or even on wet sand bars. In fact they were seen scattered over every collecting ground visited during their season. This does not corroborate the observations of Criddle who suggests that the Manitoba *C. punctulata* are confined to few spots where they are usually plentiful.

C. sexguttata represents another single brooded species of the state. They appear in early spring, are most abundant in May and June and disappear in early July. They may be found on barren spots in upland regions, but they are especially fond of damp woodland paths and rocky ravines. This species was found in great numbers in only one locality, but single specimens were distributed over wide areas.

C. vulgaris and *C. ancocisconensis* are both double brooded species, the adults appearing in early spring and disappearing in late July about three weeks before the imagoes are seen. Neither of these species is well distributed but is found in localities where it is abundant. The former is more widely distributed and extends further south than the latter. They both might be classed as upland species even though *ancocisconensis* inhabits the banks along running brooks, while *vulgaris* is found in dry clay fields and roadways.

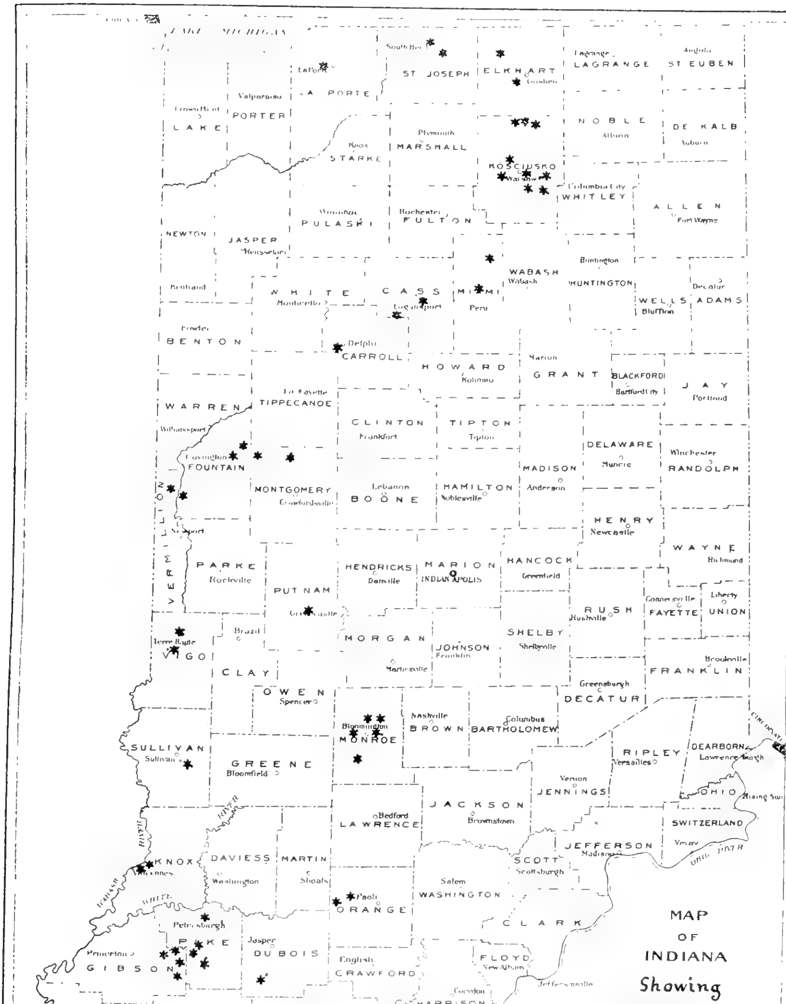
One mature female of *C. generoso* Dej. a variety of Say's *formoso* and a few *scutellaris* were found in Pike county, August 15, 1915.

C. purpurea Oliv. were seen only in southern Indiana.

All immature Cicindelidæ are very unsocial, even cannibalistic and especially so when crowded in cages.

Tiger beetles do not spend their time in barren spots as is usually supposed but seek such places only upon approach of strangers. These beetles were found to be in no way "tiger"-like in their attacks on larger and more active prey. They, on the other hand, confine their food to small and helpless specimens such as small ants, gnats, worms and larvae of various kinds.

Since the Cicindelidæ are entirely carnivorous, living upon insects, larvae and the like, which are as a whole injurious to growing vegetation, their economic value should receive greater recognition.


MAP
OF
INDIANA
Showing
Cicindelidae Collecting
Grounds
William M. Goldsmith
LAKE MICHIGAN
LAKE
PORTER
LA PORTE
ST JOSEPH
ELKHART
LAGRANGE
STEUBEN
NOBLE
DE KALB
STARKE
MARSHALL
KOSCIUSKO
WHITLEY
ALLEN
NEWTON
JASPER
PULASKI
FULTON
WABASH
HUNTINGTON
WHITE
CASS
MIAMI
WELLS
ADAMS
BENTON
CARROLL
HOWARD
GRANT
BLACKFORD
JAY
WARREN
TIPPECANOE
CLINTON
TIPTON
DELAWARE
RANDOLPH
FOUNTAIN
MONTGOMERY
BOONE
HAMILTON
MADISON
HENRY
WAYNE
VERMILLION
PARKE
PUTNAM
HENDRICKS
MARION
HANCOCK
RUSH
FAYETTE
UNION
VIGO
CLAY
MORGAN
JOHNSON
SHELBY
FRANKLIN
OWEN
MONROE
BROWN
BARTHOLOMEW
DECATUR
SULLIVAN
GREENE
RIPLEY
DEARBORN
OHIO
JACKSON
JENNINGS
LAWRENCE
SWITZERLAND
KNOX
DAVIESS
MARTIN
JEFFERSON
SCOTT
ORANGE
WASHINGTON
CLARK
PIKE
GIBSON
DU BOIS
CRAWFORD
FLOYD
HARRISON
POSEY
VANDERBURGH
WARRICK
SPENCER
PERRY

Further Notes on Indiana Birds.

Amos W. Butler.

For a knowledge of the animal life of the region within the present limits of Indiana, in the early days of our history, we are indebted to the early travelers like Col. Geo. Croghan (1765), to the pioneers who made records and to the early naturalists including Alexander Wilson (1808); John J. Audubon (1827–1840).

It was not until Dr. Rufus Haymond published his first contribution in 1856 that any one attempted a list of the birds of the state. (Birds of S. E. Ind. Proc. Phila. Acad. Nat. Sci. 1868, pp. 286–298). That was succeeded by his later paper in the report of the Geological Survey of Indiana in 1869 (pp. 209–335).

Other authors to whom we are indebted for important contributions in the next few years were Robert Ridgway, whose parents lived for a time near Wheatland, Knox County. Dr. David Starr Jordan, whose manual of vertebrates in 1876, afforded the student of back boned animals in this region a most helpful aid. E. W. Nelson, Dr. Frank W. Langdon, William Brewster, Dr. J. A. Allen and Dr. Barton W. Evermann. That brings us down to 1879. In that year appeared the first attempt to catalogue the birds of Indiana by Dr. Alembert W. Brayton. (A catalogue of the Birds of Indiana, Trans. Ind. Hort. Soc. 1879, pp. 87–165.) It was a timely work and a valuable contribution.

Following this came a notable increase in the number of publications each year on Indiana birds. These are given in the bibliography in the Report of the State Geologist for 1897, page 532. My own first catalogue of the birds of Indiana appeared in 1890 in the transactions of the same society that published Brayton's list eleven years before. (Trans. Ind. Hort. Soc. 1890. Appendix C. pp. 1–135.) This was followed in 1897 by "The Birds of Indiana" published in the report of the State Geologist for that year, pp. 515–1187.

Since that time the writer has endeavored to present to this Academy reports of additional species occurring in the state, together with notes of special interest which he thought worthy to be called to your attention. In accordance with that purpose the following eight papers have been presented and printed in the Academy's proceedings.

Notes on Indiana Birds, A. W. Butler, 1899, p. 149–151.

Some rare Indiana Birds, A. W. Butler, 1902, p. 95–99.

Conditions Effecting the Distribution of Birds in Indiana, A. W. Butler, 1903, p. 180–189.

Some Notes on Indiana Birds, A. W. Butler, 1906, p. 145–150.
An Addition to the Birds of Indiana, A. W. Butler, 1908, p. 49.
A Heronry near Indianapolis, A. W. Butler, 1912, p. 57–58.
Birds that Destroy Grapes, A. W. Butler, 1912, p. 53–55.
Further Notes on Indiana Birds, A. W. Butler, 1912, p. 59–65.

Following my practice I give herewith a few notes that should be available to students.

For several years Brother Alphonsus has published in the American Midland Naturalist, valuable records of observations made by him in the vicinity of Notre Dame, St. Joseph County. Some of these follow:

Pine Grosbeak—*Pinicola enucleator* (Linn.).

In a letter Brother Alphonsus says:—The Pine Grosbeak was found on December 4, 1914, in a mulberry tree at Notre Dame. A number of English Sparrows were curiously watching the bird. Other records of the species were made on October 22 and November 6, 1914, also April 18, 1914. On the October date a pair of these Grosbeaks was seen. The male was reddish on the head and back; the female mottled with brownish and lighter. The call note is distinctive.

A flock of Evening Grosbeaks, ten in number, appeared at Notre Dame on November 30, 1910 and remained three days. This is the first record of the species in this locality known to me. They came each day in the early part of the afternoon to a certain box-elder to feed on the seeds. On January 19, 1911, six more of the species were feeding in the same kind of tree and uttering a low note. (See also Am. Mid. Nat. Sept. 1916, p. 492, 495 and 499.)

Brown Creeper.—*Certhia familiaris americana* (Bonap.).

His observations indicate that it is much more common in winter to the northern boundary of the state than it had been supposed to be. In the winter of 1914–15 it "appeared on 10 days in December; on 18 in January; and on 12 in February, making a total of 40 records which greatly exceeded the two previous winters, 1913–14, having had 13 records, and 1912–13, only 3 records." (Amer. Mid. Nat. Sept. 1916, p. 498.).

Roseate Tern.—*Sterna dougalli* Montag.

A specimen was taken by Mr. H. L. Stoddard, of the Field Museum, Chicago, near Millers, Lake County, Indiana, August 14, 1916. He says, "The bird was alone on the beach (Lake Michigan) and attracted my attention fron this action as I never remembered having seen either of our species of white terns on the sand. They almost invarably use the fisherman's net stakes out in the lake. On studying the brid through binoculars I thought I noticed a difference so the specimen was collected. No other was seen, though Forster's and Common Terns as well as the Black Terns were there by the hundred. The specimen is in perfect breeding plumage, the breast being quite rosy in color."

This is the second record reported for the state and the only one verified by a specimen.

Long-tailed Jaeger.—*Stercorarius longicandus* Vieill.

A specimen was taken by Mr. H. L. Stoddard at Dune Park, Indiana a few miles east of Miller's Sept. 21, 1915. (The Auk. Jan. 1916 p. 75.)

This is the first Indiana record for this northern bird.

Prairie Warbler.—*Dendroica discolor* (Vieill).

Mr. Philip Baker found this warbler nesting near Helmsburg, Brown County, Indiana, in May 1916. The following account he has kindly prepared for me.

On May 8th I found a nest of the Prairie Warbler, half completed. The the nest was placed in a small apple tree on the border of a sassafras thicket. It was completed May 14th. May 21st I found 4 eggs in the nest but upon visiting it a few days later, the eggs were gone and the birds had left.

On May 21st I found another nest about a quarter of a mile from the first. This was built in a tangle of wild blackberries, close to the ground. It also contained 4 eggs. May 27th the eggs had hatched.

I tried to obtain a picture of this nest with the young birds, but my efforts were unsuccessful.

Within 2 miles of these nests, I heard at least 4 Prairie Warblers singing during May, June and July. Each bird confined its movements to a comparatively small area of densely covered "undergrowth" principally sassafras. From the fact of a continuous period of song and a closely limited feeding ground, I believe these birds were mated and their nests were close by. I am mailing both nests to you.

Bartramian Sandpiper.—*Bartramia longicauda* (Bechst.).

Mr. E. B. Williamson of Bluffton, Indiana, has the egg shells found June 16, 1916, in a nest of this bird in a meadow on the S. E. ¼ of section 26, Twp. 25 N. Range 12 E. about 3¾ miles south of that town and 2¾ miles east. The nest was discovered by Nathan Truax, about May 29, 1916, but the eggs were not hatched June 9, 1916. Birds of this species had not been seen in that vicinity before by the residents. Mr. Williamson says the day he visited the site and obtained the egg shells he saw five or six of these birds. This is the first breeding record for that part of the state.

Great Blue Heron.—*Ardea herodias* Linn.

The past spring Mr. E. B. Williamson, Bluffton, Indiana, called my attention to a heronry of this species in Huntington County, about 8½ miles west of Bluffton and a half mile west of the Wells-Huntington County, line. On July 18, 1916, he very kindly took C. C. Deam and me to the site. It is a low woods with many large cottonwoods and swamp white oaks on the land of Lewis C. Mills. Mr. Williamson said last year he counted forty-five or forty-six nests, but was unable to tell how many of these were occupied. On the day of our visit we saw few birds, but found the heronry had been "shot up." Many dead birds, young and adults, were found on the ground beneath the trees bearing the nests. Under one tree we counted fifteen carcasses. Under another an empty cartridge box doubtless indicated the means of the awful slaughter. Such an atrocious act is an outrage that ought not to go unpunished.

Mr Mills says the herons began occupying this woods for nesting purposes about thirty years ago.

The herony used by these birds for many years in the Schildemeyer woods near Julietta, Marion County, was again occupied the past season as it has been for many years and I am indebted to Mr. Hohenberger for some excellent photographs of some of the nests.

Mr. James L. Mitchell of Indianapolis, informed me recently that in 1912 or 1913 he found a heronry of this species on the Kankakee river. He counted twelve nests but there may have been more. It was approximately within three fourths of a mile of an island where George W. Miles, the Fish and Game Commissioner, had his camp not far from Hebron.

Paul Weatherwax of Indiana University called my attention to a herony of Great Blue Herons in Carroll County heretofore not reported. He has kindly supplied me with the following information from Ted Stanton who lives near its site.

These nests are about six miles southeast of Delphi and four miles northwest of Flora; on the John O. Cartwright farm. They are in an 80 acre wooded tract in almost its original condition, only the dead timber having been removed. The herony is not near any stream of considerable size.

The nests are in all kinds of trees, some tall and some smaller. Nests of sticks; no lining and are about 2½ feet in diameter and loosely put together.

The birds have been known to nest there for the last eight years, and have probably been there much longer. There were about 20 nests in 1916, and the same number in 1915.

Being of no economic importance, few of the birds are killed by people. Some of the young fall from the nest and are killed by the fall.

The eggs are greenish blue; about as large as a duck egg; four or five at a sitting, but only one sitting a year.

The young are fed on fish caught by the old ones in Wild Cat Creek, six miles away. Old birds may be seen flying to the creek to fish early in the morning. The hawks get a few of the young.

A List of Indiana Ants.

William Morton Wheeler.

Many years ago Mr. W. S. Blatchley sent me for indentification a number of ants collected in various parts of the state of Indiana. Owing to lack of funds, my report on these insects was never published. Although the list of species is undoubtedly incomplete, it seems advisable to print it, with such changes as the advances in taxonomy have rendered necessary, because it contains a number of locality records that may be useful in future studies of the geographical distribution of our North American ants.

FAMILY FORMICIDÆ

Subfamily Ponerinae

Genus *Stigmatomma* Roger.

1. *S. pallipes* Haldeman. ☿—Wyandotte.

A rather rare species which nests in small colonies in rich, damp woods, under stones, leaf-mold, or more rarely under logs.

Genus *Proceratium* Roger.

2. *P. silaceum* Roger subsp. *rugulosum* Wheeler. ☿ ♀—

Rarer than the preceding; nesting in rotten logs.

Genus *Ponera* Latreille.

3. *Ponera coarctata* Latr. subsp. *pennsylvanica* Buchley ☿—Grand Chain; Wyandotte.

Rather common; nesting in the same situations as *Stigmatomma pallipes*.

Subfamily Myrmicinae

Genus *Myrmicina* Curtis.

4. *M. graminicola* Latr. subsp. *americana* Emery. ☿—Wyandotte.

Rare; nesting in small colonies under stones and in rotten wood in shady forests.

Genus *Monomorium* Mayr.

5. *M. minimum* Buckley ☿ ♀ ♂—Shoals; Grand Chain.

This minute black ant inhabits small, clustered crater nests in rather dry, sandy or gravelly soil. The workers forage in files, visiting plants in search of the excreta of plant-lice, the secretions of extra-floral nectaries and dead insects.

Genus *Solenopsis* Westwood.

6. *S. molesta* Say ☿—Wyandotte; Pine; Veedersburg.

A minute yellow species, with 2-jointed antennal clubs, common in open grassy places where it lives in independent formicaries or more commonly as a thief-ant in the walls separating the galleries in the nests of larger ants belonging to the genera *Formica*, *Lasius*, *Myrmica*, *Aphaenogaster*, etc. It is also known to occur in houses. The males and females are much larger and of a darker color than the workers.

Genus *Crematogaster* Lund.

7. *C. lineolata* Say. ☿—Pine; Mitchell; Grand Chain; Veedersburg; Tippecanoe Lake; Culver; Wyandotte; Hammond; Arlington; Vincennes; Shoals; DeLong; Mt. Vernon; Bass Lake; Kosciusko County; Crawford County.

A very common and widely distributed species, nesting under stones in open places, under stumps, boards, the bark of old logs, etc. The workers have a disagreeable odor and move about in loose files. They sometimes carry the triangular gaster over the thorax with the tip directed forward. Owing to this habit the species of Crematogaster have been called "acrobat" ants.

8. *C. lineolata* var. *cerasi* Fitch ☿ ♀—Knox County; Wyandotte; Veedersburg.

Merely a yellowish form of the preceding species.

Genus *Aphaenogaster* Mayr.

9. *A. fulva* Roger subsp. *aquia* Buckley. ☿ ♀ ♂—Mt. Vernon; Vincennes; Wyandotte; Knox County.

Common in shady woods, nesting under stones and logs.

10. *A. tennesseensis* Mayr ☿—Wyandotte; Shoals; Vincennes.

Easily distinguished from the preceding by its deep red color, the long epinotal spines in both workers and females and the small size and polished surface of the latter. This species is a temporary social parasite on *A. aquia.*

Genus *Myrmica* Latreille.

11. *M. scabrinodis* Nylander var. *sabuleti* Meinert ☿—Vawter Park.

A very common ant, nesting in dry, open fields and along roads.

Genus *Leptothorax* Mayr.

12. *L. curvispinosus* Mayr ☿—Arlington; Tippecanoe Lake; Vawter Park; Veedersburg.

This small yellow ant nests in small colonies in hollow twigs and old galls in rather damp, shady woods.

13. *L. fortinodis* Mayr var. *melanoticus* Wheeler ☿—Wyandotte; Marion County.

Nesting in small colonies in the bark of trees.

Subgenus *Dichothorax* Emery.

14. *L.* (*D.*) *pergandei* Emery ☿—Wyandotte.

A southern species, not before known to extend its range as far north as Indiana. It nests in the ground, under stones or moss in rather dry, open places.

Subfamily Dolichoderinae.

Genus *Dolichoderus* Lund.

Subgenus *Hypoclinea* Mayr.

15. *D.* (*H.*) *mariae* Forel var. *blatchleyi* var. nov ☿—Bass Lake; Hammond.

Eight workers from these localities differ from the typical *mariae* of the Atlantic States in having the head and thorax of a deeper, more brownish red color, the yellow gastric spots smaller, the tibiæ and distal ends of the femora black and the base of the epinotum somewhat less convex. This form seems to represent a transition to *D. plagiatus* subsp. *pustulatus* Mayr (possibly a hybrid!)

16. *D.* (*H.*) *plagiatus* Mayr subsp. *pustulatus* Mayr var. *beutenmuelleri* Wheeler ☿—Hammond.

Like the preceding, this variety nests in the ground but forms much less populous colonies.

Genus *Tapinoma* Förster.

17. *T. sessile* Say ☿—DeLong; Bass Lake; Marion County.

A very common species, easily recognized by its strong odor like that of rancid butter. It nests under stones, boards, etc. in dry, sunny places. The larvæ and pupæ are salmon-colored. The nests sometimes contain one or more specimens of a beautiful myrmecophilous Staphylinid beetle, *Nototaphra lauta* Casey.

Subfamily Camponotinae

Genus *Brachymyrmex* Mayr.

18. *B. heeri* Forel subsp. *depilis* Emery ☿—Knox County.

The smallest of our ants. It nests under stones in shady woods and attends root-coccids like the species of *Acanthomyops*. The pupæ are enclosed in cocoons.

Genus *Prenolepis* Mayr.

19. *P. imparis* Say.

Not recorded from Indiana but undoubtedly occurring in the state as it is common in Illinois and the Atlantic States. It forms crater nests in oak woods. The workers often distend the gaster with honey dew to such an extent that they may be regarded as honey ants.

20. *P. imparis* var. *minuta* Emery ☿.—Hammond; Wyandotte.

Merely a small variety of the preceding.

Subgenus *Nylanderia* Emery

21. *P.* (*N.*) *parvula* Mayr ☿—Hammond.

Nests under stones in small colonies in rather dry, sunny places. It is easily distinguished from the preceding species by its smaller size and the blunt hairs covering the body. The pupæ are naked.

Genus *Lasius* Fabricius.

22. *L. niger* L. var. *neoniger* Emery ☿—Shoals; Arlington.

This form of the circumpolar *L. niger* is properly subboreal, being most abundant in British America and on mountains in the United States. The females and workers are easily recognized by the suberect hairs on the antennal scapes and tibiæ.

23. *L. niger.* L. susp. *alienus* Förster var. *americanus* Emery ☿ ♀ ♂—Hammond; Vawter Park; Veedersburg; Knox County; Grand Chain.

This is the most abundant of all our ants, occurring over the whole of North America except the artic and extreme southern and southwestern portions. It is distinguished from the typical *niger* of Eurasia and the preceding variety by the absence of suberect hairs on the tibiæ and antennal scapes in the female and worker. Like all of our species and varieties of *Lasius*, *americanus* is much given to cultivating root-coccids and root-aphids, but, with the exception of *neoniger*, it is the only one of our forms that is not exclusively subterranean in its habits. It may often be seen visiting the foliage of trees and bushes in search of small insects. Prof. A. S. Forbes and other have shown that it is of considerable economic importance on account of its injurious habit of cultivating the root-aphids of maize (*Aphis maidradicis*).

Subgenus *Formicina* Shuckard.

24. *L.* (*F.*) *flavus* DeGeer subsp. *nearcticus* Wheeler.

Not recorded from Indiana but undoubtedly occurring in the state. It nests under stones in shady woods.

25. *L.* (*F.*) *brevicornis* Emery.—

Not recorded from Indiana but undoubtedly occurring in the state. It nests under stones on dry open hill slopes.

26. *L.* (*F.*) *umbratus* Nylander subsp. *mixtus* Nylander var. *aphidicola* Walsh.

Common in Illinois and the Eastern States and undoubtedly occurring in Indiana. It nests under stones or in earthern mounds in rather damp situations.

Subgenus *Acanthomyops* Mayr.

27. *L.* (*A.*) *claviger* Roger ☿—Stark County.

The yellow Lasii of this subgenus are all subterranean, or "hypogæic" ants which attend aphids and coccids on the roots of plants and are easily distinguished from the species of *Lasius sensu stricto* and *Acanthomyops* by their peculiar and rather agreeable odor like that of oil of citronella or lemon verbena. *L. claviger* nests under old logs or stones in open woods.

28. *L. (A.) latipes* Walsh ☿—Delong.

This species has two kinds of females, one of which has the legs much flattened and dilated and the hind tibiæ shorter than the fore tibiæ, while the other resembles the female of *claviger*.

Genus *Formica* L.

29. *F. truncicola* Nylander subsp. *obscuriventris* Mayr ☿—Tippecanoe Lake.

This species forms populous colonies in woods under stones, which it banks with vegetable detritus.

30. *F. truncicola* subsp. *integra* Nylander ☿—Camelton; Wyandotte.

The largest and most conspicuous of our eastern forms of *truncicola*, forming great colonies, often comprising several nests under piles of stones, in old logs, etc. The ants stuff all the crannies of their abodes with bits of dead leaves, grass, etc. Like most other species *Formica integra* is much given to attending aphids. It is most abundant in hilly regions, where it prefers sunny glades or clearings in forests.

31. *F. ulkei* Emery ☿—Tippecanoe Lake.

This species, originally described from South Dakota, belongs to the boreal fauna. It is known also to occur in Illinois, Nova Scotia and New Brunswick. It constructs rather flat mound nests smaller than those of the mound-building ant of the Alleghanies (*F. exsectoides* Ford) which very probably also occurs in Indiana.

32. *F. ulkei* var. *hebescens* Wheeler ☿—Bass Lake; Stark County.

This form was originally described from specimens sent me by Mr. Blatchley from these localities.

33. *F. fusca* L. var. *subsericea* Say ☿—Camelton; Hammond; Veedersburg; Wyandotte; Vawter Park; Arlington; Pine; Culver; Tippecanoe Lake; Shoals; Bass Lake.

With the exception of *Lasius americanus*, this is the most abundant of our ants. It is easily recognized by its deep black color and silky pubescence. It prefers sunny, grassy places and either constructs flat, dome-shaped mounds, which are largest and most definite in outline in the Middle Western States, or excavates its galleries and chambers under stones, logs, etc. It is a very cowardly insect, except when living in large colonies.

34. *F. cinerea* Mayr var. *neocinerea* Wheeler ☿—Wilders.

Not hitherto known to occur east of northern Illinois where it is common (Rockford, Chicago). It lives in open grassy places, often in boggy meadows, usually in nests like those of *F. subsericea*.

Subgenus *Neoformica* Wheeler.

35. *F.* (*N.*) *pallide-fulva* Latreille subsp. *schaufussi* Mayr ☿—Pine; Shoals; Hammond; Wyandotte; New Harmony.

One of our commonest ants; living in rather small colonies under stones or in obscure crater nests in sunny fields. It is timid and runs very rapidly. Its food consists very largely of the excreta of plant lice and dead insects.

36. *F.* (*N.*) *pallidefulva* subsp. *nitidiventris* Emery ☿—Hammond; Kosciusko County; Marion County.

Common, with habits similar to those of *schaufussi.*

Subgenus *Proformica* Ruzsky.

37. *F.* (*P.*) *neogagates* Emery ☿—Tippecanoe Lake.

A highland or subboreal form, which nests under stones or in obscure craters in rather small colonies.

Genus *Polyergus* Latreille

38. *P. lucidus* Mayr ☿—Pine.

This rare and beautiful red ant, the "shining slave-maker" of MacCook, or "shining amazon" as it may be called, uses the workers of *Formica schaufussi* as slaves, or auxiliaries. These are bred from pupæ kidnapped from their maternal nests by the war-like *lucidus* workers. The latter are quite unable to feed themselves, excavate nests or care for their own brood, but depend for these important services on the *schaufussi* workers. Hence the shining amazons are unable to lead an independent life and may be regarded as permanently parasitic on fragments of *schaufussi* colonies which they bring together with great skill.

Genus *Camponotus* Mayr.

39. *C. castaneus* Latreille ☿ ♀ ♂—Camelton; Pine; Vincennes; New Harmony; Mt. Vernon; Grand Chain; Mitchell; Hammond; Wyandotte.

This appears to be a common species in Indiana, although it is very rare in the Eastern States north of New Jersey. It is easily distinguished from our other Camponoti by the pure reddish yellow color of the worker and female forms and the pale males. It nests in the ground under stones.

40. *C. castaneus* subsp. *amercanus* Mayr. ☿ ♂—Wyandotte; Mitchell; Hammond; Camelton.

The soldiers and workers of this form, though variable in color always have the head black. It nests under stones like the typical form of the species.

41. *C. herculeanus* L. subsp. *pennsylvanicus* DeGeer ☿ ♀ ♂—Delong; Vincennes; Knox; Mitchell; New Harmony; Culver; Tippecanoe Lake; Grand Chain; Wyandotte; Arlington; Stark County.

This is the common "carpenter ant," a large, entirely black species which usually nests in old logs and stumps in shady woods. It may migrate into old farm houses and surburban residences and become a pest by riddling the wood-work with its inosculating galleries and by visiting pantries and kitchens in search of sweets.

42. *C. herculeanus* subsp. *pennsylvanicus* var. *ferrugineus* Fabricius ☿.—New Harmony; Grand Chain; Vincennes; Mitchell; Wyandotte.

A beautiful color-variety of *pennsylvanicus*, with the legs, inferior and posterior portions of the thorax, petiole and base of gaster rust red in the worker and female. Its habits closely resemble those of the typical form, but it seems to be less abundant and more local in its distribution.

43. *C. herculeanus* subsp. *ligniperda* Latreille var. *nove boracensis* Fitch ☿ ♀ ♂—Pine; Tippecanoe Lake; Hammond.

Nesting in old stumps and logs like *pennsylvanicus*, but differing in the smoother surface and entirely red thorax of the worker.

44. *C. caryae* Fitch ☿—Wyandotte.

The types of this species, which I have recently found in the U. S. National Museum prove to be identical with the form called by Emery *C. emarginatus* Latr. var. *nearcticus*. Later it was shown by Emery that Nylander's name *fallax* should replace *emarginatus*. Now the unfortunate substitution of *caryae* as the name of the species is necessitated by the fact that Fitch described his *Formica caryae* in 1854, whereas Nylander did not give the name *fallax* to the common European form of the species till 1856. The latter form therefore becomes *C. caryae* Fitch var. *fallax* Nylander.

C. caryae nests in dead branches. It is entirely black and much smaller than *C. pennsylvanicus*, from which it may also be distinguished by the notch in the anterior border of the clypeus of the worker and female.

45. *C. caryae* var. *minutus* Emery ☿—Camelton; Grand Chain.

Smaller than the preceding, with more or less red on the thorax of the worker.

46. *C. caryae* var. *decipiens* Emery.

Cited by Emery from Indiana. His specimens were received from Mr. Theo. Pergande, portions of whose original series are now in the U. S. National Museum.

Bird Censuses.

M. L. Fisher.

The notes here recorded refer to the census taken on December 25th each year and another taken the last of May in accordance with the plans of the U. S. Department of Agriculture, Bureau of Biological Survey.

The writer got his suggestion for a Christmas Census from a copy of Bird-Lore which came into his hand in the year of 1907; since that time a census has been taken nearly every year. Results of five of these censuses are recorded in the table. Observations at Christmas time are very much affected by weather conditions; a bright sunshiny morning brings out practically all the bird life remaining in a vicinity, and they are easily discovered, but a cold, raw, cloudy day keeps many species under cover and they are not easily found. At this time of the year, one will find the birds congregating along streams and sheltered hillsides clothed with timber. An east and south exposure are favorite places for birds. One will find very few species in open country this time of year. The observations recorded in table were taken in the vicinity of LaFayette on what is known as the north river road leading to the State Soldiers' Home and on the south river road. Both areas are sheltered and have the exposure as indicated above.

In this table it will be observed that the following species were observed on but one day in the five observations recorded: Hawk, Hairy Woodpecker, Red-headed Woodpecker, Bronzed Grackle, Chewink, Winter Wren, Brown Creeper, Chickadee, Golden Crowned Kinglet, Robin, Bluebird. The Bluebird, Robin, Chewink and Grackle are probably infrequent winter residents, but it is believed that the others are usually in residence, but were not observed.

It will be noticed that certain species have been seen practically every year. The following have been recorded at least four times out of the five. Downy Woodpecker, Blue Jay, Crow, Junco, Song Sparrow, Cardinal and Tufted Titmouse.

The bird census taken the last part of May in co-operation with the Bureau of Biological Survey was taken this year (1916) for the first time. The area selected lies about three-fourths of a mile west of Purdue University campus, consisting of about forty acres. In this forty acres there are about six acres of timber land, fifteen acres of alfalfa, about eight acres of corn, and about eleven acres of oats. The alfalfa had not been cut when these observations were taken. One must be on the ground at about 3:00 o'clock if he is to make accurate observations and he has to depend almost entirely upon his ear for identifications. Just before the birds begin to fly away some can be recognized by the eye. The method of taking the census is that of moving about over the area and making note of the different birds (males) heard singing. For each bird singing a pair is recorded. This year's observations were taken on May 29 and 31, both mornings were rainy and it had rained throughout the night. Twenty different species and forty-two pairs were counted on the area as indicated. On this area the Meadow Lark was found to be nesting in larger numbers than any other species, six pairs being recorded. The Dickcissel followed closely with five pairs, while the Red-headed Woodpecker had four pairs to its credit. It is expected to continue these observations over the same area from year to year.

Another census, which is better called a survey, has been of considerable interest to the writer for several years. This is a 4th of July census. However, in this census no attempt has been made to count the number of individuals, there simply having been made a record of the species. This census has been taken over an area extending from West LaFayette to the State Soldiers' Home a distance of about four miles. A tabular arrangement of the species observed has not been prepared to accompany this paper, but the following data may be given as showing the number of species observed each 4th of July.

1912, 32 species; 1913, 41 species; 1914, 36 species; 1915, 41 species; 1916, 23 species.

CHRISTMAS BIRD CENSUS.

Table Showing the Species and Number of Each Observed on December 25. Arranged According to A. O. U. Check List.

	Dec. 25 1907	Dec. 25 1908	Dec. 25 1911	Dec. 25 1914	Dec. 25 1915
Hawk, Red-tailed or red-shouldered	....	....	....	....	2
SparrowHawk	2	....	1	1	....
Hairy Woodpecker	....	....	....	4	....
Downy Woodpecker	2	....	6	5	3
Red-headed Woodpecker	....	....	....	....	1
Flicker	2	....	1	2	....
Blue Jay	8	1	4	10	9
Crow	10	20	4	10	50
Bronzed Grackle	....	....	....	....	1
English Sparrow	Always	Numerous			
Goldfinch	....	....	....	2	4
Tree Sparrow	25	....	....	....	....
Junco	2	....	35	6	75
Song Sparrow	2	1	4	3	5
Chewink	....	....	....	....	1
Cardinal	2	4	8	5	5
Winter Wren	....	....	1	....	....
Brown Creeper	....	....	3	....	....
Wh. Br. Nuthatch	....	....	2	6	3
Tufted Titmouse	2	....	15	15	12
Chickadee	....	....	1	....	....
Gold-Cr. Kinglet	....	....	....	4	....
Robin	....	....	1	....	....
Blubird	....	....	3	....	....
	10:00-12:00 cloudy, wind west snow on ground, thawing.	10:30-11:30 cloudy, raw west wind temp. 32° Ground thaw.	10:30-12:00 cloudy, west wind temp. 32-33° snow on ground along river.		10:00-12:30 cloudy, wind, N. W 12 in. snow temp. 32°.

Summary:

- **1907:** 10 species, 57 individuals.
- **1908:** 4 species, 26 individuals.
- **1911:** 15 species, 89 individuals.
- **1914:** 13 species, 73 individuals.
- **1915:** 13 species, 171 individuals.

The Time Birds Get Up in the Morning.

M. L. Fisher.

The writer has always been curious to know at what time birds become active in the morning and what species are astir first. The table which accompanies this article shows some observations which were made the last of June and the first of July in various years. This time of year was chosen because it is the time of maximum daylight and also the time when bird-life is at its greatest activity.

Any one who wishes to take observations on the time when birds awaken will have to plan to arise early himself. As will be seen from the data given, one should be on the ground for observation by 3:00 o'clock. A place where a large number of species of birds are likely to roost should be selected. One cannot go from place to place while taking observations; he must choose a place and stay there, and take all the observations which come to him at that place. If the place seems unsuited another place can be chosen for another morning.

To some extent the time of awakening is dependent on the character of the morning. A cold morning with a chilly wind will delay the activity of the birds. A cloudy morning, threatening rain, or one on which it is raining will also delay their movements. Moonlight or the absence of moonlight does not seem to make much difference, providing the sky is clear. So far as observations has been made, the deep woods do not delay the awakening of birds. In the table, the observations taken on July 3, 1913, were taken from a place where the timber was of rather heavy stand and deep ravines hindered the coming of daylight.

Most of the observations recorded in the table were taken on the Purdue University campus. On this campus many Robins and Grackles congregate to roost. With birds the same as with men, it seems that some awake and bestir themselves sooner than others; then to, it seems that with some birds their first notes are but sleepy yawns. For example, the following notes were recorded concerning one particular observation: the first Robin chirped at 3:15, again at 3:17, and at 3:25 it burst into full song, and a minute later the robins all seemed to join in a grand chorus. This chorus continued until 3:50 when they began to fly to the ground and began to feed. The first Grackle was heard at 3:19 then all was quiet until 3:50 when there was a general disturbance among the hundreds in the trees and the chattering began in earnest. It seems as though some one of their number had taken it upon himself to awaken the entire company at 3:50, for apparently the whole flock awoke and began to chatter all at once. This chattering lasted for twenty minutes (4:10) when they began to fly away to feed.

In recognizing the various species one must depend upon his ear, since it is impossible to see the birds at this time in the morning. A study of the table will show that among our earliest birds are the Robin, Grackles, Cat Bird, Bull Bat and Bee Martin. The Bull Bat and Whippoorwill sound their notes throughout the night and ought not to be included in this list.

It is proposed to continue these observations with the hope of getting more data on each species and extend the data to more species.

Table Showing the Observed Time at Which Birds Gave Their First Notes in the Morning.

	June 23, 1913*	June 30, 1913	July 1, 1913	July 3, 1913	July 4, 1915	June 30, 1916
Cardinal	3:35	3:43		3:55		
Indigo Bunting	3:55	3:30		3:40		
Cat Bird	3:55	3:20	3:33			3:28
Blue Jay	4:00	3:45	3-53		3:52	
Md. Yellow Throat	4:00	3:38				
Green Heron	4:00			3:40		
Crow	4:08	4:00		3:58		3:52
Mourning Dove	4:08	3:44	3:25			3:41
Whippoorwill	4:07			3:35		
Song Sparrow	4:10	3-35			3:40	
Robin	4:13		3:15	3:20	3:43	3:23
Bull Bat		3:27	3:16			3:22
Wood Thrush		3:43		3:45		
Bob-White		3:47				
Brown Thrasher		3:55	3:46	3:55		
Crested Flycatcher		4:00		4:20	4:10	
Grackles		4:08	3:19			3:25
Red-headed Woodpecker		4:10				
Chimney Swifts		4:15	4:07			4:07
Flicker		4:19		4:16		4:22
Bee Martin			3:21			3:22
English Sparrow			3:45		3:57	3:57
Chipping Sparrow			3-52			3-52
Meadow Lark			3:55			
Baltimore Oriole			4:19			
Tree Sparrow				3:35	3:46	
Vesper Sparrow					3:34	
Wood Pewee				3:47		
Towhee				4:12		
Goldfinch				4:26		
Titmouse				4:28		
Cow Bird				4:33		
Yellowbilled Cuckoo				4:45		
Bluebird					4:00	
Purple Martin					4:00	

*Cloudy and rained at 3:35 and continued for 15 minutes.

THE TURTLES AND BATRACHIANS OF THE LAKE MAXINKUCKEE REGION.[1]

BARTON WARREN EVERMANN AND HOWARD WALTON CLARK.

While engaged on a physical and biological survey of Lake Maxinkuckee, Indiana, in 1899 to 1913, under the auspices of the United States Bureau of Fisheries, the present writers paid some attention to the herpetology of the region. Although this work was rather incidental to the main purpose of the survey, it very soon became evident that most, if not all of the species of reptiles and batrachians of that region bear a very close and important relation to the fish-fauna of the lake. We therefore collected specimens of the various species observed and recorded our observations on the occurrence, abundance, distribution and habits of each. Our notes on the snakes have already been published in these proceedings.[2]

In the present paper we include the turtles, frogs, toads and salamanders.

THE TURTLES.

Nine species of turtles are known from Lake Maxinkuckee and vicinity, a number probably greater than has been recorded from any other locality in the State. Five of the 9 species are abundant, while each of the remaining 4 is rare.

The turtles constitute an interesting and important branch of the local fauna. Several of the species are so abundant and easily observed as to attract the attention even of people who are little interested in nature. The great numbers that may be seen on any bright or quiet summer day, basking on timbers or boards in shallow water, or on sandy reaches of shore, can not fail of observation even by the least observing.

The turtles are also among the most useful animals of the lake. All the species are scavengers and do much to keep the lake free of dead fishes and other animals which at times are so numerous that they would prove a menace to the comfort, if not to the health, of the people about the lake, were it not for aid rendered by the turtles in removing them. Several of the species are valuable as food for man, and considerable numbers are utilized at the lake for that purpose.

All these turtles are entirely harmless except, possibly, the snapping turtle. We know of no harm that any of them does. They should all be protected.

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[1]Published by permission of Hon. Hugh M. Smith, U. S. Commissioner of Fish and Fisheries.

[2]Proceedings of the Indiana Academy of Science for 1914, pp. 337-348.

1. *Platypeltis spinifer* (Le Sueur.)

SOFT-SHELLED TURTLE.

Compared with the other turtles of the lake, the Soft-shell has a rather northern distribution. It ranges from Canada southward to Kentucky and westward to Minnesota. It is very abundant in the upper Mississippi and its tributaries, great numbers being frequently seen on or about the sandbars which furnish them basking and nesting places. It is rather a river than a pond turtle, and rarely or never ventures into small isolated ponds.

At Lake Maxinkuckee it is very abundant, much more so than would appear to the casual observer, as it is one of the shyest and most wary of turtles, quickly taking alarm and disappearing whenever it is approached. It is found everywhere in the lake. Its pointed, shapely head is often seen sticking up above the surface even over the deeper waters of the lake. Examples of all sizes have been taken from almost every part of the lake shore. It seems to be more common in the region of Norris Inlet, probably because that is the most sequestered part of the lake, where it is less likely to be disturbed than elsewhere.

The Soft-shelled Turtle is the last turtle to make its appearance in the spring, and the first to disappear in the fall. Very small ones, benumbed or dead, may often be seen along shore late in the autumn and early in the spring before the older ones appear. These have probably been unable to take care of themselves. Very small ones have been found in the spring as early as March 18, but no large ones were seen until April 29, and then they were very scarce. It is not until May or June that they appear in abundance. None has been seen in the winter, and it was a problem where they spend that part of the year, until in the autumn of 1906 (Sept. 6) an example 5 inches long was found buried up to the eyes in mud at the edge of Lost Lake. It is probable that all of them bury themselves in the mud in the bottom of the lake. As none was seen moving under the ice, it is thought that they spend the winter in a quiescent state. The last one seen swimming about was noted in Lost Lake, Sept. 7, 1906.

This turtle is fond of basking during the hotter portions of the year. At this lake it generally prefers sandy or grassy bits of shore and is not often seen on stakes or boards. One of its favorite haunts was the sandy stretch of shore near Farrar's. They also basked in numbers at the edges of small pools in the Inlet marsh. Before the shore was cleared off, they used to bask in great numbers along the south shore of Outlet Bay. On June 11 many of these, with other species, were seen basking at this place and when a rush was made at them from a boat they scattered in every direction, many of them hiding under a large dense floating mass of algæ which was along the shore at that place. The Soft-shells that took refuge under the algæ thrust up their heads now and then to see what was going on. Several were caught. Even when stationary they are hard to catch and hold by hand; the tail is too short and slippery to hold, and it is necessary to grasp them by the sides, but this permits them to claw one's hand severely. They are very pugnacious, and though the gape is not sufficiently large to allow them to get a very deep hold, even a small example is able to give a very severe pinch.

In some places this species basks not only on the sandy shore, but also on any log, board or other object upon which they can crawl. In Wild Cat Creek, just below the bridge near Stonebraker's mill, east of Burlington, Carroll Co., Indiana, hundreds have been seen on the large boulders with which the bed of the creek was strewn. There they would remain for hours basking in the sunshine, sliding quietly into the water if a passer-by came too near, but soon returning to bask again until evening or until again disturbed.

At Maxinkuckee they begin laying about the middle of June and continue until perhaps near the end of July. A large female killed June 14 contained 33 eggs of various sizes, but none fully developed; another killed on the same date contained several eggs in the large distended oviduct, but none was ready for laying. Still another examined June 17 had eggs ready to deposit. The next day a nest with about 30 eggs in it was found near the ice-houses. On June 25 one was seen digging a hole in the sandy shore at the southwest side of the lake and the next day another was seen doing the same thing. Each of 2 examples caught June 27 contained mature eggs. On July 16, 1899, 2 eggs were found on the bottom in 2 feet of water. On July 18, 1900, at the south end of the lake just east of Murray's, two large Soft-shells were seen hurrying into the water from the sand ridge pushed up by the ice. Upon examination several nests were found. The sand showed evidence of recent disturbance, and there was no difficulty in finding where the eggs were buried. There were probably 10 or 12 nests in a distance of a few yards along the ridge, though we did not dig into all of them. Some fresh holes into which we dug contained nothing; possibly the turtles had been trying different places and found some unsuitable. Each hole was usually at the edge of an abrupt ascent and was 2 to 4 inches in diameter at the mouth and generally sloped back somewhat. In one or two cases the eggs were uncovered but more often there was some sand over them. The eggs were generally at a depth of 4 to 10 inches and placed either on the bottom or on the sides of the hole which usually widened out somewhat toward the bottom. Five nests examined contained 4, 25, 3, 3 and 1 egg, respectively. The 25 eggs in the second nest evidently belonged to 2 different sets. In the bottom were 10 eggs that looked old. The yolk in each had settled into the lower half, giving it a pink tinge, while the upper half was opaque white. Above these, and partially separated from them by sand, were 15 other eggs that were uniform pink throughout and had evidently been deposited later. In and about this and other nests were a good many broken eggs, evidently destroyed by some animal, perhaps by the turtles themselves. The 3 eggs in the third nest were fresh, but those in the fourth and fifth were old and stale. Thirteen of these eggs and 2 others found elsewhere were taken to the station and placed in sand-boxes exposed to the sun, but none of them hatched. The eggs were quite uniform in size, most of them measuring 1.3 x 1 inch.

On July 21, a large female was caught on her nest by the side of the railroad north of the ice-houses. Nineteen eggs were found in the nest, and 2 fully developed eggs were taken from the oviduct. These 21 eggs represented 2 different sizes, those taken from the turtle and a portion of the others measuring 15-16 x 15-16 inch, the others 1 1-16 x 1 1-16 inches and all were decidedly more nearly spherical than any of those obtained July 18.

The female Soft-shell Turtle caught July 21 weighed just 7 pounds and gave the following measurements:

Length of carapace, 13 inches.
Width of carapace, 10.5 inches.
Length of head and neck, 9 inches.
Length of fore leg and foot, 4.5 inches.
Length of hind leg and foot, 5.5 inches.
Length of tail, 3.5 inches.

Another example measured 11.75 inches long and weighed 5.5 pounds; another 11 inches, 4 pounds; another female measured, length of carapace 12.5 inches; width 11 inches; and still another was 12.5 by 10.25 inches.

The eggs of the Soft-shell probably hatch in the autumn, and there is probably some range in the time of their hatching just as there is in the time of laying. The period of incubation doubtless varies somewhat with the season, whether such as to warm up the soil considerably or not, and also a good deal with the nature of the soil in which the eggs are laid, a warm, sandy soil hatching them out sooner than a colder soil. In the late autumn of 1906, on November 16, a nest of eggs was found in the black mucky soil near the south shore of Outlet Bay, which contained well-formed young Soft-shells, the color-markings (spots on back) being distinct. The egg-yolk was not yet absorbed, but occupied one-half the shell while the turtle occupied the other. It seems probable that the turtles would not have left the nest that year, but would have wintered there. It is possible that this was a belated nest.

As an article of food the Soft-shelled Turtle is the most highly esteemed of any of the species found in Indiana, the soup made from it being delicious. Not many of the cottagers at the lake, however, seem to have acquired a taste for this or any species of turtle, and they are not much sought after.

This turtle is the species most often caught in traps, on set-lines and by anglers. On August 8, several were caught in water 14 feet deep east of Long Point, on a hook baited with grasshoppers. On June 27, six were caught on set-lines baited with meat, 2 others were obtained the same way August 1, and one on August 17. Set-lines placed in Lost Lake were always quite sure to take several any time from June to September. In 1906, a citizen of Culver who set out turtle traps caught numbers of these.

This species probably devours dead fish or other animals found in the water. Its principal diet, however, as evidenced by a number of stomachs examined, appears to consist of crawfishes.

This turtle has few enemies and would be able to escape almost anything that attempted to capture it. A good many young appear to perish during their first winter. The stomachs of some examples studied were infested by a few parasitic round worms, but we have no evidence that these cause much injury. Unlike the scute-bearing turtles, this species is never covered with algæ or other organisms, although one example was found in 1906 which had the plastron covered with a growth of *Opercularia*.

This turtle may be readily distinguished from all other turtles of the lake by the flat body, covered with a smooth leathery skin flexible at the margins. Color, olive-green, with dark spots; head and neck olive-green with light and dark stripes; legs and feet mottled with dark. The male has the tubercles on the front of the carapace smaller than in the female, the body longer, and the tail extending considerably beyond the carapace.

2. *Chelydra serpentina* (Linnæus).

Snapping Turtle.

The Snapping Turtle is of very wide distribution, its habitat extending from Nova Scotia to the equator and west to the Rocky Mountains. It is doubtless found in every stream and pond in Indiana.

At Lake Maxinkuckee it is quite common, but not nearly so abundant as the Map, Painted, Musk or Soft-shelled turtles. Although they may be seen almost anywhere in the lake, they do not often occur in the deeper, clear portions; they prefer shallow water with soft muddy bottom, especially water that is well warmed up by the sun. They are more common, therefore, in Lost Lake than in Lake Maxinkuckee, and in the latter body of water prefer shallow bays with marshy shores, such as the region about Norris Inlet and Outlet Bay. They are fond of streams and occur in numbers in Norris Inlet, also in Aubeenaubee Creek, Culver Inlet and the Outlet. In the Norris Inlet region, Outlet Bay, or Lost Lake, they can frequently be caught on set-lines or in turtle-nets baited with meat. They are not often seen basking about the shores, but usually spend their time floating or swimming with only the head projecting above the surface of the water. Numerous examples of various sizes were captured in many places about the lake. They were captured in various ways, some in hauls of the seine, some on set-lines, and many by hand. A few were seen that had been taken in traps.

The Snapping Turtle, Snapper, Mossback, or Mud Turtle, as it is variously called, is most frequent in and about muddy ponds, streams or bogs. It may often be seen long distances from water, however, when it is traveling from one pond to another, or in search of a suitable place for depositing its eggs.

It walks along with a slow, awkward, halting gait, often stopping, holding its head well up as if listening or looking about. When traveling about on the land, a great amount of mud may sometimes be seen on the back. The back or carapace is always rough and more or less covered with mud, and there is often a heavy growth of filamentous algæ on the back, the algae being generally some species of *Microspora*.

The Snapper is a vicious brute. When attacked it neither retreats nor withdraws into its shell as most species do, but shows fight at once, snapping viciously at any object held near it. It will even leap forward toward its tormentor. When its jaws have once closed on the enemy it holds on with dog-like persistence. Dr. Hay mentions a curious belief with which the writers have been familiar since boyhood days, viz.—that a Snapper when a hold has once been secured will not let go until it thunders. Another version of this superstition with which we are also familiar is that the turtle will hold on until the sun goes down. They may frequently be carried around for sometime by the stick which they have seized.

These turtles are carnivorous and very voracious. Their food consists of frogs, fishes, crawfishes, young waterbirds, and such other small animals as they can capture. Several stomachs examined at the lake all contained opercula and fragments of *Vivipara contectoides*, indicating that this mollusk is the principal food of this species of turtle at the lake during certain parts of the year. That they sometimes capture young ducks and goslings, catching them by the feet and pulling them under the water, seems well authenticated.

They evidently bury themselves in mud in swamps, frequently some distance from the lake, and hibernate in winter. A single, rather large individual was seen under the ice (Lost Lake, December 18, 1900.) It was close up against the ice, which was chopped away, and the turtle, which was apparently too benumbed to pay any attention to what was going on, was taken out. It was kept alive over night in a coop and the temperature, which was somewhat higher than freezing (35°) kept the turtle in such a benumbed condition that it could hardly move by morning.

These turtles began coming out of the mud about the middle of March, the first one having been seen March 19. From then they came out one by one, and from that time on they continued to be seen on land until through the nesting season. In the fall they were to be seen about the lake as late as the end of September. It is possible that the young turtles spend their first winter in the water or near it; they are usually seen about the water's edge and in pools early in the spring. On April 3, one about the size of a dollar was caught in a pool east of the railroad. The first winter appears to be a critical period in their lives; quite a number of small ones were found dead at the water's edge in early spring, between April 3 and April 26.

They begin laying about the middle of June. Several were seen on or about nests between June 14 and 20. The nests consist simply of holes made in the sand, usually not very far from water. One of the favorite nesting places was the railroad embankment between the lakes. The eggs are quite spherical in shape and about an inch in diameter. The shell is calcareous, and, although not brittle, somewhat less flexible than in other species. The number may vary from 20 to 60, and they hatch in August or September. According to Agassiz, the young will snap before they have left the shell. We have never seen one so small that it would not snap viciously.

This turtle is often used for soup, though only the younger examples are suitable for that purpose. The older individuals have a strong disagreeable odor, and the flesh is tough. According to Dr. Hay, Storer wrote that in Massachusetts many persons saved the oil of this turtle and used it for healing bruises and sprains. "As a therapeutical agent it is worthy to stand alongside of goose, rattlesnake and skunk oil."

This turtle reaches a large size. Examples weighing 40 pounds each have been reported, although one of 12 or 16 pounds is generally regarded as a large Snapper.

The measurements of 3 of the larger examples taken at Maxinkuckee are given in the following table:

	1	2	3
Length of carapace, (inches)	13.25	11	7
Width of carapace	14.25	10	6.25
Length of Plastron	9.12	8.5	5.25
Width of Plastron	5	....	3.06
Length of head and neck	11	....	....
Length of hind leg and foot	9.5	....	....
Length of fore leg and foot	9	....	....
Length of tail	12	....	....
Weight	16 lbs.	13 lbs.	10 lbs.

The Snapper has very few enemies. Very young examples may occasionally fall a prey to voracious fishes, but the larger examples are exempt from the attacks of anything except leeches, which are usually present in small numbers. A Snapper kept in captivity in a live box in the lake was badly infested with them. During its confinement in the box it became much emaciated, and the algae on its back grew to extraordinary thickness and length. An immense bunch of leeches had collected in the hollow between the neck and front legs and would probably soon have caused the death of the turtle.

Shell high in front, low behind, the body heaviest forward; head and neck very large, jaws strongly hooked and very powerful; tail long, strong, and with a crest of horny, compressed tubercles; plastron small, cross-shaped, with 9 plates besides the very narrow bridge; claws 5-4, strong, the web small; color, dusky brown, head with dark spots. Size large.

3. *Kinosternon odoratum* (Latreille).

Musk Turtle.

The Musk Turtle, also called the Stink-pot, ranges from the eastern United States westward to northern Illinois. It is abundant in most parts of its habitat, particularly in the small lakes in the upper Mississippi Valley. At Lake Maxinkuckee it is one of the most abundant species, it being exceeded in numbers only by the Map, and possibly, by the Painted, Turtle. On account of its not having the basking habit well developed it is, however, far less conspicuous than either of those species.

The Musk Turtles seem to spend most of their time walking about on the bottom of the lake, and are particularly fond of muddy places, the Outlet region, Green's marsh, Lost Lake and the Inlet, being their favorite haunts. They are also found up Aubeenaubee Creek, a region well suited to them. This turtle is not built well for swimming, as it is quite deep in proportion to its diameters. There is, however, an immense amount of individual variation in this respect. It is a strictly aquatic species, and comes out on dry land, or even in the marshes, quite infrequently. It is not so much in evidence early in the spring as the Map and Painted turtles, and is rarely seen basking. The great majority of the numerous examples we have seen were observed in shallow water in such places as Outlet Bay, either walking slowly about on the bottom or partially concealed in the Chara; very rarely have they been observed swimming freely.

We have observed them during every month in the year except January and February. Our earliest record is March 18 (1901), when one was obtained near the railroad and another was seen on the bottom in Culver Inlet. From that date onward they could be seen any day when the water was smooth and the conditions favorable for observation. Even after the lake freezes over they may be seen. Our latest record is for December 31 (1904), when one was observed through the ice in Outlet Bay. It is, therefore, active practically throughout the year. On December 20, 5 were found alive in a mink burrow.

Although this species does not usually bask, it does so occasionally. Among a hundred turtles seen basking, probably there would be one or two Musk Turtles. They are quite disposed, however, to rest quietly in the water with the head just above the surface.

In disposition, this is the most vicious of any of our species except the Soft-shell and the Snapper. It is very sly and apt to take hold of one's finger when least expected. It holds on tenaciously and would be capable of inflicting a painful wound were its size not so diminutive.

As to food, one was seen June 6, 1901, in company with a Painted Turtle, swimming along behind a dead floating fish, and nibbling bites out of it. Also, in the late autumn (Oct. 30, 1904) one was seen nibbling at the body of a grass pike 13 inches long that lay on the bottom at the head of the Outlet. This turtle or others stayed near the fish several days, but did not seem to make much progress in disposing of it, perhaps because the cold season was coming on, when they probably eat little or nothing. On September 2, 3 or 4 were seen feeding on fresh cow dung in the edge of Lost Lake. Professor Newman says they often contain *Viviparа contectoides*.

We have not been able to determine definitely the breeding season of this species. Among many examples collected November 1 (1904), several pairs were copulating. On September 13 (1906), a pair were observed copulating, the female lying prone, as if dead. September 20 (1907), a female found crushed in the road contained eggs quite well developed. One was dissected November 27 (1904), which contained eggs the size of marbles. October 4, very small ones were abundant in shallow water near shore, some of them showing the placental attachment. These had probably hatched but recently. Early in June, a good many may be seen walking about on the land, and we supposed they were hunting nesting sites. Some very small ones were caught May 6 and 7, 1901, so they probably either hatch quite late in the year, or grow very slowly. This evidence is so conflicting as to render any positive statements regarding the breeding season hazardous.

The enemies of the Musk Turtle do not appear to be many. On December 20 (1904), one was found at the Inlet turned upon its back and the soft parts almost wholly gone—probably devoured by a muskrat, the tracks of which were in evidence. Another was found November 27, partly devoured. Apparently the muskrat occasionally catches one of these turtles or finds it torpid during the winter season and feeds on it. At any rate, we found them now and then (though not so frequently as we do the Painted Turtle) lying on the ice, usually belly up with the flesh chewed out from the sides. The muskrats were not actually caught doing the work, but as it took us some time to catch them actually catching mussels and cleaning out their shells, and as, on several occasions, muskrat tracks, and no other were seen coming to the turtles, we are convinced we would have caught them at it if our observations could have been longer continued. Probably the muskrats pick up the turtles and lay them aside much as they do shells they are unable to open, and after the turtles are frozen, devour them.

These turtles are often infested by leeches which doubtless cause annoyance, at least.

Like the Snapper, the Musk Turtle is frequently covered with algæ on the back, the algæ often being quite long and thick. The proportion of turtles covered with algæ varies with the season and conditions; in early summer, before the scutes were shed, all or nearly all the turtles would probably be covered; with the shedding of the epidermal scutes the turtle comes forth clean of algæ, and bright in color.

During the late summer and early autumn of 1906, many small Musk Turtles were seen surrounded by a white halo which was conspicuous at a distance, very much resembling the general appearance of Saprolegnia on fishes. It was found upon examination that the white growth consisted of a dense growth of a stalked branched protozoan, *Opercularia*. Later it was found that larger Musk Turtles harbored considerable masses of the protozoan on the plastron, this being frequently entirely covered, so that the turtles were practically botanical gardens above and zoological gardens below. Neither the alga nor the protozoan appears to do the turtles any injury. The algæ above may assist the turtle in concealment; the protozoan below is self-supporting, feeding on minute organisms. The turtles in the muddy waters of Lost Lake are much more heavily overgrown than those of the clearer waters of Lake Maxinkuckee.

The Musk Turtle is a harmless creature and certainly does some good as a scavenger. It should, therefore, be protected.

So far as we are informed, it is never utilized as food by man; its small size and disagreeable odor preclude such a possibility. It is the smallest species in the lake. In the following table are given the weights and measurements of examples of the species, the first 51 of which were caught by us in the Outlet Bay, November 1, 1904, by means of a small dipnet, and afterward sent to the American Museum of Natural History.

No.	Weight in Ounces.	Carapace		Plastron.		Date.
		Length in inches.	Width in inches.	Length in inches.	Width in inches.	
1	4.75	4.375	3.625	2.375	1.25	Nov. 1, 1904
2	7.25	4.75	4.50	3.00	1.50	
3	3.50	3.875	3.75	2.375	1.25	
4	5.50	4.625	4.00	2.50	1.375	
5	3.50	4.00	3.625	2.25	1.25	
6	5.00	4.375	4.00	2.625	1.375	
7	5.75	5.00	4.00	2.94	1.50	
8	7.00	4.75	3 375	2.875	1.625	
9	7.00	4.75	4.25	2.875	1.50	
10	7.75	5.375	4.625	3.00	1.50	
11	4.25	4.25	3.75	2.25	1.19	
12	7.00	5.00	4.50	3.00	1.50	
13	4.50	4.312	3.625	2.625	1.44	
14	6.00	4.75	3.875	2.625	1.44	
15	7.00	4.75	4.50	3.25	1.625	
16	5.50	4.625	4.00	2.69	1.44	
17	6.00	4.56	4.25	2.625	1.375	
18	5.50	4.25	4.00	2.69	1.375	
19	4.50	4.25	3.625	2.50	1.312	
20	7.00	4.56	4.375	3.125	1.375	
21	3.75	4.00	3.00	2.375	1.125	
22	7.00	4.50	4.625	3.25	1.75	
23	8.00	5.00	4.563	2.875	1.563	
24	4.50	4.06	3.802	2.25	1.125	
25	3.75	3.802	3.375	2.50	1.375	
26	2.75	3.6875	3.25	2.125	0.94	

No.	Weight in Ounces.	Carapace		Plastron.		Date.
		Length in inches.	Width in inches.	Length in inches.	Width in inches.	
27	7.00	4.802	4.50	3.312	1.75	
28	3.25	3.75	3.312	2.312	1.00	
29	4.00	4.00	3.063	2.625	1.375	
30	3.00	3.75	3.25	2.25	1.312	
31	3.00	3.625	3.44	2.063	1.25	
32	5.00	4.625	3.94	2.625	1.50	
33	6.00	4.563	4.25	2.75	1.375	
34	5.75	4.50	4.063	2.802	1.375	
35	7.00	4.802	4.44	2.802	1.50	
36	5.75	4.69	4.25	2.563	1.312	
37	6.00	4.875	4.25	2.802	1.50	
38	2.75	3.75	3.312	2.19	1.063	
39	5.00	4.563	3.802	2.625	1.625	
40	5.75	4.625	4.125	2.75	1.50	
41	3.25	4.375	4.125	2.875	1.625	
42	6.50	4.875	4.312	2.75	1.50	
43	6.50	4.75	4.25	2.625	1.563	
44	6.00	4.75	4.50	2.50	1.375	
45	4.25	4.125	3.75	2.50	1.375	
46	3.75	4.063	3.563	2.50	1.125	
47	4.25	4.25	3.802	2.50	1.44	
48	3.25	3.875	3.50	2.25	1.187	
49	2.00	3.25	3.00	1.75	1.	
50	3.00	3.50	3.25	2.187	1.187	
51	4.00	3.94	3.687	2.50	1.44	
52	3.75	3.312	2.50	2.50	1.687	April 29, 1901
53	6.375	4.25	2.75	3.375	1.875	
54	5.00	3.687	2.563	2.94	1.687	
55	7.25	5.00	4.75	3.00	1.375	Oct. 21, 1907
56	6.00	4.625	4.25	2.563	1.44	
57	6.50	4.25	4.50	2.94	1.50	
58	3.25	3.75	3.50	2.25	1.187	
59	7.00	5.125	4.44	2.75	1.625	
60	6.25	4.563	4.375	2.875	1.50	
61	4.25	4.187	3.625	2.375	1.312	
62	2.25	3.625	3.44	2.19	1.19	
63	4.00	3.94	3.75	2.375	1.25	
64	6.25	4.625	4.125	2.875	1.50	
65	4.25	4 125	3.75	2.375	1.25	
66	2.75	3.75	3.25	2.19	1.063	
67	3.75	3.94	3.625	2.44	1.25	
68	4.50	4.00	3.25	2.375	1.312	
69	5.25	4.44	4.00	2.615	1.312	
70	3.25	3.625	3.44	2.19	1.19	
71	3.00	3.625	3.375	2.25	1.125	
72	7.00	4.94	4.25	3.00	1.563	
73	4.50	3.94	3.44	2.44	1.25	
74	4.75	4.375	4.063	2.625	1.44	
75	7.00	4.875	4.50	2.875	1.50	

No.	Weight in Ounces.	Carapage		Plastron		Date.
		Length in inches.	Width in inches.	Length in inches.	Width in inches.	
76	4.50	4.063	3.625	2.50	1.25	
77	5.25	4.19	4.00	2.875	1.312	
78	7.00	4.75	4.44	2.625	1.375	
79	5.75	4.125	3.19	2.50	1.44	
80	5.75	4.75	4.125	2.563	1.44	
81	2.25	3.19	3.00	1.94	1.00	
82	4.25	4.125	3.19	2.375	1.19	
83	3.00	3.625	3.375	2.25	1.125	
84	3.00	3.50	3.25	2.25	1.125	
85	7.25	5.25	4.312	2.94	1.625	
86	4.00	4.00	3.625	2.25	1.19	
87	6.00	4.50	4.25	2.69	1.375	
88	6.25	4.75	4.25	2.75	1.563	
89	6.00	4.75	4.25	2.75	1.375	
90	4.25	4.00	3.625	2.50	1.25	
91	3.25	3.50	3.25	2.125	1.125	
92	6.00	4.69	4.312	2.625	1.375	
93	6.75	5.063	4.312	3.00	1.563	
94	3.00	3.563	3.375	2.25	1.125	
95	5.75	4.50	4.00	2.802	1.312	
96	3.00	3.625	3.25	2.25	1.125	
97	4.25	4.44	3.875	2.625	1.50	
98	4.75	4.25	4.19	2.50	1.375	
99	3.00	3.625	3.25	2.125	1.125	
100	4.50	4.19	3.75	2.625	1.312	
101	5.00	4.375	3.94	2.50	1.25	
102	4.50	4.375	3.875	2.44	1.375	
103	3.75	3.94	3.50	2.375	1.25	
104	7.00	4.75	4.69	2.875	1.50	
105	6.00	4.50	4.25	2.75	1.625	
106	7.50	5.25	4.50	2.875	1.50	Oct. 22, 1907
107	5.25	4.125	4.00	2.75	1.375	
108	6.50	4.94	4.125	2.802	1.50	
109	6.25	4.563	4.25	3.063	1.563	
110	4.00	4.125	3.94	2.50	1.312	
111	2.50	3.563	3.19	2.125	1.063	
112	6.25	4.875	4.69	2.69	1.375	
113	5.25	4.375	4.125	2.802	1.312	
114	4.50	4.25	3.94	2.75	1.25	
115	4.50	4.25	3.94	2.50	1.375	
116	6.25	4.75	4.125	2.755	1.50	
117	6.25	4.75	4.375	2.875	1.44	
118	5.25	4.312	4.505	2.69	1.50	
119	3.75	4.063	3.625	2.44	1.312	
120	5.50	4.625	4.125	2.625	1.375	
121	7.00	5.00	4.625	2.94	1.563	
122	2.75	3.563	3.312	2.19	1.125	

No.	Weight in Ounces.	Carapage		Plastron		Date
		Length in inches.	Winth in inches.	Length in inches.	Width in inches.	
123	4.25	4.375	3.802	2.50	1.375	
124	2.25	3.25	3.063	1.875	0.94	
125	4.50	4.063	3.875	2.312	1.25	
126	2.75	3.312	3.25	2.19	1.063	
127	3.75	4.063	3.75	2.50	1.19	
128	6.25	4.802	4.25	2.69	1.50	
129	5.00	4.50	4.125	2.69	1.44	
130	6.25	4.69	4.312	2.94	1.44	
131	3.50	3.94	3.69	2.375	1.312	
132	3.25	3.875	3.375	2.44	1.19	
133	3.50	3.75	3.563	2.25	1.19	
134	8.50	5.125	5.00	3.00	1.625	
135	4.25	4.312	3.875	2.563	1.375	
136	3.25	3.875	3.25	2.312	1.25	
137	5.75	4.563	4.125	2.94	1.563	
138	2.75	3.75	3.312	2.25	1.19	
139	5.25	4.563	4.125	2.563	1.375	
140	5.25	4.44	4.00	2.625	1.44	
141	4.00	4.063	3.75	2.625	1.25	
142	4.00	4.25	4.00	2.50	1.312	
143	3.50	3.75	3.625	2.125	1.19	
144	5.25	4.69	4.312	2.69	1.375	
145	3.25	3.69	3.625	2.25	1.19	
146	6.50	4.802	4..625	2.802	1.50	
147	3.50	4.00	3.44	2.375	1.19	
148	4.75	4.125	4.00	2.50	1.312	
149	4.00	4.00	3.94	2.50	1.312	
150	5.25	4.44	4.25	2.75	1.50	
151	3.00	3.75	3.50	2.375	1.25	
152	6.25	4.94	4.625	2.75	1.44	
153	4.00	4.063	3.802	2.375	1.312	
154	2.50	3.625	3.25	2.25	1.125	
155	2.75	3.563	3.19	2.19	1.125	
156	2.00	3.19	3.125	1.94	1.00	
157	3.25	3.802	3.563	2.375	1.125	Oct. 21, 1907
158	3.50	3.94	3.563	2.44	1.375	
159	4.75	4.312	4.063	2.50	1.50	
160	3.00	3.802	3.375	2.25	1.375	
161	5.00	4.312	4.063	2.625	1.44	
162	3.50	3.875	3.375	2.312	1.125	
163	2.75	3.75	3.25	2.25	1.19	
164	3.25	3.802	3.563	2.25	1.19	
165	3.50	3.563	3.375	2.19	1.125	
166	3.75	4.00	3..563	2.25	1.19	
167	1.75	3.063	2.875	1.94	0.875	
168	0.50	2.19	2.25	1.25	0.69	
169	0.50	1.94	2.063	1.19	0.563	
170	0.50	1.94	2.00	1.063	0.625	
171	0.25	1.44	1.50	0.802	0.50	
Average.	4.66	4.50	3.78	2.51	1.32	

The Musk Turtle may be known from the following description:

Carapace rather long and narrow, the outline rising gradually from the front to a point beyond the center, then abruptly descending, the bulk of the body, therefore, thrown backwards; margin of carapace turning downward and inward rather than outward; shell dusky, clouded, sometimes spotted; neck with 2 yellow stripes, one from above the eye, the other from below it; head very large, with strong jaws; carapace with traces of a keel. Length 6 inches or less.

4. *Graptemys geographicus* (Le Sueur).

MAP TURTLE.

The Map Turtle is found from the Mississippi Valley eastward to New York, but is more common in the western part of its range. It is common everywhere in the lakes and larger streams of Indiana.

At Lake Maxinkuckee it is by far the most abundant turtle and is found in all parts of the lake; the heads may often be seen sticking up above the surface even in the deeper portions of the lake. Like most of the other turtles of the lake, however, they prefer shallow bays. Examples have been taken almost everywhere about the shores of the lake. It occurs in both lakes, in the lagoons between them, in the Inlet and Outlet, and perhaps also in the smaller streams about the lake. It does not travel far from shore, and is not found in the pools and woodland ponds of the region.

The Map Turtle makes its appearance swimming at the surface or basking, early in the spring; the first seen in 1901 was on April 27, and they were seen in gradually increasing numbers from that time on. They are very abundant from May on to August or September. They are essentially aquatic in their habits and are never seen away from the water except when laying their eggs. Though most numerous near the shore and in protected bays, they may often be seen far from shore out in the lake, slowly swimming about or quietly resting at the surface. When approached, they sink silently beneath the surface, swim slowly a short distance, again come up and rest with head above the water as before. In our seining operations about the lake small Map Turtles were taken at nearly every haul. They were particularly abundant in the patches of Scirpus and on sandy bottom covered with a growth of Chara. They were less common among the Potamogetons, Myriophyllum and Ceratophyllum. A few can usually be seen on any log, board or other floating object of sufficient size and stability, but they most delight in low, sandy, somewhat grassy beaches. A favorite basking place of this kind is on the south side of Outlet Bay near the wagon bridge. Here a score or more could often be see. They would crawl out upon the shore about 8 or 9 o'clock in the morning, or earlier if the day were bright and warm, and there they would remain for many hours. They usually rest quietly basking in the sun, occasionally moving about a little. From the amount of time they spend basking during the day, it is supposed that they feed principally at night.

The basking ground along the south shore of Outlet Bay was so much used that the grass and weeds were much worn off by the turtles, and a great many shed scutes were to be found there. A dense growth of algæ occurred near shore in which the turtles would hide when frightened. On April 23, a Map Turtle of medium size was seen basking, sitting crosswise on the back of a somewhat larger Painted Turtle.

The time of mating was not positively observed. On October 4, and later in the fall, they appeared frequently in pairs walking about on the bottom of the lake, or a small one following a large one about. On April 27, small ones were also noted following large ones about as if about to mate. As a pair of Musk Turtles were observed actually mating in the autumn, it is probable that the other turtles, including this species, occasionally do so at that time. They begin laying their eggs at least as early as June 12. They do not go far from the water, but dig their nests in the sandy shores or banks near the lake. They even sometimes attempt to make nests in rather stiff clay, or in rather hard ground. On June 18 one was seen in the road back of the Miller cottage, digging a hole for a nest. The hind feet were used in digging. On June 23 one was seen on her nest between the ties of the railroad south of the ice-houses. After the turtle had left, the place was examined and 11 eggs were found. Occasionally an egg may be dropped in the water or on the shore where there is no nest. The eggs are elliptical-cylindrical, about 1½ x 7-8 inch, the shell being quite soft and flexible.

This turtle continues basking later in the fall than any other species. On November 2 and 3 quite a number were seen on the stones along the east side of the lake, and one was seen basking as late as November 22. Late in autumn when the air gets chilly these turtles, when basking on stones or boards, assume a peculiar position. The legs instead of being drawn up toward the body, are stretched out straight and stiff and the turtle on being approached tumbles rather than scrambles into the water. The cold of autumn benumbs them quite considerably. On November 30, while walking along the south shore of the lake, several turtles of this species were observed to leave shore and take to the water. They attempted to dive, but were unable to do so; they plunged their heads below the surface, tilting up the posterior part of the body, and finally succeeded in getting all under water except the hind legs, which, projecting above the surface, fanned the air frantically and in the most ludicrous fashion. Seven of these turtles were caught; four of them were quite large. They were placed in an open-bottomed live-box near the station where it was thought they would bury themselves in the soft sand for the winter. All, however, were soon frozen.

In the autumn these turtles, along with the Painted, show a tendency to migrate from the larger lake into Lost Lake. They usually go down the Outlet, but in the autumn of 1906 a dam was built across the Outlet at the railroad bridge, and the turtles were seen in considerable numbers climbing over the dam or making the journey over the road by land.

The Map Turtle does not hibernate, but many, if not all of them, keep walking about on the bottom of the lake, where they can be seen through the ice whenever it is clear.

Throughout the winter of 1900-1901, they could be seen any day when the ice was not covered with snow. In the early winter of that year these turtles appeared to congregate in considerable numbers in the northwest corner of Lost Lake, in shallow water near shore. On Dec. 15, 25 were counted in this place, and only one or two were seen elsewhere. Later on in the season they were found in various other places; a good many were found in the bottom of Outlet Bay. On Christmas day, 1900, in walking out 149 steps from Chadwick's pier, 69 Map Turtles and one Musk Turtle were counted. They were also found in some numbers in the Norris Inlet region. These turtles keep moving about more or less all winter, although they are not nearly so active, as in the summer; and they probably eat little or nothing. They do not appear to swim any or leave the bottom. They do not appear to take fright easily and would probably be unable to make good time in attempting to escape even if they tried; one can walk above them and study their actions in detail through the clear ice. While walking about the motion of the limbs is quite jerky and irregular. Where they walked over soft bare muddy bottom the tracks left by them could be plainly seen—two parallel rows of dots, the distance between the rows indicating the size of the turtle; by following these, the animal could frequently be tracked down.

The Map Turtle is unable to withstand a freezing temperature, at least in air. During the winter several were caught where the ice men had taken out ice, and were set out on the ice. They began to stiffen almost immediately, and froze solid in a very short time. They were very gradually thawed out by being placed in cold water, but did not revive.

The Map Turtle is probably a scavenger and does much to rid the lake of dead animal matter. It also feeds largely on the smaller mollusks, particularly *Viviparа contectoides*. It is never used for food— perhaps on account of its small size as compared with the two species here used for food—the Snapper and Soft-shell. So far as our observations go it has no enemies except, possibly, leeches.

The Map Turtles reach only a moderate size. The largest examples seen by us weighed 4 to 4½ pounds.

The following table gives weights and measurements of 19 individuals examined:

MEASUREMENTS OF MAP TURTLES.

No.	Weight	Carapace.				Plastron.	
		Length (Straight)	Length (Curve)	Width (Straight)	Width (Curve)	Length	Width
1	4 lbs.	10.25	10.75	7.50	9.75	9.12	5.00
2	4.25	10.75	11.00	7.50	9.00	9.25	5.00
3	4.	10.40	10.60	7.12	9.33	9.00	4.88
4	3.	8.75	9.20	6.37	8.37	8.00	4.50
5	2 oz.	4.20	4.27	3.25	3.80	3.63	2.00
6	2 oz.	4.07	2.25	3.20	3.88	3.50	1.88
7	6.14 oz.	4.75	....	3.63	....	3.88	2.88
8	4.23 oz.	3.94	....	1.13	....	3.43	2.43
9	3.32 oz.	3.63	....	2.94	....	3.13	2.31
10	2.65 oz.	3.43	....	2.81	....	2.43	2.13
11	2.43 oz.	3.25	....	3.06	....	3.00	2.25
12	0.85 oz.	2.19	....	2.00	....	1.94	1.43
13	0.81 oz.	2.13	....	1.94	....	1.81	1.38
14	2 lbs.	8.00	....	....	....	....	....
15	3 oz.	3.38	....	2.87	....	2.87	1.63
16	2.5 oz.	3.43	....	2.75	....	3.00	1.56
17	3.5 oz.	3.81	....	2.87	....	3.25	1.67
18	3.25 oz.	3.67	....	2.75	....	3.13	1.50
19	....	2.13	....	1.87	....	1.87	1.37

1	.75 oz.	2.125	....	2.25	....	1.682	.93
2	.75 oz.	2.125	....	2.25	....	1.682	.93
3	1.50 oz.	3.	....	2.93	....	2.434	1.31
4	4.50 oz.	4.434	....	3.868	....	3.50	1.744
5	6. oz.	4.744	....	4.434	....	3.93	2.

The Map Turtle is usually free from growths of algæ or other organisms. The young differ from the older in being decidedly more strongly keeled, the portions of the carapace each side of the keel being rather straight, so that the shell of the young turtle looks somewhat like a roof. The young are covered with delicate reticulations which give pleasing color patterns, but which disappear more or less completely in the adult. This is one of the most inoffensive of the turtles and can hardly be induced to bite.

Carapace ovate, broadest behind, the margins flaring outward, highest near the middle and not strongly convex; carapace strongly notched behind and usually decidedly keeled. Color, dark olive brown, with greenish and yellowish streaks and reticulations, especially distinct on neck, legs and edge of carapace; plastron yellowish.

5. *Pseudemys elegans* (Wied).

Elegant Turtle.

This is the rarest as well as the most beautiful turtle occurring about lake Maxinkuckee. Its habitat extends from the Carolinas to Mexico and in the Mississippi Valley northward to Indiana and northwestward to the Yellowstone. It was described originally from specimens taken near New Harmony, Indiana. According to Dr. Hay it has been found at Mt. Carmel, Ill., and in the Tippecanoe at Winamac. At the latter place Dr. Hay obtained a specimen about July 1, 1892. There seem to be no other Indiana records until now.

During our several seasons at Lake Maxinkuckee we obtained but one specimen of this turtle. This was secured by Mr. Clark, June 13, 1901, at the south end of the lake near the small spring, where, about 200 feet from shore, the water was about three feet deep and the bottom covered with Chara. The specimen was a very fine one. The length was about 6 inches. We saw the shell of a second example in a shop in Culver. It had been caught in a trap in Lost Lake, and the carapace was 9.5 inches long and 7 inches across.

We know but little of the habits of this fine turtle. It is probably entirely aquatic.

It may be known from the following description:

Shell broad and depressed; carapace serrated behind, a slight emargination in each scute and deeper ones between them.

Color of carapace, olive; with lines and spots of yellow and black; the lines running mostly lengthwise on the vertebral scutes, and transversely on the costals; a yellow band of varying width down the middle of each costal scute, parallel with other lines and bands of black and yellow, some narrow, some wide; on the upper and lower surfaces of the marginal scutes are spots consisting of concentric circles of yellow and black, between them a yellow band crossing each marginal; plastron yellow, with a black blotch on each scute, these often ocellated with yellow; spots on bridge usually confluent; head with numerous narrow stripes of greenish or yellow; a broad stripe from under eye extending backward on neck, being met at angle of mouth by a stripe from middle of lower jaw; another stripe, often blood red, from posterior corner of eye running back on neck; legs and tail striped with yellow.

Length 10 inches or less.

6. *Chrysemys marginata* Agassiz.

Western Painted Turtle.

The Western Painted Turtle is found from central New York westward through the Great Lakes and the Mississippi Valley and southward to the Gulf. It is generally common and is abundant throughout Indiana. It is found in practically every stream, pond and lake in the state. While it is not rare in running streams, it is in the small lakes and ponds that it most delights to dwell. Choice situations are small muddy ponds in which are many old logs or chunks on which they may bask.

Next to the Map Turtle, this is the most abundant species in Lake Maxinkuckee; and, excepting the Spotted Turtle and the Elegant Turtle, it is the most beautiful.

In the spring they are first noticed about the middle of March in the small pools along the railroad between Green's flat and the Outlet. Here they become very abundant in April, sitting on logs, chunks, or other objects, sunning themselves. They do not appear in numbers in the lake proper until later. By the first of June they can be found anywhere in shallow water about the lake.

During the summer and until December they may be seen basking in the sun. Wherever a log, post, board or other object affords support above the water there they will sit quietly all day long, sliding off into the water only when disturbed. A favorite place was on the boards and timbers in the lake off the ice-houses. From July to October, hundreds could be seen at this place. The earliest and latest dates upon which we saw this species basking were March 17 and December 3. They were observed moving about under the ice as late as December 16.

Near the end of Long Point on the north side was a portion of an old pier which had drifted ashore and grounded in shallow water. This was a favorite basking place for turtles throughout the summer and fall, and 40 to 50 could be seen there any time. When disturbed they would scurry into the water where they could be seen scattered about near the pier, their heads sticking out of the water, ready to crawl out again when the cause of their alarm has disappeared. The majority were Painted Turtles, though there were usually among them several Maps and a few Soft-shells, an occasional Musk Turtle, and now and then a Snapper.

On July 25, 1899, 280 Painted Turtles were caught at one haul with a 35-foot seine off the Assembly Grounds.

This turtle is a shallow water species and is not often observed out in the lake at any great distance from the shore; in which respect it differs markedly from the Map Turtle, the Soft-shell and the Snapper. We have no record of any Painted Turtle having been seen in the lake more than a few rods from shore.

On the other hand, it is seen oftener than any other species on dry land about the lake.

Early in June, they begin wandering about, apparently hunting for suitable nesting places. They probably wander farther from the lake than any other species (excepting the Snapper), and may be seen in the fields, pastures, along the railroad, and in the open woods. They lay their eggs about the middle of June in shallow holes which they dig in the sand with their hind feet. The eggs appear to hatch out late in the fall. On September 28 a nest of 10 young, each about an inch long was dug up in a potato field on Long Point. Favorite nesting sites are the sandy slopes of the railroad grade and the Assembly grounds, the field south of Green's flat, and the north shore of Long Point. Soon after hatching the young seek the nearest water, crawl into the mud, and remain until spring.

In the fall they seem restless and wander about a great deal. They are often seen crossing the railroad between the main lake and Lost Lake. The number killed by passing trains is astonishingly great. It is probably within safe limits to say that not fewer than a hundred are killed at Maxinkuckee every year by passing trains. Many are also killed by wagons on the public highway.

Along with the painted turtles killed in these ways there are killed a good many map turtles and a few each of the snappers and musk turtles, as well as a great many frogs, toads and snakes.

The Painted Turtle muds up and hibernates during the winter. We never observed many under the ice. Early in the fall those about Outlet Bay and along the west side of the Lake tend to migrate to Lost Lake, or more definitely to Green's flat and the shallow ponds along the railroad below the Outlet.

Here they "mud up" for a brief period. The first warm days of March call them forth, however, and they may again be seen on the logs and chunks basking in the sun.

The food of this turtle consists chiefly of small mollusks, crustaceans, insect larvæ, and dead fish. On June 6 a Painted Turtle and a Stink-pot were observed both feeding on a floating dead fish, and at other times we have seen the former species feeding upon dead fish. In every case the turtles began eating at the caudal end of the fish.

We have no evidence that this species ever catches live fish. The stomach of one examined October 8 contained a quantity of Spirogyra. Others examined contained Spirogyra and quantities of another alga, Lingbya; another contained some Naias. This turtle is therefore largely a vegetable feeder. It is probably chiefly a scavenger and in this capacity serves a useful purpose in freeing the lake beaches of dead fishes, waterdogs, and the like, which wash up on the shore in considerable numbers.

This turtle is not often used as food, although there is no reason why it should not be so utilized. It has no disagreeable odor and the flesh is doubtless tender, palatable and nutritious.

The enemies of the Painted Turtle are not many. Among animals, doubtless the worst is the muskrat. On December 18 a large example of this turtle was found at Norris Inlet, turned on its back and partly devoured. Muskrat tracks were the only ones about, and it is evident that that animal had been feeding on it. It is this turtle more than any other that is found, back up, on tussocks in the winter along the Inlet and Outlet, and with the body more or less gnawed away, probably the work of muskrats.

On another occasion (November 19) we found a small live Painted Turtle lying up side down on a log. It may have been left there by a muskrat or a raccoon.

Leeches are often found on this turtle and doubtless cause it considerable annoyance. All the turtles of the lake, but this one especially, usually harbor the flat leech (*Clespine*) in considerable numbers. These are usually found on the bare skin along the sides and in the axils of the arms, at which time they are probably sucking blood. The leeches are also frequently found on the shell of the turtle, either on the carapace or plastron, but when in this situation, it is doubtful if they are obtaining any food. Winter seems to be the period of greatest mortality with them; in spring, one occasionally finds them lying about dead in such places as they make their winter quarters, such as pools in Green's flat. Mention has already been made of the great number that are destroyed by being run over by trains on the railroad and by wagons on the public highway. Many are destroyed and many more intolerably annoyed by thoughtless men and boys who shoot them or stone them whenever they see them basking near shore.

The Painted Turtle is easily distinguished from all other species of this region by its shiny black, blue-black or brownish-black color, and bright red on the neck. It may be described as follows:

Shell broad and depressed, broadest behind the middle; shell flaring posteriorly, its surface very smooth, no trace of keel even in the young.

Color of carapace, dark green or greenish-black, the hinder border of the costal and vertebral scutes narrowly bordered with black, the anterior border with slightly wider bright red lines lying immediately against the black margin; the red or yellow lines not joining to form straight lines across the back; a very narrow red line along middle of back; upper surfaces of marginal plates with many crescent-shaped bright red marks; lower surfaces of the marginals black, with large splotches of blood-red and bright yellow; plastron bright yellow or brownish-red, with a large dusky blotch on central portion; soft skin of head, legs and tail dark olive, with red stripes; two large waxy yellow spots on back of head, nearly as large as eye, these prolonged backward as 2 narrow pale yellow stripes; another short yellow stripe from upper corner of eye and another from lower side of eye back on neck; two red stripes on front of each fore leg, and similar ones on posterior surfaces of thighs; besides these, numerous small red spots all over soft parts. Sometimes, in the brownish-black individuals, the sutures of the back are red. The red markings fade to yellow in alcohol.

The claws of some of the painted turtles caught early in the spring of 1901 (April 4) just after they came out of winter quarters, seemed to be remarkably long and sharp. Four examples were caught, and the length of the middle claw of the front feet was taken. The claw of the first was ¼ inch long, that of the second ½ inch long, that of the third ½ inch, and that of the fourth ⅜ inch. The turtles were only of moderate size, the carapace being about 4½ to 5 inches long.

The Painted Turtle varies somewhat in color, the ground-color in most of the examples being a brownish-black. In some cases there is a considerable mixture of green in the ground-color, giving the whole shell a somewhat livelier hue. In some examples seen the lines between the scutes of the carapace were red, and there were other markings of red on the back—sometimes a red dorsal median line and a small red spot in the middle of each of some of the scutes. These color-markings were observable at some distance while the turtles were in the water and made the turtles possessing them objects of peculiar beauty. As the epidermal scutes of these turtles grow old they occasionally become covered with various growths. An alga which appears to belong to the genus *Microspora* grows on the dorsal scutes, and, less frequently a branched stalked protozoan, *Opercularia*, grows on the ventral scutes. Sometime during the year, usually in the late summer, the turtles shed these epidermal scutes, and can frequently be seen with some clean new scutes and old overgrown ones. At the end of the shedding period they come forth bright and new, their colors apparently much clearer. In the autumn of 1906 one of these turtles was caught with the alga on it in fruit, the base of the alga being green, while the fruiting tips had a reddish cast.

There is considerable variation in the epidermal scutes of this turtle, one frequently being added irregularly. An example caught in 1906 had 2 additional triangular scutes, symmetrically placed at the anterior corners of the anterior dorsal scute. In some cases the anterior marginal scute, and those on each side of it are ornamented with peculiar serrations.

Excepting the musk and spotted turtles this is the smallest species found in this region. Its maximum length is bout 6 inches and the maximum weight three-quarters of a pound. The following table gives the weights and measurements of a number examined.

MEASUREMENTS OF PAINTED TURTLES.

No.	Weight.	Carapace.		Plastron.	
		Length in inches.	Width in inches.	Length in inches.	Width in inches.
1	....	4.87	3.5	4.37	3.0
2	....	4.37	3.13	4.00	2.5
3	....	4.25	3.13	3.87	2.5
4	....	4.5	3.25	4.00	2.5
5	6.75 oz.	4.67	3.25	4.19	2.13
6	12.00 oz.	5.37	2.93	4.87	3.31
7	12.81 oz.	5.63	3.87	5.13	3.25
8	2.65 oz.	3.13	2.57	2.79	2.06
9	6.25 oz.	4.87	3.87	4.00	2.00
10	11.00 oz.	....	....	....	....
11	10.75 oz.	5.94	5.19	4.87	2.37
	Average.........	4.76	3.47	4.21	2.56

Several young seen May 22 were each about the size of a silver quarter.

7. *Clemmys guttatus* (Schneider).

Speckled Turtle.

The Speckled Tortoise is found from New England to North Carolina and west to Indiana. In this state it has been found only in the northern part. It has been recorded only from Kendallville, Rochester, English Lake and Lake Maxinkuckee. It is not a very common turtle at Lake Maxinkuckee. Two specimens were obtained at the lake in May, 1891, by members of the Indiana Academy of Science.

The first example seen by us was got at the south end of the lake October 1, 1900. It was next seen April 1, 1901, when 2 were found on a tussock in Green's flat. The following is the record ot all the remaining individuals seen by us: April 3, 1901, one found dead on Green's flat and another found dead in the elevator pond; April 4, 4 caught and several other seen basking in Green's flat; April 9, several seen in a ditch in Green's flat and one in a tamarack swamp west of lake; April 15, one caught in Green's flat; April 24, several s en in Hauk's marsh chasing each other in a lively manner. They were evidently mating; 3 pairs and one odd one were caught; April 25, caught one male in Green's flat; April 26, several seen in Green's flat; April 30, one seen in Green's flat; May 14, one found dead on the west edge of Long Point; May 22, several seen in a ditch near the tamarack swamp, 4 of which were collected.

The only one see in the fall was found in Hauk's marsh September 3, 1906. One was obtained in a ditch near Fort Wayne, September 28.

This interesting and beautiful little turtle is by preference an inhabitant of the small ponds, marshes and open ditches, and is less aquatic than any of the preceding species. We never saw it in Lake Maxinkuckee proper. The one found at the south end of the lake was south of the Farrar cottage at a small pond. As may be seen from the above, its favorite haunts are Green's flat, Hauk's marsh and the vicinity of the tamarack swamp. None was seen on the east side of the lake, but careful search in April and May would doubtless reveal its presence along Aubeenaubee Creek and Norris Inlet, and possibly at Culver Inlet. Late in May, when the ponds have become pretty dry, these turtles disappeared.

They began mating about the middle of April. Several were seen paired April 19 to 24. When mating, they are more active than we have observed any other species to be. The males chase the females rapidly and persistently until the female is captured. The male would immediately climb upon the female's back. Several pairs that were placed in a tub were continually assuming this position, although actual copulation was not observed.

We have never found the eggs of this species and know very little about its nesting season or habits. Its eggs are said to be only 3 or 4 in number, about 1.25 by .75 inch in size, and to be laid in June.

This turtle is apparently silent, as we have never heard any note which we could positively associate with it.

A good many dead ones are found in the spring; the winter is probably a critical period with them.

These turtles are entirely harmless and should be protected. Their food consists chiefly of crawfish, tadpoles, angleworms, and other weak animals found about the water and in the marshes.

The Speckled Turtle may be readily distinguished from all others by the following description:

Shell moderately to strongly depressed, oval, widest behind, no trace of keel in adult and scarcely evident in the young; nuchal scutes very narrow; plastron large, the hinder lobe about three-fourths width of carapace, with a shallow notch in posterior border; anterior lobe truncated, not movable on a transverse hinge; plastron of male concave; snout not at all projecting; upper jaw notched, the edge nearly straight; legs and feet covered with scales, those on front limbs large and overlapping; feet not large, claws rather short, the web not extensive; tail long, that of the male bringing the vent beyond the carapace.

General color of carapace black, patches of reddish brown showing through the darker; on each scute from one to 12 round bright orange spots, each larger than the pupil; plastron red, orange and black, the black predominating, the orange usually occupying the center and the margin; head black above, with orange dots, usually a large orange spot just above the ear; neck black, with more or less red; shoulders with much red or orange; upper surface of limbs black, with yellow and red, lower surfaces red and orange; tail black, red at base. Length of carapace 4 to 5 inches. Weights and measurements of 14 examples are given in the following table.

No.	Weight.	Carapace.		Plastron.		Sex.
		Length in inches.	Width in inches.	Length in inches.	Width in inches.	
1	3.87 oz.	3.56	2.69	3.00	1.87	
2	4.13 oz.	3.50	2.13	3.19	1.94	
3	3.87 oz.	3.75	2.50	3.00	1.75	
4	4.13 oz.	3.81	2.69	3.13	1.94	
5	3.75 oz.	3.50	2.69	2.94	1.87	
6	4.50 oz.	3.56	2.75	3.25	1.94	
7	3.50 oz.	3.44	2.56	3.00	1.81	
8	4.37 oz.	3.63	2.75	3.37	1.94	
9	....	4.00	3.00	3.50	2.63	male
10	....	3.75	2.87	3.25	2.50	male
11	....	4.00	3.00	3.63	2.50	female
12	....	3.87	2.87	3.25	2.37	
13	4.30 oz.	3.63	2.75	3.31	2.25	
14*	3.39 oz.	3.56	2.68	3.00	2.19	male
	Average...	3.68	2.71	3.2	2.1	

*In the last specimen the carapace had strong concentric striæ and the plastron parallel radiating striæ. The tail was much larger than in the next preceding specimen.

8. *Emys blandingii* (Holbrook).

Blanding's Tortoise.

This species occurs from New England westward to Illinois. It is found in southern Canada, but is not known from the southern states.

It is nowhere abundant; indeed, in most parts of its range it must be regarded as a rare species. In Indiana it is known only from the lakes in the northern part of the state. It has been recorded from Lagrange and Steuben Counties (Levette), Lake Maxinkuckee (Hay), Rochester (Gould) and English Lake. Only one specimen has previously been recorded from Lake Maxinkuckee; this was obtained by Dr. O. P. Hay in May, 1891.

It is apparently as common about lake Maxinkuckee as anywhere in the state. Our notes record no fewer than 11 examples as having been collected or observed by us in the neighborhood. The definite dates are as follows:

March 29, 1901, one caught on west side of lake near the small pond at the elevator; April 4, one was taken in Green's flat; April 9, one taken in a ditch east of tamarack swamp; May 17, one caught climbing the bank in front of Assembly grounds, and another near same place next day; May 20, a large one found in Hauk's marsh; May 22, two taken near tamarack swamp; July 29, 1905, a large one caught in a kettle hole swamp in Walley's woods; September 11, one seen in a ditch between Arlington and Delong; September 14, a large example in Hauk's marsh; November 4, several large examples, some about 9 or 10 inches long, found dead on Yellow River west of Knox. They had been killed by pearl hunters.

Those taken May 17 and 18 were walking about on dry land as if hunting for a nesting site. We have never seen this species in the lake; it is, rather, an inhabitant of small shallow ponds, marshes and muddy ditches.

Very little was learned regarding the habits of this turtle. As only one of our specimens was found in the water, all the others being out on the land, it appears that it is somewhat less aquatic that the Speckled Turtle. On May 17 and 18 those observed walking about on the land had apparently come up out of the lake. They acted as if hunting nesting sites, though we found none.

The species is described as follows:

Shell elongate oval, widest just behind the middle, without keel; carapace not serrated behind; plastron large, entirely closing the shell; head long and wide; limbs and feet scaly; tail scaly, that of male about one-fifth length of shell, that of female shorter. Color dark green to black, each scute with several round, triangular or oblong spots of yellow or orange, the marginal ones largest, all sometimes wanting; plastron yellow, with the outer posterior portion with a brown blotch which sometimes covers the whole scute; head and neck above and along sides dusky, with numerous yellow dots; chin, throat and under side of neck yellow; legs yellow, with brown mottlings; tail striped longitudinally with yellow and brown. Length 9 inches or less.

Dr. Hay states that the young of this species can be distinguished by the absence of yellow or orange spots on the shell, in marked contrast with the young of the speckled turtle on which the spots appear even before the young are hatched.

9. *Terrapene carolina* (Linnæus).

Box Turtle.

The Box Turtle is found from New England to Texas and westward to Iowa and Kansas. Although occurring throughout Indiana, it is rare about Lake Maxinkuckee. The only record given by Dr. Hay for northern Indiana is Marshall County. During our observations there we saw only three specimens, as follows:

April 13, 1901, a dead shell found near a small pond back of the Farrar cottage at the south end of the lake.

May 22, 1901, one caught in a ditch near the tamarack swamp west of the lake.

July 10, 1902, one found in Walley's woods near the railroad south of the lake.

We have heard of perhaps half a dozen others taken or seen within a few miles of the lake.

The second and third examples listed above give the following measurements:

No.	Carapace.		Plastron.		Circumference.
	Length.	Width.	Length	Width.	
2	5 inches	3.87	4.75	3.	....
3	6.75	7.25	5.5	3.5	15.5

This species is entirely terrestial in its habits and is the only strictly land tortoise found in the vicinity of Lake Maxinkuckee. It is never seen in the water and only rarely in or about marshy situations. It most delights in dry, sandy, open woodlands where there is some underbrush and where the ground has a thick covering of dry, decaying leaves. Favorite places are old overgrown fence-rows along the borders of woodland, in blackberry and raspberry patches and in beech and oak forests where there are old decaying logs and chunks.

The Box Turtle is a silent, solitary, and solemn creature; one rarely sees more than one at a time. During the mating season, however, two are sometimes found together. Very rarely is one seen moving about, and a person is not apt to find any of these turtles unless he direct his observations to the ground. And when one is found it will be seen resting perfectly still, with its head projecting from the shell and staring at you stupidly. When you pick it up it will draw in its head and feet and close its shell tightly. Occasionally it will make a slight hissing noise, the only noise we have ever heard it make. It is a wholly harmless, inoffensive creature. It is easily domesticated and, as a garden pet, possesses many interesting and attractive characteristics, albeit not very exciting.

Their mating season in this region is in late April and May, and the eggs are laid in shallow burrows in sandy soil. We know nothing about the number of eggs laid nor the period of incubation.

The food of this species consists chiefly of grubs, angleworms and succulent plants and fruits. When kept as pets they will eat cabbage, lettuce, musk melon, tomatoes, mushrooms, angleworms and meat. They soon learn to take food from one's hand.

Shell broadly oval, sometimes four-fifths as broad as long, high, very convex, and extremely solid; plastron large, tightly closing the opening of the carapace, consisting of 2 lobes movable on each other and the carapace, the bridge entirely obliterated; plastron rounded in front and behind; head of moderate size, the snout not projecting; upper jaw with the cutting edge drawn down in front into a hooked beak, the hook not notched, the alveolar surface narrow; lower jaw turned upward at the tip; legs and feet scaly; claws stout, the web between the toes narrow; tail short.

Color of carapace yellow, brown and black, sometimes the darker color predominating, sometimes the yellow; ground color usually brown or reddish brown, the yellow appearing as spots of various shapes, often radiating from the point of growth of the scute; the ground color may appear to be yellow relieved with black spots; plastron variously ornamented with black and yellow. Young with a single yellow spot on each scute of the carapace. Length of carapace, 4 to 6 inches in full grown examples.

THE BATRACHIANS.

Eighteen species of batrachians are now known from the vicinity of Lake Maxinkuckee. These include one water-dog, seven salamanders, one toad, two tree-toads, and seven frogs.

All of these are of some importance in their relations to the life of the lake, and several of them, such as the water-dog and the various species of frogs, of every considerable importance. Of all the animals inhabiting the lake, perhaps the worst enemy of the fishes is the water-dog. And of the vertebrate animals about the lake, exclusive of the fishes themselves, frogs doubtless enter most largely into the menu of the large-mouth black bass. All of the species are more or less aquatic, all being found in or about the water.

1. *Necturus maculosus* Rafinesque.

Waterdog.

The Waterdog or Mudpuppy is one of the most common, and certainly the most interesting, of the several species of batrachians occurring in or about Lake Maxinkuckee.

It is strictly aquatic in its habits and is found only in the water. It is found in both Lake Maxinkuckee and in Lost Lake and apparently approximately abundant in each. That it was seen more frequently in the former is probably due to the fact that our observations were more often directed to that lake.

While pretty generally distributed throughout the lake, it is naturally most often met with in relatively shallow water near shore. It appears to prefer those locations where the bottom is of muck, marl or other soft material covered with a growth of short Chara. In such situations it makes considerable burrows in the bed of the lake or sometimes merely under the Chara or other covering. Here it rests when not moving about in search of food or for other reasons. The burrow usually has two openings, a few inches apart, one evidently for entrance the other for exit; and the animal, when in the burrow, is often seen with its head projecting from one of the openings as if watching for small fishes or other food that may approach. Thrusting an oar or pole into the burrow would frequently reveal the presence of the animal. They seem to occupy these burrows singly, as in no instance were two individuals found in the same hole. Whether they are more prone to remain in their burrows during the day-time or night our observations did not clearly disclose. Certain evidences, however, which will be presented later in this account, indicate that this curious batrachian is largely noctural in habit, and the burrows, if they could be examined with equal facility at night, would probably be found more frequently empty.

While nearly all examples seen in the lake were in water one to ten feet deep, they doubtless on occasion go out to greater depths, evidenced by the frequency with which they are taken on hooks of set-lines placed at a depth of 10 to 35 feet. They are doubtless most abundant in water less than 15 feet deep, but extend out to more than twice that depth in some numbers. It is probable that their bathymetric distribution is practically coincident with that of the plant covering of the lake bottom.

That the species is largely nocturnal is indicated by a number of habits which were observed. Frequently individuals were seen or were caught with seines at night when they had come near shore in shallow water evidently for the purpose of feeding on the small fishes which also come into shallow water at night to feed. Although large schools of the same species of fishes were often seen in the same places in the day time waterdogs were rarely noted and then usually in the winter and the under ice. Set-lines were much more apt to have waterdogs on the hooks when examined in the morning than when inspected in the evening.

That the species is, however, not wholly nocturnal is shown by the fact that individuals are often seen in day-time moving about on the bottom, especially in winter under the ice, and the further fact that they are sometimes taken in the day-time by anglers or on set-lines.

They also appear to be active throughout the year; there is no evidence that they hibernate. We have observed them moving about and have caught them at all seasons, practically in every month in the year.

Actually, we saw them most frequently in winter, probably not because they were more abundant then or moving about more constantly, but because they were less active in their movements and therefore more easily observed; and especially because the presence of a sufficiently strong sheet of transparent ice on the lake gives an ideal condition for observation and study of the lake bed even in considerable depths.

As already stated, the waterdogs make shallow burrows in the soft bottom or under the Chara mat, in which they make their homes. They are also found under water-logged chunks or boards where they may be sometimes seen with their heads slightly exposed. Then again they may be observed now and then among the roots of the pond-lilies or the denser patches of Potamogeton, Myriophyllum and similar aquatics.

In late autumn and early winter, when the water has cooled and the straw-colored minnows, grayback minnows and skipjacks crowd to the shore, waterdogs may be sometimes seen coming in among them, evidently for the purpose of preying upon the fishes. Later, during the winter, on bright sunny days, these animals were frequently seen in some numbers crowded close to shore and lying motionless under the clear ice. Several were caught by cutting holes through the ice above them. Occasionally one would take alarm while the ice was being chopped away, and swim off, rather slowly at first and then quite rapidly, with lateral flexions of the tail. Though not so rapid in their movements in winter as in summer, they can swim quite swiftly when occasion arises. When not frightened, if moving at all, they walk along the bottom with great deliberation, moving their heads from side to side as if smelling their way along. In walking, diagonal limbs are moved in unison, that is, the right front with the left hind leg and the other two the same way, with a good deal of circular or rotary motion at the hips and shoulders like one turning a crank. When one is caught in the hand or when a feint is made to take hold of one, it will make quick, vicious snaps at the hand. The jaws are strong enough to make the bite painful. This quick snappy motion offers a suggestion as to the manner in which the animal catches fishes.

The Waterdog seems to feed chiefly on small fishes and crawfishes. The stomachs of several examined December 10, 1900, and later the same winter, were literally packed with fishes. At various times in December one or more were seen among schools of skipjacks near shore, apparently feeding on them. Examples examined December 18 contained, in one instance, two small fishes each about 3 inches long, another the bones of the hind legs of a frog, and still another a fish hook baited with a piece of liver, evidently from some fisherman's line. Of several stomachs examined December 28, some were filled with full grown skipjacks, while others contained several small fishes each. Four examined February 27 contained several minnows evidently taken from fishermen's hooks. On March 2, several others examined contained a number of bait minnows and one a large crawfish. Three examined March 8 contained 6 shiners, 3 crawfish, 2 Asellis, 2 leeches, and several long flat worms; and a fourth contained 3 crawfish and 3 snails (probably *Physa*). One examined March 18 contained one small minnow and a large worm. The stomachs of 4 examined April 27 were all empty, as was another (a male) inspected May 9. On November 16, 1904, one was found with stomach empty and another with one long red leech. One examined January 1, 1905, contained 2 straw-colored minnows, 3 crawfish, 2 large insect larvæ, and one large brown flat leech.

The species of fishes which we have found in the waterdog stomachs are the skipjack (*Labidesthes sicculus*), the straw-colored minnow (*Notropis blennius*), the grayback (*Fundulus diaphanus*), and 2 or 3 species of bait minnows not indigenous to the lake and evidently stolen from fishermen's hooks. One fisherman reported that he had seen a waterdog trying to catch a sunfish, but we were not able to verify this observation. We have frequently observed these animals in shallow water near shore among schools of the small fishes named above and evidently intent on preying upon them; never, however, did we see one capture a fish. As already stated, they were most disposed to feed near shore at night during the summer; but in winter when ice covered the lake they seemed habitually to come into shallow water under the ice in the day-time, particularly on bright sunny days. Sometimes they seem to congregate in considerable numbers under the ice. In the winter of 1899-1900 some boys found several bunched under the ice in a little cove of Lost Lake just north of the Bardsley cottage, and succeeded in killing 15 by hitting with a stout club on the ice above them.

Crawfish also form an important and considerable element in the menu of the waterdog, while the smaller, softer-shelled mollusks, insect and other larvæ and perhaps other small aquatic animals, are utilized to some extent.

According to Mr. J. J. Stranahan, for many years Superintendent of the Fish Cultural Station at Put-in Bay, the waterdog is very destructive to the eggs of the whitefish. He states that in January, 1897, many of these animals were pumped up with the water supply of the Put-in Bay station and that the stomachs of a considerable number of them contained whitefish and cisco eggs, the contents of one stomach consisting of 288 whitefish eggs and 4 cisco eggs. From June to August, 1894, while Dr. H. F. Moore, of the Bureau of Fisheries, was engaged on investigations in Lake Erie he examined the stomach contents of a number of waterdogs at Sandusky and elsewhere and found fish-eggs present in many cases.

While writing this account (August, 1907), a specimen of waterdog was received by the Bureau from a lake near Irwin, Colorado. Its stomach contained 6 or 8 examples of *Gammarus* (a small crustacean) and several small bits of rotten wood, the latter taken incidentally along with other food.

Garman* states that the waterdog subsists on crustaceans, insects and mollusks.

It is undoubtedly a bottom feeder, and its habit of walking or crawling about over the bottom makes the finding of fish-nests and the destruction of the eggs a particularly easy matter. The evidence, therefore, would seem to be conclusive that the waterdog is wholly carnivorous in its habits; that its food consists chiefly of small fish, and in season, of fish eggs, along with a smaller proportion of crustaceans, mollusks, insect larvæ, etc.

Waterdogs may be caught quite readily in any season on hooks baited with minnows, crawfish, liver, bits of meat, or almost any animal matter. Set-lines placed by us for experimental purposes at various depths and places in the lake usually yielded at least one waterdog every time examined. When the hooks were set at a greater depth than 35 or 40 feet, however, they rarely caught any. On hooks set in Lost Lake for catfish and dogfish, waterdogs were often taken.

Anglers often catch them while still-fishing in the spring, summer and fall, but it is during ice-fishing in the winter that they are most troublesome and most frequently taken. All fishing through the ice is necessarily still fishing and the fishermen are much annoyed by the waterdogs stealing the bait from their hooks as well as being caught thereon. Their abundance in the vicinity of ice-fishing is doubtless increased to some extent by the practice of the fishermen of throwing dead minnows from their minnow buckets through the ice holes into the lake. While this attracts predaceous fish it serves also to attract the troublesome *Necturus*.

Although the waterdog is entirely harmless, fishermen scarcely without exception firmly believe it to be poisonous and are in mortal fear of its bite. So strong is this fear that when a fisherman finds a waterdog on his hook he never tries to dislodge the hook while the animal is alive but either cuts the line and lets it escape or mashes its head and then removes it from the hook with many misgivings as to whether it is safe to remove even a *dead* waterdog from the hook.

When caught on the hook this animal squirms and thrashes about a good deal at first but soon becomes quiet and remains so until lifted out of the water when it again becomes very active, its squirming contortions, slimy touch and repulsive appearance all contributing to the fisherman's dread.

The breeding habits of the waterdog have not been fully studied by us,

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*A synopsis of the Reptiles and Amphibians of Illinois. Bull. 111. State Lab. Nat. Hist., Vol. III, Art. XIII, p. 383, 1891.

though a number of interesting observations were made. Several nests were found and the eggs and young seen at different times. The breeding season is in the spring. A nest was found June 12, 1901. It was under a submerged board in shallow water at Long Point. The eggs which were not numerous, were about the size and color of yellow peas, and each was fastened to the board above by a small gelatinous cord. One of the parents remained near the nest apparently watching it. The eggs, however, disappeared one by one, probably taken by crawfishes. Apparently none of these eggs remained to hatch and we were unable to determine the period of incubation.

In our observations of these animals we were struck by the frequency with which they were found dead in pairs. There seems to be a brief period of unusual mortality among them early in the spring when considerable numbers may be found dead along the shore; a phenomenon analgous to that observed in the bluegill. During the summer and fall occasionally dead individuals are found. We are unable to say what significance, if any, lies in the observation that these animals are aften found dead in pairs; it is probably a mere coincidence. The condition of the examples found dead was such as to make it difficult if not impossible to determine the sex and the cause of their dying; nor could their stomach contents be satisfactorily examined.

The food value of the waterdog has never been fully tested. Some years ago some experiments were made at Put-in Bay by Mr. J. J. Stranahan which indicated that this batrachian might, through proper treatment, be made a very palatible and nutritious article of food. Its repulsive appearance, however, will to some extent militate against any extensive or general use of the animal for this purpose.

Summing up, then, the waterdog does not appear to have any thing to commend it or in favor of its preservation; it seems to serve no useful purpose except that it is an interesting member of the local fauna.

It is an animal feeder and is destructive to several species of fishes, in that it preys not only on the adults but upon their eggs as well.

Following are dates on which waterdogs were observed at the lake: April 6 and 7, 1885, the senior author was at Lake Maxinkuckee, and saw a large number of dead waterdogs frozen in ice in what is now known as Green's marsh south of Outlet Bay. There was more water in that place then than we have ever observed there since. The waterdogs had apparently come out into the marsh and, the temperature suddenly dropping, were caught in the freezing ice; or possibly they had died from another cause and their bodies had been carried by the current on to the marsh.

In October, 1898, Mr. Chadwick reported them as abundant and stated that they are often caught while fishing through the ice in winter; also that they are often seen in shallow water on muck bottom in winter.

In 1899, one seen September 10.

In 1900, one found under a board in shallow water on Long Point August 8; one found dead near Maxinkuckee pier August 11; one seen dead floating near Long Point August 15; one got in Culver Inlet August 21; one found dead near shore near Arlington Hotel August 22, and another at Outlet August 31; one seined in Lost Lake September 1; one very large example found dead in lake near Lakeview Hotel September 29; two found dead in Culver Bay October 11; two dead on south shore November 9; and two more November 17, also two on east side November 22; a small one dead in a pool near Farrar's December 3; one got with rake and another seen at Long Point among a school of skipjacks December 10; one seen near shore on Long Point among skipjacks and another seen through the ice farther out, December 12; December 28 many of various sizes observed under the ice, crawled up as near shore as possible. In 1901, one killed and several others seen January 7; several seen under ice, January 9; several seen near shore January 10; one seen in its burrow in front of station January 16, 18 and 19; a dead one seen January 19; one seen under the ice swimming straight for shore and later three others seen January 21; one caught by a fisherman January 23; one speared February 7; 4 caught February 27; 6 caught on hooks of set-line March 2 and about six others seen while looking down a hole in the ice where a fisherman was bobbing; a dead one found March 7, and 3 others March 8; one caught on a hook March 10; two found dead March 13, evidently killed by fishermen; a large one under a board lying on lake bottom and another caught March 18; one seen in Outlet, apparently going down toward Lost Lake March 20; one found dead April 1; a great may seen in Outlet Bay April 27; 4 seen April 27 and 5 dead at mouth of Aubeenaubee Creek, April 30; one seen under stones in Outlet April 29; a fisherman got two on a hook May 1; a dead one seen in Outlet May 4; one caught on outline May 7 and one May 9, the latter a male; three dead ones seen in Outlet May 13; five dead found along shore in various places May 20; also on May 23 and 31; a nest found June 1; several dead on shore June 4; one caught on hook from Chadwick pier June 20.

In 1904, one found near shore, and a small one under a board, November 16; one seen on bottom in about 4 feet of water off Long Point, December 15; one seen under ice near Inlet December 21; two seen near shore in south part of lake December 27.

On November 2, 1904, one caught under an old board in Outlet Bay, contained only a small bit of weed. One was caught on same date in a minnow trap which it had doubtless entered for the purpose of feeding on the minnows confined therein. One caught at Chadwick's pier November 6 contained 2 crawfish. Another taken at same place contained one crawfish and 2 Physa shells. Another taken under a board south of Green's pier November 12 had the remains of one minnow. One examined 3 days later was entirely empty. In 1905, one examined June 1 contained 2 straw-colored minnows, 3 crawfish, 2 insect larvæ and one flat leech.

Two examined January 7 contained several small fishes each, and four dissected February 27 contained several small minnows evidently taken from fishermen's hooks. On March 2 several examined contained a number of bait minnows and one large crawfish. At various times in December one or more were seen among schools of skipjacks near shore on which they were feeding. Three examined March 8 contained 6 shiners, 3 crawfish, 2 *Aselli*, 2 leeches and several flat worms. Another had 3 crawfishes and 3 snails probably *Physa*.

In 1905, a large example caught from under ice at Long Point, January 1; one seen under ice near shore January 3.

In studying the feeding habits and food of the waterdog many stomachs were examined. Several dissected December 10, 1900, were literally packed with fishes. Two other were seen on the same day among a large school of skipjacks on which they were evidently feeding. Three were examined December 18; one contained two small fishes each about 3 inches long, another the bones of the hind legs of a frog, while the third contained a fish hook baited with a piece of liver, evidently from some fisherman's line. One examined December 20 contained 2 straw-colored minnows, 2 and 3 inches long respectively. Seven waterdogs were caught and their stomachs examined December 28. The data obtained are given in the following tabulated statement:

FOOD OF WATERDOGS.

No.	Length in inches.	Sex.	Stomach Contents.
1	12	F.?	5 skipjacks packed tight.
2	12½	F.	7 large skipjacks, 1 small skipjack partly digested, 2 bluegills, 1 and 2 inches long respectively, one small fish not identifiable, one worm and a small quantity of vegetation. The waterdog's eggs were large.
3	9½	M.	2 dragonfly larvæ, 4 other small larvæ, one fish much digested.
4	9½	M.?	1 large skipjack, one small bluegill, one crustacean and 2 larvæ.
5	10	F.?	Homogenious muddy mixture, some bits of plants, remains of 3 fishes, and 2 dragonfly larvæ.
6	6½	F.?	3 small fishes (probably bluegills), 2 other fishes much digested, one isopod, and 2 larvæ.
7	7½	F.	6 small flat fine-scaled fishes, probably bluegills.

2. *Ambystoma punctatum* (Linnæus).

Spotted Salamander.

The Spotted Salamander has a rather wide range, extending from Nova Scotia to Nebraska and southward. It is not very common about Lake

Maxinkuckee, probably the soil is too sandy. One specimen was obtained at Culver in 1906, and one captured under a chunk in Farrar's woods on October 5, 1907. This one had a row of yellow spots along the middle of the back.

In spite of its rather handsome coloration, the Spotted Salamander, with its blunt, stubby head and slimy body, is a rather unattractive creature. They spend the day hiding under logs, chunks or stones, in moist cool ground. They probably seek their prey at night. Although generally viewed with distrust, they are perfectly harmless, and probably do good by devouring noxious insects.

Costal grooves 10 or 11, usually 11; sole with one indistinct tubercle, or none; black above with a series of round yellow spots on each side of the back; body broad, depressed and swollen; skin punctuate with small pores from which exudes a milky fluid; 2 or 3 clusters of enlarged pores on head; a strong dorsal groove; tail 2⅓ in length; length 6 inches.

3. *Ambystoma tigrinum* (Green).

Tiger Salamander.

The Tiger Salamander does not appear to be common in this region. Our collections contain only two specimens, one obtained in 1906, and one in Farrar's woods, October 5, 1907.

4. *Ambystoma jeffersonianum* (Green).

Common Salamander.

The Common Salamander is frequent from Virginia to Indiana and northward. At Lake Maxinkuckee it does not appear to be common, only five examples having been taken. These were obtained under logs in damp ground on the east side of the lake in the autumn of 1906 (August 3 and October 14); all had small pale blue spots along the lower portion of the sides.

In some parts of the country, one of the first signs of spring soon after the ice has disappeared and the water is still frigid, and before the frogs have yet begun to sing, is the sight of a number of these creatures in the bottom of shallow pools, too stiff almost to move, preparing to lay their eggs. The eggs are small shot-like black objects, surrounded by a thick sphere of clear jelly, a number cohering to form an irregular mass. As the water warms up, the embryos develop rapidly, first lengthening somewhat, then bending to a comma-like form, and finally the little fish-like larva, with gill-tufts on each side of the neck, wiggles through the jelly. On April 23, 1901, some larval salamanders were found swimming in Farrar's pond, which may have belonged to this species. The creatures develop rapidly into the mature form and leave the pool; in a few weeks none can be found there. The mature form spends its days under chunks and logs in moist places, and probably spends its nights in search of prey.

This species can be distinguished by its 12 costal grooves, single indistinct tubercle on the sole of the foot, and the color which is usually black or blackish, with pale bluish spots on the body.

5. *Hemidactylum scutatum* (Schlegel).

This curious little salamander appears to be quite rare. Our collections contain but 4 specimens. These were obtained October 7, 1906, under logs in a dry woodland near the tamarack swamp west of the lake. The young 44 mm. long has the tail compressed laterally as if to fit it for aquatic life; the larger examples have the taii more nearly cylindrical.

This species is brown in color, the snout yellowish, whitish below and with small inky spots.

6. *Plethodon erythronotus* (Green).

RED-BACKED SALAMANDER.

The Red-Backed Salamander is common throughout the eastern part of the United States. It is not often seen, however, except by those who especially search for it. This graceful, slender salamander does not appear to be particularly rare about the lake, although it is not often seen. October 7, 1906, 4 were obtained a few miles west of the lake. On October 16, 1906, while turning over logs in Farrar's pond, 11 examples were obtained in a short while. On October 15, 1907, a search was made in Farrar's pond again for them, but none was found. It was much wetter this year than the previous year, and it was thought that the wetness of the pond may have driven them out. On looking under chunks on higher ground bordering the pond, about dozen were secured in a little while. Some were still quite small; a few had a well-marked broad red stripe down the back, but in most this was wanting.

Little is known by us of the habits of this salamander. It is said to be nocturnal in habit, and to lay its eggs beneath logs and moist leaves, instead of in the water. The eggs are laid in the latter part of April.

"Costal grooves 16 to 18; palatine teeth not extending outward beyond inner nares; plumbeous above, often with a broad brownish red dorsal band; belly marbled; body very slender; tail cylindric; inner toes rudimentary; length 3½ inches."

7. *Spelerpes bislineatus** (Green).

Apparently rare. Our notes make mention of this species but there are no specimens in the collection.

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*As originally spelled by Green.

8. *Diemyctylus viridescens* (Rafinesque).

NEWT.

The Newt is found throughout the eastern part of the United States and is particularly abundant in the north and northeastern part of its range. At Lake Maxinkuckee only one example was captured; this was obtained in Farrar's pond, June 11, 1901, while collecting crawfishes. In addition to the example captured another very small one was seen in the swamp adjoining the lake below Farrar's, but it quickly hid among leaves in the bottom.

This graceful and bright-colored little batrachian is probably common in the region of the lake in woodland ponds. It is so elusive, however, that it is difficult to capture. It is a graceful, rapid swimmer, quickly dodging under leaves when pursued.

This salamander lays its eggs, round, clear objects, among the leaves in the bottom of brooks and ponds. They can frequently be found in late spring by lifting up the leaves, the minute yellow larvæ wriggling inside the clear envelop.

Above olive green or reddish of varying shades; lemon yellow below; each side usually with a row of several rather large scarlet spots, each surrounded by a black ring; back with a pale streak; belly with small black dots; head with 3 longitudinal grooves; three large pores behind eye. Length 3.5 inches.

9. *Bufo americanus* Le Conte.

COMMON TOAD.

The toad, familiar everywhere over the eastern United States, is not particularly common about the lake during summer and autumn. One occasionally sees them hopping about in the grass or along the road, usually one at a time. In the breeding season, however, they congregate in large numbers in pools and along the lake shore. Only a few examples were taken but they could be captured almost anywhere about the lake.

The last seen in 1900 was on October 6, at which time they were observed working their way backward into the ground, as if to hibernate. From March 31 to April 11, it was noticed that chickens were scratching them out of their winter-quarters and eating them. They came out of winter-quarters about April 23, when they repaired to the water at once and began singing. By April 27 they were in full chorus in a pool by the railroad, and were busy mating and spawning. The height of the mating season extended from about the last of April until well into May, although they continue mating until the 4th of July and perhaps even later. They have been heard singing as late as August 26.

A great number were observed mating in Culver Inlet, April 30. The males cling very tightly to the females; some captured and kept all afternoon in a botany can filled with plants did not relax their hold. The singing toads are usually unmated males. They sit at the water's edge and call with a tremulous, hardly musical, note, beginning with explosive emphasis and dying down at the end, the loose skin under the throat being blown up into a hemispherical bubble while they call. A good many dead toads were found in the pool at the same time, indicating that the mating season is one of especial mortality among them. The female toads were noted spawning while clasped by the male. The eggs are laid in gelatinous strings, 2 strings laid at a time, each string of clear jelly, about 3-16 inch in diameter and containing 2 rows of eggs, black objects about the size of pinheads with a whitish point on each. While carried in a closed vessel the toads uttered a low purring humming noise, quite pleasing to the ear. Two were kept in a bucket over night and a number of eggs were found there in the morning.

The toads of this region represent 2 distinct color phases, one type being more or less slaty blue and the other brick red. This difference in color is not usually noted when one sees single toads hopping about, but where numbers are congregated during the breeding season the contrast is quite noticeable. It appears to have nothing to do with age or sex, and toads of different colors are often found mating together.

The toads spawn in the lake as well as in the shallow pools. The eggs soon hatch into small black tadpoles which, in warm water, rapidly develop into minute toads, which can be seen hopping along shore. Young toads were seen hopping about on July 27; they are almost black, much darker than their parents. After mating and spawning, the toads scatter again, and in the autumn one comes across them of various sizes, the variation in size being probably the result of the long breeding season.

The toad is a decidedly beneficial creature, as it captures great numbers of insects. They frequently fall a prey to snakes, and these, with the exception of thoughtless boys, appear to be their only enemy.

In addition to its mating song the toad appears to have a song it sings on land, a low, pleasing, tremulous strain.

The singing is often prolonged late into the summer, and "its music in retired ponds and swamps, as darkness creeps over the face of nature, is both weird and somnific."

10. *Acris gryllus* (Le Conte).

Cricket Frog.

The Cricket Frog is common in swamps throughout the eastern United States. It is common along the shore of Lake Maxinkuckee, but more particularly abundant along such parts of the lake edge as are low and swampy. It is abundant along the shores of the various inlets of the lake, and quite common about the Outlet and the shores of Lost Lake. Numerous examples were taken representing all parts of the shore, and the various inlets of the lake.

Although the cricket frogs are related to the tree-frogs, they never stray far from the water's edge, but remain along the shore ready to jump into the water at the slightest alarm. They are very alert and strong jumpers; and are therefore difficult to catch. When they jump into the water they do not dive to the bottom, as many of the water frogs do, but swim back to shore. They are very variable in appearance; some have a bright green y-shaped mark, but in others this is brown or obscure. The cricket frogs come out of their winter-quarters and remain out until late in the fall; they have been seen on shore as early as March 7 and as late as November 30.

Although the Cricket Frog comes out early in the spring, it does not begin to sing until the water is well warmed up, which is some time after the Pickering Frog and the Swamp Tree Frog have begun their singing. They began singing as early as April 28 and continued until as late as August 5. After a short season of rest they sing again more or less in late autumn. One was heard singing September 12, and they were heard singing again October 22.

During the height of the singing season the rattle of these frogs is almost continuous, and at times nearly deafening. The note resembles the rattling of pebbles. Toward the end of the singing season, the music was rather peculiar. After an interval of silence, one would start the song, then all the others would being spasmodically and sing awhile. During the summer it is easy to start one of these frogs singing by concealing one's self and striking two pebbles together, thus imitating the note of the frog. The first one seen singing was started this way. It had been difficult actually to see any of these frogs singing as they usually became silent when approached. By the means described above, one that was in sight was started, and the whole process observed. They sit fully out of the water, hidden in grass or rushes, inflate a large bubble under the chin, and work their flanks considerably while rattling.

In raking out leaves and water weeds near shore in the late autumn these frogs are frequently brought out torpid and stiff. In such places they doubtless spend the winter.

On December 3, several dead Cricket Frogs were found in a cut-off east of Farrar's and several were found hiding and in a semi-torpid condition under leaves at the water's edge.

The Cricket Frog probably subsists on insects, especially the small midges so abundant at the water's edge. They are sometimes used for bait.

The following brief description will assist in identifying the species:

Toes broadly webbed, tipped with small disks; tympanum indistinct; hind legs very long; brownish above; middle of back and head bright green or reddish brown; a dark triangle between the eyes; sides with three oblique blotches; a white line from eye to arm. Length 1½ inches.

11. *Chorophilus feriarum* (Baird).

Swamp Tree-frog.

The Swamp Tree-frog is common throughout all parts of the eastern United States where there are ponds, swamps or creeks. Its presence is usually made known by sound rather than by sight, as the frog, though quite noisy, is both shy and inconspicuous and easily overlooked.

At Lake Maxinkuckee this frog is probably common, scattered about in the marshy regions surrounding the lake. It is not often see, however, and only a few examples were secured. One was obtained on Aubeenaubee Creek July 8, 1899, three about the shore of Lake Maxinkuckee July 28, 1900; one in Norris Inlet August 8, 1900, and one in Farrar's pond at the edge of the lake below Farrar's October 8, 1907.

A few days after the first high-pitched "peep peep" of Pickering's Tree-frog has sounded from the marshes, the announcement of the arrival of spring, the Swamp Tree-frog begins its chorus, and although it is not the first frog to be heard, it is its chorus coming from the woodland ponds and from the creeks and marshes, that announces to the world in general that "the frost is out of the ground." These frogs all seem to wake up at about the same time, so that the very first song is a pretty full chorus. They begin singing first in the pools and ponds surrounding the lake, and only later stray down to the lake shore. In 1901 they were first heard about March 23; at the beginning of their song season they sang only during the warmer parts of bright days. Intermixed with the chorus came at intervals the high piping of *H. pickeringii*.

From March 23 to about the middle of April they sang chiefly during the warmer part of the day, the chill of the night quickly silencing them. About April 24 till May 9, they sang chiefly during the evenings and mornings; later on they sang in diminishing numbers and chiefly on moist muggy nights. They were heard singing as late as June 22. The song is a rattle with a rising inflection at the end, or like the scraping of a coarse-toothed comb.

It was quite difficult at first to catch this frog in the act of singing, as they become immediately silent on one's near approach. On April 5 some were seen singing near Hauk's pond. The frogs stuck their heads above the water, expanded the skin under their throat until it looked like a large yellow bubble; this vibrated somewhat, but did not collapse while the frogs were singing. All the frog out of the water was pretty well hidden behind the bubble, so that the animal itself easily escaped detection. Later on they were occasionally seen singing in a row at the edge of the pools. A pair were seen mating April 9 over by Hauk's pond. In a pond where many were heard singing a number of small bunches of eggs were found which probably belonged to this species. They were placed in an artificial pool and kept under observation but did not hatch.

The small tadpoles soon develop, and about June, minute frogs of this species can be seen hopping about, leaving the water.

The Swamp Tree-frog has a second season of song in autumn. This is usually sung by individuals rather than in chorus, and the singers are frequently found some distance from the water, anywhere in damp situations. They are quite frequently heard in low copses or in cornfields on damp days in autumn, and one was known to have its abode in a damp cellar a good distance from any pond. One example found in autumn in a cornfield was quite plump, and was found to be full of well developed eggs. As these frogs are dormant during the winter, it is probable that the ova reach their full development in autumn, and that the brooding instinct developed by this time is held in abeyance until spring, when the frog wakes and recommences the song begun the autumn before.

During the autumn of 1900, this frog was heard singing at the edge of the lake from October 28 to November 20.

These frogs can usually be seen better during the autumn than any other time. They are then to be found on the ground in damp situations and are somewhat sluggish and inactive. They are quite handsome and elegant in appearance.

These little frogs often fall a prey to the large-mouth black bass and pickerel and are sometimes used for bait by anglers.

Fingers and toes ending in small disks; fingers not webbed, toes scarcely so. Tympanum distinct. Bluish ash, a dark dorsal stripe from snout backward, bifurcating above middle of body; a stripe on each side of this and one on side of head and body, the latter pale-edged below. Length 1 inch.

12. *Hyla versicolor* Le Conte.

Common Tree-Toad.

The Tree-toad is generally common throughout the United States east of Kansas. At Lake Maxinkuckee it is frequently heard in the evenings or in damp weather preceding a rain. Very few examples were seen, however, and it does not appear to be abundant. One was taken August 6; on September 13 one was found on the rushes near Lakeview Hotel. It was dark blue-green in color, simulating the rushes on which it was found. Three examples were obtained near the lake July 8. The first one heard in 1901 was on April 29 and the species continued trilling through the summer. In 1906, 2 examples were seen, both of the usual gray color it assumes when resting on bark.

One of the favorite haunts of the Tree-toad in spring is in clumps of low willows growing in wet situations. Here they nestle in a crotch and trill almost continuously. Even when they can be heard everywhere they are difficult to find, as the sound is hard to follow, and they become silent at one's near approach. Their resemblance in color to the object upon which they rest protects them, and by the time one gets close enough to distinguish them clearly they give a prodigious leap to safety, the bright colors of their under parts showing like a streak of yellow through the air.

Green, gray or brown with irregular dark blotches, below yellow, behind white, tympanum 2-3 diameter of eye; fingers 1-3 webbed; skin with small warts; length 2 inches.

13. *Hyla pickeringii* Storer.

PICKERING'S TREE-TOAD.

Although its range extends over all the eastern United States, there are comparatively few people who know Pickering's Tree-toad at sight. Its presence is manifest to the ear rather than to the eye. At Lake Maxinkuckee, it is seldom seen, only two examples having been obtained by us. These were captured in Aubeenaubee Creek, September 3. It appears, however, not to be uncommon. Its shrill peep is the first sound to waken the marshes in spring. It begins singing a few days before *Chorophilus*, and after that species has begun, the high-pitched "peep, peep" of the little *Hyla* can be heard above the rattling chorus of the Swamp Tree-toad. Pickering's Tree-toad does not sing in concert, but different individuals appear to pipe to each other. It sings about the edges of flat shallow marshes, such as those by the Inlet, and by the tamarack swamps. It continued to sing from early April until about May 9.

In autumn a sound much resembling the springtime note is frequently heard from forest trees or low shrubs on damp days. All attempts to find the author of the note were unavailing, but it is supposed that it is made by this toad. It is one of the characteristic sounds of autumn.

The following description will assist in recognizing the Pickering Tree-toad: Yellowish or fawn-color, with dusky rhomboidal spots and lines, the latter usually arranged in the form of an oblique cross; head with lines; limbs barred; tympanum very obscure; length one inch.

14. *Rana pipiens* Shreber.

LEOPARD FROG.

The Leopard Frog is the most widely distributed of the frogs found about the lake, its range extending over North America westward to the Sierra Nevada and southward into Mexico.

At Lake Maxinkuckee it is to be found almost anywhere along the shore and in low grassy meadows and in the shallow ponds of the region. Examples were taken in Lost Lake, in Culver Inlet, in various places about Lake Maxinkuckee, in the shallow pond by Hauk's marsh, and in the woods northeast of the lake.

The Leopard Frog is the least aquatic of the frogs. It does not spend much of its time in the water, but prefers to dwell in meadows and moist grassy places, and can even be found in quite dry situations; for this reason it is often called the Meadow Frog or Grass Frog. After the tadpoles have transformed they quit the water and scatter everywhere through pastures and meadows, in this respect rather resembling toads than frogs. One of their favorite haunts in late summer is some meadow, where they sit at the edge of a burrow snapping up insects that come along, and quietly backing into the hole at the approach of danger. One such, that had become too plump with food to squeeze into the burrow, was caught and kept a captive. When undisturbed, it frequently uttered low tremulous notes, quite pleasing to the ear. Another favorite habitat is the prairie-like flats at the edge of ponds. It is only occasionally that they are found at the water's edge, ready to jump in at the sign of danger.

There are occasions, however, when this frog seeks the water. They retire to the bottom of ponds or to the edge of the lake to hibernate, and frequently on lifting a stick or board from the bottom near shore late in autumn, one or more of these frogs can be found under it, straight and stiff, unable to move. In the spring a good many are often found dead under the ice of the thawing ponds, and it appears that the wintering-over process results in considerable mortality among them.

Early in the spring as soon as the ice has left, they begin to be commonly seen about. One of the earliest records is March 18. As soon as the sun has slightly warmed up the pools in the neighborhood of the lake they appear in numbers. A dismal croaking can be heard in marshy places, but no singer can be seen, and although all heads in sight seem to go down under water, the croaking continues. For a long time this croaking was a mystery, and was attributed to some other creature, but on a trip along a ditch west of the lake in the spring (April 9), two of these frogs were observed engaged in a lively tussle, like a boxing match. They then sank to the bottom of the ditch and began croaking. Conspicuous gular pouches projected from each side of the head, giving it a lance-like appearance, much more like that of a serpent than a frog. As the frogs croaked, the pouches worked in and out like parts of a bellows. Although the frogs were entirely under water no bubbles were seen.

In the spring when these frogs first come out of winter quarters, they are semi-torpid and easily captured, but with the advent of warm weather they become active and are difficult to capture without a landing net.

In some places these frogs are esteemed as an article of diet. In Chicago they are hunted almost to extermination. The frog hunters go with sacks to the ponds where they breed and catch them in great numbers. When placed in the sack they croak constantly, the sound being much like that which they make during the mating season. The saddles are seen in great numbers on the fish markets where they retail at 15 cents per dozen.

The Leopard Frog mates and spawns throughout April and probably into the month of May. One of the favorite spawning places was a shallow temporary pool near Hauk's marsh. Here on April 8, (1901) a great many were seen mating. The male which appears to be usually the smaller, clasps the female closely around the waist and simply hangs on and squeezes. He probably assists by this pressure in forcing out the spawn which he is at hand to fertilize. The eggs on being extruded rapidly absorb water in the gelatinous envelop and swell up to irregular masses as large as or larger than the parent frog. The eggs, which are black and resemble small shot, rapidly hatch out into rather dark tadpoles which are not so black nor so small as those of the toad. The tadpoles leave the water in the early summer of the same year, and can be seen about the beginning of July, crawling up into the grass, the shrivelled tail in some cases still persisting.

The Leopard Frog has quite a number of enemies. In the water they are eagerly seized by fish, and are frequently used for bait. The larva of the water beetle, *Dystichus*, attacks the tadpoles and devours them. Snakes catch a good many. At the edge of Bass Lake (August 14, 1906) a pitiful crying, much like that made by a young chicken when caught, was heard in the grass, and it was found that a garter snake had one of these frogs half-way into its mouth, while the frog was vainly trying to escape.

The Leopard Frog is an entirely harmless creature, and is of great service in helping keep down hordes of insects.

This frog can be easily distinguished from any other of the frogs about the lake except the Pickerel Frog, which it resembles considerably, but from which it can be told by the absence of yellow on the under part of the hind legs, the absence of any marked color, the blotches being rather rounded than square, and black in color instead of dark brown. The following description will assist in identifying it:

Brownish or green, with irregular black blotches edged with whitish, these mostly in two irregular rows on back, usually 2 spots between eyes; legs barred above, belly pale, glandular folds large; head rather elongate, length 2.75 inches.

There are two distinct shades of ground color among these frogs; some are rather dark brown, while others are bright green.

15. *Rana palustris* Le Conte.

Pickerel Frog.

The Pickerel or Swamp Frog has a rather narrow distribution compared with its near relative, the Leopard Frog, it being confined to the eastern part of the United States. It is not common about Lake Maxinkuckee; only 15 examples were collected. These were found in various situations, 4 of them being obtained at Lost Lake, one by Farrar's, 3 or 4 in Lake Maxinkuckee and 4 or 5 in Aubeenaubee Creek. One was found along the railroad between the lakes. Dr. Hay, in his report on the reptiles and batrachians of Indiana, reports 2 specimens in the State Normal School collection from Lake Maxinkuckee.

Very little was learned about its habits. It probably has nearly the same habits as the Leopard Frog. Its rank odor probably protects it from some enemies that prey on the Leopard Frog, and would prevent it being used for food, even if it were common enough to be caught for that purpose.

During the spring of 1901, a woodsman living near the lake gave information that he often heard proceeding from the forest ponds a tremendous quacking like that of many ducks. A visit was made to ponds east of the lake with the result that the same sound was heard, but the perpetrators of the noise were too shy to allow themselves to be seen. It was thought that the noise was made by the Pickerel Frog, which may sing under the water like the Leopard Frog, and thus escape detection.

The Pickerel Frog may usually be readily distinguished from the Leopard Frog which it much resembles, by the decidedly yellowish cast of the under part of the hind legs, and by its strong minky order.

The following brief description may assist further in its identification.

Light brown, with 2 rows of large oblong square blotches of dark brown on back, one or two on sides; a brown spot above eye; a dark line from nostril to eye; upper jaw white, spotted with black; head short; obtuse; toes well webbed; glandular folds low.

16. *Rana sylvatica* Le Conte.

Wood Frog.

The Wood Frog is somewhat common in damp woods through the eastern part of the United States. At Lake Maxinkuckee it is not particularly common, only about 20 examples having been seen. Of these, 4 were taken on the shore of Lost Lake, and 3 on the shore of Lake Maxinkuckee, the others were obtained in the various inlets of the lake, a few in Culver Inlet, a few in Norris Inlet, but the greater number in or along Aubeenaubee Creek.

The earliest date on which it was seen was May 24, the latest August 23. In general it prefers the neighborhood of creeks in low damp woods, and in such situations, it is the most common frog in some parts of the State. It is too small to be used for food.

This frog, with its slender, elegant form and rich coppery color, is one of the most handsome of our frogs.

Side of head with a dark brown band, wider behind, from snout to shoulder, bordered below by a yellowish white line; usually a black spot at base of arm. General color pale reddish brown; arms and legs barred above, head small, pointed; femur and tibia about equal, the latter considerably more than half body; a rounded outer metatarsal tubercle present. Length about 2 inches. This species can be easily distinguished from any other about the lake; farther north it has a relative much resembling it.

17. *Rana clamitans* Latreille.

Green Frog.

The Green Frog is well known throughout the eastern part of the United States. At Lake Maxinkuckee it is common. Examples are occasionally seen along the lake shore. It is much more common, however, about springs, pools and creeks. Of about 25 examples obtained 4 were caught at the edge of Lost Lake, 5 in Aubeenaubee Creek, 3 in Norris Inlet and 4 in Lake Maxinkuckee.

This frog is more aquatic than the Leopard, Marsh or Wood Frog, and does not often stray far from water. Its favorite haunt is the edge of some creek, spring or pool, where it plunges with a surprised chung, at the first alarm. It makes straight for the bottom and usually a bit of stirred up mud shows where it has landed; or, where leaves are present in the bottom it works its way under these. It can remain under water some little time without discomfort. As its tadpole does not develop during the first year, this frog does not spawn in shallow pools, but usually chooses some place where the water is permanent. The tadpoles—rather large grayish creatures—can be found in muddy pools and creeks.

The Green Frog makes its appearance early in the spring and can be seen until late in the autumn. A few dead ones were seen during the winter and early spring, the first live one was seen April 15, and they were noted as late as October 9. Many tadpoles were seen in Hauk's Marsh which seems to be one of their favorite breeding places. The call of the Green Frog is a repeated "thrum, thrum, thrum," usually heard late in the evening or at night. They began thrumming about May 5, and continued until as late as August 26.

The Green Frog is excellent as an article of food and grows larger than the Leopard Frog. It is occasionally seen on the markets, not so frequently, however, as the Leopard Frog, because it is much more difficult to capture. In the autumn of 1906 large numbers of these frogs were seen to jump into pools in Overmeyer's and Culver's woods, but though these pools were thoroughly dredged with a dip-net none of the frogs came to bag. This frog exhibits a marked variation in the color of the underside, some of them being plain white, others a rich yellow color; this difference seems to be merely an individual variation. They also vary greatly in the size of the tympanum. It is sometimes very difficult to distinguish this species from the young of the Bullfrog, as they greatly resemble each other in general appearance. The Green Frog has the glandular folds on the back more or less distinct and the web of the foot not reaching the tip of the fourth toe, and can be always distinguished by these characteristics. The following brief description gives the details more fully.

Green or brownish, brighter in front; generally with irregular small black spots; arms and legs blotched, yellowish or white below; tympanum large;

glandular folds large; toes well webbed; first finger not extending beyond second; tibia and femur equal 1½ body. Length 3 inches.

18. *Rana catesbiana* Shaw.

Bullfrog.

The Bullfrog was formerly rather common in sluggish streams and ponds throughout the United States east of Kansas. At Lake Maxinkuckee it is said to have been formerly abundant, but it has been hunted until it is now rare. The method of hunting them was by means of a bicycle lamp at night which so blinded them that they could easily be picked up.

This is the rarest frog about the lake, only 6 examples having been seen, and of these only one captured. This one was obtained near the Fish Commission station while seining for minnows at night. A lantern was in use which probably blinded the frog. A large one was seen November 20 down by Norris Inlet, at the edge of the water. It was somewhat torpid, but managed to escape. On January 7, 1901, one of the ice-fishers saw a large Bullfrog on the bottom in several feet of water off the Gravel Pit. He cut a hole in the ice, let down a hook and pulled out the frog. It was too torpid to move. One was obtained April 15, 1901 (No. 35445, U. S. Nat. Mus.). On May 1, a large one was seen in the pond back of the Winfield cottage, and on September 30, 1907, one was seen basking on the shore of the Outlet about 2 miles below Lost Lake.

The deep, sonorous, bull-like bellow of this frog can be heard about some portion of the lake shore throughout the summer. They usually are heard over toward the southeast shore of Lost Lake where the miry shore and fringe of rushes give them good protection. During the summer of 1906, one kept bawling almost every day from the neighborhood of the icehouses. They keep up their bawling from May 1 to as late as August 26.

Like the Green Frog, the Bullfrog rarely strays far from the water, but stays by the shore, ready to jump in at the slightest alarm. There are few animals hunted more persistently than these. They are captured by several methods—by shooting, by use of acetyline light and by the use of red flannel on fish-hooks at which they readily jump, so that in spite of the almost inaccessible bits of shore they frequent, they are unable to hold their own.

The Bullfrog is said to be very voracious, and is reported to capture and swallow young ducklings. On account of its rarity at the lake, little was learned of its habits.

The Bullfrog can usually be identified by its size and voice. The following short description will assist in identifying specimens.

Greenish, of varying shades, with small faint dark spots above; head usually bright pale green; legs blotched; tympanum large; toes broadly webbed; femur equal to tibia, not half body. Length 5 to 8 inches.

Chief Moses Day Daybway-Waindung.

Albert B. Reagan

While Indian Agent at Nett Lake, Minnesota, I met Chief Moses Day, known to the Indians by the name of Daybway-waindung, and found him to be a man of marked character. He had his faults as we all have. Also on account of his not being educated he was sometimes "worked" by disgruntled persons. But whatever his mistakes, his aim was good.

Mr. Day is not only the head chief of the Bois Fort Indians but is also their chief medicine man. His will is law. He regulates and orders their every business move. He tells them when to gather their rice and when not to cut it. He tells them when to plant and when to gather their crops. He orders their dances and medicine ceremonies. And it is also alleged that he holds them under his influence by threats of sending them to the land of fogs and storms in thė hereafter, if they do not obey him.

Mr Day came into prominence in the eighties of last century when he usurped the chieftainship of the Bois Fort Indians from Misquahgeshig, who was the direct line chief but was not suited for a chief. Later at the signing of the Sucker Point (Tower, Minn.) Agreement of 1899, he was one of the chief speakers. Here he showed his ability and also showed that he would leave nothing undone for the benefit of his people. His talk on that occasion was as follows (taken from the minutes of the meeting):

"Mr. Commissioner, about Nett Lake, where I live—there is where I was born—there is any amount of rice which never fails me and my people. We wish the commissioners to use their influence so that no dam shall ever be built below that will overflow what we depend on for subsistence. There is a place where we can take all the timber to the Little Forks of the Rainy Lake River. I wish to state that the whites have no respect for the reservation whatever. When the Indians were here three years ago, the last time we received anything from the Government, we told them there was a road going through the reservation, where the timber is piled up and going to waste, and, although we made a complaint to the agent, nothing has ever been done about it.

"The agent was never at out reservation. No, never at any time. There is a creek inside the reservation; that is where the lumbermen come without permission and help themselves to all the hay there. You can not imagine how the white men help themselves to anything on the reservation. Even our canoes they take from us without asking.

"The agent just hurries here (to Tower) and hurries right back, without giving us any attention. It would take me all day to put in complaints that can be substantiated.

"The chiefs who went to Washington and concluded a treaty with the Government saw that arrangement fulfilled only once, when they went to Fond du Lac for payment. After that it looked as if something was being stretched out, and the end failed to reach us. They told us in Washington that they would clothe these men here so they would be proud of their clothes.

"We wish to know about the children who will be born to our people after this agreement is signed; what is to become of them, and what interest or benefit shall they receive, if they are not enrolled? I wish an answer.

"At what time do you suppose the survey of our reservation will be made? We wish it made soon. We do not understand the English language, and would like to have a man connected with the survey who can speak our tongue.

Chief Moses Day.

"We are now ready to proceed with the business of signing this Agreement."

He then touched the pen handed him by the commissioners (continue the minutes), and was followed by the other chiefs and members of their respective bands.

After the signing of the Agreement of 1889, the Bois Fort Indians still remained under the jurisdiction of the LaPointe (Wisc.) Indian Agency, some 300 miles away. Mr. Day maintained that an agent to be of any benefit to the Indians should live on their reservation. On account of his constant clamoring, the agency was finally moved to Sucker Point (Tower, Minn.) sixty miles from Nett Lake, the home of the Bois Fort Indians and the site of their reservation. Undaunted, the old chief began his demands anew for an agency to be established on the Bois Fort Reserve, and in 1907, he went to Washington with Interpreter Rev. Frank H. Pequette and after a lengthy talk with the Honorable Commissioner of Indian Affairs, he was promised an agency at Nett Lake, and, in compliance with that promise, the agency was established there under Mr. Thomas J. Jackson in the spring of 1908.

Having gained the first demand, Mr. Day commenced to try to get the Bois Fort treaty with the Government of 1866 carried out. In this treaty

among other things, the Government promised the Indians that eight houses would be built on the Bois Fort Reserve for the chiefs and that a sawmill, carpenter shop and blacksmith shop would be installed there and kept in operation. The eight houses were built, but at Farmer John's Landing on Pelican Lake, nine miles east of Nett Lake, and no sawmill or shop of any sort was furnished; the only possible explanation why the houses were built at Pelican Lake and not at Nett Lake in that the contractors were too lazy to go to Nett Lake to build them. Mr. Day maintained that the houses were not built on the reserve and consequently did not fulfill the treaty stipulations. For years he kept up his clamoring till not only did the goverment build eight houses on the reservation for the chiefs, but an additional fourteen houses for the aged and indigent Indians of the tribe, and in 1914 he secured the carpenter shop, blacksmith shop and sawmill.

Another thing which Mr. Day has concerned himself about is our relations with England. When the treaty of 1783 was signed at Paris the boundary between the United States and Canada from Lake Superior to the Lake of the Woods was placed along the main watercourse of the Rainy Lake, Rainy River route and the main tributary coming into Rainy Lake from the east. Then when the survey and adjustment was made, a lesser stream north of the main eastern tributary was made the boundary, the Indians maintain. Mr. Day has made two trips to Washington to have this adjusted and has also laid the case before several congressmen. While Mr. Day will probably never realize on this demand, which would gain the United States much valuable land, it shows his wide-awakeness and his interest in things.

While Mr. Day is uneducated, his main hobby is education. There is no person in Minnesota more earnest on schools than this old chief. His demand is a boarding school at Nett Lake. The Government maintains that the Indian school at Tower, Minn., was built for the Bois Fort Indians; but the old chief maintains that the boarding school should have been built at Nett Lake and still demands that it be built there. The Government has built a nice day school at Nett Lake which is well attended, but when it comes to sending children to the boarding school at Tower, the old chief says, "No. Let the Government build a boarding school here as it agreed to and we will see that our children go to it." Furthermore, he has made several trips to Washington to demand that a boarding school be erected at Nett Lake and it is to be hoped he will live to see his greatest desire granted by the government.

Could Mr. Day have been educated, he would have made an able lawyer and statesman.

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Proceedings of the Indiana Academy of Science

1917

PROCEEDINGS

OF THE

Indiana Academy of Science

1917

LEE F. BENNETT, Editor

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING
1918

CONTENTS.

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 or 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 bcome 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 Pro-

ceedings 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.

APPROPRIATION FOR 1917-1918.

The appropriation for the publication of the proceedings of the Academy during the years 1916 and 1917 was increased by the Legislature in the General Appropriation bill, approved March 8, 1915. The Act making appropriation for the years 1917-1918 and 1918-1919 was approved March 6, 1917. That portion of the law fixing the amount of the appropriation for the Academy is herewith given in full.

For the Academy of Science: For the printing of the proceedings of the Indiana Academy of Science twelve hundred dollars: *Provided*, That any unexpended balance in 1916 shall be available for 1917 and that any unexpended balance in 1917 shall be available in 1918.

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, 1918.

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, ORNITHOLOGY....A. W. BUTLER.
ICHTHYOLOGY............................C. H. EIGENMANN.

COMMITTEES ACADEMY OF SCIENCE, 1918.

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 Avenue, Indianapolis

A. L. FOLEY, Bloomington

AMOS W. BUTLER, State House, Indianapolis

Biological Survey.

HERBERT S. JACKSON, Agr. 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 Penn. St., Indianapolis

W. W. WOOLLEN, 1628 Penn. St., Indianapolis

Publication of Proceedings.

LEE F. BENNETT, 825 Laporte Avenue, Valparaiso

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.
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. Blatchley	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.

OFFICERS—Continued.

Years.	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
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. 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.

*Deceased.

MEMBERS.*

FELLOWS.

Anderson, H. W., Urbana, Ill. . . . . †1912
Department of Botany, University of Illinois.
Botany.

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

Arthur, Joseph C., 915 Columbia St., Lafayette. 1893
Professor (Retired) of Vegetable Physiology and Pathology, Purdue University.
Botany.

Badertscher, J. A., Bloomington. 1917
Professor of Anatomy, Indiana University.
Anatomy.

Barnard, H. E., Room 20 State House, Indianapolis. 1910
Chemist to Indiana State Board of Health, State Food Administrator.
Chemistry, Sanitary Science, Pure Foods.

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

Behrens, Charles A., West Lafayette, Ind. 1917
Professor of Bacteriology, Purdue University.
Bacteriology.

Bennett, Lee F., 825 Laporte Ave., Valparaiso. 1916
Professor of Geology and Zoology, Valparaiso University.
Geology, 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.

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

Bigney, Andrew J., Moores Hill, Ind........................... 1897
Professor of Biology and Geology, Moores Hill College.
Biology, Geology.

Bitting, Mrs. Katherine Golden, Washington, D. C............... 1895
Miscroscopic Expert, Pure Food, National Canners Laboratory.
Botany.

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., Hunter Avenue, Bloomington.................. 1910
Graduate School, Indiana University.
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, or Terre Haute....... 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 Street, West Lafayette...... 1901
Director of Chemical Laboratory, Purdue University.
Chemistry.

Foley, Arthur L., Bloomington................................ 1897
Head of Department of Physics, Indiana University.
Physics.

Golden, M. J., West Lafayette................................ 1899
Formerly Director of Laboratories of Practical Mechanics, Purdue University.
Mechanics.

Hathaway, Arthur S., 2206 N. Tenth St., Terre Haute............ 1895
Professor of Mathematics, Rose Polytechnic Institute.
Mathematics, 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.
Sanitary Science, Vital Statistics, Eugenics.

Hyde, Roscoe Raymond, 636 Chestnut Street, 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., Eli Lilly Co., Indianapolis.................... 1917
Department of Research, Eli Lilly Co.
Physiology.

Logan, Wm. N., 320 S. Fess Ave., Bloomington.................. 1917
Professor of Economic Geology, Indiana University.
Geology.

McBeth, William A., 1905 N. Eighth St., Terre Haute........... 1904
Assistant Professor of Geography, Indiana Normal School.
Geography, Geology, Scientific Agriculture.

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.

Moenkhaus, William J., 501 Fess Ave., Bloomington.............. 1901
Professor of Physiology, Indiana University.
Physiology.

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.

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., 323 University St., West Lafayette........... 1902
Professor of General Chemistry, Purdue University.
General Chemistry, Organic Chemistry, Teaching.

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, 731 Atwater St., 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.
Soil Survey, Botany.

Smith, Albert, University St., West Lafayette.................. 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.

Waterman, Luther D., 226 Pratt St., Indianapolis............... 1916
Physician.

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

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

Wright, John S., care Eli Lilly Co., Indianapolis................. 1894
Manager of Advertising Department, Eli Lilly Co.
Botany.

NON-RESIDENT MEMBERS AND FELLOWS.

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

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

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

Brannon, Melvin A., President University of Idaho, Moscow, Idaho.
Professor of Botany.
Plant Breeding.

Burrage, Severance, Waco, Texas.............................. 1898
United States Public Health Work.

Campbell, D. H., Stanford University, Calif.
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.
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Zoology.

Fiske, W. A., Los Angeles, Cal., Occidental College.

Gilbert, Charles H., Stanford University, California.
Professor of Zoology, Stanford University.
Ichthyology.

Goss, William Freeman M., 61 Broadway, N. Y., 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.
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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.

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Zoology.

KleinSmid von, R. B., President Univ. of Arizona, Tucson, Ariz.

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Professor of Experimental Physics, University of Illinois.
Physics, Discharge of Electricity through Gases.

Marsters, V. F., Kansas City, Missouri, Care of C. N. Gould, Fellow 1893
Geologist.

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

McMullen, Lynn Banks, State Normal School, Valley City, N. D.
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Physics, Chemistry.

Mendenhall, Thomas Corwin, Ravenna, Ohio.
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.
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Geology, Paleontology, Ethnology.

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

Springer, Alfred, 312 East 2d St., Cincinnati, Ohio.
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Chemistry.

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

Waldo, Clarence A., 401 West 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.
Biologlical and Agricultural Chemistry.

Zeleny, Chas., 1003 W. Illinois St., Urbana, Ill.
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Zoology.

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Blose, Joseph, Spiceland.
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Officeman with William B. Burford.
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  Psychology.

Cromwell, Hobart, Salem, Ind.
  Zoology.

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Conchology.

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Physiography, Geography, Climatology.

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Franklin College.

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Entomology, Eugenics, Parasitology, Plant Pathology.

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Professor of Chemistry, Earlham.

Dolan, Jos. P., Syracuse.

Dostal, Bernard F., Philadelphia, Pa.
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Fruit Culture.

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Chemistry, Purdue University.

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Genetics, with State Board of Charities.

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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., 16 Salisbury St., West Lafayette.
Student, Zoology, Purdue University.

Fisher, Martin L., Lafayette.
Professor of Crop Production, Purdue University.
Agriculture, Soils, Crops, Birds, Botany.

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Anatomy.

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Chemistry, Nutrition.

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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.
Anatomy.

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Teacher of Botany.
Botany and Zoology.

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Professor of Pharmacy, Purdue University.

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State Normal School.

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.

Gottlieb, Frederic W., Morristown.
Care Museum of Natural History, Assistant Curator, Moores Hill College.
Archaeology, Ethnology.

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Geology.

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Science of Law.

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

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Happp, William, South Bend.
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Physiology.
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Civil Engineering and Wood Preservation.
Hess, Walter E., Greencastle.
Professor of Biology, DePauw University.
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Physician.
Medicine, Surgery, X-Ray, Electro-Therapeutics.
Hinman, Jack J., Jr., State University, Iowa City, Ia.
Senior Water Bacteriologist and Chemist, Laboratories for State Board of Health.
Chemistry and Biology.
Hoffman, George L., 321 Fourth St., Logansport.
Bacteriology.
Hoge, Mildred Kirkwood (Mrs. Aute Richards, Crawfordsville, Ind.)
Recently Instructor in Zoology, Indiana University.
Hole, Allen D., 615 National Road, Richmond.
Professor Earlham College.
Geology.
Holman, Richard M., Crawfordsville.
Professor of Botany, Wabash College.
Houseman, H. B., 901 Wabash Ave., Crawfordsville.
Instructor in Chemistry, Wabash College.
Huber, Leonard L., Hanover.
Zoology.

Hurd, Cloyd C., Crawfordsville.
Zoology.
Huchinson, Emory, Norman Station, Ind.
Zoology.
Hutton, Joseph Gladden, Brookings, South Dakota.
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Agronomy, Geology.
Hyslop, George, 65 Nagle St., New York City.
Cornell Medical School.
Iddings, Arthur, Hanover.
Geology.
Imel, Herbert, South Bend.
Zoology.
Irving, Thos. P., Notre Dame.
Physics.
Jackson, Herbert Spencer, 940 7th St., West Lafayette.
Botany, Agricultural Experiment Station.
Jackson, Thos. F., Carter Oil Co., Tulsa, Okla.
Geology.
Jacobson, Moses A., West Lafayette.
Instructor in Bacteriology, Purdue University.
James, Glenn, West Lafayette.
Mathematics, Purdue University.
Jordan, Charles Bernard, West Lafayette.
Director School of Pharmacy, Purdue University.
Kaezmarek, Regedius M., Notre Dame.
Professor of Zoology.
Knotts, Armenis F., 800 Jackson St., Gary.
Nature Study.
Kohl, Edwin J., 105 Fowler Ave., West Lafayette.
Lee, C. O., Russell St., West Lafayette.
Leigh, Howard, 307 N. 7th St., Richmond.
Student in Zoology, Earlham College.
Liston, Jesse G., R. F. D., No. 2, Lewis.
High School Teacher.
Geology.

Loomis, Nathaniel E., 127 Waldron St., West Lafayette.
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Physical Chemistry.

Ludwig, C. A., R. R. 1, Brookville.
Botany.

Ludy, L. V., 600 Russell St., West Lafayette.
Professor Experimental Engineering, Purdue University.
Experimental Engineering in Steam and Gas.

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Plant Pathology and Mycology.

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Physical Geography and Geology.

Malott, Clyde A., 316 East 2nd St., Bloomington.
Geology.

Markle, M. S., Richmond.
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Martin, Dr. H. H., LaPorte, Ind.
Surgery and Urology.

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Entomology, Purdue University and Experiment Station.

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Mathematics.

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U. S. Department of Agriculture, Bureau of Entomology.
Insect Physiology.

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Botanist for Eli Lilly Co.
Botany, Plant Breeding.

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Physics.

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Assistant Professor of Biology, Normal School.

Montgomery, Ethel, South Bend.
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Montgomery, Dr. H. T., 244 Jefferson Bldg., South Bend.
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Graduate Student and Assistant in Psychology.

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Entomology.

Morrison, Louis, 80 S. West St., Richmond (France).

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Mechanical Engineering.

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Chemistry, Purdue University.

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Chemistry and Bacteriology, Agricultural Experiment Station.

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Orahood, Harold, Kingman.
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Powell, Horace, Hazleton.
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Young, Simon J., Valparaiso.
Physician, Lt. Col., M. C., N. A.

Zehring, William Arthur, 303 Russell St., West Lafayette.
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Mathematics.

Fellows	65
Members, Active	231
Members and Fellows, Non-resident	38
Total	334

Minutes of the Spring Meeting,

INDIANA ACADEMY OF SCIENCE,

May 17 and 18, 1917.

The spring meeting of the Indiana Academy of Science was held Thursday and Friday, May 17 and 18, 1917, at Purdue University, in connection with the dedication of the new biology building, Stanley Coulter Hall of Biology.

Thursday Afternoon—2:00 o'Clock, May 17th.

Reception of the building for the University and address by President W. E. Stone.

Brief Addresses by—

President W. J. Moenkhaus, representing the Indiana Academy of Science;

John S. Wright, Esq., representing the Alumni;

Dr. H. C. Cowles, Chicago University, on Botany;

Dr. C. H. Eigenmann, Indiana University, on Zoology.

A complimentary supper was served to members of the Academy and invited guests, at 6:00 o'clock, in Stanley Coulter Hall of Biology.

Thursday Evening—8:00 o'Clock.

Address—

"The Modern Biological Laboratory and Public Health," Professor W. T. Sedgwick, Massachusetts Institute of Technology.

Friday, May 18th, Field Trip.

The members of the Academy and guests assembled at Stanley Coulter Hall of Biology at 8:00 o'clock a. m. The loaded automobiles started out at half-minute intervals for the trip. It was planned especially to view Pine Creek valley and vicinity. The automobiles proceeded along the lowland of the Wabash River to Granville Bridge, thence to Greenhill and across the upland to Rainsville, thence along Pine Creek to the "Narrows" of Mud Creek, one of its tributaries, where luncheon was served. From the "Narrows" the party proceeded to Mudlavia, thence to Attica, and then to Lafayette, following the Wabash River.

The trip afforded an opportunity to visit the Native White Pine regions of northwestern Indiana. At the high bridge east of the Warren County Farm detached rocks and high cliffs were of extreme interest to geologists and students of physiography. This is the northern extension of the geologic features which occur at Turkey Run.

Many of the party walked from the Warren County Farm to the "Narrows."

Business Session.

The meeting was called to order, after luncheon, on a hill-side near Mud Creek west of Attica, by President W. J. Moenkhaus. Sixty members attended the meeting, and about thirty additional persons participated in the field trip and luncheon, as guests of the Academy.

In the absence of members of the Membership Committee the Secretary submitted the names of persons proposed for membership. On motion, duly passed, they were elected to membership in the Academy. The new members are:

Michael James Blew, 215 Indiana Avenue, Bloomington.
Hobart Cromwell, Terre Haute.
Richard G. Dukes, West 7th Street, West Lafayette.
Loyal W. Fisher, 16 Salisbury Street, West Lafayette.
Armenis F. Knotts, 800 Jackson Street, Gary.
Edwin J. Kohl, 105 Fowler Avenue, West Lafayette.
H. H. Martin, M. D., Laporte.
C. O. Lee, Russell Street, West Lafayette.
Morris E. McCarty, 224 Fowler Avenue, West Lafayette.
Louis A. Morrison, 80 S. West 7th Street, West Lafayette.
George W. Munro, 202 Waldron Street, West Lafayette.
Robert E. Snodgrass, 1819 N. New Jersey Street, Indianapolis.
Carl G. Watson, 120 Thornell Street, West Lafayette.
Charles G. Woodbury, 615 University Street, West Lafayette.

Amos W. Butler reported the continuance of the annual appropriation of $1,200 by the State Legislature for the purpose of printing the Proceedings.

R. W. McBride discussed the matter of urging the Printing Board to speed up its work on the 1916 Proceedings.

On motion, duly passed, a committee consisting of the President, Secretary, and Judge McBride, is authorized to visit the Governor in an effort to hasten the work of publication of the Proceedings.

On motion, Editor Lee F. Bennett is empowered to use his discretion in making up the 1916 Proceedings, by elimination of some of the papers, or to reduce their length if they would otherwise add too much to the size and cost of the volume.

It is further urged that an effort be made to embody in the 1916 Proceedings a paper by Professor Hadley of Monrovia, on "David Worth Dennis—An Appreciation."

On motion, the Committee on Distribution of Proceedings is to fix prices at which back numbers of the publication may be procured, and to report at the Fall Meeting.

The following resolutions by Frank B. Wynn, on the State Parks, and by Amos W. Butler, on Appreciations, were received, and passed by the Academy:

Resolved, That the Indiana Academy of Science most heartily approves the attitude of the Governor of the State in promoting the movements for State Parks; first, because it will insure the preservation of native forests, and beautiful natural places which are now rapidly being destroyed and can not be replaced.

Secondly, We urge their preservation as health and recreation preserves for all the people for all time to come.

In the midst of this, the largest Spring Meeting of the Indiana Academy of Science, we express our appreciation of the fine hospitality of Purdue University, which has made this occasion a remarkably successful one. To President Stone, Dean Coulter and all of his associates, to the ladies for the welcome luncheon, and to the ladies of the Household Economics Department, for the splendid supper, our grateful acknowledgments are made, and to all who have contributed to this meeting our sincere thanks are given.

We also wish to make formal recognition of the notable advance made by Purdue University in the erection of the new biology building, so well planned for its purpose and so well built, to express our appreciation of the wisdom shown in naming it for the Head of the Department of Biology, Dr. Stanley Coulter, a distinguished and beloved member of this body.

Professor McBeth of the State Normal School, was then called upon to speak briefly of the geological formation of the region covered in the field trip, after which the meeting adjourned.

W. J. Moenkhaus, President.
Howard E. Enders, Secretary.

Evening—Friday, May 18th.

Reception to members of the Academy in Stanley Coulter Hall of Biology, by the University Club.

Saturday—May 19, 1917.

A number of the members of the Academy joined in a visit to the Tippecanoe Battlefield and the State Soldiers' Home.

Minutes of the Fall Meeting,

INDIANA ACADEMY OF SCIENCE,

INDIANA UNIVERSITY, BLOOMINGTON, INDIANA,

December 6, 1917.

The Executive Committee of the Indiana Academy of Science met in the Faculty Room of Maxwell Hall, and was called to order by the President, W. J. Moenkhaus, of Bloomington. The following members were present: F. M. Andrews, Lee F. Bennett, Wm. M. Blanchard, H. L. Bruner, W. A. Cogshall, C. C. Deam, Howard E. Enders, Edwin Morrison, D. M. Mottier, Will Scott, Charles Stoltz, and John S. Wright.

The minutes of the Executive Committee of 1916 were read and approved.

The reports of the standing committees were then taken up.

Program Committee—F. M. Andrews, Chairman, reported the work completed as indicated by the printed program of fifty-one titles. On motion, the following title, which arrived too late for entry, was added to the program: "Disposition and Intelligence of the Chimpanzee", by W. Henry Sheak, of Philadelphia, Pa.

Committee on Distribution of Proceedings—Howard E. Enders, chairman, reported that the 1915 Proceedings had been sent out since the last meeting, through the co-operation of the State Librarian, and that the 1916 issue, now in page-proof, will be mailed as early as possible.

Committee on Restriction of Weeds and Diseases—D. M. Mottier, member, reported informally upon the possible value of the work of such committee, but that in view of the fact that the State Board of Health and other agencies in the State are engaged in such work, it would seem to be unnecessary to continue this committee.

On motion, duly passed, the committee is discharged, and this committee hereafter is to be discontinued.

Committee on Relations of the Academy to the State—John S. Wright reported for the committee that the customary twelve hundred ($1,200) dollar appropriation has been made available for the printing of the Proceedings.

Committee on Publication of Proceedings—Lee F. Bennett, chairman and Editor, reported on the incidents in delay of Proceedings. Half of the page-proofs are now in hand, and others will be received soon.

On motion, the Editor of Proceedings is to be allowed the sum of fifty ($50) dollars for expense of clerical hire for the 1916 issue. It is the sense of the Executive Committee that this sum be continued from year to year.

Advisory Council—John S. Wright and W. A. Cogshall reported for the committee that they had conferred with the Governor of the State relative to the matter of placing properly qualified men in the scientific offices of the State, and that he had given assurance of such co-operation.

Committee on Academy Foundation—The report of this special committee, appointed a year ago, was read by the chairman, H. L. Bruner.

On motion, the report is hereby received and is to be submitted to the members of the Academy for consideration at the business session tomorrow.

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

Balance in Treasury December 2, 1916	$378 49
Dues collected during the year	344 00
Total	$722 49
Expenditures	197 91
Balance in treasury, December 1, 1917	$524 58

The report was received and, in the absence of P. N. Evans, was referred to W. A. Cogshall for audit.

There were no reports from the committees on State Library and Biological Survey.

H. E. Enders reported relative to the matter of setting a price for back numbers of the Proceedings, as directed at the Lafayette Spring Meeting. The committee advises that, inasmuch as the State pays for the publication of the Proceedings, we have no authority to offer for sale or receive money for copies of the Proceedings. It is advised that the practice be followed of sending copies to interested workers upon application, and prepayment of the carriage charges.

On motion, a committee of three was appointed to prepare amendments to the Constitution and By-Laws to define the duties of Editor of Proceedings, and to recognize the position as an officer of the Executive Committee.

John S. Wright, Lee F. Bennett and W. A. Cogshall were appointed to serve as members of this committee.

On motion it is recommended that the 1918 Program Committee determine the feasibility of inviting the members of the Illinois Academy of Science to hold their Spring Meeting as a joint meeting with the Indiana Academy of Science, at some time and place to be determined by the committees of these Academies.

Adjourned.

W. J. Moenkhaus, President.
Howard E. Enders, Secretary.

GENERAL SESSION.

Science Hall, 10:15 a. m., Dec. 7, 1917.

The meeting called to order by President W. J. Moenkhaus.

In accordance with the arrangements of the Program Committee the Academy proceeded at once with the reading of the general papers numbered 1 to 5, after which the body went into businss session.

Business:

The minutes of the Executive Committee were read and approved.

The report of the committee appointed to investigate the advisability of establishing a research endowment fund to be known as the Academy Foundation, was received and was considered at some length, after which the following resolution was passed:

Resolved, That the Academy expresses sympathy in the movement and refers the matter back to the Committee on Academy Foundation for further amplification, and for private publication and circulation among members of the Academy during the ensuing year, with a view to its consideration in 1918.

Auditor W. A. Cogshall reported upon the correctness of the report of the Treasurer.

Report of progress in the Biological Survey was made by chairman, C. C. Deam.

The following named persons were proposed for membership, and were elected:

Harold R. Brown, Earlham College, Richmond, Indiana.
Anna Mary Collins, Irvington, Indianapolis, Indiana.
Martha L. Denny, Bloomington.
Charles S. Driver, Bloomington.
Walter N. Hess, Greencastle.
Richard M. Holman, Crawfordsville.
Moses A. Jacobson, West Lafayette.
Jacob Papish, Bloomington.
Louis Roark, Bloomington.
Lewis A. Taylor, Earlham College, Richmond.
Eben Henry Toole, West Lafayette.

The following named members were elected Fellows:

J. A. Badertscher, Professor of Anatomy, Indiana University.
Charles A. Behrens, Professor of Bacteriology, Purdue University.
Edward W. Koch, Department of Research, Eli Lilly Co., Indianapolis.
William M. Logan, Associate Professor of Geology, Indiana University.
Barnard Schockel, Professor of Geography, State Normal School.

The report of the Nominating Committee was as follows:

President—E. B. Williamson, Bluffton.
Vice-President—Dr. Charles Stoltz, South Bend.
Secretary—Howard E. Enders, West Lafayette.
Assistant Secretary—P. A. Tetrault, West Lafayette.
Treasurer—Wm. M. Blanchard, Greencastle.
Editor—Lee F. Bennett, Valparaiso.
Press Secretary—Frank B. Wade, Indianapolis.

The Committee on Amendments moved the following amendments to the Constitution and By-Laws, for final action to-morrow:

Amendment to Constitution, Article III, Section 1, second sentence, by insertion of the word "Editor" after the words "Press Secretary."

The article and section so amended will read:

"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 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."

Amendment to the By-Laws:

"BY-LAW 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."

AFTERNOON SESSION—1:30 P. M.

Papers numbered 6, 7, and 8 were read in general session after which the Academy adjourned to sectional meetings. President Moenkhaus served as chairman of the section on Bacteriology, Botany and Zoology; and Edwin Morrison presided over the section on Astronomy, Chemistry, Geology and Physics.

EVENING SESSIONS.

The address of the retiring President, Professor W. J. Moenkhaus, was delivered at the informal dinner, at the Cafeteria, at 7:00 p. m.

At 8:30 Professor Charles T. Knipp, of the University of Illinois, addressed the members of the Academy and guests on the subject: "Electric Discharge in Vacuum Tubes—The Electron." The extensive equipment and the facilities of the Department of Physics made it possible to illustrate the whole of the lecture in a striking manner.

A smoker and informal entertainment was given by the Sigma Xi Scientific Fraternity at the Faculty Club rooms immediately after Professor Knipp's address.

SATURDAY, DECEMBER 8, 1917.

Business:

The meeting was called to order at 8:45 by President Moenkhaus.

The amendments to the Constitution and By-Laws were called for second reading, and were passed on motion.

The following named Fellows were elected Non-Resident Fellows:

Charles Zeleny, Professor of Experimental Zoology, University of Illinois, Urbana, Illinois.

Severance Burrage, Resident of Massachusetts, now with a medical commission in Serbia.

The matter of the Spring Meeting was discussed. In view of the fact that members of the Illinois Academy of Science have suggested that a joint meeting be held with their Academy it is advised that the 1918 Program Committee take up the matter and determine whether this is feasible; if so to complete the plans, otherwise to determine a place and time for an independent meeting.

The Academy adopted the following resolution presented by Wm. M. Blanchard:

Resolved: That we extend to Indiana University, and particularly to the members of the Academy who are connected with the University, as well as to our special visitor, Professor Charles T. Knipp, a vote of thanks for the entertainment and courtesy manifested at this December meeting of the Academy.

The Academy then went into general session for the reading such papers as remain from the several sections.

Adjourned.

W. J. MOENKHAUS, President.
HOWARD E. ENDERS, Secretary.

Program of the Thirty-third Annual Meeting,

of the

INDIANA ACADEMY OF SCIENCE,

held at

Indiana University, Bloomington, Ind.,
Friday and Saturday, December 7 and 8, 1917.

OFFICERS.

W. J. Moenkhaus, President
Edwin Morrison, 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.

F. M. Andrews H. L. Bruner
Stanley Coulter

GENERAL PROGRAM

Thursday.

Meeting of the Executive Committee in the Faculty Club Rooms .... 8:00 p.m.

Friday.

Business Session .... 11:30 a.m.
General Session .... 10:00 a.m.
Sectional Meetings .... 1:30 p.m.
Informal Dinner at the Cafeteria........ 7:00 p.m.
The address of the retiring President, Professor William J. Moenkhaus, of Indiana University, will be delivered at this time.
Address by Professor Charles T. Knipp........ 8:30 p.m.

Subject: Electric Discharge in Vacuum Tubes—"The Electron," Science Hall, Room 38.

A smoker will be given by the Sigma Xi Scientific Fraternity at the Faculty Club Rooms immediately after Professor Knipp's address.

SATURDAY.

Business Session .... 8:00 a.m.

GENERAL SESSION.

FRIDAY, 10:00 A.M.

1. Transplantation of Testes into Ovariectomized Female Guinea Pigs, 5 min............................By Mathew Winters
   Presented by Dr. B. D. Myers, Indiana University.
2. The Physiography of Indianapolis, 15 min. (by title) .Chas. R. Dryer
3. The Pygidiidae, 30 min.......C. H. Eigenmann, Indiana University
4. Some criteria of Skeletal Homologies, 15 min..J. S. Kingsley, University of Illinois
5. A Fish Epidemic in Huffman's Lake, 10 min..Will Scott, Indiana University
6. Germinal Changes Affecting Facet Number in the Bar-eyed Race of Drosophila, 10 min...Charles Zeleny, University of Illinois
7. The Dwarfing Effect of Attacks of Mites of the Genus Eriophydae upon Norway Maples, 10 min...Howard E. Enders, Purdue University
8. Where the Feeble-minded are Self-supporting, 12 min..............................Hazel I. Hansford, Indiana University

SECTIONAL MEETINGS.

FRIDAY 1:30 P.M. AND SATURDAY 8:30 A.M.

Astronomy.

1. A New Form of Telescope Mounting, 10 min..W. A. Cogshall, Indiana University

Bacteriology.

2. Bacterial Action on Proteins in presence of Carbohydrates, 10 min. H. M. Weeter, Purdue Univ.; George Spitzer, Purdue Univ.

3. Hydrolysis of Proteins and Methods of Separating the Cleavage Products, 10 min.............Geo. Spitzer, Purdue University

Botany.

4. Plastids, 10 min. (by title)......D. M. Mottier, Indiana University
5. Species of Martyniaceae, 5 min..Flora Anderson, Indiana University
6. Variation and Varieties of Zea Mays, 10 min...Paul Weatherwax, Indiana University
7. Improved Technique for the Control of Pollination in Corn, 10 min....................Paul Weatherwax, Indiana University
8. Dormant Period of Timothy Seed after Harvesting, 10 min..................................M. L. Fisher, Purdue University
9. The Plant Succession on Niagara and Hudson River Limestone, near Richmond, Ind., 5 min. (by title)..M. S. Markle, Earlham College
10. Notes on Microscopic Technique, 5 min. (by title)...M. S. Markle, Earlham College
11. The Ustilaginales of Indiana, 10 min...H. S. Jackson, Purdue University
12. The Uredinales of Indiana, 10 min..................H. S. Jackson
13. A Suspected Case of Live-Stock Poisoning by Wild Onion (Allium Canadense), 10 min. (by title)..F. J. Pipal, Purdue University
14. Additions to the list of Plant Diseases of Economic Importance in Indiana, 10 min. (by title)..Geo. A. Osner, Purdue University
15. Reaction of Culture Media, 10 min. (by title)..H. A. Noyes, Purdue University
16. Studies on Pollen, 5 min........F. M. Andrews, Indiana University
17. Stoppage of a Sewer Pipe by Roots of Acer Saccharum, 5 min............................F. M. Andrews, Indiana University
18. Anthocyanin of Beta Vulgaris, 5 min..F. M. Andrews, Indiana University
19. Improved Forms of Maximow's Automatic Pipette, 5 min...............................F. M. Andrews, Indiana University
20. The Effect of Centrifugal Force on Plants, 5 min.....................................F. M. Andrews, Indiana University

21. The Effect of Aeration on the Roots of Zea Mays, 5 min.......
........................Colonzo C. Beals, Indiana University
22. Resistance of Mucor Zygotes, 20 min......................
......................Mildred Nothnagel, Indiana University

Chemistry.

23. The Absorption of Iron by Platinum Crucibles in Clay Fusions, 5 min...............................W. M. Blanchard, DePauw University; Roscoe Theibert, DePauw University
24. The Injurious Effect of Borax in Corn Fertilizers, 10 min. (by title).....................S. D. Conner, Purdue University
25. Chemical Estimations of Fertility in Fulton County (Ind.) Soils, 15 min.........R. H. Carr and G. A. Gast, Purdue University
26. By-products of the Preparation of Ether, 10 min. (by title)... ....P. N. Evans and G. K. Foresman, Purdue University
27. Quantitative Precipitation of Manganese as the Sulphide, 15 min..........................James Brown, Butler College
28. The Influence of Methyl Iodide Vapor and Tobacco Smoke on the Growth of Certain Bacteria and Fungi (by title)..C. A. Ludwig

Geology.

29. Brief Notes on the New Castle Tornado, 10 min...............
........................Colonzo C. Beals, Indiana University
30. "The Mt. Carmel Fault," 5 min....W. N. Logan, Indiana University
31. "Some Criteria of Dip," 5 min.....W. N. Logan, Indiana University
32. "Possible Utilization of Indiana Kaolin," 5 min...............
..........................W. N. Logan, Indiana University
33. "The Physiographic Divisions of the United States as made by the Fenneman Committee," 5 min......................
...........................F. J. Breeze, Indiana University
34. "Glacial Boulders in Brown and Monroe Counties, South of the Limit of Glaciation, 15 min......................
..........................F. J. Breeze, Indiana University
35. "Field Methods in the Mid-Continental Oil Field," 15 min......
...........................Louis Roark, Indiana University

Physics.

36. Energy Loss in Commercial Hammers, 15 min................ ....Edwin Morrison and Robert L. Pelry, Earlham College
37. Some Experiments on Resonance of Tubes and Horns, 5 min... ....Arthur L. Foley, Indiana University
38. Two New Photographic Methods of Measuring the Speed of Sound Waves, 10 min......Arthur L. Foley, Indiana University
39. Conditions Affecting the Speed of Sound Waves, 10 min........ ....Arthur L. Foley, Indiana University
40. The Conduction of Heat and Electricity Thru Selenium, 10 min. ....Arthur L. Foley, Indiana University
41. Some Observations on Fluorescence, 5 min.................... ....Arthur L. Foley, Indiana University
42. Further Notes on the Identity of X-Rays and Light, 10 min.... ....Mason E. Hufford, Indiana University
43. An improved Form of High Vacuum High Speed Mercury Vapor Air Pump, 10 min......Charles T. Knipp, University of Illinois

43a. A Possible Standard of Sound. Chas. T. Knipp, University of Illinois

44. Visible Color Effects in a Positive Ray Tube Containing Helium, 10 min..................Chas. T. Knipp, University of Illinois

Zoology.

45. The Effect of Artificial Selection upon Bristle Number in the Fruit Fly and the Interpretation of the Results, 15 min... ....F. Payne, Indiana University
46. The Unionidæ of Lake Maxinkuckee, 20 min. (by title)....... ....Barton Warren Evermann, California Academy of Science; Howard Walton Clark, U. S. Biological Station, Fairport, Iowa
47. A Day with the Birds of a Hoosier Swamp, 10 min. (by title)... .....Barton Warren Evermann, California Academy of Science
48. Further Experiments with the New Mutant, Scarlet in the Drosophila Repleta, 10 min......................H. W. Cromwell
49. A Seasonal Study of the Stickleback Kidney, Cayuga Jordan, 15 min......................Walter N. Hess, DePauw University
50. On the Locus of the Gene for the Mutant, Curved (by title).. ....Roscoe R. Hyde, Indiana State Normal

51. The Erdmann New Culture Medium for Protozoa, 20 min. . . . .
. . . . By C. A. Behrens, Purdue University; H. C. Travelbee, Purdue University
52. Disposition and Intelligence of the Chimpanzee. . . . .
. . . . W. Henry Sheak, Philadelphia, Pa.
53. The Uredinales of Delaware. . . . . . H. S. Jackson, Purdue University
54. The Trees of White County, Indiana. . . . .
. . . . Louis L. Heimlich, Purdue University

The Physiography of Indianapolis.

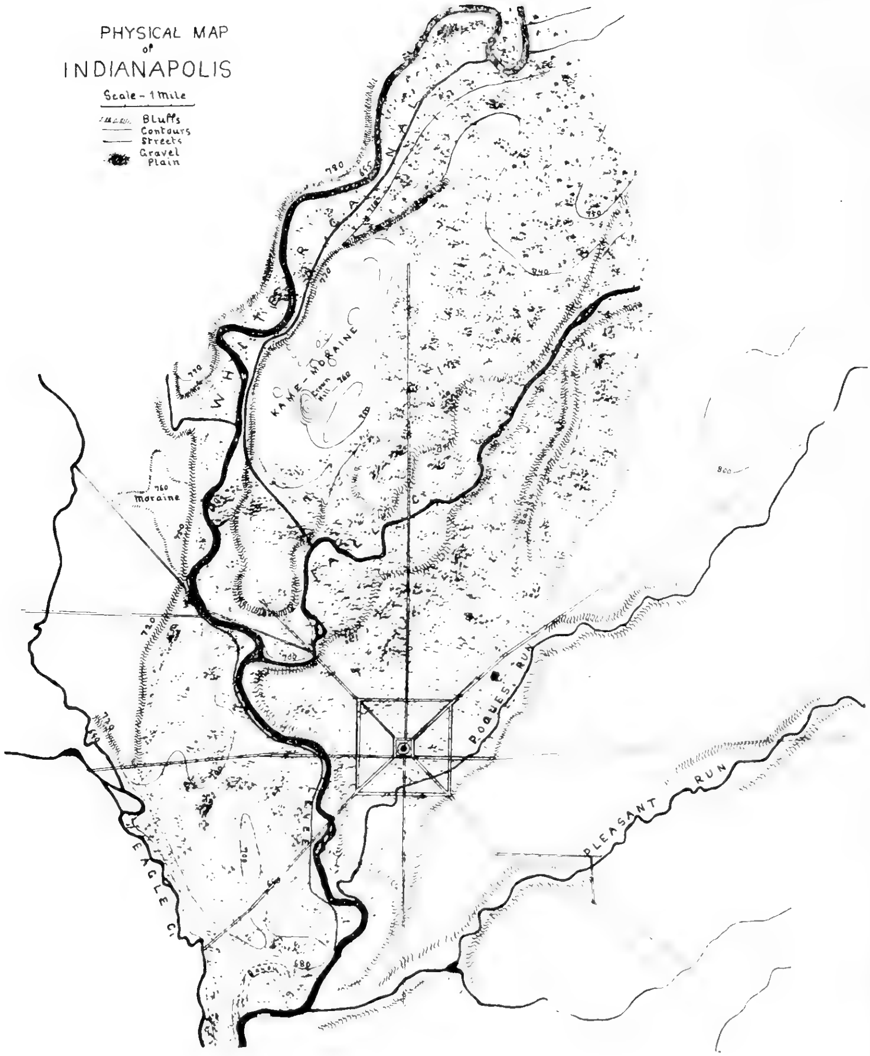
Charles R. Dryer, Indiana State Normal School.

In 1820, the Indiana Commissioners fixed upon a point in the uninhabited wilderness, "on White river at the head of navigation" and within ten miles of the geographical center of the State for the location of the future capital. Congress had granted to the State four square miles for use as a seat of government, and in 1821 a plat of one square mile was surveyed which now comprises the official and commercial center of the city. The area was situated near the eastern border of the flood plain of White River and a few feet above it, but was traversed by Pogues Run, a small tributary. Fall Creek, a much larger stream, entered the river from the northeast just above the city and Pleasant Run a short distance below. On the opposite side of the river, Eagle Creek came in from the west.

The present metropolitan district would be enclosed by a parallelogram 8 by 10 miles, of which about 35 square miles are built up. The underlying bed rocks are Devonian limestones and shales too deeply buried beneath glacial material to influence topography. The Illinoian drift sheet of compact blue clay, varies from 20 to 80 feet in thickness. A few feet of sand and gravel separate it from the usual bouldery till of Wisconsin age, the whole forming a mantle 70 to 170 feet thick. This glacial subtratum has been eroded and replaced by gravel to an extent presently to be described.

In the absence of a topographic map relief can be described only in approximate terms. Central Marion County is crossed from northwest to southeast by a belt of undulating drift in part morainic about ten miles wide, its surface lying about 800 feet A. T. It is bordered on the south by massive gravel ridges and other morainic features.* Through this belt nearly at right angles, White River and Fall Creek cut a trench about 200 feet deep, having its bottom on or near bed rock. During the period of glacial retreat this trench was filled half full of gravelly outwash. A readvance of the ice margin, accompanied by the

* Leverett, Frank. U. S. Geol. Surv. Monograph LIII, p. 96.


PHYSICAL MAP
of
INDIANAPOLIS
Scale - 1 mile
Bluffs
Contours
Streets
Gravel Plain
WHITE R.
CANAL
KAME-MORAINE
Crown Hill 760
Moraine
760
POGUES RUN
PLEASANT RUN
EAGLE C.
FALL C.
780
720
840
800
680

escape of subglacial streams, deposited near the western border of the outwash plain a belt of sand and gravel hills three miles long and rising in the sharp knob of Crown Hill 90 feet above the plain and 150 feet above the river. White River passes through this kame-moraine in a gorge three miles long and half a mile wide, bordered by steep bluffs 40 to 80 feet high. The gravel plain about three miles wide is bounded on the east by a gentle rise or bluff 15 to 30 feet high, which parallels Fall Creek and touches the river at the mouth of Pleasant Run, below which the plain lies on the west side of the river. Its surface slopes from about 740 feet A. T. in the north to 680 feet in the south, or about six feet to the mile and is cut by the high water channels of the river, Fall Creek and Eagle Creek, into a series of low but well defined terraces. The city occupies the gravel plain, the kame-moraine and the gorge, bluffs and flood plain of White River, and extends on the east and south several miles beyond the bluff over the more elevated undulating drift.

The physical features have influenced the development of the city, favorably and unfavorably, in various ways. White River is a commercial obstruction, too small for navigation, inadequate for sewerage and entailing large expense for bridges and levees. It pays some compensation in water supply and picturesque sites for parks and residences. The gravel plain makes grading and excavation inexpensive and surface drainage rapid; but this credit account is balanced by a debit of 25,000 wells subject to serious contamination. Pogues Run has cost untold sums in damage to health and property by floods and the expense of conversion into a covered sewer, but furnishes a route by which several railroad lines enter the city. The low bluffs and terraces of Fall Creek and Pleasant Run are utilized for boulevards and parkways. The Crown Hill kame-moraine, the most striking and attractive natural feature of the area, is admirably suited for the abode of the living or the dead and forms the beautiful site of Crown Hill Cemetery. The smooth surface of the surrounding drift plain is a prime factor in the accessibility which makes Indianapolis the largest center of exclusively land transportation in the United States.

The Pygidiidae.

Carl H. Eigenmann, Indiana University.

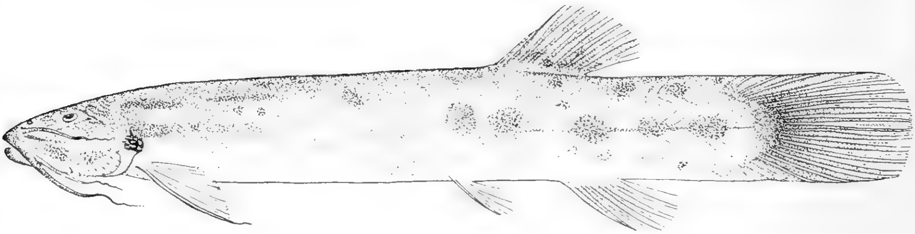
There is a widespread belief in parts of South America that a fish called Candirú has the vicious habit of entering the urethra of bathers. Its opercle and interopercle bear retrorse spines that are erectile. The fish, therefore, cannot be withdrawn. An operation, if not amputation, is necessary to get rid of the pest, and if it has penetrated to the bladder it causes death. This story has been told many different travelers. Some have rejected it as beyond belief, others have added to the marvelous, while still others have tried to identify the fish. The result of the latter attempt has been ludicrous at times, inasmuch as the identification would require the reverse of the well recognized principle of logic that the greater cannot enter the lesser. Some of the Candirús reach a considerable size, a length of at least a foot and a thickness of at least two inches. We will return to the Candirús.

I have finished a monograph of the family of fishes, the Pygidiidæ, of which the smaller Candirús are members, and I want to give a brief account of the different types of fishes that are included in this family. Other species of the family have well authenticated habits as remarkable as those of the Candirú, and I am figuring all the species I can get.

I find that there are nearly a hundred well defined species of the Pygidiidæ. Many of these are very rare. Forty-four are known from the types only, several have been recorded from but two localities. The types are widely scattered in the museums of North America, South America, and Europe. At one time or another I have examined practically all of the specimens in American museums, and have myself discovered nine of the nineteen genera, and forty-three of the ninety-seven species. Eight or ten of the types are in Vienna, two are in Berlin, twelve in Paris, eleven in London, one in Torino, two probably in Munich, one in Leipzig, two in Copenhagen, one in Berne, three presumably in Santiago, Chile, three in Buenos Aires, three in Rio de Janeiro, two in Cordoba, Argentine, one in the Field Museum, two in the Philadelphia

* Contribution from the Zoölogical Laboratory of Indiana University, No. 163.

Academy of Sciences, eight in the Museum of Comparative Zoölogy, five in Indiana University, one in Princeton University, twenty-four in the Carnegie Museum. The type of one species, the only known specimen of the species, has been lost.



A Pygidium.

The particular type of catfish underlying all of the Pygidiidæ is that of a short eel with a little barbel on the anterior nostril, twin barbels at the angle of the mouth, small teeth in bands in the jaws, bunches of spines on the margin of the preopercle and on the opercle, the first dorsal and pectoral rays not spinous, the dorsal placed behind the middle of the body and not followed by an adipose fin. The principal peculiarities are the twin barbels at the angle of the mouth, the absence of an adipose fin and the development of opercular and interopercular spines—never mind the internal economy. Nobody knows, at least I don't, why there are *twin* barbels at the angle of the mouth, or why there is no adipose fin. It is easy to see that the spines on interopercle and opercle are important. They are an adaptation to the insinuating habit and prevent an exsinuation if the fish objects to coming out.

From this basal idea of the Pygidiidæ have been developed by addition, subtraction and modification several distinct subfamilies, each with subsidiary basal ideas and a larger or smaller number of radiations. There are the Nematogenyinæ with barbels on the chin, remnants really of the more ancient, less specialized cat-fishdom, the Pygidiidæ which are the least specialized of the Pygidiidæ, and meander over all the mountains of South America, both east and west. The most that can be said of them is that there are a lot of them and that when big enough they are good to eat. Then there are the Stegophilinæ with a broad, inferior mouth with innumerable fine teeth in many rows on lips and jaws, and some, at least, which have exaggerated the insinuating habit to the extent of becoming parasites in the gills of other fishes. Also there are the Vandelliinæ, in which the lower jaws are weak, the rami no longer meeting in the middle, the teeth largely reduced to a few pointed ones in the middle of the upper jaw, with which they make abrasions in the skins of other fishes and of an occasional bather, to drink his blood. To this crowd of disreputables belong the aforementioned Candirú. Finally there are little odds and ends tied into the Tridentinæ, minute creatures, the smallest of which is but 17 mm. long, and the largest but 27 mm. The most that we can say of them is to express the wonder that any of them were caught at all.

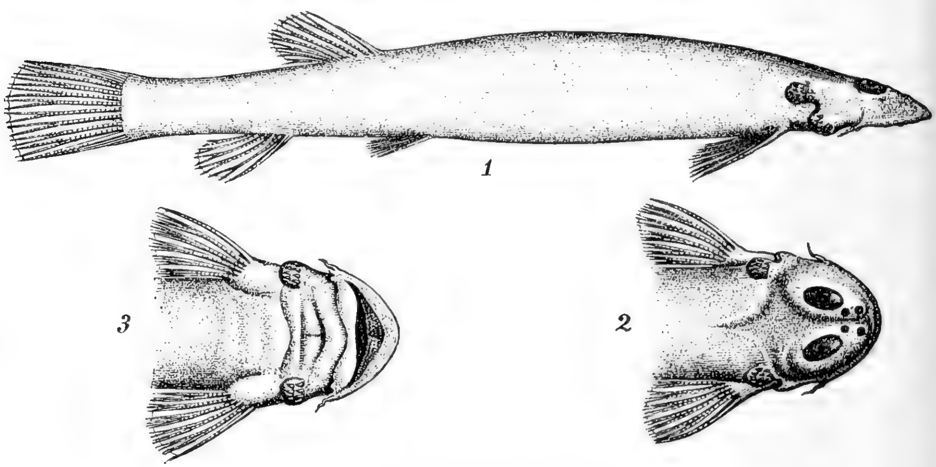
The Nematogenyinæ have either lost or never got opercular spines. Nematogenys is large enough to be noticed. It has received the common name "Bagre", and reaches a length of over ten inches at least.

The Pygidiinæ flourish in the mountains from southern Panama to southern Patagonia, and in southeastern Brazil, also in the cataracts of Guiana. A few of them are found in the lowland, but their optimum is only reached in high altitudes, and with Astroblepus, a representative of another catfish type, they reach the highest altitudes attained by fishes in South America.

One of them, *Eremophilus mutisii,* is exceedingly abundant on the Plains of Bogotá, where its name, "El Capitan", expresses the estimation in which this Pygidiid is held. It has the habit of worming its way into the mud and into the banks of streams and lakes. "El Capitan" is speckled like a lake trout, and it is all but confined to the elevated basin in which Bogotá is situated. In the mountain brooks of Colombia many species of the genus Pygidium are found in abundance. I recall one sultry day sitting in a cool, clear, shallow brook near Honda, Colombia, leisurely raking my fingers through the sand and pebbles on the bottom. Minute fishes darted out of the sand and into it and under small rocks. I lined a dipnet with cheese-cloth and went for them, dipping up sand. gravel and all. I soon had a good number, eighty-nine to be exact, of a new species of the genus Pygidium. Mr. E. B. Williamson caught a specimen of another species, which was making its way up the vertical wall of a waterfall. The sixty-three members of the genus Pygidium range from southern Panama to Chile, Guiana and Rio Grande do Sul. Very few species are known from the lowlands, but every mountain brook has one or more species, never many, and none of them have a wide distribution. They are abundant in Lake Titicaca, and in southern Chile are replaced by the related genus Hatcheria.

A halfway station between the Pygidiinæ with nasal barbel, free gill-membranes and ordinary fish mouth and the small commensals, parasites and disreputables without nasal barbels, with narrow gill-openings and inferior mouth, is found in Pareiodon. In shape and size Pareiodon resembles the Havanas sold to tourists in Habana for a dollar, each one put up in an individual bottle, a corkscrew furnished gratis with each cigar.

Some, at least, of the Stegophilini live in the gill-openings of other fishes. The head in the species of this group is flat below, the mouth a transverse slit, the teeth are minute and numerous, there is no nasal barbel, the gill-opening is greatly restricted, the membrane being united with the broad, flat isthmus. Some of them roam the billows free as cats, others are known to live, occasionally at least, as commensals or parasites in the gill-cavities of other fishes. Reinhardt, a Danish naturalist living for the time at Lagoa Santa, on the Rio das Velhas, a tributary of the San Francisco, was the first one to note this fact and to secure specimens. Reinhardt being told that one of the giant catfishes, *Pseudoplatystoma coruscans*, carried its young in its gills, offered a re-



Stegophilus insidiosus Reinhart.

ward for one with young. Two Platystomas were brought with young, but instead of being the young of the giant catfish, he found that the small fishes were the types of a distinct parasitic or commensal fish, which he called "Stegophilus insidiosus."

It is certain that some members of the Stegophilini live in the open, very probably on sandy beaches; in fact, while but one species is known to live part of its time, at least, in the gills of other fishes there are a number of species that have only been caught in the open. Several years ago Prof. J. D. Anisits, then living in Asuncion, Paraguay, sent me one of these little creatures, which he had caught in a brook near Sapucay. He tried to get others but sorrowfully reported that the locality was gone, the arroyo was dry. While the original member of the Stegophilini came from a medium altitude, the members of the subfamily live largely in the lower levels of the Amazon and La Plata. As it is more probable that specimens living in the open will get into the ichthyologists' bottles than those living in the gill-cavities of larger fishes, it must be left an open question whether the species living in gill-cavities are more numerous than those living in the open, and whether the same species live in the open and in gill-cavities indiscriminately, or whether they only occasionally get into gill-cavities as the result of their inborn, insinuating habit coupled with the blood-sucking specialization.

The three known species of the Tridentinæ, all collected during the Thayer Expedition, in the Amazon Basin near the boundary between Brazil and Peru, were described by my wife and myself in 1898. One of them, *Miuroglanis platycephalus*, captured in 1866 by the combined efforts of James, Thayer and Talisman, in the Jutahy, is or was only seventeen millimeters long. A recent effort to locate the specimen has failed. The same fate seems to have befallen the specimen of *Tridens brevis*. It was but twenty-one millimeters long, and caught in 1866 by Bourget at Tabatinga. The third and last of this group is *Tridens melanops*. In 1866 the future philosopher, William James, caught twenty-seven of them at Iça, the largest only twenty-seven millimeters long. In 1891 the Museum of Comparative Zoölogy sent me one of these, which has just been figured for my monograph. The Tridentinæ are fishes with a greatly depressed head and a large eye placed on the edge of the head; in one, at least, they look down rather than up.

One of the Vandelliini, *Branchioica bertoni*, lives in the gill-cavities of a large Characin. Several years ago Mr. Bertoni sent me one of these, and it seems that I at once described it with much gusto. Later Mr. Bertoni sent me another lot of minute fishes, and this summer I discovered that two of these were taken from the gills of a Characin. I again described them, of course, as a new genus and species. Still later I found the totally forgotten original specimen and description carefully laid away.

Ribeiro, of the National Museum of Rio de Janeiro, caught another very similar member of a related genus, Paravandellia, among the weeds of the stream near San Louis de Caceres in the upper Paraguay Basin.

With fishes as rare as these and as small as these, the question sometimes arises whether the differences are due to the fact that one worker uses a hand lens and the other a binocular dissecting microscope with an arc spotlight. The results of the two instruments are comparable to the effects produced by an old-fashioned cannon and a modern forty-two-centimeter howitzer.

Two species I have just described with the three previously known, brings the number of Vandellias up to five—maybe. I used a howitzer, and my distinguished predecessors, Pellegrin, Castelnau, Valenciennes and Cuvier used hand lenses. The Vandellias are long, slender, eel-like in shape. There are really two genera in the genus Vandellia, but I don't yet know which one of these Valenciennes had when he named the genus. The other is, for the present, without a legitimate name. When we know which one can legitimately lay claim to the name Vandellia the other one can be baptized as Urinophilus. One of these, possibly two of them if they are different, *Vandellia hasemani* and *Vandellia wieneri,* is or are too large to enter the urethra of man when it is or they are fully grown. On the other hand, *Vandellia cirrhosa, sanguinea,* and *plazai* could, as far as their size is concerned, enter the urethra. Do they?

Pellegrin, who has written on this subject, quotes Dr. Jobert who collected fishes in Brazil for the Jardin des Plantes. Jobert tells that a highly reputable physician of Belem, Para, Dr. Castro, told him he had taken a Candirú from the urethra of a negress.

Boulenger (Proc. Zool. Soc. London, 1897, p. 901) says of Vandellia cirrhosa:

"The 'Candirú', as the fish is called, is much dreaded by the natives of the Jurua district, who, in order to protect themselves, rarely enter the river without covering the genitalia by means of a sheath formed of a cocoanut-shell, with a minute perforation to let out urine, maintained in a sort of bag of palm-fibers suspended from a belt of the same material. The fish is attracted by the urine, and when once it has made its way into the urethra, cannot be pulled out again owing to the spines which arm its opercles. The only means of preventing it from reaching the bladder, where it causes inflammation and ultimately death, is to instantly amputate the penis; and at Tres Unidos, Dr. Bach had actually examined a man and three boys with amputated penis as a result of this dreadful accident. Dr. Bach was therefore satisfied that the account given of this extraordinary habit of the 'Candirú' is perfectly trustworthy. Mr. Boulenger further showed a photograph, taken by Dr. Bach, of two nude Indians wearing the protective purse."

It is to be noted here that, while this evidence is quite circumstantial, it is only circumstantial. Dr. Bach did not himself operate or help to operate or remove the Candirú, and a much simpler operation than amputation would have been sufficient to remove it.

Pellegrin (Bull. Soc. Philom. de Paris, (11), I, 1909, pp. 5-8) further quoting Jobert's account, says that at Para there are two species of Candirús, only one of which penetrates the urethra, the other, the horse Candirú, attaches itself to any part of the body and also attacks horses. Dr. Jobert himself, who went in bathing near Para, was attacked within less than five minutes and found scratches in a group five to six inches long and a centimeter or more wide. He did not secure the creature which attacked him.

In "Die Natur", XIX, p. 180, Müller, in reporting on the travels of Gustav Wallis, says that Wallis noted a fish in the Huallaga called the Candirú, which is as much feared in the water as mosquitoes and ants on land. This Candirú attaches to any portion of the body like a leech and spreads retrorse hooks in the wound so that it is only with considerable pain that it can be removed. It prefers the most secret parts of the body and it was reported to him that the consequent operation sometimes causes death. One specimen of this Candirú was given to Leukart and by him to Lütken, who described it as *Acanthopoma annectens.* It probably belongs to the Stegophilini.

That a fish, or several species of fishes, found in the Amazon Valley and called Candirú is or are a nuisance is certain. Whether the widely distributed belief that the Candirús are tropic to urine and consequently have a tendency to enter the urethra, or whether the candirú's tendency to burrow leads them accidentally to enter the urethra are all matters that must, for the present, remain in debate. A very interesting subsidiary question is whether, if Candirús are tropic to urine, they do not also enter the urethra of aquatic mammals and large fishes. Further study may demonstrate that some species of Candirús have become parasitic in the bladder of large fishes and aquatic mammals. These are all questions that may legitimately be taken up by the expeditions that will, I hope, result from this article.

An Epidemic Among the Fishes of Huffman's Lake.

Will Scott, Indiana University.

This paper describes an epidemic among the fishes in Huffman's lake during October and November, 1917. The data indicate that these fish died from poison which was derived from a blue-green algæ, either by its metabolism or decay.

Huffman's lake is located in Kosciusko County, Indiana, (Tp. 33 N., R. 5 E.) about one mile northwest of Atwood. It is just west of the Erie-Saginaw interlobate moraine and lies in a slight depression of the ground moraine. It is roughly oval in outline. Its greatest length is about one mile and its greatest width is about one-half mile. Its longitudinal axis extends north and south. Near the middle of the lake there are three small islets situated along the major axis of the lake. Its maximum depth is 9.8 meters.

The land surrounding the lake is low. Much of it near the shore is marshy. To the east, a short distance, the rougher topography of the interlobate moraine begins. The lake is therefore quite exposed to the action of the wind especially to the south, west, and north.

Dead and dying fish were first noted in large numbers after a storm that occurred on October 29th. This storm left a distinct wave deposit some distance above the normal lake level. On November 16 the fish were counted in several sections of this deposit. The average was about one fish per lineal foot of deposit. Six species were collected and identified, bluegill, (Lepomis pallidis Mitchill); large mouthed black bass (Micropterus salmoides Lacépède); calico bass (Pomoxis sparoides Rafinesque); sucker (Catostomus commersonii Lacépède); hickory shad (Dorosoma cepedianum Le Sueur), and yellow perch (Perca flavescens Mitchill).

One hickory shad was identified struggling on its side near the center of the lake. It was able to avoid a dipnet and escape. Near the shore, two rock bass and five bluegills were taken swimming slowly on

* I am under obligation to Mr. Chauncey Juday for identifying the alga, to Mr. J. H. Armington for the Winona Lake temperatures, and to Mr. S. L. Blue who made the field work possible.

their sides. Several small bluegills, that were still alive, were picked up stranded at the edge of the water.

Nothing is known of the summer conditions of this lake. The autumnal overturn in Eagle Lake (Winona) takes place the latter part of November. It seemed possible that there might be a deficiency in oxygen in the lower levels of the lake that was killing the fish as their actions simulated those of fish suffering from dyspnea.

An examination of the water for dissolved gases and carbonates demonstrated that the lake is a hard water lake and that there was an abundance of oxygen. (See table. 4cc. O. per liter. Temperature 6°C.) The fall overturn had taken place but the water was only about half saturated. It is barely possible that the first fish to die may have died from dyspnea, although this is not likely on account of the shallowness of the lake, the contour of its bottom, and its exposure to the wind. It is certain that the fish that were dying in November were not suffering from the lack of oxygen.

TABLE OF TEMPERATURES AND DISSOLVED GASES.

	T.	O.	% Sat.	CO_2	Cb.
Surface	6.9	4.09	49%	1.51	42.72
2 M	6.9				
Bottom	6.9	4.06	47%	1.26	42.72

Air temperature 10°C.
Secchi's disc reading .9 M.
Gases expressed in cc. per liter. Cb. is CO_2, as carbonate.

The fish were examined very carefully for infections, sporozoan and bacterial, but the tissues showed no lesions or postules. The anus, nares, mouth, and gills were examined with especial care. There was no indication of gas disease.

It has been suggested that the lake might have been dynamited. There were no ruptured blood-vessels to indicate that the fish had suffered from concussion. Moreover, the fish were dying during a period of more than six weeks, a fact that would preclude their having been killed by a single charge of explosive.

The only prenomenon that could be associated with the death of the fishes as a causal factor was a tremendous growth of blue green alga Oscillatoria prolifica (Grenville) Dumont. This alga occurred near the surface of the lake in enormous quantities. It was difficult to make a quantitative estimate of it by the ordinary limnological methods on account of the wind drifting it. Some notion of its abundance may be gained from the following observations:

At 10:00 a.m. there was still a very heavy fog on the lake. When rowing to the center of the lake the water appeared pink when disturbed by the oars, and in the wake of the boat. By 3:00 p.m. a slight breeze had drifted the algæ in a solid scum along the east side of the lake. In the bays this scum reached a thickness of 4-6 mm. The alga when concentrated in this scum had a rather dark brick-red appearance.

That the alga caused the destruction of the fish is probable on account of two facts. First, it is the only associated extraordinary phenomenon. This is of course only presumptive. Second, certain blue-green algæ (cyanophycæ) seem to produce substances, either by their metabolism or decay, which when concentrated are toxic to vertebrates, and may even cause death.

Arthur ('83) reports two instances in which cattle were poisoned by drinking water that was covered with a thick scum of blue-green alga (Rivularia fluitans Cohn).

Nelson ('03) after discussing the cyanophycæ that cause "water bloom" closes with these words: "In several instances it has been almost conclusively proved that the presence of one or more of these species in drinking water used by stock has caused fatal results."

Cause of the Excessive Growth of Algæ.

This lake has been under the observation of Mr. Maurice Miller for thirty-two years. He reports that this autumn (1917) is the first time that a red scum has appeared.

Olive ('05) identified this algæ from the ice in Pine Lake (Wisconsin), where there evidently had been a considerable growth just before the lake froze.

Red pigment is very characteristic of the plankton of arctic and alpine regions (Steuer 1910, pp. 277-8). The red coloration of lakes and ponds in the Swiss Alps seems to be a rather common phenomenon.

Brunn ('80) reports the ice on Lake Neuchatel being colored red with a growth of Pleurococcus palustris Küntzig. He also refers to the freezing of Lake Morat in 1825 in which the ice was colored by Oscillatoria rufescens.

Klausener ('08) made a study of the so-called "Blutseen" of the High Alps. Most of these were colored by Euglena sanguinea Ehr.

TABLE SHOWING THE MEAN TEMPERATURES FOR OCTOBER AND NOVEMBER. DURING THE DECENNIUM 1908-1917.

Station: Winona Lake, ten miles from Huffman's Lake.

YEAR.	October.	November.
1908	54.6	42.1
1909	49.6	48.4
1910	57.2	35.8
1911	53.0	36.2
1912	54.8	41.4
1913	53.4	45.7
1914	56.7	41.9
1915	54.0	42.8
1916	53.0	41.4
1917	44.0	39.0
Mean	53.0	41.5

The appended table of temperatures* indicates that the mean for October, 1917, was 5.6 degrees F. lower than for any other October in the ten years preceding, and 9 degrees F. colder than the mean for this decennium. This means that the lake was cooled early in the autumn and remained at a rather low temperature for six to eight weeks instead of the normal, much shorter, period. That is, arctic conditions maintained in this lake for nearly two months. This is, I think, one of the factors that caused this alga to develop so luxuriantly.

Against this view, are the observations of Hyams and Richards ('01, '02, '04), and others on O. prolifica in Jamaica Pond. Here the maxima occurred in the warmer months, although a dense growth often developed just before the ice formed.

In the present state of our knowledge it is impossible to harmonize these observations with those on the so-called "blood lakes" of the Alps, those of Olive (loc. cit.) and the ones here presentd on Huffman's lake.

Brunn ('80) suggests the presence of iron compounds as one of the conditions for the development of red pigment in the blue-green algæ. This condition is satisfied by the large amounts of iron oxide in the affluent springs at its margin.

* These temperatures are for the Winona Lake Station, which is about 10 miles east of Huff man's Lake.

Remaining Problems.

It remains to be determined experimentally whether or not this alga produces a toxin, the nature of the toxin, the action of the toxin on fishes, etc.

A much more difficult problem is to determine the exact condition under which this alga will develop. If this alga reappears this problem will be attacked.

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Germinal Changes in the Bar-Eyed Race of Drosophila During the Course of Selection for Facet Number.*

Charles Zeleny, University of Illinois.

In recent discussions two explanations of the effect of selection have been offered. According to the first of these the results obtained are due merely to a sorting out of differences existing in the stock at the beginning of selection. According to the second, new germinal differences arise during the course of selection.

Among those who admit the continued production of new germinal differences there is a disagreement as to the manner in which the germinal changes occur. Some hold the view that the changes consist wholly of the production of new unit factors or genes. Others on the contrary believe that gradual change in the original genes is the principal mode of action and even that selection itself is an efficient determiner of the direction of such variation.

It is my intention to mention briefly some of the results bearing on this problem which have been obtained in the course of selection for facet number in the bar-eyed race of Drosophila ampelophila.

Bar-eye appeared in 1913 as a single mutant male in a full-eyed stock. This male gave rise to the bar-eyed stock in which the faceted region of the eye is bar shaped and the facet number is reduced from one thousand or more to about one hundred. An analysis of the hereditary behavior of bar-eye shows that it differs from full-eye in a single sex-linked genetic factor which acts as an incomplete dominant, the heterozygous condition being intermediate between bar and full-eye. My stock was obtained from Professor T. H. Morgan in January, 1914, and since that time experiments on selection for high-facet and for low-facet number have been in progress, but not in a continuous series because of loss of the lines on several occasions. In these experiments it has been shown that selection for low-facet and for high-facet number is effective. and low-bar, high-bar, emarginate eye and full eye have been produced

* Contributions from the Zoölogical Laboratory of the University of Illinois, No. 110.

from bar-eye. The analysis of the factors involved has yielded the following results:

1. Germinal diversity was present in the stock at the beginning of selection.

2. This germinal diversity was due to accessory unit factors or genes and not to differences in the bar-gene.

3. New accessory genes producing somatic differences of small degree have appeared during the course of selection. Some of these are located in the autosomes.

4. New accessory genes producing somatic differences of marked degree have also appeared during the course of selection. These also are autosomal.

5. Reverse mutation in the bar gene causing a return to the original full-eye both somatically and genetically was observed several times.

Original Germinal Diversity.

That germinal diversity was present at the beginning of the experiments is indicated by the pronounced effect of the early selections. Crosses between the high selected lines and the low selected lines show that the factors causing the difference are not sex-linked as is the main bar factor. This absence of sex-linkage shows that the difference between high and low lines can not be due to original diversity in the bar gene nor to accessory factors originally present in the sex chromosomes. The factors involved must be in the autosomes. Such differences in autosomal factors might have been present in the parental full-eyed stock from which the bar was derived. They would then have been transferred to the bar-eyed stock at the time of its formation, which involved not only change in the bar gene in a single male but also the crossing back with a full-eyed female to produce the bar-eyed stock.

Germinal Changes of Small Degree.

That the original diversity is not a sufficient explanation of the effectiveness of selection and that germinal changes continued to occur during the progress of selection in some of the lines is indicated by the continued effect of selection in these lines for many generations. It is highly improbable that a sustained effectiveness of this kind could have lasted for twelve generations, as in line V, merely as a result of the continued sorting out of an original diversity without additions to the diversity due to the formation of new genes or change in old ones. After such long continued and still effective selection reciprocal crosses between high and low lines still give no indication of sex-linkage. The germinal changes of small degree which must be assumed to explain such a long continued effect of selection therefore are not changes in the bar gene nor are they due to new accessory genes occurring in the sex chromosome. New genes must have arisen in the autosomes. Experiments are under way to determine their chromosomal loci more definitely.

Germinal Changes of Marked Degree.

In the high facet selection line marked mutations have occurred which have yielded full-eyed individuals indistinguishable from the wild ones which originally mutated to form the bar stock. These new full-eyed flies are genetically of two distinct types. One type is the result of a reverse mutation involving the return of the bar gene to the original full-eye-producing condition. Its hereditary behavior is similar to that of the wild Drosophila in all the tests that have been made.

The other type retains the bar gene unchanged, the somatic appearance of full eye being due to the formation of a modifying gene outside of the sex chromosome. This new gene is effective in producing full eye when present in double dose in females heterozygous for the bar gene. Such full-eyed females when crossed with wild full-eyed males produce males half of whom are bar and females half of whom are heterozygous bar.

In males with the bar gene and in females homozygous for bar the double dose of the new gene produces an eye which is nearly full but which differs from full in the presence of a defect at the anterior margin. Such an eye may be designated by the term "emarginate." Emarginate females when crossed with full wild males give males all of whom are bar and females all of whom are heterozygous bar. The reciprocal cross gives males all of whom are full and females all of whom are heterozygous bar. Numerous tests bear out in detail the hypothesis as stated above indicating that the chromosomal formula for this type of female with a full eye is $\frac{B}{=} \; \frac{m}{m}$, for the emarginate-eyed female $\frac{B}{B} \; \frac{m}{m}$, and for the emarginate-eyed male $\frac{B}{-} \; \frac{m}{m}$. Experiments are under way to determine the exact locus of the new gene.

Conclusions.

The data obtained are of interest in a number of ways:

1. Bar-eye may return to the full-eyed somatic condition by two distinct routes. (a) Reverse mutation in the bar gene may bring the individual back to the condition of the full-eyed stock not only in somatic appearance but also in genetic behavior. (b) A similar somatic appearance of full-eye may be produced by a mutation in one of the autosomes which leaves the original bar gene unchanged, as proven by the fact that the crosses between new full-eyed females and full-eyed wild males yield low bar individuals. Change in a gene and production of new genes without change in the principal gene may produce the same result somatically. Breeding tests alone can show the difference. The change in the principal gene brings the individual truly to its original condition.

2. Both of these mutations occurring as they did in the course of upward selection furnished material of immediate value in aiding the progress of upward selection so that it is proper to say that with the aid of mutations occurring during the course of the experiment the bar-eyed mutant was returned to its original full condition. It is not intended, however, to emphasize the fact that these mutations have so far appeared only in the high line and not in the low line. Whether this is merely a matter of chance or has a fundamental significance can be determined only by further observation.

3. The genetic behavior of the type of full eye due to the addition of an accessory factor is similar to that of the individuals of the high selected line before the appearance of the mutants of large degree. The difference between high bar and low bar is due to accessory factors in the same way. In other words the accessory factors with pronounced somatic effect are different in no respect but degree from the the accessory factors with small effect which form the ordinary materials for the action of selection.

4. It is evident that with respect to this one character, facet number, three separate conditions contributed to the effectiveness of selection; first, the differences in accessory autosomal genes present at the beginning of selection; second, the new autosomal genes arising during the course of selection, and, third the mutations in the bar gene. The

original differences are comparatively of low degree, and the new autosomal genes represent in some cases small differences in somatic appearance and in one case a large difference. The mutations in the bar gene so far have been of large degree in all cases, bringing the bar stock back to its original condition.

5. The demonstration of all three of these modes of producing an effective selection in the case of a single character indicates clearly that the selection problem and with it the problem of stability of the unit factor or gene is not capable of solution by any single formula.

Dwarfing Effect of Attacks of Mites of the Genus Eriophyes Upon Norway Maples.

Howard E. Enders, Purdue University.

The peculiar dwarfed and somewhat blighted condition of a portion of the branches of Norway maple trees in and about the town of Hershey, Pennsylvania, attracted my attention during August of 1917, and an effort was made to determine the cause of this condition. The gen-

Fig. 1. Norway maple infested with mites (Eriophyes) for a period of at least three years. Its stunted growth is suggestive of excessive trimming.

eral appearance (Figure 1) of the trees seemed to indicate that they had been heavily pruned one or more seasons ago. They were greatly branched in a manner suggestive of the excessive branching often seen in the "witches' brooms" on the hackberry.

Fig. 2. Short branches of infested Norway maple, partially defoliated to show the dwarfed condition of foliage and stems.

At the time of observation a portion of the terminal branches bore some foliage that was green but many of the leaves were small and brown-edged, while others had become wholly brown in the affected regions. A weak post-season growth of an inch or thereabout had occurred in which the young tender foliage was expanding in an apparently normal manner. This type of post-season growth was quite similar to that reported by Miss A. M. Taylor in 1914 (Journal of Agricultural Science, Vol. 6), as characteristic of gooseberry—*Ribes grossularia*—in England, infested with *Eriophyes ribis* (Nalepa). In the plants which she studied she found that after the first effects of the attack by

Fig. 3. Short branches of infested Norway maple, partially defoliated to show the dwarfed condition of foliage and stems.

Eriophyes were overcome the later growth of foliage and wood was apparently normal, though many of the early leaves bore "blisters" that ranged from single to more or less confluent masses.

The maples, however, seemed not to recover until too late in the season to make a marked growth. The foliage bore no malformations, blisters, typical erineums, or galls that would indicate the cause of injury. It was observed that many of the leaves bore numerous trichomes on the under surface at the proximal portion of the laminæ where the veins converge toward the petiole.

Large numbers of mites, identified as Eriophyes sp(?),* were seen to crawl from beneath and among the trichomes when the point of a teasing needle was drawn through these regions. When the mites are thus disturbed they crawl rapidly over the under surface of the leaf, or

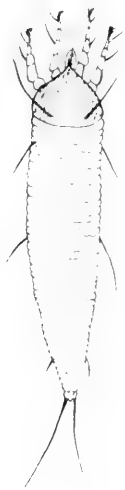


Fig. 4. *Eriophyes vitis* from Banks, in "The Acarina or Mites." It is here reproduced to indicate the generic character of the maple mites rather than the specific characters.

stand on end and, attached by the caudal adhesive disk, sway the anterior end of the body in a circle; others seem to make a leap, and disappear from sight. No effort was made to determine the relative number on each infested leaf, but it was estimated to be a hundred or more for the many leaves that were examined.

During the cooler hours of the morning the mites were to be found

* The author has not found it possible to procure satisfactory material for drawings, since his interruption in the observations, therefore, a drawing of *Eriophyes vitis* by Banks (in Report No. 108, Contributions from the Bureau of Entomology, U. S. Dept. Agr., Washington, D. C., 1915, on "The Acarina or Mites"), is introduced to indicate the character of the mites, rather than the species, which infest the Norway maple.

among the trichomes of the leaves, but during the warmer periods of the day a few were found usually crawling about the under surface of the leaves, chiefly close to the main veins.

Foliage was examined after a light frost late in August, and again after a killing frost early in September. In the first instance relatively few mites remained among the trichomes, and after the killing frost none were found on the leaves, but a much smaller number—ten to twenty—was found in the axils of the leaves, and around the young buds where they seem to have taken shelter. Three instances were observed in which a single mite, and another in which two, had pressed into the young buds, just beneath the outer scale-leaves.

An unexpected interruption in the observations made it impossible to trace the effect of cold upon the mites, and to study their method of passing the winter, if it actually occurs. Twigs collected through the kindness of Mr. Charles Gemmill, student in Lebanon Valley College, Annville, Pennsylvania, were sent me early in October, but I was unable to locate the mites in any of the buds, or in the axils of such leaves as remained attached to the twigs. None of the buds showed any swelling or enlargement that could suggest the "big bud" similar to that observed in the black-currant infested with *Eriophyes ribis* (Nalepa). Miss Taylor (Jour. Agri. Sci., Vol. 6) in 1914 described the enlargement of buds on black-currant in England, when so infected. In that instance the mites penetrate the buds, causing them to swell, and if badly infested, to die without opening. She found the mites to breed throughout much of the year, and to migrate in the spring when the buds are opening. This may be suggestive of the possible mode of hibernation of *Eriophyes* (species undetermined) in the maple, but without producing hypertrophy of the buds.

Similar stunted growth of Norway maples was observed in other towns, and occasionally along the highways of Lebanon and Dauphin counties in Pennsylvania, in sufficient numbers to suggest a wide dispersal of these mites through the agency of birds or insects rather than by the wind. English sparrows crowded into the trees in large numbers in Hershey, and it is quite possible that they may carry many of these small mites on their legs and body, from tree to tree, and even from village to village in their migrations.

Though the trees showed no very serious ill effects from the attack of 1917, it was apparent that growth had been retarded and that subsequent attacks would mar their beauty permanently. An extreme case of injury by mites is clearly indicated in the accompanying photographs (Figures 1, 2, and 3), of a tree and branches which have been infested for a period of at least three years.

The remedies which Professor Slingerland found effective for mites that attack other plants may prove effective on the maple. He has found that they can be exterminated by spraying trees in winter with kerosene emulsion diluted with five to seven parts of water. This will penetrate buds and kill the mites which hibernate there.

Where the Feeble-Minded Are Self-Supporting.

Hazel Hansford, Indiana University.

It has long been recognized that many of the feeble-minded can be made self-supporting in a relatively simple environment if properly trained for the things which they can best do. This is being done for a small number of these unfortunates in some of our institutions. The boys are being taught wood work, farming under supervision, while the girls learn to cook, sweep, and to do many other simple household tasks. In this way they earn their keep, whereas if turned loose in the world, most likely they would become dependents.

Very little is being done in the way of educating our mental defective to earn his own living. Our state law compels him to attend the public schools until he is sixteen, where he studies the same things as the normal children. He remains in each grade for two or three semesters, or until the teacher is tired and is ready to push him onto the next instructor. As a result he ends up in the fourth or fifth grade with nothing in his head to show for his long years of wasted time, the wasted time of the teacher, and the other pupils. He knows no arithmetic, grammar, or history. All has gone into one ear and out of the other. He is turned loose with no training. He and his brothers and sisters go into unskilled labor, maybe. Sometimes their life-long profession of idleness begins immediately. If they are lucky enough to reside some distance from town, they will probably get by as farm tenants—the kind that moves to a new place every year.

For some time the writer has been making a study of a family of mental defectives and it has been interesting to note the kind of occupations common to the different groups within the larger group. To give some idea of two of these groups and their characteristic employments, some facts concerning the family will be given very briefly.

About 1798 there came from Virginia to Kentucky a man whom we will call John Jones. We know little about him except that he hunted most of the time. His family raised corn, part of which was made into cornmeal, and part into that beverage for which the Kentucky mountains are famous. He had eight children all of whom lived and died in or near the old homestead, except two, who came to the southern part of the State of Indiana. About all the descendants of children numbers 2, 4, and 7 are still living in the Kentucky mountains from twenty to fifty miles from a railroad. The descendants of child number 5 settled in Orange County of this State. The descendants of child number 1 are in two groups, the legitimate and the illegitimate. The former are also in the mountains while the descendants of the illegitimate are in Indiana. In 1856 the illegitimate son of number 1 came here to live. He and his family left their home because they could no longer make a living there. For two years the crops had failed to grow and no corn had been raised to make their bread and mush. Other people have said that it failed to grow because the family was too shiftless to tend it. The man and the three older children walked, while the wife and the two younger ones rode on an old broken down mule. He carried an iron skillet in his hand and when night came, he would cook what he could find or beg. Haystacks, barns, and sympathetic country folks furnished lodging. In this manner they finally reached the south-central part of Indiana.

There they made their home, and from that time until this they have rapidly multiplied and degenerated until their name is a synonym for shiftlessness. Eight more children were born in rapid succession, the last six of whom the mother never saw because of blindness. The descendants of these thirteen children form the first group, of whose occupations I wish to speak.

They live in or near a town of about 12,000 in the south-central part of Indiana. There is plenty of work in this town for unskilled laborers in the factories, stone quarries, and on the streets. But in spite of the fact that there is plenty of work, the majority of the Joneses are unemployed most of the time.

Those above the age of fifteen years have been used for the following figures: Out of fifty-seven men and women, fifty-four are feeble-minded. They have been found to be so in one of the three following ways: (1) by a formal examination in the laboratory; (2) by a judgment of the field worker where the condition was so apparent that no examination was necessary, and (3) where the person has been judged feeble-minded by his reaction to society. The normal individuals of Jones blood are the result of marriages into fairly good families, and each of these have normal consorts. They are self-supporting and do much to keep some of the relatives from becoming entirely dependent on the community.

Of those fifty-four feeble-minded men and women, thirty-four have received poor relief for the greater part of their lives; in poor relief I include also the poor asylum cases; ten have served sentences, and one has spent most of his life in an insane asylum. Four of the fifty-four have worked regularly, the other fifty only when the spirit moved them.

Fifteen have no occupation at all.
Seven do odd jobs.
Six are fairly good housekeepers.
Four are farm tenants.
Three work in factories as unskilled laborers.
Three are housemaids.
Three are prostitutes.
Two are washerwomen.
Two are stone quarry laborers.
One was a brakeman.
One is a wood cutter.
One is a barber.
One is in a slaughterhouse.
One is a well cleaner.
One is a street cleaner.
One is a hod carrier.
Seven per cent. of these are entirely self-supporting.
Twenty-nine per cent. are non self-supporting.
Sixty-three per cent. are partly self-supporting.

The simplest environment in which we find the Joneses living is down in the Kentucky mountains where living conditions are of the most primitive to be found. The district is so far from a railroad and the roads so nearly impassable that they have never been far from their homes. They raise all they eat and eat all they raise, or let it waste, because there is no market. So there is no incentive for folk to be ambitious, but to work just enough to feed and clothe themselves. On the other hand, it is necessary that they do have the needful things of life, for there is no kindly poor relief law to care for them, and oftentimes they are living so far from neighbors that they could starve before help would arrive.

Eighty-one adults who are, or should be, earning their living represent this group. Of this number fifty are feeble-minded and thirty-one are normal. The normal cases will be eliminated as they were in the Indiana group. Of the fifty feeble-minded people:

Sixteen have no occupation.
Fifteen are farm tenants.
Eight help at home.
Five are farmers.
Two hunt gingseng.
Two are bootleggers.
One is a prostitute.
One does odd jobs.
Total, 50.

Six of those listed as having no occupation are not dependents in the real sense of the word. They manage to live without work, but also without begging. They gamble, steal, and hunt. One entire family lives mostly on the squirrels the men are able to kill. Oftentimes their aim is so poor that they miss the squirrels and kill sheep. The remaining ten who are non-self-supporting, are idiots and imbeciles, who could not care for themselves in any environment, so this 20 per cent. is not really comparable to the 29 per cent of non-supporting individuals in the Indiana group. The people whose mentality was of the same level as the Indiana paupers, were all self-supporting in the simpler environment. And if we exclude those idiots and low grade imbeciles, we have no non-self-supporting mental defectives to compare with those of Indiana.

It may be that the simple environment is not responsible for these figures, but there are other instances where the feeble-minded are self-supporting in a relatively simple environment. In some of the European countries where the work history of a man is pretty well determined when he is born, and where he is bound by certain industrial conditions which we do not have here, there is less unemployment, tramps are fewer, and there is very much less unrest and changing about than among our subnormal laborers. In the institutions which are run on the colony plan, the inmates are taught to do certain things well, and are kept at those particular tasks by the men in charge. It is now the dream of some of the men interested in the problem of the care of mental defectives, that in the near future we can have large farms or colonies where these people can be kept at work, protected from the complex conditions of the outside world which they are unable to meet. And this will make it possible for them not only to take care of themselves, but to relieve society of the burden placed upon it by the crimes and other social evils to which this class is naturally addicted.

A Study of the Action of Bacteria on Milk Proteins.*

George Spitzer and H. M. Weeter, Purdue University.

It is generally recognized that most bacteria have an action on organic food material which is characteristic for different species and is influenced by their previous environment and the kind and relative proportion of the different foods in the media. As the food and water requirements of higher plant and animal life and of bacteria are similarly related, bacterial metabolism involves the change which the food materials undergo by virtue of bacterial action and is determined by the properties and composition of the end products. With the present chemical methods of analysis it is possible to determine with considerable degree of accuracy the initial composition of the bacterial foods, also the end products. Of what takes place within the organisms little is known. Inferences can only be drawn from the changes in the medium and the nature of the enzymes secreted by the bacteria. When bacteria are grown in a medium containing both proteins and carbohydrates it has been found that the cleavage products are modified, depending upon the source and chemical complexity of the protein and carbohydrates.

B. Coli, when grown in a nitrogenous medium in presence of easily fermentable carbohydrates, fails to produce indol or the production of indol is extremely rare, but when B. Coli is grown in a medium containing the same nitrogenous foods in presence of carbohydrates which do not ferment readily indol is produced. The character of the proteins likewise influences the growth and metabolism of bacteria and the cleavage products are not of the same kind and character. The proteins are hydrolized by bacterial enzymes into simpler complexes, such as proteoses, peptones, and possibly peptids and amino acids.

There is a marked difference depending on the source of nitrogen, and a still greater difference depending on the species of bacteria, in the production of cleavage products. According to Taylor (Ztschr. f. Physiol. Chem., Vol. 36), B. Coli digests casein mainly into proteoses and peptones with the formation of only a small per cent. of amino acids,

* "Contribution from Purdue University Agricultural Experiment Station, Department of Dairy Husbandry."

while when grown in egg meat mixture according to Rettger (Journal Bio. Chem., Vol., 13), this same bacterium produces profound changes, giving indol, skatol, and amino acids.

Also, the utilization of any of these simpler nitrogenous products of hydrolysis depends upon the life history and the species of the bacteria and of food material other than the nitrogen compounds; that is, carbohydrates, salts, etc. Concerning the utilization of the amino acids, under certain conditions the basic amino acids or diamino acids are used to a greater extent as a source of nitrogen instead of the monoamino acids, and the reverse may happen; the monoamino acids are used more readily and fail to appear in the final products.

From our own work during the past year on bacterial metabolism, unpublished data are at hand showing the utilization of the amino acids. Lots of 500 c. c. of sterile milk were inoculated with pure cultures of B. proteus, B. liquifaciens, B. subtilis, and B. megatherium. These lots of inoculated milk were stored at room temperature for six months. The nitrogen distribution was then determined, ammonia, melanin, amino acids, etc.

The following table shows the per cent. of monoamino and diamino acids obtained upon hydrolyzing the milk before inoculation, also the per cent. of the same amino acids after inoculation for six months.

TABLE I.

	Sterile Milk.		At End of Six Months' Incubation.	
	Monoamino Acid N. %	Diamino Acid N. %	Monoamino Acid N. %	Diamino Acid N. %
B. proteus	56.50*	23.66	42.14	5.61
B. liquifaciens	56.50	23.66	45.02	5.82
B. subtilis	56.50	23.66	54.14	7.61
B. megatherium	56.50	23.66	40.00	7.24

*Per cent. of total nitrogen.

In Table I the relative proportion of the utilization of the two groups of amino acids is shown for the four different bacteria. It will be noted that the diamino acids are used in greater amounts than the monoamino acids.

Table II shows the per cent. of the total monoamino and diamino acid nitrogen utilized by the four bacteria calculated from Table I.

TABLE II.

	Monoamino Acid N. %	Diamino Acid N. %
B. proteus	25.42	76.29
B. liquifaciens	20.32	75.40
B. subtilis	4.17	67.83
B. megatherium	29.15	69.40

In general, this is in agreement with the work of Robinson and Tartar (Journal Bio. Chem., Vol. XXX, page 135). However, this comparison can only be roughly made since their medium consisted of an aqueous soil extract plus a nitrogenous food material; i. e., fibrin, pepton, egg albumen, gliadin, and casein, with a small amount of carbohydrate in the form of mannite and synthetic solution of salts in addition to the salts extracted from the soil.

The pure cultures used by Robinson and Tartar were B. mycoides, B. subtilis, and B. vulgaris. The above facts concerning the utilization of the amino acids by bacteria are in harmony with the work of most investigators on bacterial metabolism. No doubt the utilization of the amino acids is influenced by the character and quantity of proteins and carbohydrates present in the media. We know, if carbohydrates are absent or hydrolyzed into compounds which do not yield the desired food material—namely, the carbon—as readily as the original carbohydrates, bacteria must necessarily derive their carbon supply from the protein or amino acids. There is no quantitative relation connecting the increase of acidity with the loss of carbohydrates by bacterial action on the respective carbohydrates. So some of the carbohydrates must be used in supplying energy to the organisms.

About six years ago, while the senior author was conducting an extensive investigation concerning the keeping qualities of butter when placed in cold storage, the results of the investigation suggested to him the advisability of taking up a systematic study of pure cultures of known bacteria in a medium composed of milk proteins in presence of carbon compounds such as lactose and lactic acid, etc.

By pursuing this method of investigation it will be possible to arrive at more definite information regarding the bacterial action on milk proteins and the character and quantity of the final cleavage products. The selection of the respective bacteria are those frequently found in milk, cream, and butter. By the selection of these bacteria and using a medium which is naturally present in milk products, we are able, in a great measure, to avoid introducing disturbing factors on the end products, also factors foreign to our previous work concerning the changes produced in stored butter.

Our preliminary study included the following bacteria: B. proteus vulgaris, B. viscosus, B. butyricus, B. mycoides, B. lactis acidi, B. mesentericus, B. liquifaciens, B. fluorescens putidus, B. subtilis, B. megatherium, and B. coli. The medium was sterilized milk to which the pure cultures were added and kept at room temperature. The pure cultures were previously grown in the same media and transfers were made three times before being used for experiment. At intervals of three days an analysis of the inoculated milk was made. The following products were determined each time the analysis was made: acidity, aldehyde number*, lactore (polariscope), ammonia (Folin's method), and nitrogen compounds not precipitated by phospho tungstic acid. This was continued for five periods or during a period of sixteen days. (First period four days.)

The following table shows the changes in the nitrogenous constituents of the milk and the change in lactose by the different bacteria at the end of the sixteenth day.

TABLE III.

Showing the per cent. of gain of ammonia (NH_3) and amid nitrogen based on total nitrogen and the loss of lactose based on the total lactose.

	Ammonia (NH_3), N. % Gain.	Amid, N. % Gain.	Lactose, % Loss.
B. proteus	5.42	1.63	27.65
B. viscosus	11.01	22.13	50.30
B. butyricus	4.49	6.59	23.04
B. mycoides	10.28	8.38	14.84
B. lactis acidi	2.04	1.88	34.87
B. mesentericus	10.28	12.38	62.92
B. liquifaciens	20.20	25.63	60.00
B. fluorescens putidus	1.46	2.13	17.83
B. subtilis	12.10	22.84	47.10
B. megatherium	7.34	24.64	54.11
B. coli	3.66	3.63	17.63

* The aldehyde number gave no more information concerning protein hydrolysis than did phospho-tungstic acid.

Ammonia, amid nitrogen, lactose, and acidity were estimated in the sterile milk before inoculation for the purpose of comparison. This gave for lactose 4.99 per cent., total nitrogen .56 per cent., and acidity .17 per cent. as lactic acid. Ammonia .89 per cent. and for amid nitrogen 2.87 per cent. based on total nitrogen present in the sterile milk.

The changes in acidity for the different bacteria are shown in Table IV.

TABLE IV.

Showing changes in acidity, expressed in per cent. of lactic acid, during the period of sixteen days.

	Per Cent. Lactic Acid.
B. proteus	.027
B. viscosus	.324
B. butyricus	.180
B. mycoides	.261
B. lactis acidi	1.161
B. mesentericus	.459
B. liquifaciens	.909
B. fluorescens putidus	.045
B. subtilis	.468
B. megatherium	.369
B. coli	.135

Comparing Tables III and IV, it is shown that the acidity of the milk medium is not in proportion to the loss of lactose, nor gain in ammonia. Therefore neither the production of ammonia nor the acidity is an exclusive measure of the activity of the organisms. It has been stated that the production of ammonia is an index of the metabolic activity of the organisms. This must be taken with some qualification inasmuch as proteolysis does not take place by leaps; that is, that the different cleavage products are produced in regular order, as proteoses, peptids, amino acids, etc., but it is more natural and in harmony with enzymic action on proteins and carbohydrates, that as soon as proteolysis begins, a series of simpler compounds are formed and all the cleavage products appear, the proportion depending upon the medium, kind of organisms, and enzymes produced by each specific bacterium. Since it is possible to measure the production amino acids and ammonia at short intervals with a good degree of accuracy, it has given additional evidence to show the mode and rate of the activity of bacterial metabolism and their proteolytic power.

Of the eleven bacteria studied there was a continual change in acidity from the first period until the last, except the lactic acid bacillus which produced its maximum acidity within the first period (four days) which was 1.61 per cent. as lactic acid. No change in acidity occurred after this period, nor was there any increase in ammonia. The amid nitrogen increased slightly at the expiration of four days and there was a agin of amid nitrogen of .0077 per cent. and at the expiration of the sixteenth day there was a gain of .0105 of amid nitrogen, a gain of .5 per cent. on total nitrogen, showing a continual proteolytic action due either to enzymes or auto-proteolytic digestion.

It may be noted that some bacteria utilizing the larger amount of lactose were also quite active in the production of ammonia and amino acids. On the other hand, in Table III the fermentation of lactose was proportionately greater than the production of ammonia and amino acids by B. proteus, B. butyricus, B. mesentericus, B. fluorescens put., and B. Coli.

We hope to study further the action of these organisms in pure culture on nitrogen from different sources, the effect of carbohydrates and also the associative action of these cultures on milk proteins.

Plastids.

D. M. Mottier, Indiana University.

(Abstract)

The major part of the results of an extended study on plastids and similar bodies in cells of various plants, of which the following is an abstract, has been published in the Annals of Botany, Vol. 32, pp. 91-114, 1918.

The investigation was concerned chiefly with the origin of leucoplasts and chloroplasts from their primordia, as found in meristematic cells. The primordia of leucoplasts and chloroplasts appear as very minute, granular or rod-shaped bodies, which multiply by direct division. From such primordia, leucoplasts develop as rounded or pear-shaped bodies with the starch inclusion accumulating within. In case the primordium is rod-shaped, the leucoplasts, in such tissues as the root tip of *Pisum*, take on the form of a hand mirror with the inclusion in the larger end.

In certain typical cases the primordium of the chloroplast may first become lenticular with a pale center and a densely-staining periphery. With further growth they finally assume the form present in the adult plant organ.

Morphologically the primordia of leucoplasts and chloroplasts are precisely alike. It may be of interest to note that the morphological identity of leucoplasts and chloroplasts was pointed out by A. F. W. Schimper about thirty-eight years ago. The following is a translation of his summary (Bot. Zeit., p. 899, 1880): "The results of this brief study show that the deep chasm hitherto supposed to exist between the starch formers in assimilating and in non-assimilating cells does not, in fact, exist. In cells free from chlorophyll there are definite organs which generate starch, and these organs are none other than undeveloped chloroplasts (Chlorophyllkörner), which under the influence of light are able to develop into the latter. On the other hand, chlorophyll grains are not always organs of assimilation merely, but they may, in the conducting tissues and in cells which contain reserve material, function as starch

formers in the non-assimilating cells; they produce starch from assimilated materials supplied by other parts of the plant."

It may be stated also that the origin and formation of starch grains as described by this brilliant Alsatian was essentially correct, as later studies of others have shown. At that date the technique which now so clearly brings out the primordia of plastids was unknown.

In the aleurone layer of the endosperm of *Zea Mays*, the primordia of the aleurone grains are first recognized as very minute, rounded granules which may stain densely and uniformly. As they increase in size, they become globular with a smooth and sharply-defined contour and reveal a pale or colorless center. They may be represented by making a minute circle with a pencil. As they become older, they increase in size and usually take on a pale yellowish or orange color with the stains used.

It may be remarked also that the starch grains in the endosperm of *Zea* originate in a similar manner and from primordia that are indistinguishable morphologically from those of the aleurone granules, with the difference that in the case of the leucoplasts the starch inclusion stains blue with gentian violet.

In addition to the primordia of the plastids mentioned, other similar though smaller bodies are present—frequently in very large numbers in the cells—which do not become either leucoplasts or chloroplasts. To these I have confined the term *chondriosome*. Such chondriosomes are especially well demonstrated in cells of the liverworts, *Anthoceros* and *Marchantia.*

The conclusion reached is that the primordia of leucoplasts and chloroplasts and the bodies here designated as chondriosomes are permanent organs of the cell, having the same morphological rank as the nucleus.

The function of chondriosomes is not known. It is generally conceded that they are concerned in certain metabolic activities of the cell. Being definite organs of the cell, they may be regarded also as playing some part in the rôle of heredity.

Variation and Varieties of Zea Mays.

Paul Weatherwax, Indiana University.

Indian corn is commonly known to be a very variable plant, and any farmer can name off-hand from a dozen to fifty more or less definite varieties. Many attempts have been made to dispose of the plant in a technical way by naming, describing, and classifying these varieties, but the layman, and even the botanist who has not made a special study of the subject, is much in the dark as to what nomenclature is advisable in speaking scientifically of corn. To point out briefly the range of variability of the plant and to discuss critically some of the technical names that have been applied to the varieties of corn is the object of this paper.

In all parts of the maize plant there is a striking variability of size. I have grown healthy plants in a normal environment which were eighteen inches tall at maturity; and plants twenty-four feet tall have been reported. Some plants have stems no larger than a lead pencil, and the stems of others measure six inches in circumference. The leaves and other vegetative parts vary proportionately.

Stalks of most varieties bear only one or two ears, but as many as ten well-developed ears have been seen on a single stalk. An ear may have from four to thirty rows of grains, and there is as great a variation in the number of grains in a row.

The fruit of the plant, being the economic part and the part best known, has been made the basis of most classifications. The pericarp varies from white through shades of pink, red, and yellow to a dark brown, and definite color patterns in the form of stripes are common. The endosperm is usually characterized by the development of a large amount of starch, but in sweet corn the starch is partly replaced by another carbohydrate. In physical character the endosperm is partly soft and partly corneous, and these parts have a more or less definite ratio and arrangement in each variety. The soft portion is always white; the corneous part may be white or yellow. The aleurone is white, red, or blue to black, and mixtures of either of these colors with white occur in definite patterns in some varieties. The largest grain I have ever seen weighed fifty-six times as much as the smallest. The fruits of most varieties are naked, except for the well-known covering of husks, but there is a variation from this in the podded types, each grain of which has a separate covering composed of the enlarged glumes and palets.

Still further illustrations of ordinary variability might be mentioned, but these will suffice. Besides these, there are some less common variations—sometimes termed mutations and sometimes reversions—which add interest to our investigations but complicate our classifications. A few examples may serve as illustrations. The production of male elements in female inflorescences or female elements in male inflorescences is of common occurrence, and varieties breeding true to these characteristics have, in some instances, been isolated. Emerson has a variety whose leaves have no ligules, and another—a dwarf variety—whose ears bear hermaphrodite flowers. Gernert has isolated a constant strain whose ear is a loose panicle.

The difficulty at the bottom of any attempt to classify the varieties of maize is in the perplexing lack of correlation between these variant characteristics. Some authorities maintain that definite correlations do exist, and others are as confident that they are almost if not quite independent of one another. The merits of either argument is irrelevant to our present consideration. That certain physical correlations do exist is accepted without argument, but all the genetic correlations that have ever been discovered are of little avail in classification. If the various characters had a tendency to remain in groups affording rigid types, a basis for classification would be provided; but, in a practical way, it seems possible to combine in a single plant or to separate at will any two characteristics which are not connected in any physical way, allelomorphs of course being excepted.

Pure botanists, as well as those prompted chiefly by a utilitarian motive, have taken their turn at the problem, and many articles have been published by experiment stations and other institutions. Without going into details, we might analyze the principles employed and see what progress has been made.

I have made no attempt at a thorough investigation of the tribulations through which the maize plant originally passed in getting itself named. Suffice it to say that all that we usually call maize or Indian corn passes technically under the name *Zea Mays* L., the generic root being the Greek name of some cereal, and the specific a corruption of an Indian name for the plant.

When a distinct variation from the described limits of a species is found, it is customary to make of it a new species or to include it as a variety of the parent species. Both systems have been applied to maize. Sturtevant adopted the plan of a trinominal nomenclature to distinguish seven varieties, as follows: *Zea Mays tunicata,* pod corn; *Zea Mays saccharata,* sweet corn; *Zea Mays indentata,* dent corn; *Zea Mays indurata,* flint corn; *Zea Mays everta,* pop corn; *Zea Mays amylea,* soft corn; and *Zea Mays amylea-saccharata,* a poorly-defined type, part soft and part sweet. Some later authorities have dropped the word *Mays* from these names, giving the types specific rank.

The inadequacy of either system is obvious on close examination. It is based upon a single set of characteristics, and in other respects each variety or species is subject to the full range of variation. In fact even these seven varieties are not distinct with regard to the set of charactristics which forms the basis of division; pod corn necessarily exists in one of the other six forms or in a mixture of them. The name of a species should stand for a description; its value is lessened as exceptions to this description are found, and utterly destroyed as soon as it overlaps other species so far as to render them indistinguishable. If the names stand for nothing but individual characters, then, it would be better to mention the character than the variety possessing it. There is also another disadvantage to the system; it establishes a bad precedent, which, with a little encouragement, would soon lead to a condition bordering on absurdity; in fact, I am not sure that it has not already reached that point. Upon this basis a number of new variety names have already sprung into existence, and more are due to arrive at any time. Blaringhem mutilates a corn plant and gets, or thinks he gets, as a result, a number of new varieties which breed true. To these he gives such names as *Zea Mays praecox,* a very precocious form indeed if we accept his interpretations, and *Zea Mays pseudo-androgyna, pseudo* because a *Zea Mays androgyna* already existed. Although his methods and conclusions are a trifle shady, his naming of the new forms illustrates the point in question. Seed companies advertise *Zea gracillima, Zea Mays gigantea quadricolor, Zea japonica,* and *Zea Curagua;* and the Department of Agriculture is now offering for distribution through the

Office of Seed and Plant Introduction a new discovery, *Zea guatemalensis*, which seems to be ordinary corn from Guatemala. Besides these we have a *Zea Mays chinensis* and a *Zea Mays pensylvanica*, and in this way we might continue until we run out of habitats and combinations of characteristics. Gernert's Branch Corn was hailed as a new seventh species, *Zea ramosa*. Emerson might have named his liguleless variety *Zea Mays aligulata* and his dwarf variety *Zea Mays pygmea-androgyna*, and Stewart or the writer might, on discovering the two-flowered condition of the female spikelets of Country Gentleman sweet corn, have reveled in the invention of some such name as *Zea Mays saccharata geminata*—but none of us did. The difficulty is not in finding new varieties or in naming those found, but in avoiding being led to more ridiculous ends—in stopping the naming process soon enough to permit a name to mean anything; for when anyone has made a complete list of all the varieties that he knows, someone else can always add a few more that he knows, or, if need be, make a few to order by judicious hybridization.

The cause of this confusion is easier to find than is its remedy. It lies in our limited knowledge of the evolutionary history of the plant. No wild form of corn has ever been seen by civilized man. When America was discovered, the plant cultivated by the Indians was almost as complex as it is today. We can, however, imagine the evolutionary process reaching a place where its product was a plant of more or less uniform character agreeing with the generic description of *Zea*. Further evolution, aided by reversion, then proceeded to produce in isolated environments a number of varieties possessing in definite combinations the various characteristics already mentioned. If we knew what these combinations were, we should have a basis for naming varieties. But the plant readily hybridizes with other varieties of its kind, and these different original types, brought together and mixed by the savage or semi-civilized agriculturist, gave us the heterogenous combination that we know corn to be. It is probably safe to say that there exists nowhere in the world today a primary variety of corn that has not been complicated by hybridization with some other variety. Hybridization with teosinte, one of the nearest relatives of maize, has added further difficulties in the tropics, and it is probably due to the limited habitat of teosinte as compared with that of maize, that the dividing line between the two genera has not long ago been obliterated. Few other plants, wild or cultivated, present these difficulties, because few others combine such a range of variability with such ease of hybridization.

I am fully aware that some of these latter remarks are not in accord with the commonly accepted theory of the hybrid origin of maize, but I do not believe that theory to be the correct explanation of the origin of the plant. My full discussion of that point will be presented elsewhere.

A specific name is to be understood as only an abbreviated description, and the only thing about maize that is constant enough to have a fixed description is the whole genus. It is true that in some variations it borders closely upon some other genera and even encroaches upon the territory allotted to another tribe of grasses, but its limits are sufficiently definite to obviate any doubt as to whether or not a plant under observation is corn.

The best taxonomic treatment, then, seems to be to consider *Zea* a monotypic genus and discard all other names than *Zea Mays* L. Reference to the numerous variations can be made to the characteristic directly and not to any arbitrary variety possessing that characteristic in varying combination with other properties.

Improved Technique for Corn Pollination.

Paul Weatherwax, Indiana University.

Many devices have been described for the control of pollination in various plants, and a number of these have been found especially serviceable in the extensive work that has been done in corn breeding. The best points of two or three of these methods have been combined and used successfully during the past year.

The protection of the female inflorescence is made of an 8x12 sheet of typewriter paper. Its construction can best be explained by reference to the accompanying diagram. (Fig. 1.) Half an inch along one end of the sheet is folded over and pressed down along AA; one side is similarly folded along BB, and the other along CC. One of these latter folds is glued down to the other, and the result is a long, flat envelope, open at both ends and reinforced at one end by the half-inch fold.

The glue employed may be any of the common brands that are purchased ready for use; this can be rendered almost insoluble by the addition of a small quantity of any readily soluble chromate and drying the pasted article in sunlight. To make the envelope waterproof, a solution of hard paraffin in benzole is applied with a tuft of cotton. The evaporation of the benzole leaves the paper dry and smooth but impregnated with paraffin.

The manipulation of the device is simple. It is usually best to remove the lamina of the leaf in whose axil the ear is borne and to slit its sheath down the sides. The reinforced end of the envelope is then slipped over the ear and made tight by means of a tuft of cotton stuffed in from below. The top of the envelope is folded over and fastened with a paper clip, which is tied loosely to the stem of the plant. (See Fig. 2.) When the silks have appeared, the clip is removed without untying from the stalk, the pollen poured in, and the clip replaced.

As the ear continues to grow, the string by which the clip is tied slips upward on the stalk, and little further attention is required. The tuft of cotton is compressed to make room for the increasing thickness of the ear, until the latter is large enough to burst the envelope without injury to itself. By this time the silks are usually no longer receptive.

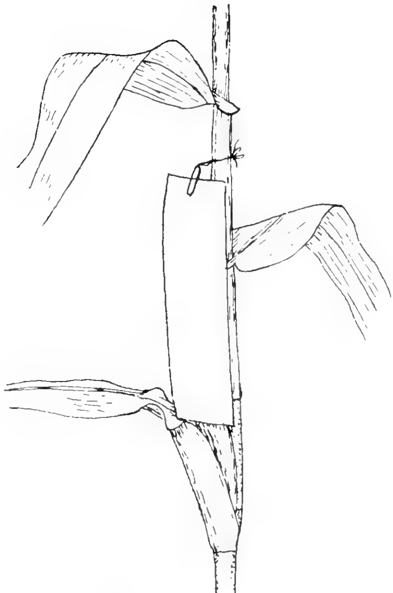


Fig. 1

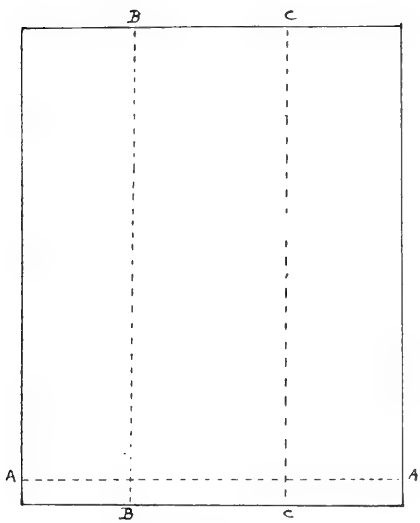


Fig 2

Technique for corn pollination.

The best method yet found for collecting the pollen is by means of ordinary paper bags, the size depending upon the size of the corn tassel. Early in the morning the bag is put over the tassel and tied or pinned around the stalk below. The anthers open soon after the sun begins to shine on the plants, and from 10:00 o'clock until noon is a good time to do the pollenizing. Pollen is shed most freely on warm, clear days.

The method here described has a number of distinct advantages when used with corn. The envelopes are easily made; after a little practice one person can make 25 or 30 in an hour. The worker is independent of the whim of any manufacturer, paper, twine, and paper clips being the only manufactured things that are necessary. The device is easily applied and easily manipulated; while the bag of pollen is held with one hand, the clip can be removed and the envelope opened with the other. The chance for contamination by stray pollen grains is minimized, for the envelope is never removed after being put in place, the silks are never touched by the hands, and the opening of the envelope exposes only a small surface for a short time. No umbrella or other protecting device is needed. The cover is well ventilated through the cotton, and the silks are protected from extremes of temperature, desiccation, or humidity. Well-filled ears have often resulted from a single pollination, and no failures have occurred which could be attributed to the lack of efficiency of the device.

While this method has been used chiefly with corn, it is capable of adaptation to other plants. The envelopes may be made in any size. When used over bisexual inflorescences to insure self-pollination, the envelope can be permanently closed at the top. A support can be provided when the plant is too small to hold the weight of an envelope large enough to cover its inflorescence.

A Comparison of the Plant Succession on Hudson River Limestone with that on Niagara Limestone, Near Richmond, Indiana.

M. S. Markle, Earlham College.

The outcrops of bed-rock in the vicinity of Richmond, Ind., consist of two kinds of rock, namely, Niagara limestone and Hudson River limestone. The marked differences between these two kinds of rock make a study of the plant succession on the outcrops very interesting.

The principal outcrop of the Hudson River limestone is in the gorge of the Whitewater River, where it passes through the city of Richmond. This gorge is about three miles long, 200-300 feet wide and up to 100 feet or more in depth. This gorge is supposed to have been formed immedi ately after the ice age.

Outcrops of Niagara limestone occur only south of the city, the principal ones being in the gorges below the falls at Elliott's Mills and at Elkhorn Mills, two and three miles southeast of Richmond, respectively. The present report is the result of a study of the outcrops in the Whitewater gorge and the gorge at Elkhorn Mills.

The principal differences between the two kinds of rocks is in their physical character. The Hudson River limestone is composed of alternate layers of calcareous shale and rather soft limestone. These constituents vary greatly in amount, the rock consisting in some places almost entirely of shale and in others almost entirely of limestone. Generally, however, they are about equal in amount. The Niagara limestone is not accompanied by shale, but consists entirely of hard thick-bedded limestone.

On account of the physical character of the Hudson River limestone, the plant succession in the Whitewater Gorge is very rapid for a rock cliff. The stage of the succession of any part of the cliff is due to the length of time that has elapsed since the cessation of active undercutting by the river. All stages of succession from the plantless rock to the climax mesophytic forest are to be found. The earliest stage in the succession occurs where the cliff is being actively eroded by the river.

The walls are almost vertical. No plants exist, except those hanging from the top of the cliff. In most successions on bare rock, lichens are the pioneer plants, being found in the most xerophytic situations. No lichens are found anywhere on the Hudson River limestone, on account, no doubt, of the unstable nature of the substratum. This plantless stage persists until after active undercutting by the stream has ceased.

Then the cliff becomes less steep. The talus accumulates undisturbed by the stream, and bears a considerable vegetation. In this stage occur the pioneer cliff plants, occupying the shelves formed by projecting layers of limestone. The most of the plants are annuals and many of them are plants that have slipped down from the top of the cliff. The following plants are common in this pioneer association: Ambrosia artemisiaefolia, Poa compressa, Lactuca scariola, Nepeta cataria, Melilotus alba, Dipsacus sylvestris, Aster spp.

The shale layers of the cliff change readily to soil, which is washed down by rains. Layers of limestone thus left projecting break off of their own weight and fall. With the consequent reduction in slope, an increasingly larger number of plants gain a foothold. In addition to some of the pioneer plants mentioned above occur the following: Equisetum arvense, Aster nova-angliae, Daucus carota, Heracleum lanatum, Melilotus officinalis, Verbascum thapsus, Elymus canadensis, Cornus paniculata.

Up to this point, the succession has been controlled almost entirely by physiogenic factors. The stage in succession depends upon the slope of the cliff. When, however, the slope has become sufficiently gentle to permit the accumulation of a layer of soil, biogenic factors, those due to other organisms, come in. The plants, particularly the grasses, hold the soil and retard the further degradation of the cliff. The slope of a portion of the cliff occupied by a mesophytic forest is about the same as that of a portion occupied by the bush stage. Each plant association prepares the way for the succeeding one by holding the soil, accumulating humus and providing shade.

The herbs are soon partially displaced by a bush association. The most common species is Rhus aromatica, which often forms large colonies. Cornus paniculata, Salix longifolia, Rhus toxicodendron, Vitus vulpina, crataegus, Psedera, Ptelea trifoliata Rubus, Ribes and others are accompanying species.

The shrub stage is succeeded by a xerophytic tree stage, corresponding probably to the usual oak-hickory stage. Ulmus americana is the pioneer tree. With it occur Celtis occidentalis, Crataegus, Robinia pseudo-acacia, Cercis canadenses, Prunus americana, Gleditschia triacanthos, Juglans nigra and Sambucus canadensis.

The pioneer tree association gradually merges into the ultimate stage of the region, the mesophytic forest. Mesophytism is indicated by the following species: Fagus grandifolia, Acer saccharum, Coprinus caroliniana, Ostrya virginica, Asimina triloba, Impatiens pallida, I. biflora, Viola cucullata, Galium spp.

For a more complete account of the succession in the Whitewater Gorge, see a paper by the writer in the proceedings of the Indiana Acadmy of Science for 1910.

The rock exposed in the gorge at Elkhorn Falls is Niagara limestone. The falls are occasioned by the presence underneath the hard Niagara limestone of a softer layer, which is probably Hudson River limestone. Below the falls is a gorge about one-half mile in length and 150 to 350 feet in width. On the walls of this gorge, various stages in plant succession may be observed.

In general, the earliest stages in the succession are to be found nearest the falls, though they may be found wherever a rejuvenescence of the succession has occurred. The pioneer association consists almost entirely of lichens, a large, gray, leathery species of Umbillicaria being the most prominent. This lichen covers the rock in all exposed situations, sometimes growing to a diameter of three inches.

The lichen association is followed by another, made up of a small black moss, probably a species of Grimmia, and such seed plants as Poa compressa, Nepeta cataria, Verbascum thapsus, Aster and Solidago.

These are succeeded, after further weathering of the rock and the accumulation of humus in the widening cracks, by an association dominated by Hydrangea arborescens and Aquilegia canadensis. These may be accompanied by Psedera quinquefolia.

The falls overhang a distance of 10 to 20 feet, on account of the weathering away of the softer lower stratum. For the same reason, the cliff soon becomes overhanging. This condition is more marked where stream action is prominent. Under these overhanging cliffs a very mesophytic association develops. Here occur Conocephalus, Cystopteris bulbifera, Camptosorus rhizophyllus, Pilea pumila, Aquilegia canadensis and Hydrangea arborescens. Psedera quinquefolia hangs in long streamers from the top of the cliff. On the edge of the cliff or on the talus beneath, where stream action is absent, occur Ulmus americana, Ostrya virginica, Prunus serotina, Celastrus scandens and Vitis. Under the cliff flourish such herbaceous plants as Sedum ternatum, Pilea pumila, Impatiens, Equisetum arvense, Eupatorium perfoliatum, Ambrosia trifida, Stellaria media, Galium, Carex and various mesophytic mosses. The mesophytic condition is due largely to the constant shade.

The vegetation becomes more and more mesophytic as the cliff becomes more overhanging. On account of the stability of the limestone, this may continue until the cliff overhangs to a surprising extent, but eventually overhanging portions of the cliff fall in large masses. This process is aided by the presence of prominent cleavage planes in two series at right angles to one another, but neither parallel to the edge of the cliff. The breaking off of the large masses gives the cliff a jagged appearance. The immediate result of the breaking off of a portion of the cliff is a rejuvenation of the succession. The mesophytic vegetation beneath the overhanging cliff is destroyed, both by being covered by the fallen fragments and by exposure. Stream action on the base of the cliff is hindered or rendered impossible by the covering of the soft underlying stratum. The stream is too weak to remove or wear away the fallen fragments. The fallen portions of the cliff eventually become covered with vegetation. The new, vertical faces of the cliff after a longer period are clothed with plants. Soil and humus accumulate more readily than before the interstices of the fragments, giving better conditions for the growth of trees. With the increase of shade, more mesophytic conditions prevail.

Slowly the edge of the cliff and the fallen masses of rock are crumbled by action of the weather. The result is finally a gentle slope with occasional remnants of the cliff projecting through the soil. The climax mesophytic forest does not occur here, though conditions approaching it are found at the lower end of the gorge. Tilia americana, Robinia pseudo-acacia, Morius rubra and Fraxinus americana are the principal trees, with an undergrowth of Sambucus canadensis and such herbs as Galium, Poa pratense, and Sedum ternatum.

On the whole, it would be difficult to find two rock-cliff successions more different than the two just described. The differences become more striking when it is considered that the two successions are both on limestone, in the same region and on cliffs extending in the same general direction. The principal differences are as follows: (1) The succession on Hudson River limestone is more rapid than that on Niagara limestone. (2) There is a striking contrast in the pioneer stages. The pioneer association on Hudson River limestone is characterized by the complete absence of lichens, liverworts, xerophytic mosses and ferns, all of which are prominent on Niagara limestone. (3) In the Whitewater Gorge, the degradation of the cliffs of Hudson River limestone is accomplished by the crumbling of the rock into small fragments, while at Elkhorn Falls the fragments of Niagara limestone are of many tons' weight. (4) On account of the overhanging character of the cliff at Elkhorn Falls, an intermediate mesophytic stage is introduced into the succession.

Notes on Microscopic Technique.

M. S. Markle, Earlham College.

During the past few years I have been using very successfully a method of staining a number of slides at one time, a description of which may be of interest to others who have occasion to prepare large numbers of slides for class use or for research. The principal features of the method were suggested to me by Miss Louise Sawyer of the Department of Biology of Beloit College.

As shown in the illustration, the slides are held between the soils of a brass spring about an inch in diameter, made of No. 13 wire and wound with the coils in contact. By holding the spring in the left hand and forcing the first two coils apart with the thumb nail, the first slide may be inserted. After this, pressure applied by the thumb upon the slide just inserted separated the coils for the reception of the next slide.

As staining jars, I am now using Bausch and Lomb preservation jars No. 15166 holding 600 c.c., but Stender dishes about 100 mm. deep might prove to be more satisfactory. Vessels to contain stains in which the slides rest for a time (such as safrannin) are more economical of stain if larger.

A coil long enough to hold 12 to 15 slides has been found to be most satisfactory. The spring is kept uppermost until the final xylol is reached, when the spring is reversed, allowing the slides to be pulled out one at a time for mounting. It is easy to hold the rest of the slides with one hand while removing a slide with the other.

The spring I am using was made by Orr and Lockitt, Chicago; a spring about 18 inches long cost 65 cents at that time. Any hardware dealer ought to be able to obtain such a spring.

I have found it desirable to use 3 jars of 95 per cent. alcohol as well as 3 jars of xylol in the series of reagents through which the slides are run. As the alcohol becomes loaded with stain or water, the lowest grade is discarded, each of the others is reduced one grade and the third jar refilled with pure alcohol. The same scheme is used for xylol. By this means, one always has one vessel of pure reagent. Economy of reagents and efficiency of work are facilitated.

Balsam may be kept from spreading beyond the cover-glass and leaving a halo on the finished slide by wiping off the slide with an absorbent cloth close to the sections before putting on the cover-glass. The balsam will then spread to the edge of the cover-glass and stop.

A small amount of valuable material may be made to serve for a larger number of slides, smaller covers may be used, sections may be better oriented and worthless sections discarded if sections are examined just after the paraffin ribbons are stretched. Desirable sections may be cut out by rocking a round-edged scalpel. By laying a new slide smeared with fixative on the table in close contact with the original slide, the sections may be transferred to the new slide with the point of a scalpel, after adding a few drops of water to facilitate the moving of the sections. The sections may be more easily examined while in the paraffin if a little Magdala red is added to one of the higher alcohols in which the material is dehydrated previous to imbedding. The small amount of stain absorbed will not affect future staining operations.

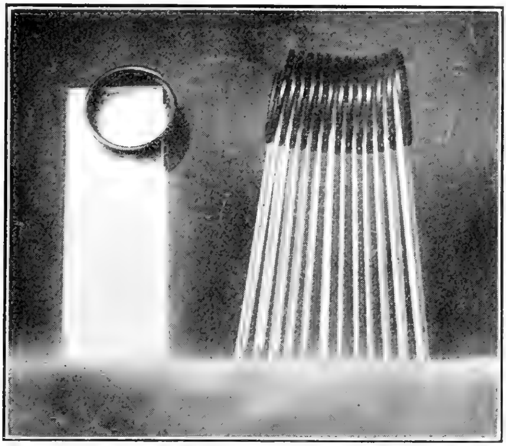
Female gametophytes in pine ovules usually shrink greatly when fixed and imbedded. This may be almost entirely obviated by cutting a slab off each side of the ovule before it is fixed. A Gillette razor blade is very satisfactory, since on account of its thinness it does not crush the material.

Seeds of the pinyon pine (Pinus edulis) are very satisfactory to illustrate the gross anatomy of the gymnosperm seed, since they are very large and easily dissected. The gametophyte and contained embryos or the embryos alone may be dissected out, soaked in water a short time, fixed and imbedded. They cut very easily.

A modification of Land's Fixative (See Botanical Gazette, Vol. LIX, page 397), has been used very successfully for refractory sections that will not adhere readily with egg albumen. Land's fixative dries very quickly, causing the liquid added to float the sections to spread with difficulty. By using the following formula, the liquid spreads as easily as with egg albumen:

2% gum arabic in water	50 c. c.
Glycerin	50 c. c.
Sodium salicylate	1 gram.

Use as egg albumen. Float sections on water slightly yellow with potassium dichromate. Stretch over warm plate. Melting the paraffin does not impair the efficiency of the fixative. When aqueous stains are used, no previous treatment is necessary; but when alcoholic stains only are to be used, it is best to set the slides for a short time in water to dissolve the excess of fixative adhering to the slide. Otherwise this precipitate will take the stain and spoil the appearance of the slide.



Method of holding microscopic slides in brass springs for staining.

This is best done before the paraffin is removed from the slides. The slides should be re-dried.

A hot-plate for stretching paraffin ribbons that is a great improvement over the old copper plate and gas flame may be made by putting an incandescent lamp in a box and making a glass lid. The heat is uniform. The glass plate gives better contact, though it is better to fill the space between the slide and the glass lid by putting a drop of water on the lid before placing the slide on it. A small box may be made of an ordinary chalk box, the sliding lid of which is replaced by a discarded photographic plate or other piece of glass. It is easier to remove the slides, however, if the lid is flush with the sides of the box.

The Ustilaginales of Indiana.[1]

H. S. Jackson—Purdue University.

The following list of the Ustilaginales or "smuts" of Indiana is based primarily on the material in the writer's herbarium and in that of the Purdue University Agricultural Experiment Station. All of the Indiana material in the herbarium of the New York Botanical Garden has also been included, most of the specimens deposited there being collections made in Indiana by Dr. L. M. Underwood during the period when he was connected with DePauw University. The only previous lists of the smuts of Indiana were included in the List of Cryptogams prepared by Dr. Underwood, which appeared in the Proceedings of the Indiana Academy for 1893, and in the Supplementary list of 1894. A total of sixteen species were recorded. A few other scattered records appear in the literature, several having been made in the various lists of the Fungi of Indiana, by Prof. J. M. VanHook, which have been published in the Proceedings at various times. No attempt has been made to include all the localities recorded for the more common species. In general only those specimens are listed which the writer has had an opportunity to examine. Several species are included, however, which are based on the distribution records in the monograph of the Ustilaginales by Dr. G. P. Clinton, published in the North American Flora Vol. 7, pt. 1, 1906.

The present list includes a total of forty-seven species on as many hosts. A large number of other species undoubtedly occur in our range. The writer would greatly appreciate it if collectors would furnish duplicates of specimens not recorded here, or which they may collect in the future, for use in preparing a supplementary list.

Acknowledgment is gratefully made to all those who have furnished specimens for study or who have assisted in any way in the preparation of the list.

[1] Contribution from the Botanical Department of the Purdue University Agricultural Experiment Station.

USTILAGINACEAE.

1. Cintractia Caricis (Pers.) Magn. Abh. Bot. Ver. Prov. Brand. 37:79. 1896.

Uredo Caricis Pers. Syn. Fung. 225. 1801.

ON CYPERACEAE:

Carex umbellata Schk., beech woods, ½ mile S. W. Chestnut Ridge, May 11, 1913, C. C. Deam 127116.

This species has a wide distribution in America as well as in other parts of the world where Carex species are native. It should be found on other host species in Indiana. The sori occur in the ovaries and when mature are rather conspicuous subspherical bodies 3-4 mm. in diameter.

2. CINTRACTIA JUNCI (Schw.) Trel. Bull. Torrey Club 12:70. 1885.

Caeoma Junci Schw. Trans. Am. Phil. Soc. II. 4:290. 1832.

ON JUNCACEAE:

Juncus diffusissimus Buckley, Versailles, Ripley County, June 18, 1915, C. C. Deam 16087.

Juncus tenuis Willd., Reynolds, White County, August 2, 1916, G. A. Osner.

3. CINTRACTIA LUZULAE (Sacc.) Clinton, Jour. Myc. 8:143. 1902.

Ustilago Luzulae Sacc. Myc. Ven. Spec. 73. 1873.

ON JUNCACEAE:

Juncoides campestre (L.) Kuntze, Greensburg, Decatur County, May 10, 1889, J. C. Arthur; Terre Haute, Vigo County, May 12, 1917, C. C. Deam 22959; Kramer, Warren County, May 18, 1917, C. C. Deam 23104; Salem, Washington County, C. C. Deam 23194.

Previously known from North America only from the one collection made in 1889 by Dr. Arthur at Greensburg, Ind. The sori are in the ovaries but are inconspicuous and hence easily overlooked. The species is doubtless of much wider distribution in this State than the above collections would indicate.

4. CINTRACTIA MONTAGNEI (Tul.) Magn. Abh. Bot. Ver. Prov. Brand. 37:79. 1896.

Ustilago Montagnei Tul. Ann. Sci. Nat. III. 7:88. 1847.

ON CYPERACEAE:

Rynchospora glomerata (L.) Vahl., Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains.

5. MELANOPSICHIUM AUSTRO-AMERICANUM (Speg.) G. Beck, Ann. Nat. Hofmus. Wien 9:122. 1894.

Ustilago austro-americana Speg. Anal. Soc. Ci. Argent. 12:63. 1881.

ON POLYGONACEAE:

Persicaria pennsylvanica (L.) Small, Plymouth, Marshall County, September 5, 1916, H. S. Jackson.

A species causing conspicuous hard black sori in the infloresence.

6. SCHIZONELLA MELANOGRAMMA (DC.) Schröt. Beitr. Biol. Pfl. 2:352 1877.

Uredo melanogramma DC. Fl. Fr. 6:75. 1815.

ON CYPERACEAE:

Carex pennsylvanica Lam., Shades, Montgomery County, May 16, 1913, F. D. Kern; Happy Hollow, Lafayette, Tippecanoe County, May 3, 1906, G. W. Wilson 5485; Battle Ground, Tippecanoe County, June 18, 1916, Evelyn Allison; Rochester, Fulton County, May, 1894, L. M. Underwood, Ind. Biol. Sur. 10, May 17, 1894, J. C. Arthur; Pine Creek, Warren County, May 5, 1917, G. N. Hoffer.

Carex picta Steud., Bloomington, Monroe County, May 25, 1917, J. M. VanHook 3746, June 9, 1917, C. C. Deam 23569; Brown County, June 16, 1912, C. C. Deam.

A very common species, occurring on the leaves, forming epiphyllous linear black sori, which superficially resemble those of a rust.

7. SOROSPORIUM CONFUSUM Jackson Bull. Torrey Club 35:148. 1908.

ON POACEAE:

Aristida sp., Elberfeld, Warrick County, October 4, 1916, H. S. Jackson.

An inconspicuous species the sori of which occur in the ovaries, which remain enclosed in the glumes. This species was formerly confused with *S. Ellisii*, which is now interpreted as occurring only on Andropogon.

8. SOROSPORIUM SYNTHERISMAE (Peck) Farl.; Farl. & Seym. Host Index N. Am. Fungi 152. 1891.

Ustilago Syntherismae Peck, Ann. Rep. N. Y. State Mus. 27:103. 1875.

ON POACEAE:

Cenchrus carolinianus Walt., Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains, Greencastle, Putnam County, October, 1892, L. M. Underwood, Ind. Biol. Sur. 6; Dayton, Tippecanoe County, November, 1917, H. S. Jackson.

Panicum dichotomiflorum Michx., Muncie, Delaware County, September 29, 1915, H. S. Jackson; Hammond, Lake County, October 14, 1914, F. J. Pipal.

The sori of this species as a rule cause the abortion of the entire infloresence.

9. SPHACELOTHECA SORGHI (Link) Clinton, Jour. Myc. 8:140. 1902.

SPORISORIUM SORGHI Link, in Willd. Sp. Pl. 6^2:86. 1825.

ON POACEAE:

Sorghum vulgare Pers. Muncie, Delaware County, September 29, 1915, H. S. Jackson; West Lafayette, Tippecanoe County, September 18, 1912, E. J. Petry, September 20, 1917, G. A. Osner, September, 1915, H. S. Jackson.

This, the kernel smut of sorghum, is evidently quite common. The head smut *S. Reilana*, which generally involves the whole inflorescence, has not yet been collected in Indiana.

10. USTILAGO ANOMALA J. Kunze, Wint. in Rab. Krypt. Fl. 1^1:100. 1881.

ON POLYGONACEAE:

Tiniaria scandens (L.) Small, Fern, Putnam County, September, 1893, L. M. Underwood, Ind. Biol. Sur. 1; Crawfordsville, Montgomery County, September 20, 1908, V. B. Stewart 8.

11. USTILAGO AVENAE (Pers.) Jens. Charb. Céréales 4:1889.

Uredo segetum Avenae Pers. Tent. Disp. Fung. 57. 1897.

ON POACEAE:

Avena sativa L., Greencastle, Putnam County, June 1893, L. M. Underwood; Lafayette, Tippecanoe County, 1893; J. C. Arthur (Und. Ind. Biol. Surv. 2); West Lafayette, Tippecanoe County, June 10, 1908, F. D. Kern, June 25, 1916, J. C. Summers; Holman, Dearborn County, 1889 (?), H. L. Bolley; Crawfordsville, Montgomery County, June 1892, E. W. Olive; Plymouth, Marshall County, June 29, 1916, G. A. Osner; Surrey, Jasper County, July 10, 1917, Chas. Chupp; South Bend, St. Joseph County, October 28, 1916, M. C. Gillis; Oaktown, Sullivan County, June 25, 1916, J. C. Summers; Lebanon, Boone County, July 17, 1916, P. S. Lowe; Griffiths, Lake County, July 27, 1916, G. A. Osner.

12. USTILAGO CALAMAGROSTIDIS (Fuckel) Clinton, Jour. Myc. 8:138. 1902.

Tilletia Calamagrostis Fuckel, Symb. Myc. 40. 1869.

ON POACEAE:

Calamagrostis canadensis (Michx.) Beauv., Plymouth, Marshall County, June 21, 1916, G. A. Osner.

Evidently a rather rare species, but having a wide distribution. The sori occur on the leaves and sheaths and in general features the species resembles *U. Striaeformis*.

13. USTILAGO CRAMERI Körn.; Fuckel, Jahr. Nass. Ver. Nat. 27-28:11. 1873.

ON POACEAE:

Chaetochloa italica (L.) Scribn., West Lafayette, Tippecanoe County, September 14, 1915, H. S. Jackson.

14. USTILAGO HORDEI (Pers.) Kellerm. & Swingle, Ann. Rep. Kans. Agr. Exp. Sta. 2:268. 1890.

Uredo segetum Hordei Pers. Tent. Disp. Fung. 57. 1797.

ON POACEAE:

Hordeum vulgare L., Lafayette, Tippecanoe County, July 2, 1891, J. C. Arthur; Auburn, Dekalb County, July 19, 1917, F. J. Pipal.

This is the so-called covered smut of barley. It is undoubtedly much more common than the above listed collections would indicate.

15. USTILAGO LEVIS (Kell. & Sw.) Magn. Abh. Bot. Ver. Prov. Brand. 37:69. 1896.

Ustilago Avenae levis Kell. & Sw. Ann. Rep. Kans. Agr. Exp. Sta. 2:259. 1890.

ON POACEAE:

Avena sativa L., Lafayette, Tippecanoe County, June 1890, J. C. Arthur, June 26, 1915, C. A. Ludwig (Barth. Fungi Columb. 4795);

Griffiths, Lake County, July 27, 1916, G. A. Osner; Greencastle, Putnam County, June 1893, L. M. Underwood; Lebanon, Boone County, July 25, 1916, P. S. Lowe; North Liberty, St. Joseph County, August 9, 1916, G. A. Osner.

16. USTILAGO NEGLECTA Niessl, Rab. Fungi Eur. 1200. 1868.

Erysibe Panicorum Panici-glauci Wallr. Fl. Crypt. Germ. 2:216. 1833.

Ustilago Panici-glauci Wint.; Rab. Krypt. Fl. 1[1]:97. 1881.

ON POACEAE:

Chaetochloa glauca (L.) Scribn., Lafayette, Tippecanoe County, 1893, J. C. Arthur (Und. Ind. Biol. Surv. 3); West Lafayette, Tippecanoe County, September 24, 1915, H. S. Jackson; Middletown, Henry County, September 30, 1915, H. S. Jackson; Argos, Marshall County, September 26, 1916, G. A. Osner.

17. USTILAGO NUDA (Jens.) Kell. & Sw. Ann. Rep. Kans. Agr. Exp. Sta. 2:277. 1890.

Ustilago Hordei nuda Jens. Charb. Céréales 4. 1889.

ON POACEAE:

Hordeum vulgare L., Manchester, Dearborn County, June 20, 1889, H. L. Bolley; Griffith, Lake County, July 27, 1916, G. A. Osner; Lafayette, Tippecanoe County, July 2, 1891, J. C. Arthur, June 22, 1917, H. S. Jackson; Fremont, Steuben County, June 27, 1910, O. S. Roberts; Auburn, Dekalb County, July 19, 1917, F. J. Pipal.

This, the loose smut of barley, is everywhere common and causes considerable loss each year. A collection made in the greenhouse showed infection on the sheaths and leaves as well as the infloresence.

18. USTILAGO PERENNANS Rostr. Overs. K. Danske Vid. Selsk. Forh. 1890:15. Mr. 1890.

Cintractia Avenae Ellis & Tracy, Jour. Myc. 6:77. S. 1890.

ON POACEAE:

Arrhenatherum elatius (L.) Beauv., Lafayette, Tippecanoe County, June 10, 1897, Wm. Stuart.

19. USTILAGO PUSTULATA Tracy & Earle, Bull. Torrey Club 22:175. 1895.

ON POACEAE:

Panicum dichotomiflorum Michx., Evansville, Vanderburgh County, October 4, 1916, H. S. Jackson.

20. USTILAGO RABENHORSTIANA Kühn. Hedwigia 15:4. 1876.

ON POACEAE:

Syntherisma sanguinale (L.) Dulac., Greencastle, Putnam County, October 1892, L. M. Underwood, Ind. Biol. Surv. 5; Oakland City, Gibson County, October 5, 1916, H. S. Jackson; Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains; Lafayette, Tippecanoe County, September 11, 1891, J. C. Arthur; West Lafayette, Tippecanoe County, September 3, 19, 1915, H. S. Jackson; Paoli, Orange County, September 27, 1915, H. S. Jackson; Marion, Grant County, October 11, 1915, F. J. Pipal; Plymouth, Marshall County, September 12, 27, 1916, G. A. Osner; Goshen, Elkhart Co., October 10, 1916, G. A. Osner; Evansville, Vanderburgh County, October 4, 1916, H. S. Jackson.

Perhaps the most common, at least the most frequently collected smut occurring on a native grass in our region. The entire infloresence is usually affected.

21. USTILAGO SPERMOPHORA B. & C. Sacc. Syll. Fung. 7^2:466. 1888.

ON POACEAE:

Eragrostis major Host., Middletown, Henry County, September 30, 1915, H. S. Jackson.

An inconspicuous but probably not uncommon species.

22. USTILAGO SPHAEROGENA Burrill, Sacc. Syll. Fung. 7^2:468. 1888.

ON POACEAE:

Echinochloa Crus-galli (L.) Beauv., Blooming Grove, Franklin County, September 7, 1913, C. A. Ludwig; Lafayette, Tippecanoe County, October 5, 1909, A. G. Johnson, October 1, 1916, H. S. Jackson.

23. USTILAGO TRITICI (Pers.) Rostr. Overs. K. Danske Vid. Selsk. Forh. **1890**:15. Mr. 1890.

Uredo segetum Tritici Pers. Tent. Disp. Fung. 57. 1797.

ON POACEAE:

Triticum vulgare (collective), Lafayette, Tippecanoe County, 1893, J. C. Arthur (Und. Ind. Biol. Surv. 4), June 20, 1916, H. S. Jackson; Greencastle, Putnam County, June 1893, L. M. Underwood; Brown County, May 1893, L. M. Underwood; Crawfordsville, Montgomery County, June 1892, M. B. Thomas; Wabash County, June 20, 1888, A. Miller 18; Plymouth, Marshall County, June 29, 1916, G. A. Osner; Petersburg, Pike Co., October 18, 1910, Blake A. Lamb; Mt. Vernon, Posey County, May 14, 1910, A. G. Johnson; Franklin County, July 1, 1912, C. A. Ludwig; Claypool, Kosciusko County, June 11, 1916, R. C. Hathaway.

The loose smut of wheat is undoubtedly present in all counties of the State and is estimated to cause a reduction in yield of 3-4 per cent for the State. This means that from one to one and one-quarter million bushels are lost annually from this disease.

24. USTILAGO STRIAEFORMIS (Westend.) Niessl, Hedwigia 15:1. 1876.
Uredo striaeformis Westend. Bull. Acad. Roy. Belg. 18^2:406. 1851.

ON POACEAE:

Agrostis alba vulgaris (With.) Thurb., Plymouth, Marshall County, June 22, 1916, G. A. Osner; Brazil, Clay County, June 22, 1917, G. A. Osner.

Phleum pratense L., Greencastle, Putnam County, May 1893, L. M. Underwood, Ind. Biol. Surv. 9; Plymouth, Marshall County, June 22, 1916, G. A. Osner; Lafayette, Tippecanoe County, June 24, 1898, Wm. Stuart; Monroeville, Morgan County, July 28, 1917, G. A. Osner.

Poa pratensis L., Plymouth, Marshall County, June 21, 29, 1916, G. A. Osner.

25. USTILAGO UTRICULOSA (Nees) Tul. Ann. Sci. Nat. III. 7:102. 1847.
Caeoma utriculosa Nees, Syst. Pilze 1:14. 1817.

ON POLYGONACEAE:

Persicaria amphibii (L.) S. F. Gray, Wabash County, October 16, 1890, A. Miller 10.

Persicaria pennsylvanica (L.) Small, Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains; Lafayette, Tippecanoe County, October 3, 1915, H. S. Jackson; Muncie, Delaware County, September 29, 1915, H. S. Jackson; Plymouth, Marshall County, September 5, 1916, G. A. Osner, September 5, 1916, H. S. Jackson; Oakland City, Gibson County, October 5, 1916, H. S. Jackson.

26. USTILAGO VILFAE Wint. Bull. Torrey Club **10**:7. 1883.

ON POACEAE:

Sporobolus neglectus Nash, West Lafayette, Tippecanoe County, October 23, 1912, E. J. Petry.

27. USTILAGO ZEAE (Beckm.) Unger, Einfl. Bodens 211. 1836.

Lycoperdon Zeae Beckm. Hannov. Mag. 6:1330. 1768.

Uredo Zeae Schw. Schr. Nat. Ges. Leipzig 1:71. 1822.

ON POACEAE:

Euchlaena mexicana Schrad., Bloomington, Monroe County, Summer 1917, P. Weatherwax.

Zea Mays L., Greencastle, Putnam County, October 1893, L. M. Underwood, Ind. Biol. Surv. 7; Plymouth, Marshall County, September 5, 1916, H. S. Jackson; Lebanon, Boone County, August 1, 1916, P. S. Lowe; Grovertown, Starke County, August 22, 1917, C. R. Hoffer; Lafayette, Tippecanoe County, September 1, 1917, G. A. Osner.

The common corn smut is known in every county of the State. Only a few localities are listed, which include those from which specimens are preserved.

28. USTILAGO sp.

ON POACEAE:

Secale cereale L., Bainbridge, Putnam County, June 1917, G. A. Osner; Lafayette, Tippecanoe County, June 5, 1917, G. A. Osner; Surrey, Jasper County, July 10, 1917, Chas. Chupp.

A loose smut of rye, indistinguishable in its morphological characters from the loose smut of wheat, U. Tritici, has been found in three fields in Indiana. Usually only a portion of the florets are infected. The exact status of this smut must remain in doubt till infection work has been conducted.

TILLETIACEAE.

29. DOASSANSIA DEFORMANS Setch. Proc. Am. Acad. 26:17. 1891.

ON ALISMACEAE:

Sagittaria latifolia Willd., Michigan City, Laporte County, September 13, 1916, H. S. Jackson and E. B. Mains.

This species causes considerable distortion of the affected parts. The collection recorded above consisted in the main of a distorted flower stalk.

30. DOASSANSIA OPACA Setch. Proc. Am. Acad. **26**:15. 1891.

ON ALISMACEAE:

Sagittaria latifolia Willd., Winona Lake, Kosciusko County, August 31, 1916, H. S. Jackson and G. N. Hoffer.

This species forms opaque spore balls in the mesophyll of the leaf causing considerable thickening.

31. ENTYLOMA AUSTRALE Speg. Anal. Soc. Ci. Argent. **10**:5. 1880.

ON SOLANACEAE:

Physalis pubescens L., Greencastle, Putnam County, October 1893, L. M. Underwood, Ind. Biol. Surv. 8.

Physalis subglabrata Mackensie and Bush, Urmeyville, Johnson County, November 1890, E. M. Fisher 816.

32. ENTYLOMA CRASTOPHILUM Sacc. Michelia **1**:540. 1879.

ON POACEAE:

Muhlenbergia mexicana (L.) Trin., Lafayette, Tippecanoe County, November 11, 1916, E. B. Mains.

This collection is referred to this species somewhat doubtfully. We have seen no other record of a species of Entyloma on this host species.

33. ENTYLOMA COMPOSITARUM Farl. Bot. Gaz. 8:275. 1883.

ON AMBROSIACEAE:

Ambrosia elatior L. (*A. artemisiaefolia* L.), Lafayette, Tippecanoe County, July 2, 1889, J. C. Arthur.

ON CARDUACEAE:

Senecio aureus L., Lafayette, Tippecanoe County, May 22, 1916, H. S. Jackson.

34. ENTYLOMA FLOERKEAE Holway; Davis, Trans. Wisc. Acad. **11**:170. 1897.

ON LIMNANTHACEAE:

Floerkea proserpinacoides Willd., Lafayette, Tippecanoe County, May 8, 1898, J. C. Arthur.

A rather rare species reported otherwise only from Illinois, Ohio and Wisconsin. The writer has also collected it in Delaware.

35. ENTYLOMA LOBELIAE Farl. Bot. Gaz. 8:275. 1883.

ON LOBELIACEAE:

Lobelia inflata L., Bloomington, Monroe County, Campus Indiana Univ., October 26, 1915, J. M. VanHook 3664.

36. ENTYLOMA MICROSPORUM (Ung.) Schröt.; Rab. Fungi Eur. 1872. 1874.

Protomyces microsporus Ung., Exanth. Pfl. 343. 1833.

ON RANUNCULACEAE:

Ranunculus septentrionalis Poir, Lafayette, Tippecanoe County, May 17, 1883, J. C. Arthur, May 29, 1894, K. E. Golden, May 1, 1906, G. W. Wilson 5473, October 29, 1916, H. S. Jackson.

37. ENTYLOMA POLYSPORUM (Peck) Farl. Bot. Gaz. 8:275. 1883.

Protomyces polysporus Peck; Thüm. Myc. Univ. 1813. 1881.

ON AMBROSIACEAE:

Ambrosia elatior L. (*A. artemisaefolia* L.).

Reported on the above host from Indiana by Clinton (N. A. Flora 7:62. 1906). We have not seen specimens.

38. ENTYLOMA SANICULAE Peck, Ann. Rep. N. Y. State Mus. 38:100. 1885.

ON AMMIACEAE:

Sanicula sp., Greencastle, Putnam County, May 1893, L. M. Underwood.

39. ENTYLOMA SPECIOSUM Schröt. & P. Henn. Hedwigia 35:220. 1896.

ON POACEAE:

Panicum dichtomiflorum Michx., Evansville, Vanderburgh County, October 4, 1916, H. S. Jackson.

Otherwise reported on this host (as *P. proliferum*) from North America only from Illinois. The specimen recorded above was obtained from the same plants on which *Ustilago pustulata* was collected.

40. ENTYLOMA VERONICAE (Wint.) Lagerh., Pat. & Lagerh. Bull. Soc. Myc. Fr. 7:170. 1891.

Entyloma Linariae Veronicae Wint.; Rab.-Wint. Fungi Eur. 3001. 1884.

ON SCROPULARIACEAE:

Veronica perigrina L., Lafayette, Tippecanoe County, April 18, 1916, May 6, 19, 1916, H. S. Jackson; Mt. Vernon, Posey County, May 11, 1916, H. S. Jackson.

A very common species in the vicinity of Lafayette, causing yellowish or whitish well defined spots on the leaves.

41. Tilletia laevis Kühn; Rab. Fungi Eur. 1697. 1873.

Ustilago foetens B. & C. Grevillea, 3:59. 1874.

On Poaceae:

Triticum vulgare (collective), Haw Patch, July 17, 1889; Jonesboro, Grant County, July 30, 1910, Neill and VanHook; Fort Wayne, Allen County, July 21, 1910, O. S. Roberts; Franklin, Johnson County, July 5, 1909, Comm. E. A. Feight; New Carlisle, St. Joseph County, July 10, 1917, G. A. Osner.

This, the "stinking smut" or "bunt" of wheat, is much more widespread in the State than the above distribution would indicate.

42. Tilletia Tritici (Bjerk.) Wint. Rab. Krypt. Fl. 1[1]:110. 1881.

Lycoperdon Tritici Bjerk. K. Sv. Vet.-Acad. Handl. 36:326. 1775.

On Poaceae:

Triticum vulgare L., New Carlisle, St. Joseph County, July 10, 1917, G. A. Osner.

This specimen consists of a single head found mixed with the preceding species. This species undoubtedly occurs not infrequently in the northern part of the State. It is not to be expected that it is as common as *T. laevis* however.

The report of the occurrence in Indiana of *T. Tritici* made in the Proceedings for 1915 (p. 396) has been found to have been based on an error in determination.

43. Urocystis Agropyri (Preuss) Schröt. Abh. Schles. Ges. Abth. Nat. Med. 1869-72:7. 1870.

Uredo Agropyri Preuss, in Sturm, Deutsh. Fl. III. 25:1. 1848.

On Poaceae:

Agropyron repens (L.) Beauv., West Lafayette, Tippecanoe County, May 30, 1915, C. R. Orton and F. D. Fromme.

Elymus virginicus L., Lafayette, Tippecanoe County, July 22, 1917, E. B. Mains.

44. Urocystis Anemones (Pers.) Wint.; Rab. Krypt. Fl. 1[1]:123. 1881.

Uredo Anemones Pers. Tent. Disp. Fung. 56. 1797.

On Ranunculaceae:

Anemone virginiana L., Lafayette, Tippecanoe County, April 24, 1906, G. W. Wilson.

Hepatica acutiloba DC., Lafayette, Tippecanoe County, May 29, 1893, J. C. Arthur, June 29, 1916, G. N. Hoffer.

45. UROCYSTIS CEPULAE Frost. Farl. Ann. Rep. Sec. Mass. Board Agr. 24. 175. 1877.

ON ALLIACEAE:

Allium cepa L.

Reported by Underwood (Proc. Ind. Acad. Sci. 1894:151. 1895), as occurring on onions in market, Putnam County, December 1893. Clinton (N. Am. Flora 7:57. 1906), also reports this from Indiana. A specimen in the N. Y. Botanical Garden, collected by Underwood in Indiana, is sterile. The species undoubtedly occurs in northern Indiana.

46. UROCYSTIS COLCHICI (Schlecht.) Rab. Fungi Eur. 396. 1861.

Caeoma Colchici Schlecht. Linnaea 1:241. 1826.

ON LILIACEAE:

Quamasia hyacinthina (Raf.) Britton, Lafayette, Tippecanoe County, May 30, 1907, F. Vasku, May 22, 1916, H. S. Jackson, May 1917, G. N. Hoffer.

These collections are referred here somewhat doubtfully. The writer is unaware of any record of the occurrence of Urocystis on this host genus though he has made similar collections in Oregon on a western member of the genus.

47. UROCYSTIS OCCULTA (Wallr.) Rab.; Klotzsch. Herb. Viv. Myc. II. 393. 1856.

Erysibe occulta Wallr. Fl. Crypt. Germ. 2:212. 1833.

ON POACEAE:

Secale cereale L., Plymouth, Marshall County, June 20, 1916, G. A. Osner; Avilla, Noble County, June 23, 1908, H. H. Whetzel; Lafayette, Tippecanoe County, June 1917, H. S. Jackson; Brainbridge, Putnam County, June 27, 1917, G. A. Osner.

The flag smut of rye is evidently not uncommon, but usually causes little damage.

HOST INDEX.

The Uredinales of Indiana II.[1]

H. S. Jackson, Purdue University.

The following records of Indiana rusts are presented at this time as the first supplement to the article by the writer on "The Uredinales of Indiana," which was published in the Proceedings of the Academy for 1915. All the unrecorded species which have come to hand since the publication of that list are included, together with a few forms which for one reason or another were omitted at that time.

A large number of collections have been examined which add many new localities and a number of new hosts for previously recorded species. These are not included in the present list but will be recorded at another time. The previous list contained records of 141 species exclusive of unconnected species of Aecidium. The latter are included in the present list and taken together with other accessions brings the number of species known from the State to a total of 155.

In order to avoid making new combinations the older and more familiar nomenclature is used.

The writer is under great obligation to all those who have been kind enough to furnish specimens for study, especially to Dr. J. C. Arthur, Prof. G. N. Hoffer, Mr. C. C. Deam and Mr. J. B. Demaree, who have placed their collections at his disposal.

UREDINACEAE.

142. Melampsora Euphorbiae-Gerardiana W. Müller, Centr. Bakt. 17^2:210. 1906.

On Euphorbiaceae:

Tithymalus commutatus (Engelm.) K. and Garcke, West of High Lake, Noble County, June 11, 1916, C. C. Deam 20083A; Wea Creek, S. W. Lafayette, Tippecanoe County, April 22, 1917, E. J. Petry.

The above are the only collections of this species from North America (Mains, Phytopath. 7:102. 1917).

[1] Contribution from the Botanical Department of the Purdue University Agricultural Experiment Station.

The second collection also bore some *Aecidium Tithymali.* Both species develop the sori on a diffused mycelium.

143. UREDINOPSIS ATKINSONII Magn. Hedwigia 43:123. 1904.

ON POLYPODIACEAE:

Dryopteris thelypetris (L.) A. Gray, Winona Lake, Kosciusko County, August 31, 1916, H. S. Jackson and G. N. Hoffer.

144. UREDINOPSIS MIRABILIS (Pk.) Magn. Hedwigia 43:121. 1904.

Septoria mirabilis Pk. Ann. Rep. N. Y. State Mus. 25:87. 1873.

ON POLYPODIACEAE:

Onoclea sensibilis L., Winona Lake, Kosciusko County, August 31, 1916, H. S. Jackson and G. N. Hoffer.

PUCCINIACEAE.

145. PUCCINIA ACETOSAE (Schum.) Körn. Hedwigia 15:184. 1876.

Uredo Acetosae Schum. Enum. Pl. Saell. 2:231. 1803.

ON POLYGONACEAE:

Rumex acetosella L., North Madison, Jefferson County, May 14, 1916, J. B. Demaree.

This is the first collection which we have seen of this species from any inland state. It is known otherwise only from Atlantic coast states and from near the Pacific coast in Oregon.

146. PUCCINIA LYSIMACHIATA (Lk.) Kern, Mycologia 9:215. 1917.

Aecidium Lysimachiae Schw. Schrift. Nat. Ges. Leipzig 1:67. 1822.

Puccinia Limosae Magn. Amtl. Ber. Vers. Deutsch. Naturf. u. Aerzte 1877:200. 1877.

ON PRIMULACEAE:

Naumbergia thyrsiflora (L.) Duby, Ligonier, Noble County, June 18, 1917, C. C. Deam 23665.

Aecia only have been collected in Indiana. Uredinia and telia are recorded from the eastern and middle western States on various species of Carex. No successful culture work has been conducted in America, the connection having been established by European authors.

147. UROMYCES HOUSTONIATUS (Schw.) Sheldon, Torreya 9:55. 1909.
Caeoma (Aecidium) houstoniatum Schw. Trans. Am. Phil. Soc. II. 4:293. 1832.

ON RUBIACEAE:

Houstonia caerulea L., Bennettsville, Clarke County, May 30, 1917, C. C. Deam 23260.

This species has uredinia and telia on Sisyrinchium sp., culture work having been conducted first by Sheldon (l. c.) and later confirmed by Arthur (Mycol. 1:237. 1909). The telia have not yet been collected in Indiana.

148. UROMYCES MAGNATUS Arth. Mycologia 9:311. 1917.
Aecidium magnatum Arth. Bull. Torrey Club 28:664. 1901.

ON CONVALLARIACEAE:

Polygonatum biflorum (Walt.) Ell., Ontario, Lagrange County, June 17, 1917, C. C. Deam 23642.

This aecidium has not before been reported from Indiana. It has recently been shown by Arthur (l. c.) to be connected with uredinia and telia on Spartina formerly included with *Uromyces acuminatus* Arth. (*Nigredo Polemonii* (Pk.) Arth.). The telia are indistinguishable from the collective species which has aecia also on various members of the Caryophyllaceae, Primulaceae and Polemoniaceae. This form is here listed under the distinctive name as the aeciospores are considerably larger than the forms on other aecial hosts belonging to the families mentioned above.

Telia have been collected in Indiana on *Spartina Michauxiana* and reported in previous lists under the collective name. Aecia are also known on *Polemonium reptans.*

149. UROMYCES SEDITIOSUS Kern, Torreya 11:212. 1911.

ON POACEAE:

Aristida ramosissima Engelm., Washington, Daviess Co., September 29, 1910, C. C. Deam 7618; Elberfeld, Warrick County, October 4, 1916, H. S. Jackson.

Aecia occur on various species of Plantago but have not yet been collected in Indiana.

UNCONNECTED FORMS.

150. AECIDIUM BOEHMERIAE Arth. Bull. Torrey Club 34:590. 1907.

ON URTICACEAE:

Boehmeria cylindrica (L.) Willd., Shades, Montgomery County, May 26, 1899, J. C. Arthur.

An unconnected Aecidium the relationship of which is uncertain. It has been collected otherwise only in Tacoma Park, District of Columbia.

151. AECIDIUM DICENTRAE Trel. Trans. Wis. Acad. Sci. 6:136. Nov. 1884.

ON FUMARIACEAE:

Bicuculla Cucullaria (L.) Millsp., Crawfordsville, Montgomery County, June 1893, E. W. Olive.

No clue to the relationship of this interesting aecidium is available.

152. AECIDIUM TITHYMALI Arth. Bull. Torrey Club 45:151. 1918.

ON EUPHORBIACEAE:

Tithymalus commutatus (Engelm.) Kl. & Garcke, Lafayette, Tippecanoe County, June 7, 1901, H. B. Dorner, 1905, G. W. Wilson, May 13, 1910, F. D. Kern and T. Billings, April 27, 1917, E. J. Petry; Crawfordsville, Montgomery County, May 17, 1913, F. D. Kern.

While many attempts have been made to culture this presumably heteroecious form, no success has been met with and its relationship is still in doubt. It has formerly been commonly reported as *A. Euphorbiae* Pers., now interpreted as a European species not occurring in America.

153. AECIDIUM HYDNOIDEUM B. & C. Grevillea 3:61. 1874.

ON THYMELIACEAE:

Dirca palustris L., Crawfordsville, Montgomery County, 1893, E. W. Olive; Everton, Fayette County, June 24, 1913, May 14, 1915, C. A. Ludwig (Barth. N. A. Ured. 901; Fungi Columb. 4501); West Lafayette, Tippecanoe County, June 5, 1911, G. N. Hoffer; Urmeyville, Johnson County, 1890, E. M. Fisher 929.

A very distinct and quite common heteroecious form which has not been successfully connected, though many attempts at culture have been made.

154. AECIDIUM PHYSALIDIS Burrill, Bot. Gaz. 9:190. 1884.

ON SOLANACEAE:

Physalis heterophylla Nees, Wea Creek, below Elston, Tippecanoe County, June 27, 1900, Wm. Stuart.

A distinct form developing from a diffused mycelium. Only pycnia are present in the specimen listed above though the species has frequently been observed in this locality. Another collection is reported by Underwood.

155. AECIDIUM TRILLII Burrill, Bot. Gaz. 9:190. 1884.

ON TRILLIACEAE:

Trillium sp., Lafayette, Tippecanoe County, June 1894, K. Golden.

Reported by Miss Lillian Snyder in the Proceedings for 1896, p. 218. No specimens have been seen. A rather rare species whose relationship is unknown.

A Suspected Case of Stock Poisoning by Wild Onion (Allium Canadense.)[1]

F. J. Pipal, Purdue University.

On June 23, 1917, a case of live-stock poisoning had been reported by Mr. William Feldt, living about five and one-half miles southeast of Lafayette. Dr. G. M. Funkhouser, of Lafayette, who investigated the case, reported, in substance, the following facts:

Five cows and one heifer were taken from a timothy pasture, which was rather dry and short at that time, and turned into a woods pasture on Sunday morning. In the evening of the same day, only four cows and the heifer returned from the pasture to the farm barnyard. The fifth cow was found in the pasture lying down and unable to get up. When the cows were milked it was noticed, with one exception, that the milk emitted a very strong and offensive odor and had considerably decreased in quantity. The breath of the cows was also strongly tainted with this odor and, in fact, it seemed that their whole bodies exhaled it.

On the following morning the doctor found the cow left in the pasture in a complete paralytic condition, her temperature, however, being quite normal; she died two days later. One of the cows in the barnyard was, by this time, in a similar condition and died the same day. One of the remaining three cows stood with her head erect, the hair bristling, and refused to move. Another had a tendency to draw her head to one side and when compelled to move went around in a circle and fell down. The third had a staring attitude and also a tendency to move in a circle. The temperature of all three animals was normal. All died on the following day. The heifer also had a staring attitude and in addition showed signs of cerebral disturbance, acting rather wildly.

The post-mortem examination showed that the inside membrane of the paunch was strongly affected, appearing as though scalded and

[1] Contribution from the Department of Botany of the Purdue University Agricultural Experiment Station.

sloughing off very readily. The feces of the affected animals were comparatively thin and very dark. The intestinal tract was inflamed and

Wild Onion (Allium canadense).

showed effects similar to those produced by gastro-enteritis. The contents of the paunch also emitted a very strong odor identical with that noted in the milk.

In treating the animals cathartics and stimulants were administered, but, as already stated, all cows died and only the heifer survived after a long struggle. It may be of interest to note that this heifer refused feed for several days after becoming poisoned; however, when a bunch of wild onions was offered to her, she displayed a greedy appetite for it and would have devoured it had she been permitted to do so.

The strong odor detected in the milk, breath and the paunch of the poisoned animals closely resembled that of wild onion and provided a clue for the probable cause of poisoning. In making a close search of the pasture in question a good-sized patch of wild onion (Allium canadense) was found. No other poisonous plants were noticed. The onion patch showed much evidence of recent grazing and it appeared quite certain that the cows had partaken of the onions. The plants in question were nearly mature, each having a cluster of a dozen or more aerial bulblets. The leaves were nearly all dried and the stems were rather tough. It was quite apparent, therefore, that the aerial bulblets formed the main portion of the cows' feast.

All evidence seemed to point to the onions as the cause of the poisoning. This particular species and its close relative, wild garlic (Allium vineale), are well known to taint dairy products and the flesh of animals feeding on them in the pastures of southern Indiana. In addition to the tainting effect, they may also produce colic and diarrhoea, especially in horses. No effects of more serious consequence, however, were ever recorded. All kinds of live-stock are fond of wild onions and garlic and will usually take them in preference to any forage plants. However, the plants are generally eaten, whenever found in the pastures, in their tender leaf stage early in the spring. The young plants are very mild in flavor as compared with the mature plants, especially the aerial bulblets. The oil which gives the plants their characteristic odor and which may seriously affect the grazing animals, is, undoubtedly, developed in greater proportion in the bulblets than in the foliage of the young plants. This may account for the fact that young plants cause no serious poisoning while plants with fully developed aerial bulblets are liable to prove of serious consequence when eaten in excessive quantities, especially if the stock is not accustomed to them. Two other heads of stock had been in the pasture in question throughout the spring months and no doubt pastured on the onions. Owing to the reasons stated above, however, they did not seem to be troubled in any way. The poisoned animals were turned in from a pasture in which good feed was very scant and coming upon the onion patch, they undoubtedly gorged themselves with the succulent onion bulblets.

Literature on poisonous plants records no case of live-stock poisoning due to wild onion. The Lily family, to which wild onion belongs, contains several poisonous plants, the most dangerous of which are, perhaps, Death Camas and Colchicum, the latter species containing an alkaloid known as colchicin ($C_{22}H_{25}NO_6$). It is said[2] that "the animals which eat the plant (Colchicum) suffer with acute gastro-enteritis, coma, staggering, weak pulse and increased urination." Inasmuch as the cows in question showed some of these symptoms, particularly the first three, it appears probable that the onion bulblets contained some poisonous principles similar to those of Colchicum. Allium unifolium,[3] a close relative of Allium canadense, is said to be poisonous in California.

Pammel[4] mentions a report published by Dr. W. W. Goldsmith in the Journal of Comparative Pathology and Therapeutics, and later abstracted in the American Veterinary Review (36:63), by Prof. A. Liautard, upon cattle poisoning, caused by the garden onion. The following facts are submitted:

"Loads of onions partly started to shoot and partly decayed, were unloaded in a meadow where nine head of cattle were grazing. After a week the cattle seemed sick and one died, displaying the following symptoms: Intense onion odor; tucking up of flanks; constipation in some; purging freely in others; one vomited abundantly; another very ill, grunted, was much constipated, staggered in walking, was very tender in loins, temperature 103°, urine dark and smelling of onions. Treatment: Feeding with soft food and hay. Large doses of linseed oil. One animal that was very ill got also extract of belladonna and carbonate of soda. All but one of the animals recovered. At the autopsy of the dead one, the rumen was found inflated and also the bowels. Liver enlarged and of light color. Kidneys dark green and with offensive odor. Rumen contained large quantity of onions and grass. The whole carcass and organs smell of onions."

[2] Pammel: Manual of Poisonous Plants, Part II, Page 375.
[3] Pammel: Manual of Poisonous Plants, Part I, Page 104.
[4] Pammel: Manual of Poisonous Plants, Part II, Pages 383-384.

The oil which gives all species of the onion family their characteristic odor, consists of oxide and sulfides of allyl. According to the National Dispensatory, rectified oil contains mainly a sulfide compound $(C_3H_5)_2S$. This compound is said to possess a stimulating effect upon the organs of the digestive system. If taken in excessive quantities it produces nausea, vomiting, colic and diarrhoea. When in contact with the skin it reddens it and may even vesicate it. In mucous membranes this effect would no doubt be even more pronounced.

In summarizing the evidence pointing to wild onion as the probable cause of poisoning the cows in question, the following facts stand out prominently:

1. Apparently healthy cows were taken from a pasture where feed was scant and turned into a woods pasture where they found and grazed heavily on a patch of succulent wild onions.

2. Symptoms of poisoning appeared within twelve hours after pasture was changed.

3. The attending veterinary found no other cause, aside from forage poisoning, which might have been responsible for the condition of the affected cows.

4. The characteristic odor of wild onion was strongly pronounced in the milk and the whole system of the poisoned animals.

5. No other plant was found in the pasture, aside from wild onion, to which the poisoning could be attributed.

6. The poisoned cows refused to eat any ordinary feed, but when one of them was offered a bunch of wild onions she manifested a greedy appetite for them.

7. The oil which gives the species of Allium their characteristic odor is known to have an irritating effect on skin and membraneous tissues, and causes digestive disturbances if taken in excess. The bulblets of wild onion undoubtedly contain this oil in comparatively large quantities.

8. A number of plants closely allied to wild onion are definitely known to be poisonous, and some of the symptoms of poisoning produced by them, such as gastro-enteritis, coma, and paralysis, are quite similar to those shown by the cows in question.

II. Additions to the List of Plant Diseases of Economic Importance in Indiana.[1]

George A. Osner, Purdue University.

The following list of plant diseases represents collections and observations made by the writer and other members of the staff of the Botanical Department of the Agricultural Experiment Station, mainly during the past season. Specimens of the diseases listed have been deposited in the herbarium of the Department of Botany, Purdue University Agricultural Experiment Station. Unless otherwise stated the collections were made by the writer.

Barley, (*Hordeum* sp.).

Leaf Spot. *Helminthosporium sativum* P. K. B. Tippecanoe, June, 1917 (H. S. Jackson). *Helminthosporium teres* Sacc. Tippecanoe, June, 1917.

Bean, (*Phaseolus vulgaris* L.)

Leaf Spot. *Phyllosticta phaseolina* Sacc. Wells, August, 1917 (H. V. Knight). This disease has been reported previously on cowpeas.[2]

Mosaic. Cause not known, Allen, July, 1917; Tippecanoe, August, 1917. This disease was very common during the past season.

Bean, Lima (*Phaseolus lunatus* var. *macrocarpus* Benth.).

Mosaic. Cause not known. Marshall, August, 1916; Tippecanoe, July, 1917.

Blue Grass (*Poa pratensis* L.).

Ergot, *Claviceps microcephala* (Wal.) Tul. Tippecanoe, July, 1917. This disease has been reported previously on orchard grass and timothy.[3]

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[1] This list is supplementary to "A List of Plant Diseases of Economic Importance in Indiana," by F. J. Pipal, Ind. Acad. Sci. Proc. 1915: 379-413, and to "Additions to the List of Plant Diseases of Economic Importance in Indiana," by Geo. A. Osner, Ind. Acad. Sci. Proc. 1916: 327-332.

Contribution from the Department of Botany, Purdue University Agricultural Station, Lafayette, Indiana.

[2] Osner, Geo. A. Ind. Acad. Sci. Proc. **1916**: 328.

[3] Osner, Geo. A. Ind. Acad. Sci. Proc. **1916**.

Leaf Smut. *Ustilago striaeformis* (West.) Niessl. Marshall, June, 1916; Tippecanoe, July, 1917. (See also under red top.) This disease has been reported previously on timothy.[4]

Calendula (*Calendula officinalis* L.).

Root Rot. *Corticium vagum* B. & C. Tippecanoe, July, 1917 (C. C. Rees). This disease has been reported previously on carnation, celery, potato and bean.[5]

Clover, Red (*Trifolium pratense* L.).

Leaf Spot. *Cercospora zebrina* Pass. Tippecanoe, July, 1917.

Cucumber (*Cucumis sativus* L.).

Leaf Spot. *Stemphylium Cucurbitacearum* Osner. Marshall, September, 1915; St. Joseph, September, 1915 (W. W. Gilbert); Marshall, St. Joseph, Starke, September, 1916.

June Berry (*Amelanchier Botryapium* D. C.).

Leaf Spot. *Fabrea maculata* (Lev.) Atk. Jasper, July, 1917 (Chas. Chupp). This disease has been reported previously on quince and pear.[6]

Mignonette (*Reseda* sp.).

Leaf Spot. *Cercospora Resedae* Fckl. Tippecanoe, August, 1907 (H. B. Dorner).

Pansy (*Viola tricolor* L.).

Leaf Spot. *Ascochyta Violae* Sacc. Tippecanoe, July, 1917 (F. J. Pipal).

Potato (*Solanum tuberosum* L.).

Leaf Roll. Cause not known. Laporte, Tippecanoe, July, 1917.

Mosaic. Cause not known. Tippecanoe, September, 1917.

Silver Scurf. *Spondylocladium atrovirens* Harz. Tippecanoe, August, 1917; Laporte, Floyd, December, 1917.

Wilt. *Fusarium oxysporum* Schl. Tippecanoe, Lake, August, 1917.

Raspberry (*Rubus* sp.).

Yellows. Cause not known. Laporte, August, 1917.

Red Top (*Agrostis alba* var. *vulgaris* (With.) Thurb.).

Leaf Smut. *Ustilago striaeformis* (West.) Niessl. Marshall, June, 1916; Clay, June, 1917. (See also under blue grass.)

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[4] Underwood, L. M. Ind. Acad. Sci. Proc. **1893**: 48. Pipal, F. J. Ibid. **1915**: 394.

[5] Osner, Geo. A. Ind. Acad. Sci. Proc. **1916**: 328, 331. Pipal, F. J. Ibid. **1915**: 383.

[6] Pipal, F. J. Ind. Acad. Sci. Proc. **1915**: 391, 392.

Rye (*Secale cereale* L.).

Anthracnose. *Colletotrichum cereale* Manns. Tippecanoe, June, 1917; Monroe, Allen, July, 1917 (F. J. Pipal). Severe losses were caused by this disease in several fields during the past season. This disease has been reported previously on blue grass, timothy and wheat.[7]

Stem Smut. *Urocystis occulta* (Wal.) Rab. Marshall, June, 1916; Tippecanoe, Putnam, June, 1917.

Loose Smut. *Ustilago* sp. Tippecanoe, Putnam, June, 1917; Jasper, July, 1917 (Chas. Chupp). This disease was rather rare in the three fields in which it was discovered. The fungus shows close resemblance to *Ustilago Tritici* (Pers.) Jens., but in the absence of cross inoculations it is retained as Ustilago sp.

Sunflower (*Helianthus* sp.).

Leaf Spot. *Cercospora Helianthi* E. & E. Tippecanoe, July, 1907.

Turnip (*Brassica Rapa* L.).

Albugo candida (Pers.) Rouss. Tippecanoe, October, 1915 (G. N. Hoffer). This disease has been reported previously on a number of other hosts.[8]

Wheat (*Triticum vulgare* L.).

Ergot, *Claviceps purpurea* (Fr.) Tul. Tippecanoe, Elkhart, July, 1917; Jasper, July, 1917 (Chas. Chupp). This disease has been reported previously on rye.[9]

Stinking Smut, *Tilletia Tritici* (Bjerk.) Wint. This species was reported by Pipal in 1915.[10] Further examination shows that the specimen on which the report was based was mislabeled, the species really being *Ustilago Tritici* (Pers.) Jens.

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[7] Pipal, F. J. Ind. Acad. Sci. Proc. **1915**: 384, 394, 395.

[8] Underwood, L. M. Ind. Acad. Sci. Proc. **1893**: 31; 1894: 153.
Wilson, G. W. Ibid. **1907**: 81.
Van Hook, J. M. Ibid. **1910**: 206.
Pipal, F. J. Ibid. **1915**: 392.

[9] Underwood, L. M. Ind. Acad. Sci. Proc. **1893**: 41.
Wilson, G. W. Ibid. **1894**: 157.
Pipal, F. J. Ibid. **1915**: 393.

[10] Pipal, F. J. Ind. Acad. Sci. Proc. **1915**: 396.

Reaction of Culture Media.

H. A. Noyes, Purdue University.

The reaction of culture media has worried every bacteriologist at some time in his career. During the past two years there have appeared several papers, in American publications, dealing with the reaction of bacteriologic culture media. Among these may be mentioned those by Clark (1), (2), (3), (4); Itano (5); Anthony and Ekroth (6). Clark and Lubs have presented papers (3) and published a series of articles entitled, "Colorimetric Determination of Hydrogen Ion Concentration and Its Applications in Bacteriology" (4). This work, as well as all papers published to date, including those presented at the 1916 meeting of the American Society of Bacteriologists shows that bacterial activities in general are greatest when the culture medium is neutral or approximately so. A simple, practically neutral medium is most desirable for general use. Anything which tends to produce or make it necessary to adjust acidity should be avoided if possible.

Evidence points to physical and chemical laws applying to culture media just as well as they do to water solutions of pure salts, the only difference being, media are more complicated and not as fully understood. Bacteriological media are of two kinds, liquid and solid. This paper is almost entirely confined to solid media. The bases of solid media are usually agar agar, gelatin or silicate jelly. Chemicals are added to these bases to furnish food for bacterial life and to make the reaction of the media such, that bacteria may thrive. More attention has been paid to the adding of chemicals for supposed food values than to the ascertaining of the reactions that take place between the chemicals themselves and the basis of the media.

Acidity or alkalinity of culture media are due to the nature of the basic substance used in making the media, and to the nature of the chemicals added to this base. The resultant equilibrium, produced by physio-chemical phenomena, notably ionization and hydrolysis, as influenced by mass action, temperature and pressure determines the reaction of the culture media.

The two principal methods now employed to determine the reaction of media are the determination of the hydrogen ion concentration by means of the hydrogen electrode, and the total titratable acid present as determined by titration. The hydrogen electrode was applied to biochemistry by Sorensen (7). Since 1912 several investigators have used the hydrogen electrode in the study of bacterial activities. Among these are Michaelis and Marcola (8); Brunn (9); Clark (1); Itano (5); and Clark and Lubs (10).

The advantages of the hydrogen electrode in bacteriological work are claimed to be that it gives the hydrogen ion concentration the bacteria are in contact with and that it can be used advantageously in colored solutions. Its disadvantages are that it can not be used in solid media and that for every grouping of chemicals there is a new electro chemical problem. Different investigators working with the hydrogen electrode, from a purely scientific point of view, have not agreed on the contact potential between 0.1 N. HCl.—0.1 N. KCl. (11).

This paper is written not to find fault with the hydrogen electrode in its applications to bacteriology but to point out some factors in the making of culture media and in the controlling of its reaction that are as important as the method by which the reaction is determined. It is (so-called) acidity due to the crude methods of making media that is discussed in the following paragraphs.

Hot Solutions.

The usual procedure followed in titrating culture media is crude. Titrations are conducted in hot solutions (12). Hydrolysis increases with temperature and titrations of culture media containing meat, peptone, gelatine, agar agar or plant extracts when made at high temperatures are much greater than they would be at lower temperatures. The difference between hot and cold titrations is often more than the titration of the media at room temperature. Clark (1) mentions a 10 per cent gelatine, 1 per cent peptone, and 5 per cent meat media titrating plus 1.0 per cent acid when hot and plus 0.5 per cent acid at room temperature.

Small Aliquots.

Too small aliquots of media are generally used. Aliquots are pipetted or poured out from graduated cylinders. These methods of taking aliquots allow errors as great as 10 per cent of the 5 cc. aliquot taken. An error of .5 cc., which is easily made with a graduate, means an error of 10 cc. per 100 cc. of media. Again an error of .05 cc. (one drop) of N/10 alkali in titrating means an error of plus or minus 0.1 per cent in the calculated acidity.

INDICATOR.

Large amounts of indicator are used. In the literature and in the standard methods (12) 1 cc. of a ½ per cent solution of phenolphthalein is specified. In accurate chemical work the amount the mass of indicator affects the accuracy of the determination is taken into consideration. One or two drops of indicator have proven sufficient. Anthony and Ekroth (6) give a list of shades of color called suitable or correct end-points with phenolphthalein. The colors listed vary from "first trace of pink" to "brilliant red." Clark (1) presents a table showing that the variations in acidity of a 1 and a 5 per cent peptone media when these media were titrated by four chemists and four bacteriologists. The acidities calculated from the titrations of the different workers varied from 0.58 cc. to 1.40 cc. N/40 alkali for the 1 per cent and from 2.68 cc. to 7.40 cc. N/40 alkali for the 5 per cent media.

Clark and Lubs (4) describe indicators which undergo rapid color changes at certain definite hydrogen ion concentrations. They give Brom thymol blue as undergoing color changes between P_H 6.0 and P_H 7.6. These indicators are new and have been manufactured (and there, almost under protest) by only one chemical supply house. Their stability and the exactness with which they can be used under the crude conditions phenolphthalein has been used are unknown. At the present time it is fair to assume that these new indicators will come into general use, but as long as different investigators do not agree on a definite value for the contact potential between 0.1 N. HCl. and 0.1 N. KCl. phenolphthalein is not to be discarded for use under exactly defined and proper conditions.

A further evidence that phenolphthalein (properly used) is satisfactory for determining neutrality of media is found in Itano's work on the proteolysis brought about by certain bacteria when put under known initial hydrogen ion concentration. The reaction of all the media (19) changes to very close to the hydrogen ion concentration at which phenolphthalein changes from colorless to pink.

The last report (13) of the committee on standard methods for bacteriological analysis of milk makes no recommendation as to the adjusting of the reaction of the media. This is taken as an indication of a growing realization by this committee that proper selection of materials in making media gives a media near to neutral in reaction. Other evidence that most bacteria will thrive when media are somewhere near neutral is brought out in the fact that most ensymes function when kept close to neutral.

Carbon Dioxide.

Usually some carbon dioxide is present in the alkali used, and many bacteriologists consider freshly distilled water carbon dioxide free. Carbon dioxide has affected the accuracy of some titrations, for we have reference to where investigators advise against titrating the media to a low per cent of aciditiy for fear of volatilizing ammonia from the ammonium salt used in making the media, (14). Ammonia is not easily volatilized from acid solutions but is slowly evolved by alkaline solutions even at low temperatures (40° C.), therefore these investigators are making their media nearer neutral than they think. Slightly alkaline media saturated with carbon dioxide is acid to phenolphthalein.

Apparatus supply houses are advertising water stills which, according to the advertisements, give pure distilled water. Quoting from the advertisement of one of the leading firms, we have "water of the highest purity—free from ammonia and all gaseous and organic impurities." These stills, as shown by the titrations given in the following table do not give carbon dioxide free water where the water used in them is hard. Freshly distilled water made from the same local hard water supply with different stills gave the following titrations with N/10 carbonate free alkali and phenolphthalein.*

* The water from which distilled water is prepared in many localities is as hard or harder than that in this locality.

TABLE I.

CARBON DIOXIDE IN FRESHLY DISTILLED WATER.

Titrated at room temperature 22°C.

MAKE OF STILL.	cc. N/10 Alkali per 100 cc. H_2O.	
	Water from Collecting Vessels.	Water Direct from Still Outlet.
Stokes stills—		
No. 1	0.40	.45
No. 2	0.05	.50
Barnstead still	0.08	.35
Large local plant	0.65	2.10

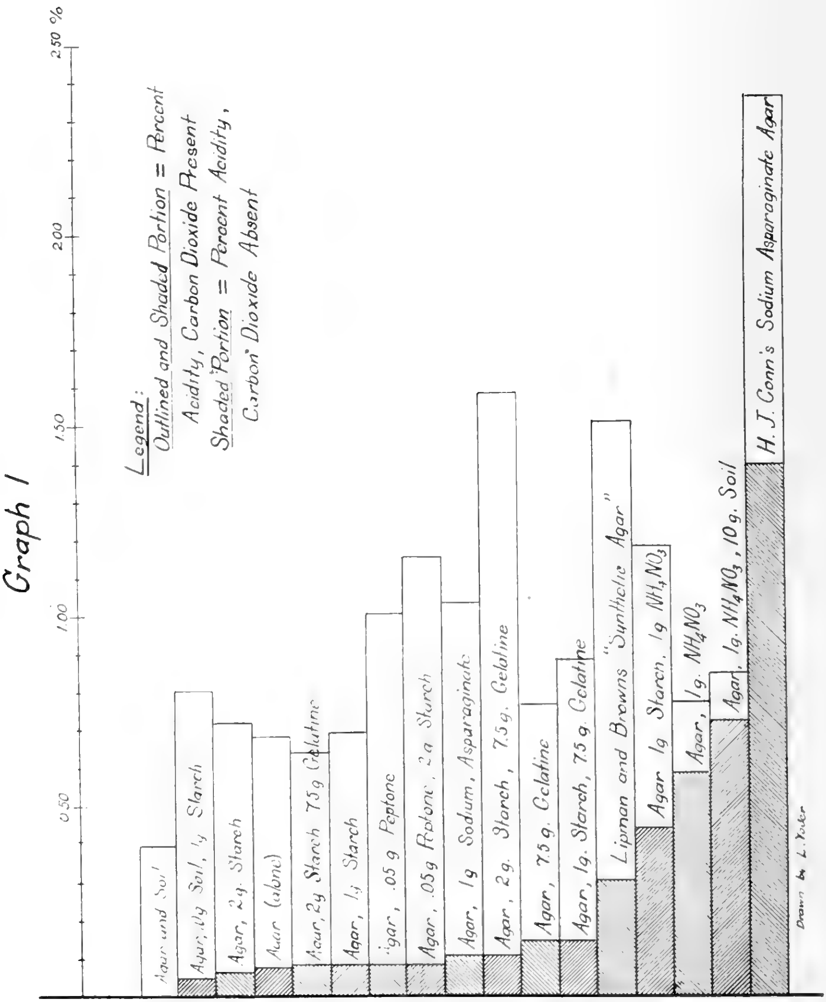
All yield water containing carbon dioxide and the amount of carbon dioxide varied with the same make as well as different makes of stills.

TEST OF EFFECT OF CARBON DIOXIDE ON MEDIA TITRATIONS.

The results reported in Table II were an attempt to find out how much the titration of media would be affected by the carbon dioxide present in distilled water from one of the above stills. The point under investigation being to determine the effect of carbon dioxide, the water was prepared and titrations were made at about 70°C. so that it would be evident that the results were not due to carbon dioxide being absorbed by the media or water from the air of the room while cooling to room temperature. Two two-liter flasks which had previously been proven to be made of non-soluble glass were filled with distilled water. The water in one flask was boiled for about five minutes to remove the carbon dioxide present while that in the other flask was heated to 75°C.

Duplicate twenty-five cc. aliquots of each media were weighed into clean, carbon dioxide free, erlenmeyer flasks; 100 cc. of the hot carbon dioxide free water was added to one of each of the duplicate aliquots of media and 100 cc. of the hot yet unboiled water added to the other flask of each set of duplicates. Two drops of phenolphthalein were added to each flask after they had been shaken until the contents appeared homogenous. Titrations were made with carbonate free N/10 sodium hydroxide* and the faintest discernible, yet permanent pink coloration

* Make a solution of the alkali (sodium) so strong that the carbonate contained will be precipitated. Add the clear supernatant liquid which is carbonate free to carbon dioxide free water and standardize.


Graph I
Legend:
Outlined and Shaded Portion = Percent Acidity, Carbon Dioxide Present
Shaded Portion = Percent Acidity, Carbon Dioxide Absent
0.50
1.00
1.50
2.00
2.50 %
Agar (alone)
Agar, 2g Starch 7.5g Gelatine
Agar, .05 g Peptone
Agar, 1g Sodium, Asparaginate
Agar, 2g. Starch, 7.5g. Gelatine
Agar, 7.5 g. Gelatine
Agar, 1g. Starch, 7.5 g. Gelatine
Lipman and Browns "Synthetic Agar"
Agar 1g Starch, 1g NH_4NO_3
Agar, 1g. NH_4NO_3
Agar, 1g. NH_4NO_3, 10g. Soil
H. J. Conn's Sodium Asparaginate Agar
Drawn by L. Yoder

was taken as the end point. The results of these tests with 23 lots of media are shown in Table II and Graph I.

TABLE II.

ACIDITY OF MEDIA (*CALCULATED IN PER CENT.) AS AFFECTED BY CARBON DIOXIDE IN DISTILLED WATER.

	(1) CO_2 Present in Dilution Water.	(2) CO_2 Free Dilution Water.	(3) Acidity Due to CO_2 in (1).	(4) Actual Acidity if Corrected to .80 by (1).	(5) Actual Acidity if Corrected to .50 by (1).
Agar† (alone)	.68%	.07%	.61 (c)	.19	alk.
Agar and 1 gm. starch	.69	.08	.61	.19	alk.
Agar and 2 gm. starch	.72	.06	.66	.14	alk.
Agar and 10 gm. soil	.39	.00—	.39+	—.41	alk
Agar and ammonium nitrate	.76	.58	.18	.62	acid.
Agar and 7.5 gms. gelatine	.72 (a)	.12	.60	.20	alk.
	.80	.16	.64	.16	alk.
Agar and .05 gms. peptone	1.00	.08	.92	—.12	alk
Agar and 1.0 gms. sodium asparaginate	1.03	.10	.93	—.13	alk
Agar, 1 gm. starch and 10 gms. soil	.80	.04	.76	.04	alk
Agar, 1 gm. starch and 1 gm. (ammon. nitrate (b))	1.18	.44	.74	.06	alk.
Agar, 1 gm. starch and 7.5 gelatine	.66	.11	.55	.25	alk.
	1.10	.16	.94	—.14	alk
Agar, 2 gm. starch and 7.5 gelatine	1.58	.10	1.48	—.68	alk.
Agar, 2 gm. starch and .05 gm. peptone	1.15	.08	1.07	—.27	alk.
Agar, 10 gms. soil and 1 gm. (ammon. nitrate)	.84	.72	.12	.68	acid.
Agar, 10 gms. soil, 2 gms. starch and 7.5 gelatine	.64	.08	.56	.24	alk.
Lipman and Brown's "synthetic agar"	1.25	.22	1.03	—.23	alk.
	1.40	.28	1.12	—.32	alk.
	1.48	.32	1.16	—.36	alk.
	1.87	.36	1.51	—.69	alk.
H. J. Conn's (sodium asparaginate agar)	2.24	1.38	.86	—.06	alk.
	2.46	1.40	1.06	—.26	alk.

*1.00% would mean the requirement of 1 cc. normal alkali for neutralization of 100 cc. of media.

†Fifteen grams of air dry agar basis of all media.

(a) Each figure given represents one lot of media. No two lots of same media were made on same date.

(b) Phenolphthalein is not the most desirable indicator to use when ammonium salts are present.

(c) Distilled water prepared from soft water is often practically free from carbon dioxide.

The table shows—

(1) That the carbon dioxide normally present in distilled water prepared from hard water by a modern still affects the titration of media.

(2) That the titration, due to carbon dioxide present in diluting water may be much greater than the total titration of the acidity of the media itself.

(3) That the carbon dioxide does not affect the acidity of all media in the same proportion.

(4) Media adjusted by results of titrations made of aliquots diluted

with water containing carbon dioxide are always less acid than desired, in fact some media are alkaline, note columns headed (4) and (5).

Distilled water is believed *by so many* to be carbon dioxide free, no matter whether the water from which it is made is hard or soft, that, as a rule bacteriologic culture media has been adjusted to a less degree of acidity than planned for. Litmus is not sensitive to carbonic acid, thus it seems fair to assume that acidities of culture media, observed with phenolphthalein, but which do not prove out with litmus may be partly due to the carbon dioxide present in the dilution water added to the aliquot titrated. Anthony and Ekroth (6) make statements concerning the work of MacNeal, Muir and Ritchie, Stilt, and others concerning comparisons between litmus and phenolphthalein titrations. Titrations with phenolphthalein carried out near the boiling point of the media are unreliable, due to the increased hydrolysis of the media and to the fact that phenolphthalein is more sensitive in cold solutions (15).

Hot and Cool Titrations With Especially Prepared Media.

An experiment was conducted to find out the effect of temperature on acidity titrations when agar agar plus gelatin were present with salts that undergo changes in hydrolysis with increasing temperature. The agar agar and gelatin used were selected because of their small changes in acidity when autoclaved or heated. They were selected by a procedure described by the author (16) in another article. Unfiltered water solutions of the agar and gelatin used were free from precipitates and thus by themselves did not even need filtering.

Two basic media were made up according to the following procedure:

Agar agar Media.—Thirty grams of agar agar were dissolved in the inner part of a double boiler in 2,000 cc. of carbon dioxide free distilled water. When solution was complete distilled water (carbon dioxide free) was added to make the weight of agar and water up to 2,000 gms.

Agar plus Gelatin Media.—This was made up exactly as the agar media except that 7.5 grams of gelatin were added per 1,000 grams of media.

Fifty gram aliquots of each media were weighed out into clean 250 cc. erlenmeyer flasks. Thirty-four aliquots of each media were taken. The chemicals were previously prepared by making water solutions of them of such concentration that they contained .05 grams of salt per cc. of solution. One cc. aliquots of the proper solutions were added to aliquots of the media using a 1 cc. pipette graduated to .01 cc. This was to give a concentration of the salt of 1.0 gram per liter of media.

The flasks were tightly plugged with cotton and autoclaved for different lengths of time under 17 pounds pressure of live steam. It was assumed from previous tests that the one cc. of water added with the salt would be lost in the autoclaving. As soon as autoclaved approximately 100 cc. of boiling carbon dioxide free distilled water was added to each flask. Titrations were made at the temperatures specified using 2 drops of 0.5 per cent solution of phenolphthalein as indicator and N/10 *carbonate free* sodium hydroxide. The results are given in Table III.

TABLE III.

ACIDITY OF AGAR AGAR AND AGAR PLUS GELATINE MEDIA AS AFFECTED BY SALTS AND LENGTH OF TIME OF STERILIZATION.

(Figures express cc. normal alkali needed to neutralize 100 cc.)

	Hot 90°.	40° to 45°.	Increase 90° Over 40°.	(1) Increase Due to Salts. 90°	(1) Increase Due to Salts. 40°.	(2) Increase Due to Gelatin. 90°	(2) Increase Due to Gelatin. 40°.
Potassium nitrate (3)	.03	.01	.02				
Ammonium nitrate (3)	.30	.30	.50				
Aluminum nitrate (3)	.84	.80	.04				
Agar—							
Autoclaved 0.0 hours	.03	.01	.02				
Autoclaved 0.5 hours	.04	.03	.01				
Autoclaved 1.0 hours	.04	.03	.01				
Autoclaved 2.0 hours	.03	.03	.00				
Autoclaved 4.0 hours	.03	.03	.00				
Average			.008				
Agar and KNO_3—							
Autoclaved 0.5 hours	.05	.03	.02	.01	.00		
Autoclaved 1.0 hours	.05	.03	.02	.01	.00		
Autoclaved 2.0 hours	.05	.04	.01	.02	.01		
Autoclaved 4.0 hours	.03	.03	.00	.00	.00		
Averages			.013	.01	.003		
Agar and NH_4NO_3—							
Autoclaved 0.5 hours	.36	.21	.15	.32	.18		
Autoclaved 1.0 hours	.38	.20	.18	.34	.17		
Autoclaved 2.0 hours	.35	.20	.15	.32	.17		
Autoclaved 4.0 hours	.40	.18	.22	.37	.15		
Averages			.175	.338	.168		

TABLE III—Continued.

	Hot 90°.	40° to 45°.	Increase 90° Over 40°.	(1) Increase Due to Salts. 90° 40°.	(2) Increase Due to Gelatin. 90° 40°.
Agar and Al $(NO_3)_3$—					
Autoclaved 0.5 hours	.71	.62	.09	.67 .59	....
Autoclaved 1.0 hours	.73	.63	.10	.69 .60	....
Autoclaved 2.0 hours	.75	.60	.15	.72 .57	....
Autoclaved 4.0 hours	.78	.68	.10	.75 .65	....
Averages	....	....	.110	.708 .602	
Agar plus Gelatin—					
Autoclaved 0.0 hours	.11	.07	.04	. . .	.08 .06
Autoclaved 0.5 hours	.12	.10	.02	....	.08 .07
Autoclaved 1.0 hours	.13	.10	.03	....	.09 .07
Autoclaved 2.0 hours	.13	.08	.05	....	.10 .05
Autoclaved 4.0 hours	.13	.10	.03	....	.10 .07
Averages			.034	....	.09 .064
Agar plus Gelatine and KNO_3—					
Autoclaved 0.5 hours	.11	.10	.01	-.01 .00	.06 .07
Autoclaved 1.0 hours	.10	.10	.00	-.03 .00	.05 .07
Autoclaved 2.0 hours	.13	.10	.03	.00 .02	.08 .06
Autoclaved 4.0 hours	.13	.10	.03	.00 .00	.10 .07
Averages	....	....	.018	-.010 .005	.073 .068
Agar plus Gelatin and NH_4NO_3*—					
Autoclaved 0.5 hours	.53	.29	.24	.41 .19	.17 .08
Autoclaved 1.0 hours	.53	.28	.25	.40 .18	.15 .08
Autoclaved 2.0 hours	.53	.18	.35	.40 .10	.18 —.02
Autoclaved 4.0 hours	.58	.38	.20	.45 .28	.18 .20
Averages	....	....	.26	.413 .188	.17 .085
Agar plus Gelatin and Al $(NO_3)_3$*—					
Autoclaved 0.5 hours	1.03	.99	.04	.91 .89	.32 .37
Autoclaved 1.0 hours	1.03	.98	.05	.90 .88	.30 .35
Autoclaved 2.0 hours	1.03	.91	.12	.90 .83	.28 .31
Autoclaved 4.0 hours	1.13	.88	.25	1.00 .78	.35 .20
Averages	....	....	.115	.928 .845	.313 .308

*Precipitation occurred in all aliquots of this series.

(1) Figures in this column are difference between the media without and with added salt.

(2) Figures in this column are difference between corresponding media containing no gelatin.

(3) These salts were used because they are typical of classes of salts that vary in hydrolysis.

Table III brings out the following:

(1) The temperature of the media affects the titration.

(2) The effect of temperature on titration varies with the bases of the media and the chemicals used in making the media.

(3) Increasing length of time of autoclaving does not appreciably change the acidity of the media.

(4) Potassium nitrate did not appreciably change the acidity of the agar or the agar plus gelatin media.

(5) The effect of the nitrates used seemed to be due more to the hydrolysis of the nitrates themselves rather than to reactions taking place between them and the agar and gelatin.

(6) Reaction of media should be adjusted by titrations made at the temperature at which they are to be used.

The results of this test lead one to presume that if proper care was used in selecting the chemicals to be used in culture media, the acidity of bacteriologic culture media would rarely have to be neutralized.

Evidence Drawn From Literature in Support of Contention That Hydrolyzable Substances Should Be Avoided.

Anthony and Ekroth (6) give a table which shows the reaction of different peptones when titrated at room and boiling temperatures with phenolphthalein as indicator. The results show that the variations in acidity of the different peptones are large but that the peptone having the lowest acidity at room temperature also has the lowest at boiling temperature. Witte's peptone has been almost universally agreed upon as the best and is it not fair to suppose that this is due to its freedom from hydrolyzable material?

The same authors found that "Leibig's Extract of Beef" does not undergo the hydrolysis that homemade extracts do. They say, "This stability is due probably to very prolonged heating in the preparation of the beef extract itself." In other words the more stable the extract the more reason for its use.

Itano (5) working with the hydrogen electrode finally, after experimentation, decided on a medium containing both "Leibig's extract" and Witte's peptone. He found that if these constituents were sterilized before mixing, i. e., if they were stabilized, "the medium prepared from them maintained the figured P_H fairly constantly."

Fellers (17) finds that soil bacteria prefer a very slightly acid, a neutral or just alkaline media.

Summarizing the results obtained by these recent workers and realizing that the standard method of titrating media (12) gives too high titrations and thereby low acidity of adjusted media, it seems probable that bacteriologic media in most cases should be very slightly acid or neutral in reaction.

The following procedure which is based on results reported in Tables

I, II and III, has proven satisfactory for the titration of media: Twenty-five gram aliquots of the hot media are weighed out into 350 cc. erlenmeyer flasks (Jena, pryex or non-sol), which have just been rinsed with carbon dioxide free water. Approximately 250 cc. of hot, carbon dioxide free distilled water is added to each flask and the flasks are shaken until after the mixture of water and media appear homogeneous. They are then loosely stoppered and set to one side until they attain room temperature. Titrations are then made with N/10 carbonate free alkali and two drops of a ½ per cent solution of phenolphthalein. The end point is reached on the appearance of the faintest, yet permanent pink color. The fainter the color one is able to titrate to, the more accurate the titration.

SUMMARY.

(A) Ideal media for routine bacteriological work, if rightly prepared from selected agar agar from stabilized peptone, from stabilized meat extracts and from chemicals which hydrolize but little, does not need to be adjusted in reaction unless the chemicals inter-react (which should lead to a choice of other chemicals).

(B) It is fairly well established that most bacteria will thrive in a neutral medium. The standard methods (12) have allowed media to be adjusted to nearer neutral than the figures would indicate.

(1) Titrations have been carried out in hot solutions where hydrolysis is great and media corrected to certain standards by these titrations is always nearer neutral when at blood heat or a lower temperature.

(2) Many have used alkali and water containing carbon dioxide and the errors resulting have caused media to be adjusted to lower acidity than desired.

(C) Hydrolyzable chemicals have been used and their use has made results uncertain.

(D) Meat infusions, peptones, and other extracts have been found to vary greatly in reaction. Those extracts and peptones giving best results happen to be those that are most stabilized.

(E) Some organizims tolerate more acidity than others (3) and the hydrogen ion concentration must be determined if classifications are to be made on the basis of tolerance to H and OH ion concentrations.

(F) Workers in physical chemistry have determined that for each acid there is a dilution beyond which the per cent ionized remains constant. When 25 cc. of media that is, at most, only slightly acid is further diluted with carbon dioxide free water (as must be done to titrate at room temperature) the per cent acid ionized has reached its limit. The difference between the value obtained with the hydrogen electrode and that obtained by titration under proper conditions is thus small or negligible.

(G) Itano (5) (19) has found that proteolysis is optimum when the hydrogen ion concentration of media is in or at the range where phenolphthalein titrations properly carried out would indicate neutrality.

Different investigators have suggested brom thymol blue and phenol red for phenolphthalein. This has not been done because the paper is intended to bring out errors in making media which must be corrected if any indicator is used. The values used at present for the contact potential prevent one from adopting any shade of any indicator as absolute neutrality.

The author wishes to make acknowledgment to Dr. Redfield of the Bureau of Chemistry for criticisms and suggestions. Acknowledgments are also due to Director C. G. Woodbury, for it is only with his consent that the writer can devote any time to consideration of this subject.

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Studies on Pollen.

F. M. Andrews—Indiana University.

Since the time of Amici it has been known that pollen grains germinate and send out one or two tubes. Amici carried on his studies on this point on the plant Portulaca oleracea. Ever since the work of Amici various investigations have been made on the germination of pollen and especially concerning the different conditions that would promote its growth. Even yet, many points remain obscure and much investigation will be necessary before these are solved. As the chemical nature of the stigmatic fluid is complicated and varies greatly in different plants, it renders the culture medium used to induce growth a matter of one experiment after another with different media in order to ascertain which will induce growth or is best adapted to the various cases. Of course it is known that in a good many cases a sugar solution will cause growth, but this is by no means the case with the pollen of all plants, so that other means frequently have to be tried. Moreover the physical character of the culture medium is a factor that has been very generally overlooked.

In the experiments here mentioned I have investigated to date the behavior of the pollen of 435 plants with respect to a culture medium of cane sugar. Of these, 110 showed no response whatsoever as no growth occurred. The remainder showed a more or less pronounced growth. A wide range in the percentage of the cane sugar solutions was used so that ample opportunity for growth was afforded by this medium if such a medium would produce it. Plants from many different families as well as from the same family were tried so as to see in how far differences in germination under such conditions would occur.

Stoppage of a Sewer Line by Roots of Acer Saccharum.

F. M. Andrews—Indiana University.

The many well-known examples of stoppage of sewer and pipe lines is probably exceeded from the standpoint of time, at least, by the following example:

A six-inch sewer pipe line was laid five feet deep between two trees of Acer saccharum. For two years the line remained perfectly clear of all obstruction and no difficutly was experienced. Late in the summer of the third year a stoppage of this line suddenly occurred. The trees above referred to are 21 years old, about 6 inches in diameter and about 50 feet high and are vigorous specimens. They stand on a west exposure and on a bank in the open where they are subjected to the direct rays of the sun. The bank was a narrow one, so that the ground was quickly dried out and the most actively growing part was excessively dry. This caused the roots to grow down very quickly in search of water and to escape the upper and lateral very dry layers of the soil. On nearing the pipes there was also a chemotactic attraction exerted. The roots finding a small opening grew in quickly, effecting a complete closure of the tile line for a distance of fifteen feet. By their further quick growth, especially after entrance, the heavy cement joints were completely ruptured. The sewer line was replaced in the region affected by heavy double-hub cast-iron pipe whose joints were sealed with lead. Within the space of a few months, therefore, the roots of these trees had completely blocked the pipes. The universally known tendency of Populus deltoides as well as the roots of other trees and plants to grow into sewer and water pipes is common knowledge. The location of the stoppage in a sewer line may be ascertained with comparative accuracy. This can be easily done, since one can ascertain the volume of a given section of the pipe and the metered volume of water required to fill the pipe from stoppage to the water supply, due consideration of course to be paid to those cases in which the stoppage may not be complete and where some water may pass through.

Anthocyanin of Beta Vulgaris.

F. M. Andrews—Indiana University.

If a freshly made solution of chlorophyll is placed in a transparent vessel in the direct sunlight it is well known that in a few hours the chlorophyll will be broken down and will become more or less brown in color. If, however, part of the freshly made solution of chlorophyll is placed in the dark it will remain apparently unchanged in color even after twenty-four hours or longer. The above mentioned behavior of chlorophyll acts quite differently from the anthocyanin of Beta vulgaris. The anthocyanin of this plant forms one of those examples where the pigment forms in the subterranean parts. The behavior of this pigment with reference to the light is quite different as regards preservation in the light. If a strong solution of the anthocyanin of Beta vulgaris is placed in a test-tube in darkness it will continue to preserve its normal color for more than a week. Quite different from chlorophyll if a strong solution of this anthocyanin is exposed in a test-tube in direct sunlight it will retain its normal bright color for a week, or sometimes more, or until broken down and disorganized by bacterial action. This latter effect finally happens to the solution of anthocyanin of Beta vulgaris in the dark. So that whether in the light or dark the color remains almost the same length of time. While it is clear that the presence of anthocyanin in various plants is not important like chlorophyll, still a comparative, exhaustive study of the two pigments under different physiological conditions is much to be desired and would make a valuable contribution.

Improved Forms of Maximows' Automatic Pipette.

F. M. Andrews—Indiana University.

Grafe[1] figures and describes the automatic pipette of Maximows (Fig. 1). The pipette as given by Maximows is very practical but is in part difficult of manipulation and needs some improvements, which I have supplied. In the first place a Woulfe bottle with three openings at the top is not necessary nor is a bottle with a tubulure at the base absolutely essential, although it is convenient. Any bottle having an opening at the top and provided with a stopper having four holes is sufficient. The funnel shown in Maximows' drawing is also unnecessary. If, as Grafe describes, one closes A and B (Fig. 1), and opens C the NaOH in D flows out, creating a partial vacuum in D and causing the desired solution, in this case baryta water, to rise in the pipette E if the pinch cock F is open. If now one opens B air will enter D, allowing the solution in E to sink and thus measure the quantity of fluid. In this last operation is the chief difficulty, for when B is closed after opening the solution in E will generally not cease to sink at once owing to the reduced pressure in D produced by the column of solution in E. Since accuracy is the prime consideration here a slight error is fatal for correct results. Furthermore the glass tube B should extend below the surface of the NaOH or KOH solution to insure the removal of all CO_2 and the outside air not be allowed to enter too rapidly. Also it will be seen according to Fig. 1 that the NaOH or KOH solution would be wasted in the Maximows apparatus. The control of the outflow of the solution in E should be for the sake of accuracy and convenience not at B but at the lower end of the pipette E. Maximows used the funnel A for refilling, which is unnecessary.

The above difficulties I have removed by a modification of Maximows' apparatus as shown in Figs. 2, 3, and 4, which I will now briefly describe. In both Figs. 2 and 3, which are photographs, bottles with one opening at the top could be used instead of the Woulfe bottles.

[1] Grafe, Dr. Viktor—Ernährungsphysiologisches Praktikum der höherer Pflanzen, p. 360.

Fig. 2 shows the apparatus in a position on the ring stand A for filling the pipette E. If one opens C the NaOH solution in D will run into G which, when I is open, will cause the baryta solution to rise in

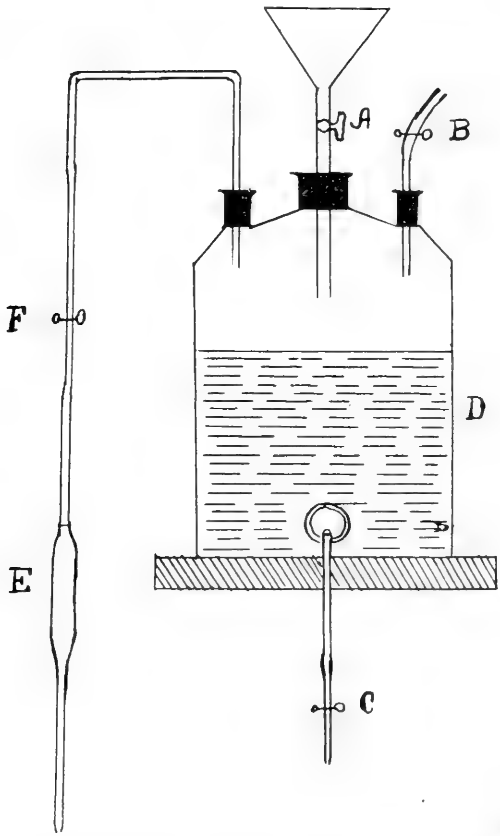
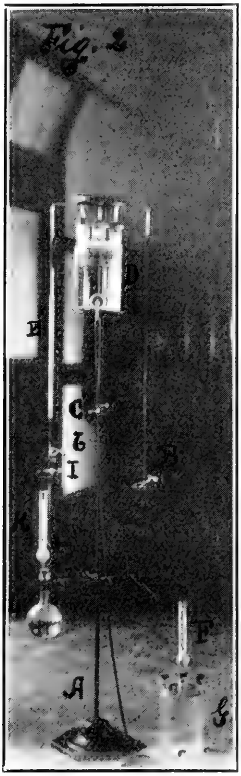


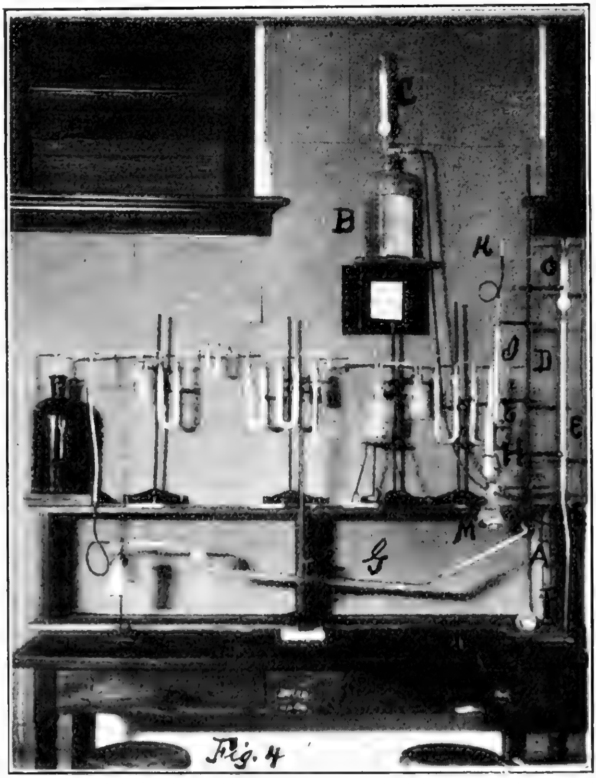
Fig. I

E to the desired height. If now C and I are closed and B opened it will allow the air to enter D when J is opened and the solution allowed to run out. The NaOH or KOH solution in D will arrest any CO_2 present so that the baryta solution will remain clear. The baryta solution in L remains clear since the calcium chloride tube K, which contains soda lime, extracts the CO_2 of the air as it enters L when any of the solution is drawn into the pipette E. The solution of NaOH or KOH in D in Fig. 1 is not used further after escaping according to Grafe's figure. In Fig. 2 I show that it is collected in another bottle H, which



is similar in size and construction to D. By elevating the bottle G to a position M on the ring stand A above D and opening J, as shown by Fig 3, the same solution of NaOH or KOH runs back into D and can be used again. By this apparatus a large number of measurements may be quickly and very accurately made. The tube F with soda lime is not necessary in Figs. 3 and 4 since the KOH removes the CO_2.

Figure 4 is a photograph of the apparatus used by Detmer[1] for estimating the amount of CO_2 produced by plants, and including also the titrating apparatus for measuring used by him. The apparatus as shown in Fig. 4 is given only to demonstrate an improved form of



Maximows' automatic pipette, which may advantageously be used in connection with the Detmer apparatus.

If one opens the pinch cock A (Fig. 4), the baryta water in B, freed from the CO_2 by the soda lime in C, flows into the burette D as shown by Detmer and the air in D escaping through E. If now one

[1] Detmer, W.—Practical Plant Physiology. Translation by S. A. Moor, pp. 264 and 267.

closes A and E and opens F the measured baryta water in D will flow into the Pettenkofer tube G. This outflow from D will cause the baryta water in the Erlenmeyer flask M to rise in the pipette I. It goes without saying that for convenience the capacity of D and I should be equal. Next close F and H and open E and J. The air will then enter E when the CO_2 will be removed by the soda lime in O before entering I through K. This will allow the measured baryta water in I to flow out of J into a suitable vessel for titration. In this way the baryta water measured into G, through which CO_2 is to be passed, furnishes the power in a convenient way for filling and accurately measuring an equal amount in I, through which the CO_2 of respiring plants is passed for comparison.

The Effect of Centrifugal Force on Plants.

F. M. Andrews—Indiana University.

The effect of the successive displacement of contents in plant cells has never been carried out to the full extent. This would be an interesting piece of research in as much as it would show not only the capacity of plant cells to resist possible injury by repeated displacement of the contents over long periods, but also that it would demonstrate the recuperative power of such cells. Especially if this latter began to diminsh it would be important to know when and how rapidly the protoplasm reacted in this respect. I have already performed a few experiments of this kind where, however, the contents of Closterium moniliferum was displaced only a few times successively.[1] Approximately no difference was noticed in this plant when centrifuged successively a few times and the specimens kept in the dark.

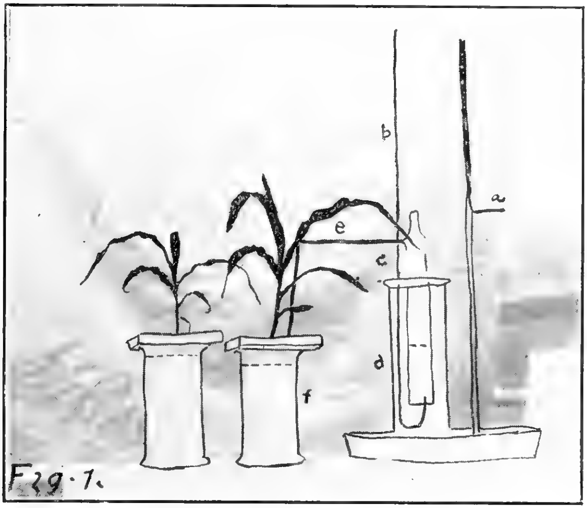
I have more recently tried the same experiments on Oedogonium ciliatum with similar results. The following four experiments will show the response of the plant when centrifuged 15 minutes at 26°C. I centrifuged Oedogonium ciliatum, using 1,500 gravities. All the contents were displaced which returned in the light in 7 days. After the second centrifuging the contents returned in 6½ days. After the third centrifuging in 6 days and after the fourth centrifuging in 6½ days. Clearly, from these few experiments, the protoplasm is apparently not detrimentally affected and shows that a large number of such experiments would be necessary to determine this point. There are interesting questions to be ascertained in such experiments, among them being that of the response of the protoplasm to certain stimuli when the contents are displaced.

[1] Jarbücher für wissenschaftlichen Botanik, 1915, Vol. 56, pp. 229-233.

The Effect of Aeration on the Roots of Zea Mays.—I.

Colonzo C. Beals—Indiana University.

This experiment was conducted for the purpose of learning the effect of aeration on the roots of Zea Mays. In water cultures as commonly conducted, the only aeration that the growing plants receive comes from the surface of the water.



Effect of aeration on roots of Zea Mays.

The plants were grown as water cultures in normal solutions minus the sodium chloride. The cylinders used had a capacity of one and one-half liters and the solution was changed at frequent intervals. One cylinder was aerated by means of letting a stream of water flow through a glass tube (a) from a hydrant. The tube protruded slightly through a rubber cork fitting tightly in the larger end of condensing tube that was cut in two pieces. The cork should have an opening for a tube to admit air. The lower end of the tube was connected to a second one (b) leading to a cylinder (d) filled with water resting in a drain pan. The larger end of a cutoff condensing tube (c) was suspended over the open end of the small bent tube. The upper end was connected to the cylinder of solution by a glass tube (e) which extended almost to the bottom of f. All connections between the glass tubes were made by tight-fitting rubber tubing. The flow of air was regulated by varying the amount of water that passed through the hydrant. A drain tube carried away the excess of water from the pan. The apparatus stood about four feet high and was held in an upright position by a ring-stand.

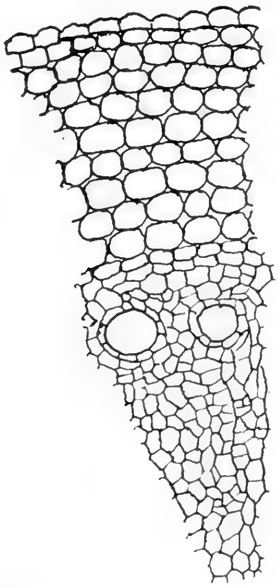


Fig. 2

Effect of aeration on roots of Zea Mays

This apparatus was after W. Ostwald as given in his *Chemico-physical Measurements.* Aeration of plants is mentioned, however, by Julius Sachs in his *Vorlesunger über Pflanzen-physiologie,* 1887, pages 268-269.

The glass tube fed a constant supply of air into the cylinder of normal solution. The two plants were started at the same time and received like treatment except the aeration of the solution.

The following table gives the height of the plants at different stages of growth:

	Aerated.	Nonaerated.
2 days	2.8 cm.	1.9 cm.
3 days	5.9 cm.	4.7 cm.
6 days	14.50 cm.	12.00 cm.
8 days	25.00 cm.	23.00 cm.
11 days	28.00 cm.	24.00 cm.
15 days	37.00 cm.	33.00 cm.
20 days	47.00 cm.	37.00 cm.
26 days	65.00 cm.	46.00 cm.

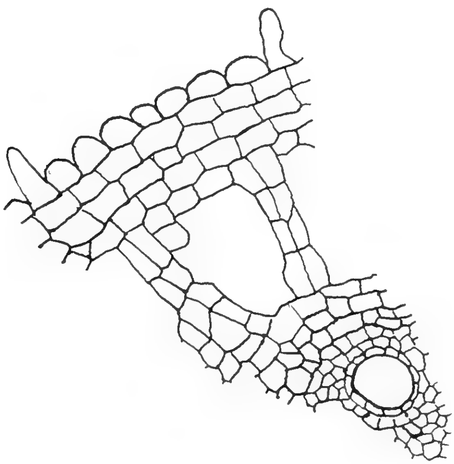


Fig. 3.

Effect of nonaeration on roots of Zea Mays.

After three months' growth in the greenhouse under as nearly normal growing conditions as possible, the plants were removed and burned. The ash of the aerated plant including the roots weighed 2.182 grams, while the ash of the nonaerated amounted to 1.303 grams.

A cross-section of a root when magnified showed that the cortex cells of the aerated plant (Fig. 2) were uniform in size with no conspicuous air cavities, while the cortex of the nonaerated root (Fig. 3) contained large air cavities separated by narrow strands of tissue.

This experiment shows the great importance of the presence of air not only for the normal growth of plant tissue but also the obtaining of the maximum plant growth.

The work of which this study is the result was taken up at the suggestion of Prof. Andrews of the Department of Plant Physiology of Indiana University, and his constant interest and help have contributed to its completion.

Resistance of Mucor Zygotes.

Mildred Nothnagel—Florida Experiment Station.

In the fall of 1916, while attending Indiana University, various experiments were begun to test out the resistance of Mucor zygotes and spores to desiccation, to heat, and to different chemicals.

Fortunately the writer had a good culture of zygote material from which fresh zygotes could always be raised. Since the zygotes are supposed to be more resistant than the asexual spores, the experiments were made with the former in order to make them more conclusive.

After sterilizing the bread, inoculating it with zygotes, placing in a dark place, room temperatures, zygotes in unlimited number would be found in 5 to 7 days.

The work was carried out along several lines, and in all cases, unless otherwise stated, zygotes that had been just freshly matured, and those a year old, were used in order to make comparison.

Outline of Work.

1. Resistance of zygotes to desiccation.
2. Resistance to heat of zygotes in the desiccator.
3. Resistance to heat of zygotes upon oven-dried bread.
4. Resistance to heat of zygotes placed upon bread with its normal amount of moisture present.
5. Resistance to heat of zygotes in presence of large amount of moisture.
6. Resistance of zygotes to various chemicals.

In all the experiments the utmost care was used to have everything sterile and, in case water or nutrient material had to be added, every precaution was taken so that spores from the outside would not be introduced. Control experiments were run for the purpose of checking.

1. *Resistance of Zygotes to Desiccation.*—Into sulphuric acid desiccators were placed numerous cultures of the one-year zygotes as well as the freshly matured zygotes with no nutrient material. These cultures

were left in this environment for various lengths of time ranging from one week to one year. At the end of these respective periods the small dish with the mucor within it was removed, and with the utmost care a piece of moist, sterilized bread was introduced, after which it was set aside in a warm, dark place.

In all cases but the last one a vigorous growth was made within seventy-two (72) hours and in many cases zygotes were found within a week.

The results of the cultures remaining in the desiccator for one year were not very conclusive, due to a slight accident. The culture of the zygotes, that was freshly matured when it was placed in the desiccator, produced growth within twenty-four (24) hours, and sporangia within forty-eight (48) hours, but the culture with the older zygotes in it failed to grow within two (2) weeks after being removed from the desiccator and moistened, though upon further moistening a vigorous growth was produced. Unfortunately, though, when the culture was being moistened the second time the lid slid off for an instant and there is a slight possibility of spores from the outside gaining entrance.

In one of the first experiments performed, growth failed to take place until further moistening, and it is the belief of the author that such was the case in this last experiment.

2. *Resistance to Heat of Zygotes in Desiccator.*—Zygotes were placed upon oven-dried bread, put in a sulphuric acid desiccator, and then placed in an oven at 60 degrees centrigrade for various lengths of time, ranging from seventy-two (72) hours to five (5) weeks. At the end of these periods a culture would be removed and the bread moistened with sterile water. In all the cultures the zygotes survived the heat, and within forty-eight (48) hours after being removed there was a vigorous growth, in many cases zygotes being formed within a week.

Another set of experiments was run along similar lines, through in this case the temperature was raised to seventy (70) degrees centigrade, the time ranging from one week to one month. In the case of the freshly matured zygotes, or as will hereafter be termed *New Zygotes*, a culture was able to survive two (2) weeks of heat and desiccation, though at the end of three (3) weeks, no growth took place when placed in favorable environment. The one year old zygotes were not able to withstand the heat and desiccation for two (2) weeks, though the culture that had been in the heat for one week germinated readily.

3. *Resistance to Heat of Zygotes Upon Oven-dried Bread.*—The bread was first dried in an oven, the temperature of which was kept at 110-120 degrees centigrade for several hours. In each test tube was placed a small cube of this bread, which had been inoculated with zygotes; the test tubes were plugged with cotton, and then placed in the oven at 100 degrees centigrade for different lengths of time ranging in close series from 1 min. to 25 min. After the cultures were removed and allowed to cool the bread was moistened with sterile water. In every instance, up to and including those remaining in the heat for 17½ minutes, zygotes were produced within a week; but in those cultures remaining in the heat 20, 22½, and 25 minutes, no zygotes were formed, though there was a vigorous growth.

Other cultures were placed in the oven at a temperature of 60 degrees centigrade. This experiment is scarcely complete, since the various lengths of time were not close enough together to warrant any conclusions. Cultures remaining in this heat for one week grew vigorously after being removed to suitable environment; but those remaining in the heat for five weeks failed to germinate after being removed to room temperature and moistened.

The third set of experiments under this heading was placed in an oven at seventy (70) degrees centigrade, the duration being from four (4) days to three (3) weeks. New zygotes produced growth after they had remained at seventy (70) degrees centigrade for two (2) weeks, though at the end of three (3) weeks there was no sign of germination. Old zygotes did not resist the heat as long, the longest duration being one week.

4. *Resistance to Heat of Zygotes in Presence of Small Amount of Moisture.*—In these cultures the amount of moisture was that which is ordinarily found in fresh bread. Experiments placed in the oven at sixty (60) degrees centigrade for one week showed no growth after being removed to favorable environment and neither did cultures after being in the oven for only forty-eight (48) hours at this temperature.

5. *Resistance to Heat of Zygotes in Presence of Large Amount of Moisture.*—These experiments were performed, first, by thoroughly soak-

ing small cubes of bread, placing one in each test tube, sterilizing them, and then inoculating the bread; after which the test tubes were tightly plugged and placed in warm water the temperature of which ranged from forty-five (45) to seventy (70) degrees centigrade.

The following table will give the temperature and the longest time for each of these temperatures that the zygotes were able to remain in it, and still retain the power of germination.

TABLE I.

	70°C.	65°C.	60°C.	55°C.	50°C.	45°C.	40°C.
1 yr., Zygotes	0 min.	1 min.	2 min.	4 min.	10 min.	30* min.	45* min.
New Zygotes	0 min.	3 min.	5 min.	10 min.	15 min.	30* min.	45* min.

*Experiments of longer duration were not made for this temperature.

6. *Resistance of Zygotes to Various Chemicals.*—The resistance of the zygote and the growing mycelium toward a few chemicals was tested out. Molecular solutions of NaCl (common salt), Fe_2Cl_6 $12H_2O$, $CuSO_4$, and C_2H_5OH (ethyl alcohol) were the solutions used and were the only moisture that the germinating zygotes and growing mycelia received. Oven-dried bread was moistened with the chemical and then inoculated with zygotes after which the cultures were set aside in a warm, dark place to germinate. The first column of Table II indicates the highest molecular solution, or fraction of molecular solution, in which the zygotes and the mycelia would grow; while the second column shows the same in terms of per cent of the chemical in solution. Column three gives the highest molecular solution in which a vigorous growth took place, the last column indicating the same thing in per cent of the chemical in solution.

TABLE II.

	Highest Concentration in which Growth Occurred.		Highest Concentration in which a Vigorous Growth Occurred.	
	Mol. Sol.	% Sol.	Mol. Sol.	% Sol.
NaCl	Mol.	5.48%	M/10	.548%
Fe_2Cl_6 $12H_2O$	M/11	1.2%	M/15	.808%
$CuSO_4$	M/70	.213%	M/150	.0994%
C_2H_5OH	3M+	13.8%+	2M	9.2%

Discussion.

It has been generally thought that zygote material of Mucor would not retain the power of germination for more than one year, but the first experiment demonstrated that they retained this power for at least two years, one year of which they were entirely without moisture. Since this is the case one might expect to find the zygotes in the air for a longer period than that.

When heat was added as a factor, a remarkable power of resistance was still shown. How long the zygotes would be able to resist the sixty (60) degrees centigrade in a desiccator remains to be seen, as five (5) weeks was the longest period tried. When the temperature was raised to seventy (70) degrees centigrade the old zygotes showed the lesser resistance, not being able to withstand the heat for as long a period as the newly matured ones.

When the temperature was seventy (70) degrees centigrade the inoculated oven-dried bread resisted to the same extent as those in the desiccator, though when the temperature was sixty (60) degrees centigrade the inoculated oven-dried bread was not able to stand the heat as long as the zygotes in the desiccator. How near it would come to it was not ascertained. The only explanation that the author can give is that the amount of moisture that would be present at sixty (60) degrees centigrade in the oven would be sufficient to be detrimental to the zygotes.

Those experiments in which the zygotes were placed upon oven-dried bread in an oven at one hundred (100) degrees centigrade would have practically the same degree of desiccation as the three experiments that were placed in the desiccators. In this experiment there is shown the most remarkable case of resistance, twenty-five (25) minutes in this heat not being sufficient to kill the zygotes; but another interesting fact is brought out, that being, that the ability of the mucor to produce zygotes is gone from those cultures remaining in the heat over 17½ minutes.

According to the present understanding of the formation of zygotes, there must be what is termed "two strains." By the term "strain" the author means not different varieties, but what in higher plants would probably be called male and female plants. In other words, there is a differentiation of mycelial threads, the union of the two (2) being

TABLE III.

	20°C.	40°C.	45°C.	50°C.	55°C.	60°C.	65°C.	70°C.	100°C.
1 year zygotes in desiccator	(524,160) 1 yr.					(50,400) 5 wks.+		(10,080) 1 wk.	
New zygotes in desiccator	(524,160) 1 yr.+					(50,400) 5 wks.+		(20,160) 2 wks.	
1 year zygotes on oven-dried bread						(10,080) 1 wk.+		(10,080) 1 wk.	
New zygotes on oven-dried bread						(20,160) 2 wks.+		(20,160) 2 wks.	(25) 25 min.
1 year zygotes on moist bread		(45) 45+ min.	(30) 30+ min.	(10) 10 min.	(4) 4 min.	(2) 2 min.	(1) 1 min.	(0) 0 min.	(0) 0 min.
New zygotes on moist bread		(45) 45+ min.	(30) 30+ min.	(15) 15 min.	(10) 10 min.	(5) 5 min.	(3) 3 min.	(0) 0 min.	(0) 0 min.

NOTE.—The numbers within the parenthesis indicate the relationship between the various experiments as to the endurance in the heat and the desiccation.

necessary for the formation of the zygote. If this is the case, then one of the "strains" must be weaker than the other and killed out by the unfavorable conditions, since zygotes were not formed in those cultures that had remained in the one hundred (100) centigrade heat for more than 17½ minutes.

The difference in the resistance between the old and the new zygote material in this set of experiments was not ascertained, as only the new was used.

When moisture was added as a factor, even when the amount was small, the resistance of the zygotes to the heat declined rapidly. With the amount of moisture ordinarily found in bread it was found to be sufficient to kill the zygotes in less than forty-eight (48) hours, when the temperature was raised to seventy (70) degrees centigrade, the time probably being only a matter of minutes as can be seen from comparing the results of the different experiments as shown in Table III.

In case there was a large amount of moisture there was a very great dropping off of the power of resistance and also a marked difference in the resistant power of the old and the newly matured zygotes. The rapid decline is when the temperature reaches fifty (50) degrees centigrade. How long the zygotes would resist the temperature of forty-five (45) and forty (40) degrees centigrade was not ascertained.

From a general survey of all the experiments (See Table III) it will be seen that the zygotes are able to withstand a large amount of heat as long as no moisture is present; but the addition of only a slight amount causes the resistant power to fall off very rapidly. Also the factor of dessication is a very small factor, if any, in the lowering of the vitality of the zygote. On the other hand it is a decided factor in increasing the power of resistance to heat.

If, then, one wishes to kill mucor, the surest way to do so is to use heat and moisture, not much heat being necessary in this case; while if moisture is not present a high temperature and a long application will be required.

To Dr. F. M. Andrews of Indiana University, I wish to express my appreciation for the encouragement and assistance given during the progress of the work. The author also wishes to express her appreciation for the help that Miss Flora Anderson rendered in completing some of the experiments.

The Absorption of Iron by Platinum Crucibles in Clay Fusions.

W. M. Blanchard and Roscoe Theibert—DePauw University.

A short time ago on making a number of clay analyses, we were surprised at the persistent gain in weight of our platinum crucibles and the repeated appearance of ferric oxide after reheating a crucible that had been used in making a fusion. No note of such phenomena could be found in the standard treatises on analytical chemistry at hand, no mention of the absorption of iron by platinum being mentioned by Fresenius, Treadwell and Hall, Olsen, Morse, or Scott. The only mention of such action to be found in the literature available was in a paper by Sosman and Hostetter, Jour. Washington Academy, 5, 293-303, and only a synopsis as given in Chem. Abstracts, 9, 1580, was at hand. In this paper account is given of experiments made on the heating of hematite and magnetite in platinum crucibles at high temperatures, resulting in the absorption of iron and the loss of oxygen. The statement is made that it is a generally known fact that platinum crucibles will absorb small quantities of iron when heated to high temperatures with ferric oxide. In this synopsis in Chemical Abstracts no reference is made to any published data.

If a sample of ordinary clay is mixed with the usual amount of sodium carbonate and the mixture fused in the usual manner, the crucible will present the appearance of perfectly clean platinum when the product, on cooling, is removed by the treatment with hydrochloric acid. If this crucible is now heated for several minutes over the blast lamp or No. 3 Meeker burner, the lower third of the inside of the crucible will have an appearance varying from that of ordinary ferric oxide to that of certain bronzes. If strong hydrochloric acid is now added and the crucible heated gently, what appears to be a rather strong solution of ferric chloride is obtained. If this is removed, the crucible will have again the appearance of clean platinum, but, in many cases, when heated a second time, more iron will be driven to the surface and converted into ferric oxide. In some cases it has been found necessary to subject the crucible to several successive heatings and treatment with strong hydrochloric acid in order to remove all of the iron absobed in a single fusion.

In order to determine whether this amount of iron is what might be considered merely a "trace" or whether it is sufficient to make an appreciable difference in the results of a quantitative analysis, several determinations were made. A platinum crucible was heated to constant weight after it had been subjected a number of times to the treatment just mentioned. A clay fusion was then made and the product removed by the aid of 20 per cent hydrochloric acid. The heating and treatment with the acid was then repeated until no further change was observed. The combined solutions of ferric chloride was reduced with stannous chloride, excess of mercuric chloride added, and the amount of iron determined by means of a standard solution of potassium dichromate. Some of the results obtained are as follows:

Weight of platinum crucible (from previous fusion) after successive heatings over an ordinary burner:

25.0089 25.0089 25.0090 25.0089

Same crucible after successive heatings of fifteen minutes each over a Meeker burner:

25.0097 25.0097 25.0095 25.0097

After treatment with the acid and complete removal of the iron:

25.0089 25.0090 25.0090 25.0089 25.0089

A fusion of a mixture of 0.5 gram of clay and 2.5 grams of sodium carbonate was then made and the product removed by the aid of the acid. Successive heatings over the Meeker burner, each followed by removal of the iron present, left the crucible weighing as follows:

25.0099 25.0097 25.0099 25.0103

After removal of the iron successive heatings gave

25.0089 25.0084 25.0088

After further treatment with the acid and successive heatings, the weights ran as follows:

25.0084 25.0083 25.0084 25.0081 25.0081 25.0082

The total amount of iron oxide found by titration with the potassium dichromate was 0.00459 gram.

After a third fusion, removal of the product, and heating over the Meeker burner the crucible weighed

25.0097 25.0098

After removal of the ferric oxide and reheating,

25.0080 25.0080 25.0080 25.0080

Amount of ferric oxide by titration, 0.0063 gram.

After a fourth fusion, removal of fusion product, successive heatings gave

25.0103 25.0100 25.0100

After removal of the iron oxide,

25.0085 25.0085

Total amount of ferric oxide by titration, 0.0051.

It seems that in fusing the clay and sodium carbonate mixture a very small amount the ferric oxide formed, or the ferrous oxide present is reduced, the iron dissolving in the platinum. When the crucible is afterwards heated to a high temperature, the iron is driven to the surface and reoxidized, thereby becoming soluble in the acid.

It was thought that this might be prevented by adding a small amount of potassium nitrate to the fusion mixture before making the fusion. A few experiments were made to test this hypothesis.

Weight of the crucible before fusion, 25.0079.

To the mixture of 0.5 gram clay and 2.5 grams sodium carbonate was added 0.3 gram pure potassium nitrate, the fusion made and the product removed in the usual way. The crucible was then heated eight times, fifteen minutes each, and weighed after each heating, the ferric oxide being removed before the succeeding heating. The weights were as follows:

25.0104 25.0103 25.0103 25.0103 25.0091 25.0087 25.0079 25.0079

The total amount of ferric oxide obtained by titration, 0.0021 gram.

A second fusion with the addition of 0.5 gram of potassium nitrate brought the weights of the crucible to the following:

25.0125 25.0122 25.0121 25.0120 25.0120 25.0120

The total amount of ferric oxide by titration, 0.0015 gram.

A third fusion, using again 0.5 gram of potassium nitrate resulted in the following weights:

25.0154 25.0152 25.0149 25.0149 25.0149 25.0149

No ferric oxide was detected by titration although a trace of ferric oxide was observed in the crucible.

A fourth trial with 0.5 gram of the nitrate resulted as follows:

25.0182 25.0181 25.0181 25.0178 25.0170 25.0165 25.0165

Total amount of ferric oxide by titration, 0.0025 gram.

It will be seen that the amount of iron absorbed by the crucible is sufficient to be taken into account in making an accurate analysis. In other words, after making a clay fusion, the crucible should be heated to a high temperature and the ferric oxide formed dissolved out and added to the vessel containing the main fusion product. Furthermore, it is seen that treatment with potassium nitrate is not a satisfactory way of avoiding the trouble, for while it does prevent the absorption of the iron to a large degree, it is the means of introducing other foreign substances into the crucible which may prove undesirable.

That this absorption of iron is not a peculiarity of this particular crucible, due to the presence of some other metal alloyed with the platinum, would seem to be indicated by the fact that the same phenomenon was observed in connection with two other crucibles purchased at different times and from different dealers; that it was not due to some unusual property of this particular clay is evidenced by the fact that the same thing occurred with clays obtained from widely different sections of the State.

A further study of this behavior is in progress.

Since the above paper was submitted for publication, the chief cause of the phenomena described has been discovered. The crucibles in which the fusions were made were heated over Meeker burners. In order that they might be heated to the highest temperature obtainable from these burners the crucibles were supported just above the top of the burners. As a result they were more or less enveloped in an atmosphere of reducing gases and it was due to these gases rather than to the organic matter in the clay that the iron was brought to a condition to be absorbed by the platinum. When these fusions are made with a good blast lamp directed upon the crucible at a considerable angle, practically no iron is afterwards found in the platinum. It is probably because these burners have not generally been used for this purpose that this phenomenon has not been observed by others. It is clear that the Meeker burner is not a satisfactory substitute for the blast lamp in making fusions of clays or silicates that contain appreciable amounts of iron.

13—11994

The Injurious Effect of Borax in Fertilizers on Corn.

S. D. Conner—Purdue University.

About June 1, 1917, the Experiment Station was notified that in a large number of fields near Francesville the young growing corn had lost its green color and had turned white or had entirely wilted down. Together with Mr. O. S. Roberts of the State Chemist's Department, I visited the cornfields on June 5th. We found a number of fields where the corn was entirely white. The damage was all on land where fertilizer was used, and by far the greatest damage was caused where fertilizer containing 5 per cent of potash and 5 per cent of available phosphoric acid had been used. There appeared to be no question about the fertilizer having caused the damage as in a number of fields one or more rows of unfertilized corn remained good alongside of badly damaged fertilized corn. In some fields several amounts of fertilizer had been used and the damage was greatest where the largest amounts of fertilizer were used. The fertilizer injured the corn by retarding germination, also by turning the corn white and holding it back so that insect damage was greater where the corn was fertilized, and in some cases the corn had even been killed. Some of the corn which was not damaged very badly was said by the farmers to be looking better than it had a few days before. Later reports indicate that some of the white corn recovered almost entirely while other fields had to be replanted, while still other fields remained more or less damaged even to time of harvest.

On September 24th another visit was made to the damaged fields. Some of the corn had been permanently damaged probably seventy per cent., other fields much less and in some cases there was no apparent damage. The damage seemed to vary on different types of soil, some of the worst was on light sandy and some on peaty soils. As a rule there was not so much damage on heavier soils. Corn fertilizer in Indiana is generally drilled along the row where the corn is checked or drilled. Fifty pounds of the 5-5 fertilizer per acre seldom caused much damage, while 200 pounds to the acre nearly always caused great

Fig. 1. Borax test with fertilizer on corn, Purdue soil.

Fig. 2. Borax test with fertilizer on corn, Francesville soil.

damage. Some farmers seemed to think that a fertilizer attachment with a spreader was better than an attachment that placed the fertilizer directly on the seed. Differences in amount of injury were undoubtedly caused by the different weather conditions, such as rain either just before or after planting.

All farmers who had used fertilizer which caused damage to the corn and who made complaint have been compensated by the fertilizer company selling the goods. The amount of damage was mutually agreed upon by the farmer and a representative of the fertilizer company with O. S. Roberts, Chief Inspector of the State Chemist's Department of the Experiment Station, acting as a disinterested referee.

Experimental Work.

To find the cause of the damage, the writer secured a sample of the 5-5 fertilizer which produced damage in one of the fields. Upon analysis this sample was found to contain 2.35 per cent boric acid (H_3BO_3) equivalent to 1.92 per cent borax ($Na_2B_4O_7$) soluble in water. Borax is an ingredient not usually found in fertilizer. It has been found by other investigators to be harmful when used in very large amounts.[1]

With the assumption that borax might be the harmful ingredient, quantities of soil were obtained from the field near Francesville damaged by the particular sample of 5-5 fertilizer analyzed; also soil from the Experiment Station farm. The Francesville soil is a black sandy loam neutral in reaction. The Purdue soil is brown silt loam, acid in reaction. Ten earthenware pots were filled with each type of soil and fertilizer applied as follows:

Pot. No.

1. No treatment.
2. 50 lbs. per acre in row of 5-5 fertilizer sold.
3. 100 lbs. per acre in row of 5-5 fertilizer sold.
4. 200 lbs. per acre in row of 5-5 fertilizer sold.
5. 200 lbs per acre broadcast of 5-5 fertilizer sold.
6. 100 lbs. per acre in row 5-5 fertilizer made in laboratory. No borax.

[1] Cook, T. C. and Wilson, J. B. in Jour. Agr. Res., Vol. X, No. 12, 1917; also Nakamura in Bul. Col. Agr., Tokyo, 1903; also Voelcker in Jour. Roy. Agr. Soc., Vol. 76, 1915.

7. 200 lbs. Same as No. 6.
8. 100 lbs. per acre in row of 5-5 fert. made in laboratory with 2 per cent borax.
9. 200 lbs. Same as No. 8.
10. 200 lbs. per acre broadcast 5-5 fert. made in laboratory with 2 per cent borax.

Where the fertilizer was applied in the row, the soil was furrowed out and the fertilizer applied, then the corn dropped in the same furrow and covered. The broadcast application was worked in the entire surface of the pot two inches deep. Corn was planted October 8, 1917, and the pots were kept uniformly watered in a greenhouse.

The notes in Table I indicate the results on the test up to January 1, 1918. Figures 1 and 2 show the appearance of the corn November 26th.

The results obtained in this pot test show that without doubt the commercial 5-5 fertilizer containing 1.92 per cent borax will injure corn if applied in the row 100 lbs. or more to the acre. Fifty pounds to the acre caused no damage.

The damage is caused by preventing germination, by bleaching the leaves of the young corn and by stunting or killing the young plant. This injury is identical to that which was noted in the field.

A 5-5 fertilizer made from kainit and acid phosphate did not bleach leaves or kill the plants when used 100 or 200 pounds in the row. In the 200 lb. application, this fertilizer caused some temporary stunting which later disappeared.

An artificial 5-5 fertilizer with 2 per cent borax added caused bleaching and even worse damage than the commercial sample did.

When the fertilizer was applied 200 lbs. to the acre broadcast that containing borax caused a slight bleaching but no permanent injury.

There seems absolutely no question but that 2 per cent borax in a fertilizer when used 100 pounds to the acre in the row will bleach the leaves of the corn plant and cause more or less permanent injury.

Chemical Estimation of the Fertility of Soils in Fulton County, Indiana.

R. H. Carr and W. K. Gast—Purdue University.

During recent years there has been an effort on the part of many States to invoice their soils as to plant food content in addition to making the usual survey in order to classify them into types and series. This invoice is useful first to the farmer in pointing out any deficiencies or excesses in the soil's food supply, and second to the State in estimating the wealth, since this usually resides in the fertility of the soils. Usually only the plant food elements are determined which seem to be the most important or have the greatest influence in modifying crop yield. They are the following: total organic carbon, total nitrogen, total phosphorus, total potassium, total calcium, total inorganic carbon. The test for the last is made for the presence of limestone, the absence of which often indicates soil acidity. There are many factors other than plant food concerned in producing a crop on any piece of land, as rainfall, tillage, drainage, etc., but deficiencies in these can be determined often by observation. But a deficiency in the main chemical elements is not so easily estimated and is a matter of life or death to the plant.

Availability of Plant Food.

Much discussion has arisen over the availability of these plant foods even when analysis has shown plenty to be present. It is conceded, however, that it is possible to make two per cent of total nitrogen, one per cent of phosphorus and one-fourth of one per cent of potassium available in one year by approved agriculture methods. If this were true, or somewhere near true, it would make a big difference in the crop yield to be expected whether there were 500 or 5,000 lbs. of phosphorus or nitrogen, etc., present per acre to a depth of six and two-thirds inches.

Plant Foods Present in a Good Soil.

It is difficult to set a definite standard of plant food content, but if we choose samples of our productive loam soils frequently producing

75 bushels of corn per acre, we find a plant food content about as follows:

POUNDS OF PLANT FOOD PER 2,000,000 POUNDS OF SURFACE SOIL.

Nitrogen 4,500 lbs., 2 per cent possible available in 1 year...... 90 lbs.
Phosphorus 1,500 lbs. (too low), 1 per cent.................... 15 lbs.
Potassium 32,000 lbs., one-fourth of one per cent.............. 80 lbs.
Organic matter, 160,500 lbs.
Limestone present, 350 lbs.

A 50-bushel corn crop would need about 74 lbs. of nitrogen, 11.5 lbs. of phosphorus and 35.5 lbs. of potassium in addition to the other essential elements usually present, and this amount of plant food could more than be supplied in a soil like the above.

PLAN OF INVOICING FULTON COUNTY SOILS.

The soil samples chosen numbered 128 and they were collected from the eight townships. Most of the soil samples were taken from surface soil (7 ins. deep), but 38 were from subsoils (6 to 20 ins.). Twenty of the samples were from virgin soil and represent more or less the original fertility of the soil unchanged by cropping. Many items were noted while the samples were being collected (August, 1916) or information was secured from the people living on the farms as to the prevalent weeds, stand of clover, kinds of timber, grain yield per acre, use of fertilizers and manures, etc. The following determinations were made on the soil samples: first, total organic matter; second, total nitrogen; third, total phosphorus; fourth, presence of carbonates and acidity to litmus. An attempt was made to correlate this data with the yield of corn per acre. It was thought this could be done best by means of graphs. Since the presence or absence of organic matter is so vitally related to crop yield, the soils were grouped into eight series depending on the amount of organic matter present in the soil. The samples are numbered as follows:

Richland Twp., 1-10 and 108-111, inclusive.
Aubbeenaubbee, 11-19 and 106-107.
Henry, 20-24 and 124-128.
Newcastle, 25-27 and 112-123.

Rochester, 28-31 and 45-60 also 66.
Liberty, 61-65 and 67-75.
Wayne, 76-87 and 91-93.
Union, 80-90 and 94-105.

The tables and graphs which follow will give a partial composition of the soil in per cents and pounds per acre and express this in terms of bushels of corn per yield.

TABLE I.

The N. P. and Organic Matter, from 0.5 to 1% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	9 Subsoil	.5143	10,286	.014	280	.0243	486
2	116 Subsoil	.6664	13,328	.017	340	.0462	924
3	87 Subsoil	.6789	13,578	.015	300	.0725	1,450
4	103 Subsoil	.7945	15,890	.0042	84	.0576	1,152
5	16 Subsoil	.8014	16,028	.014	280	.0674	1,348
6	*68 Subsoil	.8046	16,092	.027	540	.0364	728
7	2 Subsoil	.8614	17,228	.0084	168	.0553	1,106
8	79 Subsoil	.9824	19,648	.021	420	.0580	1,160

*Acid.

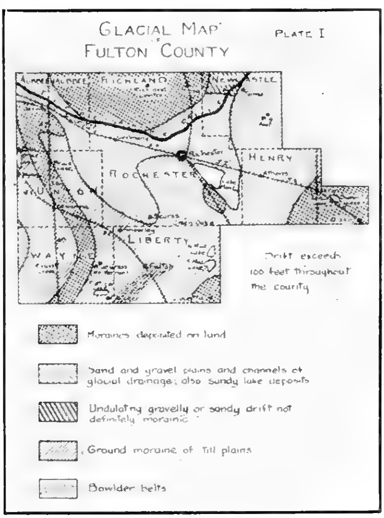


TABLE II.

The N. P. and Organic Matter, from 1 to 2% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	12 Subsoil	1.141	22,820	.025	500	.0320	640
2	98 Subsoil	1.158	23,160	.015	300	.0539	1,078
3	5 Subsoil	1.171	23,420	.018	360	.0381	762
4	*33 Subsoil	1.233	24,460	.011	220	.0324	648
5	*96 Subsoil	1.318	26,360	.043	860	.0677	1,354
6	*55 Subsoil	1.376	27,520	.046	920	.1072	2,144
7	70 Subsoil	1.389	27,780	.017	340	.0755	1,510
8	89 Surface	1.396	27,920	.018	360	.0239	478
9	*110 Surface	1.397	27,940	.029	580	.0694	1,388
10	77 Subsoil	1.404	28,080	.627	540	.0674	1,348
11	*104 Virgin	1.472	29,440	.034	680	.0485	970
12	*61 Surface	1.576	31,520	.029	580	.0398	796
13	57 Subsoil	1.646	32,920	.014	280	.0516	1,032
14	*11 Surface	1.711	34,330	.059	1,180	.0526	1,052
15	67 Surface	1.744	34,880	.041	820	.0644	1,288
16	48 Surface	1.814	36,280	.066	1,320	.0768	1,536
17	*47 Surface	1.844	36,880	.063	1,260	.0256	512
18	*50 Virgin	1.902	38,040	.053	1,060	.0310	620
19	*102 Surface	1.992	39,840	.050	1,000	.0465	930
20	*86 Surface	1.997	39,940	.050	1,000	.0613	1,226

*Acid.

12.2% of Surface Soils in this organic group.

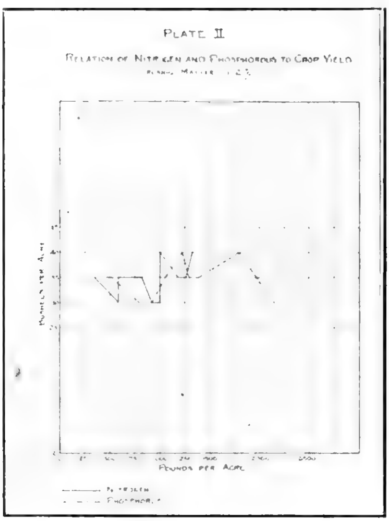


TABLE III.

The N. P. and Organic Matter, from 2 to 3% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	*60 Subsoil	2.023	40,460	.048	960	.0745	1,490
2	*97 Surface	2.063	41,260	.069	1,380	.0559	1,118
3	*64 Subsoil	2.065	42,300	.021	420	.1543	3,086
4	*76 Surface	2.073	41,460	.056	1,120	.1180	2,360
5	*1 Surface	2.114	42,280	.063	1,260	.0273	546
6	*115 Surface	2.197	43,940	.083	1,660	.0182	364
7	*63 Surface	2.198	43,960	.053	1,060	.0411	822
8	*107 Surface	2.245	44,900	.067	1,340	.0816	1,632
9	†13 Virgin	2.307	46,140	.063	1,260	.0654	1,308
10	*21 Subsoil	2.394	47,880	.032	640	.0762	1,524
11	†29 Subsoil	2.403	8,060	.022	440	.0162	324
12	*56 Surface	2.422	48,440	.077	1,540	.0634	1,268
13	*31 Surface	2.442	48,840	.062	1,240	.0580	1,160
14	*75 Surface	2.475	49,500	.038	760	.1031	2,062
15	*99 Virgin	2.526	50,520	.070	1,400	.1031	2,062
16	*90 Subsoil	2.564	51,280	.055	1,100	.0738	1,476
17	* Surface	2.567	51,340	.070	1,400	.0849	1,698
18	*32 Surface	2.579	51,580	.064	1,280	.0479	958
19	51 Surface	2.585	51,700	.076	1,520	.0499	998
20	*4 Surface	2.620	52,400	.081	1,620	.0580	1,160
21	19 Subsoil	2.679	53,580	.036	720	.0394	788
22	65 Virgin	2.722	54,440	.059	1,180	.0600	1,200
23	†58 Virgin	2.798	55,960	.039	780	.0620	1,240
24	*105 Surface	2.841	56,820	.011	220	.0229	458
25	*111 Virgin	2.886	57,720	.076	1,520	.1092	2,184
26	95 Surface	2.935	58,700	.125	2,500	.0644	1,288
27	*6 Virgin	2.994	59,880	.076	1,520	.0519	1,038

*Acid. †Very acid.

23.3% of Surface Soils in this organic group.

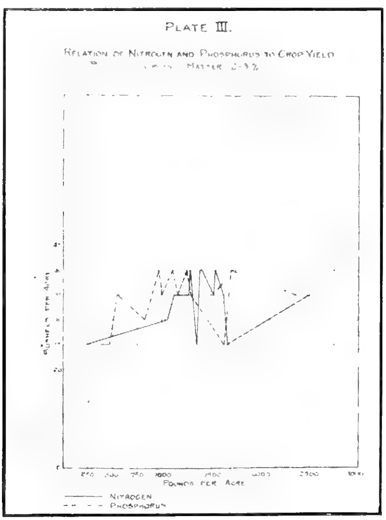


TABLE IV.

The N. P. and Organic Matter, from 3 to 4% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	*69 Surface	3.000	60,000	.085	1,700	.0576	1,152
2	34 Virgin	3.006	60,120	.085	1,700	.0843	1,686
3	118 Subsoil	3.101	62,020	.080	1,600	.0708	1,416
4	*43 Surface	3.131	62,620	.083	1,660	.0718	1,436
5	9 Subsoil	3.164	62,280	.032	640	.0414	828
6	*28 Surface	3.170	63,400	.070	1,400	.0634	1,268
7	52 Subsoil	3.176	63,520	.028	560	.0209	418
8	37 Surface	3.202	64,040	.090	1,800	.0516	1,032
9	122 Surface	3.228	65,160	.118	2,360	.0738	1,476
10	*62 Surface	3.258	65,360	.102	2,040	.0839	1,678
11	*10 Virgin	3.291	65,820	.074	1,480	.0401	802
12	92 Subsoil	3.338	66,760	.062	1,240	.0445	890
13	*42 Surface	3.405	68,100	.111	2,220	.0704	1,408
14	123 Subsoil	3.433	68,660	.078	1,560	.0623	1,246
15	74 Surface	3.489	69,780	.105	2,100	.0462	924
16	*8 Surface	3.589	71,790	.101	2,020	.0516	1,032
17	*14 Surface	3.837	76,740	.111	2,220	.0630	1,260
18	*7 Surface	3.861	77,220	.106	2,120	.0741	1,482
19	*38 Surface	3.905	78,100	.104	2,080	.0775	1,550
20	46 Subsoil	3.912	78,240	.062	1,240	.1132	2,264
21	*15 Surface	3.913	78,260	.143	2,860	.0593	1,186

*Acid.

16.6% of Surface Soils in this organic group.

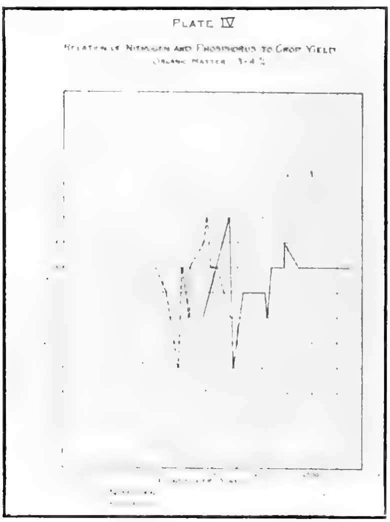


TABLE V.

The N. P. and Organic Matter, from 4 to 6% Organic Matter.

	Sample No.	% O. M	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	80 Virgin	4.010	80,200	.109	2,180	.0812	1,624
2	†20 Surface	4.057	81,140	.113	2,260	.0593	1,186
3	*17 Virgin	4.119	82,380	.118	2,360	.0937	1,874
4	128 Virgin	4.233	84,660	.099	1,980	.1014	2,028
5	*66 Surface	4.299	85,980	.146	2,920	.1078	2,156
6	109 Surface	4.473	89,460	.133	2,660	.0317	634
7	*83 Surface	4.547	90,940	.120	2,400	.0600	1,200
8	91 Surface	4.833	96,660	.140	2,800	.0846	1,692
9	126 Surface	4.892	97,840	.112	2,240	.1001	2,002
10	*85 Surface	4.901	98,020	.164	3,280	.1099	2,198
11	100 Surface	5.130	102,600	.157	3,140	.0620	1,240
12	27 Subsoil	5.334	106,680	.0084	168	.0101	202
13	*59 Surface	5.335	106,700	.176	3,520	.0752	1,504
14	*93 Virgin	5.451	109,020	.175	3,500	.0866	1,732
15	127 Subsoil	5.504	110,080	.077	1,540	.2123	4,246
16	78 Surface	5.579	111,580	.090	1,800	.0647	1,294
17	119 Virgin	5.703	114,060	.220	4,400	.1479	2,958
18	125 Subsoil	5.833	116,660	.108	2,160	.0696	1,392
19	*30 Virgin	5.996	119,920	.169	3,380	.0910	1,820

*Acid. †Very acid.

17.7% of Surface Soils in this organic group.

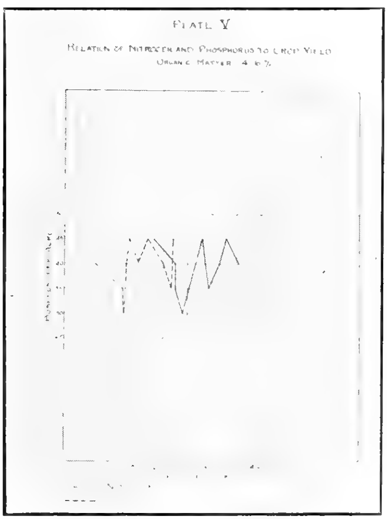


TABLE VI.

The N. P. and Organic Matter, from 6 to 10% Organic Matter.

	Sample No.	% O. M	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	117 Surface	6.278	125,560	.195	3,900	.0667	1,334
2	113 Subsoil	6.462	129,240	.192	3,840	.0654	1,308
3	73 Virgin	6.737	134,740	.190	3,800	.1382	2,764
4	72 Subsoil	7.215	144,300	.167	3,340	.0317	634
5	114 Virgin	7.427	148,740	.258	5,160	.1533	3,066
6	108 Surface	7.603	152,060	.020	400	.1412	2,824
7	112 Surface	8 645	172,900	.307	6,140	.1587	3,174
8	18 Surface	8.695	173,900	.245	4,900	0108	216
9	94 Surface	9.312	186,240	.076	1,520	.0559	1,118
10	23 Subsoil	9.377	187,540	.227	4,540	.1031	2,062
11	26 Surface	9.634	192,680	.274	5,480	.1122	2,244
12	45 Surface	9.835	196,720	.295	5,900	.1692	3,384

10% of Surface Soils in this organic group.

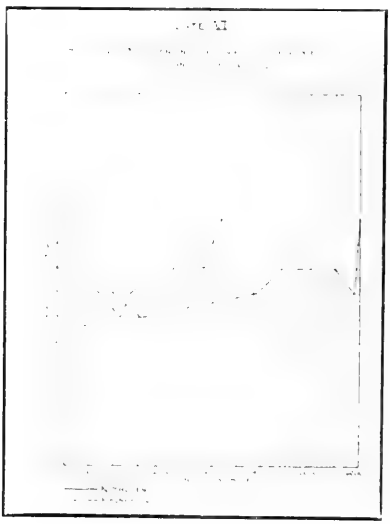


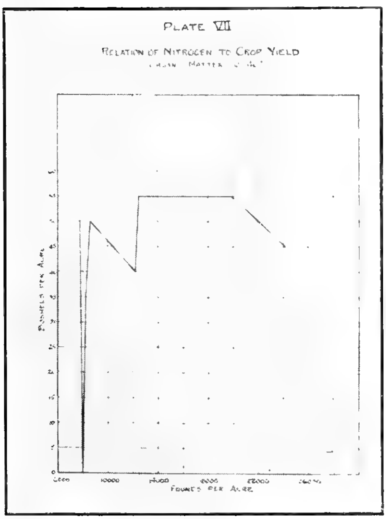
TABLE VII.

The N. P. and Organic Matter, from 10 to 40% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	25 Surface	11.205	224,100	.409	8,180	1361	2,722
2	24 Virgin	11.891	237,820	.403	8,060	.1227	2,454
3	121 Surface	12.009	240,190	.399	7,980	.0341	688
4	82 Surface	12.025	240,500	.000	0,000	.1301	2,602
5	*71 Surface	13.146	262,920	.391	7,820	.0839	1,678
6	22 Surface	13.228	264,560	.428	8,560	.0816	1,632
7	84 Surface	16.318	326,360	.610	12,200	.1752	3,504
8	81 Surface	20.026	400,520	.626	12,520	.2763	5,526
9	39 Surface	28.239	564,780	.994	19,880	.1995	3,990
10	101 Surface	33.230	664,600	1.205	24,100	.3936	7,872

*Acid.

11.1% of Surface Soils in this organic group.



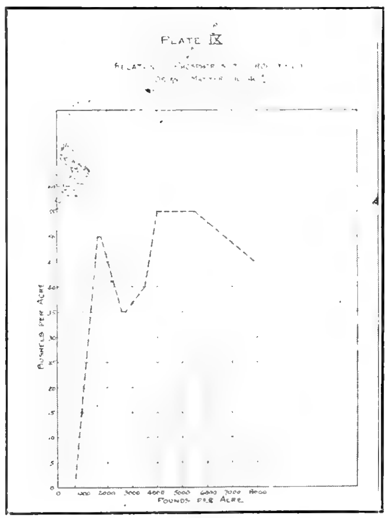


TABLE VIII.

The N. P. and Organic Matter, from 40 to 85% Organic Matter.

	Sample No.	% O. M.	Pounds per Acre.	% N.	Pounds per Acre.	% P.	Pounds per Acre.
1	*120 Surface	41.666	416,660	1.491	14,910	.0903	903
2	41 Virgin	51.778	517,780	1.529	15,290	.2258	2,258
3	*36 Subsoil	56.469	564,690	1.876	18,760	.2642	2,642
4	†44 Surface	64.652	646,520	2.138	21,380	.2116	2,116
5	124 Surface	66.196	661,960	2.124	21,240	.2035	2,035
6	†35 Surface	68.514	685,140	2.254	22,540	.3060	3,060
7	106 Surface	72.343	723,430	2.656	26,560	.3923	3,923
8	53 Surface	76.913	769,130	3.276	32,760	.3572	3,572
9	54 Subsoil	80.661	806,610	3.157	31,570	.3478	3,478
10	40 Subsoil	81.260	812,600	1.928	19,280	.3977	3,977
11	88 Surface	84.698	846,980	2.496	24,960	.2912	2,912

*Acid. †Very acid. *1,000,000 pounds per acre 6 2-3 in.=weight of muck soil.
8.8% of the Surface Soils in this organic group.

SUMMARY.

Analysis shows that a large per cent of the soils of Fulton County are deficient in organic matter. About half of them are below 4 per cent.

The soils are not very acid to litmus. Only six samples were found to be unusually acid while fifty-two others were slightly acid to the same indicator. Most of the acid samples were among the soils containing a low amount of organic matter.

A considerable number of the soils contained less than 1,500 pounds of phosphorus and nitrogen per acre (6 2/3 in.). These amounts are deficient and such soils would undoubtedly respond profitably if fertilized with these elements.

The tables show a considerable decrease in content of plant food in cultivated soil compared with corresponding virgin soils.

The accompanying graphs indicate that there is a close relationship between the yield of corn and the nitrogen and phosphorus content of the soil. As the nitrogen and phosphorus content increases, the yield increases.

Sulphur By-Products of the Preparation of Ether.

P. N. Evans and G. K. Foresman—Purdue University.

The formation of ethyl ether from alcohol and sulphuric acid was first explained by Williamson in 1852. According to his theory the first reaction is the formation of ethyl sulphuric acid and water, according to the equation,

$$C_2H_5OH + H_2SO_4 = C_2H_5HSO_4 + H_2O.$$

The ethyl sulphuric acid then reacts with more alcohol to form ether and sulphuric acid,

$$C_2H_5HSO_4 + C_2H_5OH = C_2H_5OC_2H_5 + H_2SO_4.$$

If these changes were the only ones taking place a limited quantity of sulphuric acid might convert an unlimited quantity of alcohol into ether and water.

Experience has shown, however, that there is a limit to the quantity of alcohol that can be converted into ether by a given weight of sulphuric acid, and two explanations have been offered for the limitation.

Many writers accept the theory that the water produced in the first reaction so dilutes the sulphuric acid that the change can not continue. It has been shown, however, by Evans and Sutton, that the water does not accumulate enough to prevent the reaction but distills over with the ether, normal results having been obtained when starting with very dilute sulphuric acid, the acid becoming concentrated enough for its normal effect by the time the proper temperature (140°) is reached.

Others, including the present writers, accept the explanation that the sulphuric acid employed is gradually converted into other sulphur compounds, either carried out of the generator with the ether and water, or, if remaining, incapable of inducing the formation of ether. The purpose of the work here reported was to determine the quantities of these sulphur by-products formed during the heating.

Numerous by-products have been reported by previous workers, including the following: Sulphur dioxide, sulphurous acid, ethyl sulphurous acid; sulphuric anhydride, ethyl sulphuric acid, ethyl sulphate;

ethyl sulphonic acid, isethionic acid, ethionic acid, butyl sulphonic acid and the ethyl esters of these acids.

Experimental.

Outline.

The experimental work consisted of the preparation of ether in the usual way from ordinary alcohol and strong sulphuric acid, maintaining as nearly as practicable a constant temperature of 140°, as long as ether resulted from introducing fresh alcohol. The distillate and residue were then examined quantitatively for by-products containing sulphur, which were determined as of three classes: sulphurous acid and sulphites, sulphuric acid and sulphates, and sulphonic acids and sulphonates; no distinction was made between the different possible substances within any class, as between the acid and its esters, except in the case of sulphuric acid and its esters.

Sulphuric Acid Used.

Twenty-five cubic centimeters of commercial concentrated acid were used, so-called 66° Baumé or 1.84 sp. gravity. Unfortunately an accurate determination of its concentration was not made, but assuming that the material used was in accordance with its specification it contained about 95 per cent H_2SO_4, and the weight of pure acid used was 43.7 grams. This figure agrees fairly well with the total sulphur found in the products, which was equivalent to 45.25 grams of sulphuric acid. The work is being repeated with accurate observations.

In the percentages given below reference is made to the total sulphur found by direct analysis of the products, and not this 43.7 grams of sulphuric acid.

Ether Preparation.

The apparatus included a 250 cc. distilling flask provided with a thermometer dipping into the liquid, and a dropping funnel delivering alcohol just above the surface and bent away from the thermometer; the flask was attached to a condenser, connected with a 2½ liter receiving bottle, followed by two wash-bottles containing bromine water, the entrance tube of each reaching to the bottom, to catch any possible sulphur dioxide escaping from the receiving bottle. Each bottle was provided with a safety tube reaching nearly to the bottom, which in the case of the wash-bottles served also for the introduction of bromine as needed.

In the flask were placed 25 cc. concentrated sulphuric acid and 25 cc. ordinary strong alcohol, so-called 95 per cent; the mixture was heated to 140° and the temperature maintained as nearly constant as possible, alcohol being run in continuously from the funnel. The distillation lasted a total of 33½ hours exclusive of interruptions. Air was then aspirated through the whole apparatus to sweep out remaining vapors; a small quantity of black residue was left in the flask.

Examination of the Distillate.

The distillate measured 4,100 cc. from 4,700 cc. of alcohol used; it was acid to litmus and its gravity was 0.830 at 18°.

The apparent loss is due largely to the formation of ethylene, evidence of which was shown by a layer of ethylene bromide in the wash bottles.

One liter of the distillate was saponified with an excess of sodium hydroxide, to convert all esters into the corresponding sodium salts, and distilled down to 50 cc., the distillate being again distilled down to about 5 cc. and the residues were mixed. It was alkaline.

Sulphur as Sulphur Dioxide and Sulphites.

The alkaline residue was diluted and an aliquot part was acidified with hydrochloric acid and distilled into bromine water to convert the sulphur dioxide evolved into sulphuric acid, which was determined as barium sulphate; the sulphur found amounted to 1.03 per cent of that employed as sulphuric acid. The contents of the two wash-bottles containing bromine water were freed from bromine and precipitated with barium chloride and 0.96 per cent of the original sulphur found. During the preparation of ether, therefore, 1.99 per cent. of the sulphur of the acid used was lost from the generating flask in the form of sulphur dioxide and sulphites.

Sulphur as Sulphuric Acid and Sulphates.

An aliquot part of the alkaline residue from the saponification was analyzed for sulphates by precipitation as barium sulphate. The sulphur found amounted to 89.42 per cent of the total found.

In order to distinguish between sulphuric acid, ethyl sulphuric acid and ethyl sulphate in the ether distillate, the residue on evaporation of an aliquot part was dissolved in water and precipitated with barium chloride; the barium sulphate corresponded to 46.54 per cent of the total sulphur as sulphuric acid. The total acidity of another aliquot part of the residue of the ether distillate was determined by titration with standard alkali; the free sulphuric acid already found as described was subtracted, and the remaining acidity considered as due to ethyl sulphuric acid, the sulphur in this form amounting to 8.49 per cent of the total sulphur. The total sulphur in the ether distillate (89.42) less the sulphur as sulphuric acid (46.54) and that as ethyl sulphuric acid (8.49) would represent the sulphur as ethyl sulphate, namely, 34.39 per cent of the total sulphur.

As several months elapsed between the preparation of the ether and this examination of the product it is probable that there had been considerable change from ethyl sulphate into ethyl sulphuric acid and sulphuric acid, on account of the hydrolytic action of the water present. At the temperature of 140°, however, sulphuric acid (boiling point of the dihydrate is given as 170-199°) might distill as readily as ethyl sulphate (boiling point 208°); nothing seems to be known as to the possibility of ethyl sulphuric acid distilling as such.

Sulphur as Sulphonic Acids and Sulphonates.

The filtrate from the barium sulphate precipitate obtained in the determination of sulphur as sulphuric acid and sulphates was evaporated to dryness and the residue subjected to a Carius determination for sulphur; 4.62 per cent of the total sulphur was found.

Examination of the Residue.

Sulphur as Sulphur Dioxide.

The residue, weighing 3 grams, stood several months in the closed distilling flask. Air was aspirated through the flask and then through bromine water, and 0.15 per cent of the total sulphur was found in the bromine water.

Sulphur as Sulphuric Acid.

The residue was extracted with water and an aliquot part of the filtrate was treated with barium chloride; 1.69 per cent of the total sulphur was found.

Sulphur as Sulphates.

An aliquot part of the filtrate from the black residue was saponified with sodium hydroxide and total sulphuric acid determined as barium sulphate. Deducting the sulphuric acid found without saponification treatment, 0.99 per cent of the original sulphur was found as sulphates, presumably ethyl sulphuric acid and ethyl sulphate.

Sulphur as Sulphonic Acids and Sulphonates.

The filtrate from the barium sulphate obtained in the determination of sulphur as sulphates was evaporated to dryness with potassium nitrate and barium hydroxide, and the residue after ignition, was treated with dilute nitric acid, filtered and weighed as barium sulphate, showing 1.02 per cent of the original sulphur.

Sulphur in the Insoluble Carbonaceous Residue.

The extracted black residue was fused with potassium nitrate and barium hydroxide and the resulting barium sulphate was weighed. It corresponded to 0.12 per cent of the original sulphur.

Conclusions.

From the following results it appears that the formation of ether ceases because of the disappearance of the sulphuric acid from the generating flask.

Sulphur was found in the following forms and proportions, referred to their total as 100 per cent.

Sulphur dioxide escaping from the receiver during distillation		0.96 per cent.
Sulphur dioxide and sulphites in ether distillate		1.03
Sulphuric acid and sulphates in ether distillate		89.42
Sulphuric acid in ether distillate	46.54	
Ethyl sulphuric acid in distillate	8.49	
Ethyl sulphate in ether distillate	34.39	

Sulphonic acids and sulphonates in distillate	4.62
Sulphur dioxide in residue	0.15
Sulphuric acid in residue	1.69
Ethyl sulphuric acid and ethyl sulphate in residue	0.99
Sulphonic acids and sulphonates in residue	1.02
Sulphur in insoluble carbonaceous residue	0.12
Total	100.00

The Effect of Tobacco Smoke and of Methyl Iodide Vapor on the Growth of Certain Micro-Organisms.

(Abstract. Published in full in Am. Jour. Bot. 5: 1918.)

C. A. Ludwig—Lawrence University, Appleton, Wis.

The work here abstracted was carried out under the direction of Prof. F. C. Newcombe at the University of Michigan and was supplementary to a similar investigation in which illuminating[1] gas and its constituents were employed.

The organisms used in the case of tobacco smoke included 14 species of bacteria and 2 of fungi, and in that of methyl iodide vapor 13 species of bacteria and 2 of fungi. The cultures were on glucose nutrient agar slants. The culture chambers were tubulated glass bell jars set in crystallizing dishes and sealed with paraffin.

The methyl iodide was introduced into the chamber on a pledget of cotton attached to the end of a glass rod fastened in a stopper. The stopper, in turn, was used to close the tubulature in the bell jar.

When smoke was used it was introduced by means of a tube through a two-hole stopper in the tubulature. The suction was provided by an aspirator connected with the interior of the bell jar by a tube through the second hole in the stopper. The tobacco was burned in a cob pipe. In some tests the smoke was used without being treated in any way; in others it was passed through one or two wash bottles of water.

The results indicated that tobacco smoke is toxic to the organisms tested but not so extremely toxic as to some phanerogams. In view of the large number of compounds in smoke it is hardly worth while to venture an opinion as to what substances caused the results observed. The wash smoke, however, showed less toxicity than the unwashed smoke. This would suggest that something capable either of being condensed or of being dissolved in water has some part in causing the results.

The effect of methyl iodide vapor was to kill the cultures where the concentration was great enough. Where the concentration was less it resulted in an initial great retardation in the development of the streaks followed later by a very vigorous growth.

[1] The influence of illuminating gas and its constituents on certain bacteria and fungi. Am. Jour. Bot. 5: 1918.

Brief Notes on the New Castle Tornado.

C. C. Beals—Indiana University.

A number of destructive tornadoes occurred in Indiana during 1917. The first one of these passed over a part of New Castle. Mr. Melvin Kelleher and the writer mapped the tract of the storm under the direction of the Geology Department of Indiana University.

The New Castle tornado formed about 3:00 o'clock in the afternoon on March 11, 1917. At the point of origin objects were displaced by two currents of air. One from the southwest and the other from the northwest, meeting in Sec. 11, Tp. 17 N, R. 9 E. The wind from the southwest seemed to be a straight wind but the one from the northwest evidently had a spiral motion, judging from the direction the fences, trees and other objects fell. The first evidences of wind disturbance occurred about one mile southwest of Cadiz. The storm traveled almost due east except for a few short curves. It struck New Castle about the center on the west side, after crossing a broad glacial valley, and emerged near the southeast corner of the town. The tornado continued in a general eastward direction, going south of Hagerstown, and ceased inflicting damage about four miles southeast of that place.

The storm evidently continued eastward high in the air, going about eight miles north of Richmond into Ohio. Fragments of articles were found in Ohio.

One interesting feature noted was in a large wood about sixty rods from north to south which lay in the path of the wind where the storm first formed. Trees were uprooted and broken off, all falling toward the general direction of the wind except two trees at either end, which were crossed. The main destruction was caused by the portion of the storm south of the storm center and the crossing was produced by the opposite current in the whirl.

The track of the storm could be easily traced except at two points, where there was no disturbance for over one-half mile in each case.

The storm first appeared like a huge mass of black coal smoke rolling, tumbling forward, which later formed a black cloud with a funnel-shaped tail. The noise made by it was described as being like a hundred autos running at once.

The noise of the wind was heard at Richmond for over an hour first coming from the west, then north, and finally from the east. The winds at Richmond were countershift winds, which blew at a velocity of perhaps forty miles per hour during the greater part of the day.

Most of the destruction was in New Castle where the side walls of numerous houses seemed to be blown out, especially near the center of the storm's path. The buildings on one side were thrown toward the center and forward. The storm did not make as wide a path of destruction as the one at New Albany a few days later.

The barograph record of the Richmond high school showed the same amount of fall in the air pressure as that of the Ben Davis storm of a few years ago which passed over the town. This storm was about eight miles to the north when nearest to the barograph.

The daily weather map for March 10th and 11th did not show unusual weather conditions for Indiana. The storm developed because of sudden local changes.

The New Castle storm seemed to form in a comparatively level district and crossed over the valleys and divides between the streams. The large glacial valley on the west side of New Castle extends from the northeast to the southwest, but it did not materially change the course of the storm although the width seemed to be greater at that point, due perhaps, to the wind rushing along the trough to the storm area. As the map shows, all the main streams flow in an almost north and south direction across the tract of the storm, and each of these follow a valley. The area between the streams is gently undulating.

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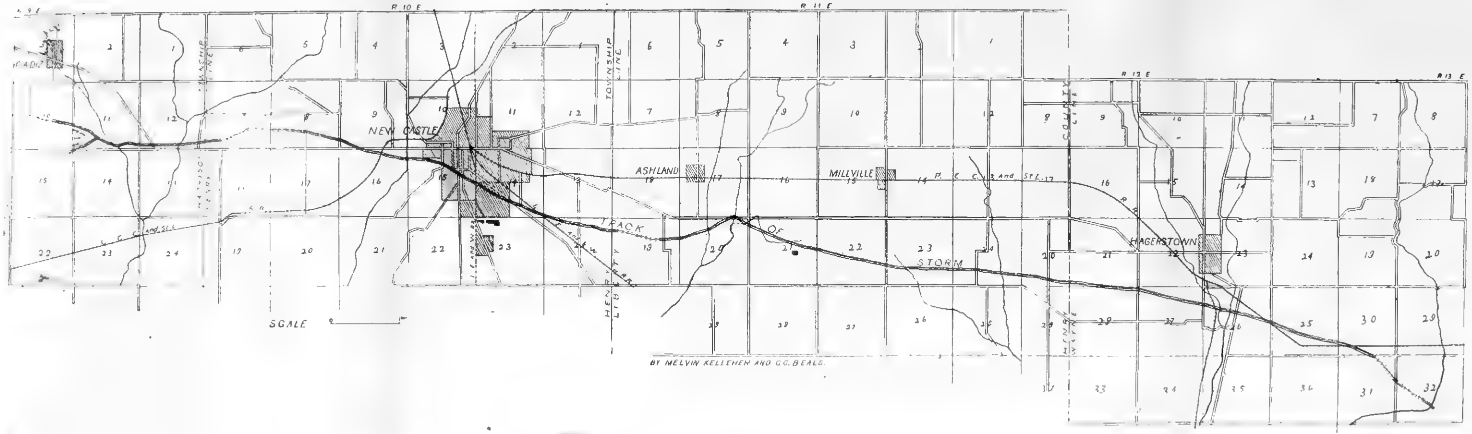

Track of the New Castle Tornado.

The Mount Carmel Fault.

William N. Logan—Indiana University.

Early in the fall of 1916 the attention of the writer was attracted to a reversal of dip in some beds of limestone lying in eastern part of Monroe County. In places this reversal of dip was noticeable in the limestones which overlie the Knobstone shales and sandstones, in other places in the sandstones of the Knobstone and again in beds of limestone occupying certain horizons in the Knobstone. Upon an investigation of the available geological literature I found in the Report of the State Geologist for 1896, pages 390-91, that Siebenthal discusses the Heltonville Limestone Strip as follows: "Commencing at Limestone Hill, eight miles southeast of Bloomington and extending east of southeast through Heltonville to, and probably beyond, Fort Ritner, Lawrence County, is a band of limestone from one-half to one and a half miles in width, bordered sharply, both east and west, by Knobstone, and known in that neighborhood as the Limestone Strip. Isolated patches of similar limestone occur north of this strip and in line with it. The strip is well developed in the vicinity of Heltonville, Lawrence County, where it gives exposures of the Harrodsburg, Bedford Oölitic and Mitchell limestones."

At many points the Knobstone contains intercalated lenticular beds of limestone, and it is possibly conceivable that the conditions which prevailed while these beds were being deposited might have been extended over a narrow territory like the Heltonville strip. However, the fact, first, that Knobstone has not been found overlying this limestone, and second, that it shows the lithological facies of the Harrodsburg, the Bedford Oölitic and the Mitchell limestones, and the faunas of these formations, identifies it with them and shows conclusively that it is a narrow band of these formations, occupying a depression in the Knobstone, and not an included member of the Knobstone.

This depression may have resulted from a double fault or may be an old erosion channel. Some things seem to point to one as the origin and some to the other. The facts at hand incline us to the latter view.

The most palpable objection to this view is the fact that no nonconformity exists between the Knobstone and the Harrodsburg limestone at their contact a few miles west of the strip. Another objection is that the bottom of the channel, at present at least, is not all of uniform elevation throughout its length. The principal objections to the view of a double fault are two—at no point was a direct vertical contact of Knobstone and limestone visible, nor was there to be seen any of the tilting, crushing and shattering which usually accompanies faulting. On the other hand, as the vicinity of the contact line is approached the shaly layers of the limestone become more and more argillaceous and apparently pass over into the Knobstone. To determine the exact conditions under which the limestone strip was laid down would require more extended study than is consistent with the scope of this report. What has been done was to trace upon the accompanying maps the outcrop of the Bedford oölitic and to examine the bed more carefully at places where it is now being quarried, namely at Heltonville and Fort Ritner."

In the proceedings of the Academy of Science of Indiana for 1897, page 262, J. A. Price discusses the boundary of the limestone strip and says in conclusion: "It is not possible, from data in hand, to say surely whether this strip of limestone owes its existence to an unconformity or a fault."

In 1903 J. F. Newsom published a description of a "Geologic Section Across Southern Indiana" as a part of the 26th Annual Report of the State Geologist. On pages 274 and 275 Newsom refers to the structure as a fault in the Knobstone area. He gives its extent as being from near Unionville in Monroe County to a point in the northern part of Washington County.

In referring to the discussions of Siebenthal and Price in the 27th Annual Report of the State Geologist, 1903, on page 90, Ashley says: "It is evident that if the limestone strip north of White River is due to a fault its effects should continue to the south rather than turn and follow the outcrop. A glance at the map in the region north of Campbellsburg is alone sufficient proof of the fault character of the disturbance."

In studying this structure in detail the writer has found that it is much more extensive than Newsom stated; that there is a second fault;

that other disturbances were connected with it and that the actual contact which he has found presents some interesting features.

Extent of the Fault.—While I have not yet been able to trace the fault to the borders of the State at either of its extremities I have been able to trace it far beyond its mentioned boundaries and feel confident that the particular disturbance under discussion extended from the Ohio to the Wabash along the western border of the Knobstone outcrop and perhaps beyond. Tracing the fault south of Campbellsburg in Washington County is difficult because the area on each side of the rift is occupied by limestone.

Along the northern end of the displacement glacial deposits conceal the bedrock to such an extent as to render observation difficult. Under these circumstances the best that can be done is to trace the disturbance by the reversal of dip of the limestones, as the finding of the rift will be extremely difficult. By such observations as it was possible to make I have traced the disturbance from a point southeast of Campbellsburg in Washington County to a point northwest of Waveland in Montgomery County.

Rift.—The actual contact of the rocks along the fault plane is revealed in only a few places. There are numerous places where the harder, more resistant stratum of limestone stands forth like a wall on one side of the rift, but the opposite side is occupied by mantle rock which was derived by the weathering of the Knobstone and which conceals the actual rift. Excavations made at such places would doubtless reveal the actual contact of the limestone and the Knobstone.

In a few localities the rift is exposed and the plane of the fault is bordered on the one side with limestone and on the other by shale. One outcrop of the rift zone was found in the bed of the north fork of Leatherwood Creek near Heltonville. At this point the Knobstone occurs on one side of the fault plane and the Harrodsburg limestone on the other. The line of rift is distinct, being marked by a thin bed of breccia. The brecciated zone is composed mainly of fragments of limestone in which small fragments of shale are intermingled. These fragments have been cemented together with calcite and the whole zone more or less marbleized. In a cross-section of the brecciated rock the veins of calcite stand out clearly, as they are whiter than the fragments of limestone and shale which they bind together. Small quantities of other minerals are present in some parts of the brecciated zone, but there is an absence of the more insoluble minerals, such as silica or the silicates. This fact leads to the conclusion that meteoric rather than thermal waters have played the leading role in the concentration of these minerals.

Periods of Movement.—The question of whether the displacement took place all at one time or was intermittent is an interesting one. All of my attempts to find an evidence of intermittent movement by an examination of surface features have been unsuccessful. If there were intermittent movements of any considerable extent we would probably find them revealed in hanging valleys on the upthrow side and the rapid broadening of valleys on the downthrow side of the fault. In case there were two stages of movement, and the movement in the last stage an exceedingly slow one, the vertical cutting of the main stream might be as rapid as the uplift, but still the rejuvenation of the tributaries should result in a narrowing of the valleys. In the rift zone there is evidence of two stages of movement though the amount of displacement in the second stage is slight. The time interval between the two movements was of considerable length, since the fragments of the brecciated zone were firmly cemented before the second movement took place. Fragments of shale which were included in the limestone fragments during the first movement were faulted by the second movement. These shale inclusions would not have undergone faulting had they not been held rigidly in place by the cementing material.

Amount of Throw.—The amount of throw of the fault varies probably from 200 to 300 feet. Opportunities for measuring the amount of throw are not numerous. It can best be computed by estimating the total amount of eastward dip of the formations along the line of contact between the Harrodsburg and the Knobstone. At a point south of Mt. Carmel the difference in elevation of the contact above sea level is 50 feet in a distance of one-fourth mile. Since the width of the down-thrown block is at least one mile and a half in this locality the throw of the fault is at least 300 feet. The amount of dip of the down-thrown beds in other localities is less than at this point, so much less that the indicated throw is not more than 200 feet.

Age of the Fault.—The time at which the dislocation occurred can not be fixed definitely. It is probable that it occurred at the close of the

Paleozoic Era when the Appalachian revolution which resulted in the elevation of the eastern part of North America took place. Contemporaneous with or subsequent to that great epeirogenic movement, faulting and minor folding took place in Indiana, Illinois and Iowa, and other States lying as far west as these from the region of maximum disturbance. These faults like the one under discussion have a northwest trend.

The Heltonville Fault.—About one mile west of the Mt. Carmel fault there is a second fault. This I have named the Heltonville fault because the rift is exposed a short distance east of Heltonville in the bed of the north fork of Leatherwood Creek, at a point just east of the wagon crossing under the Southern Indiana railroad. This fault lies approximately parallel with the Mt. Carmel fault. The limestone has been faulted down against the Knobstone. Slickenslides have been produced in the limestone and it has been much fractured. In places the limestone has been thrust backward and fragments of the Knobstone shales have been thrust into the limestone. In places these formations are dovetailed, fingers of limestone projecting into the Knobstone and vice versa as first one and then the other yielded to the pressure. The fragments of limestone containing inclusions of shale have been united by calcite veins.

Though the fault character of the disturbance at this point is incontestable it is not equally clear at other points. The disturbance extends both north and south of this point, but it probably passes into a fold in both directions. In Monroe County near Unionville there is an anticline which occupies about the same position in relation to the Mt. Carmel fault as the Heltonville fault does. Similar folds have been noted at intervening points and also to the south of Heltonville.

Effect Upon Topography.—The general effect upon topographic conditions within the area of disturbance has been to produce a narrow limestone belt extending parallel with the main Knobstone outcrop and bordered on each side by outcrops of Knobstone. In the southern portion of the faulted area the western belt of Knobstone is absent, but its nearness to the surface along the line of the eastward reversal of dip is revealed in the channels of many streams which have carved their valleys at right angles to the line of reversal. Probably the most marked effect is on the drainage. Both surface and underground drainage lines are affected. In the faulted area the ground waters which have found their way through the limestone have a tendency to follow the eastward sloping surface of the Knobstone to the rift, and near this point often come to the surface in a stream valley which lies near the rift and generally parallel with it. This tendency of the underground streams is modified by local dips of the strata north or south.

The surface streams, especially those along the line of the fault plane, have been influenced by the displacement. They have worked off the harder limestones on to the Knobstone in many places. These follow the line of rift until a local north or south dip has caused them to change the direction of their course. Small tributaries of the larger cross-cutting streams have developed, as has been noted again and again, along the line of rift.

Utilization of Indiana Kaolin.

William N. Logan—Indiana University.

Extensive beds of kaolin exist in Lawrence and Martin counties in the horizon of the Huron formation. The kaolin has been mined and utilized to a limited extent only. Its abundance and quality justifies a more extended use. Attempts have been made to use it as a substitute for southern kaolin used in Indiana in the manufacture of encaustic tile. The lack of bonding power is evident from the cracks and crazes which occur in the burned ware. The writer undertook to find a clay which might be mixed with the kaolin for the purpose of supplying bonding power and tensile strength. Mixtures of pottery clays and Indiana fire clays were made and the objects burned. It was found that tile could be manufactured successfully out of the kaolin when from 25 to 40 per cent of fire clay was added.

Certain Indicia of Dip in Rocks.

William N. Logan—Indiana University.

The object of this paper is to bring together certain indications of dip and the direction of dip in rocks which the writer has observed in his field work. All of these indicia have been noted doubtless by other observers of geological conditions. However, they are brought together here in the hope that the collection may be of assistance to students of structural problems in geology.

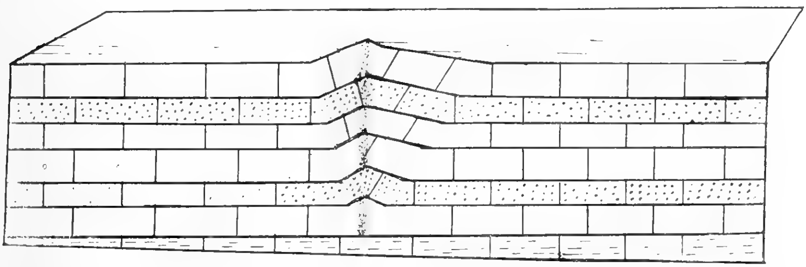

Fig. 1. Cross-section of strata, showing dipping beds with a gulch approximately at right angles to the dip. Right surface of rocks in gulch damp, left surface, dry.

Wet or Damp Surfaces.—In the case of an outcrop extending approximately at right angles to the dip of the beds the exposed surface of the rocks on the lower side of the dipping beds may be bathed in moisture. The presence of the moisture is due to the seepage of water from the porous layers in the rocks. Such seepage can take place only under certain conditions of humidity and would not be noticeable in an arid region. If the outcrop is in a railroad cut or in a stream with precipitous banks the outcrop on the opposite side from the damp surface will be dry because the water is conducted away from its surface, instead of toward it. The conditions are illustrated in the following diagram in which the shaded side of the cut on the down-dip side is kept moist by water flowing along the bedding planes and through porous layers, while the surface of the rocks on the opposite side of the cut is dry because the water is conducted away from the exposure. If the dip were, say, a southwest dip, then the southward direction of the dip would be revealed by wet surfaces on the north side of outcrops, while the westward dip would be revealed by moisture on the east side of exposures.

Springs.—Such conditions as have been outlined above often result in the formation of springs. Sometimes a chain of springs is formed

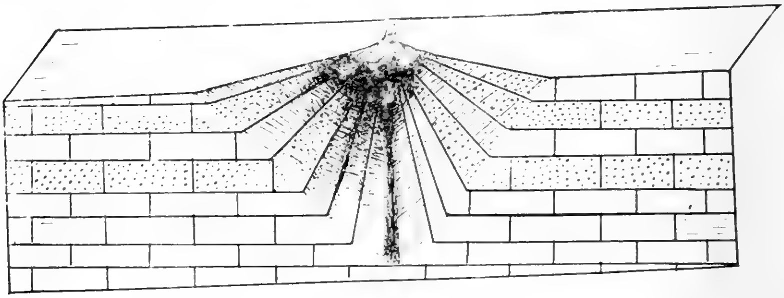

Fig. 2. The case of a stream cutting through strata approximately at right angles to the dipping beds. Springs will be formed at the contact of porous and impervious layers on the left bank of the stream.

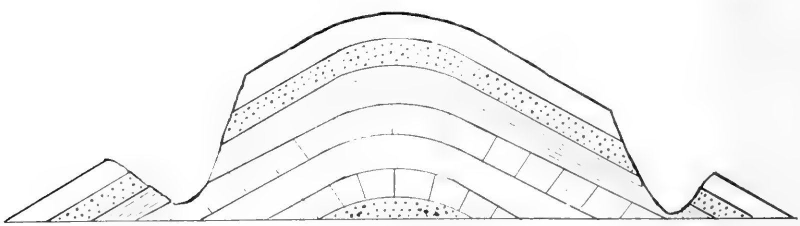

Fig. 3. Showing cross-section of a partly disected anticline. Springs may be formed in the valleys on each side of the axis at the points of contact of pervious and impervious layers.

along an exposure on its down-dip side. The essential conditions for a spring, such as a porous layer overlying an impervious one, must be present. Springs are of especial value as indicia in cases of concealed outcrop. Even if the bed-rock be concealed by mantle rock, springs often break forth at the point of contact of the pervious and impervious beds and by observing the position of these along the valley walls of cross-cutting streams, as in the case of wet surfaces, the direction of dip may be determined.

Springs are also good indicia of reversal of dip. Take for example the occurrence of a porous bed overlying an impervious bed in an anticline. Springs will be formed one each side of the anticline at the point of contact of the porous bed with the impervious one. If the anticline is a symmetrical one a chain of springs may occur at about the same elevation on each side of the fold. If the anticline is unsymmetrical the springs may occur at a higher elevation on one side than on the other.

Springs may also indicate the reversal of dip produced by the downthrow of a block along a normal fault. The springs will occur on the banks of depressions following the general direction of the strike and on the down-dip side of the outcrop.

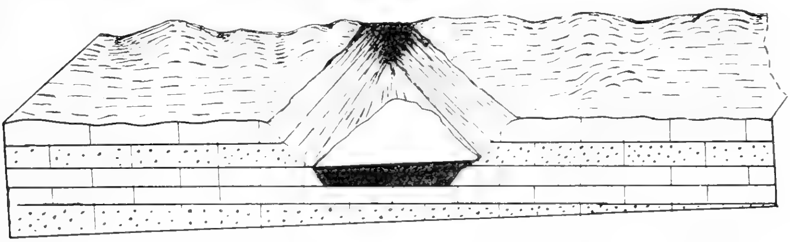

Fig. 4. Shows pool of water formed on surface of dipping bed. Note position of water level with reference to position of bedding planes on each side of pool.

Surface of Pools.—The surface of pools of water in inclined strata furnishes a horizontal plane by means of which even slight degrees of dip may be recognized. The conditions most favorable to such observations are the presence of inclined beds of hard rock or alternate layers of hard and soft rock which have been crossed by a stream in the bed of which pools have been formed. Using the surface of the water in the pool as a level, even slight dips may be detected by the difference in the elevation of the surface of the water upon layers on opposite sides of the pool. If the water stands on the uneroded surface of a hard layer it will have greater depth on the down-dip side of the pool.

Stream Channels.—The channels of dry streams are useful in determining the direction of dip. In the case of a stream trending in a line which is, in general, parallel with the strike and cutting across hard layers or beds composed of alternate hard and soft layers the stream will be thrown toward the down-dip side. The channel of the stream will have a more gentle slope on the up-dip side and a more abrupt slope toward the down-dip side. The stream, tending to follow the surface of the hard layer in the bottom of the channel, cuts against the bank on the lower side of the inclined bed making that bank more abrupt by under cutting. At the same time the more shallow depositional area of the stream is on the opposite side and its slope is rendered more gentle.

Overhanging Ledges.—Outcrops of rock in inclined strata which contain layers of sufficient induration to project unsupported form on the upper side of the inclined beds overhanging ledges. These ledges occur in layers of hard rock but are more pronounced in outcrops containing alternate layers of hard and soft rock. Slight degrees of dip

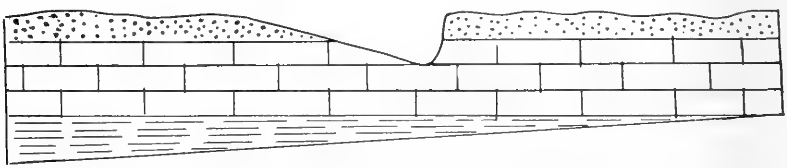

Fig. 5. Notch cut by stream in dipping strata. Note gentle slope on left and abrupt slope on right.

may be noted by observing the plane of shadows under these overhanging rocks. Frequently the direction of dip may be determined by the movement of water on the underside of these ledges.

Caves.—In limestone regions the position of caves serves as an indication of the direction of dip. Wherever a stream cuts through a thick bed of inclined limestone the valley wall opposite the down-dip side of the stream will have a series of caves which mark the positions of tributaries or of former tributaries of the stream. The opposite side of the valley will contain no caves in its wall. If these caves occur on the west side of a valley trending north and south the direction of the dip of the beds is eastward.

In the case of a stream heading in an inclined bed of limestone it frequently happens that more than one cave is formed. Frequently one at each terminal of the small tributaries. If these tributaries be close together and approximately parallel one will necessarily be farther down on the inclined slope of the beds than the other. Now since these tributaries are supplied with water draining down the surface of the impervious layer beneath the limestone the tributary farthest down on the slope will receive the greater amount of water. Thus it often happens that there is a lower cave from which a stream of water is issuing and an upper cave that contains little or no running water. In regions of such occurrences the cave on the lower part of the slope is referred to as the "wet cave" and the upper one as the "dry cave." The direction of dip is readily determined by the relative positions of these caves.

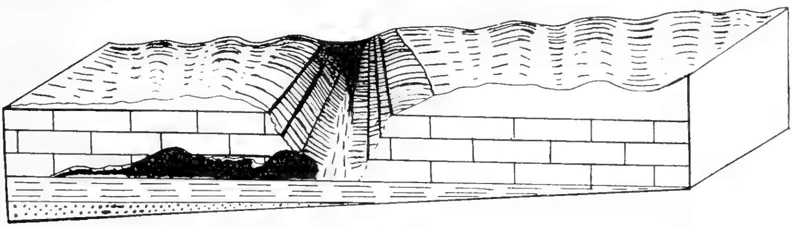

Fig. 6. Shows valley trending at right angles to the dip of inclined strata. Cave and overhanging ledges on left.

Sink Holes.—On moderately to steeply inclined limestone surfaces the shape of the sink holes may be an indication of the direction of dip. As a rule the longer axis of the sink hole will lie parallel to the direction of dip. Erosion produced by water flowing into the sink will be greater on the side opposite the direction of dip. The slope on this side of the sink becomes longer and more gentle. Very frequently there will be one or more short surface streams entering the sink from the side of this gentler slope.

Length of Tributaries.—In the case of a stream cutting in a direction approximately at right angles to the direction of dip the tributaries which follow down the dip will be longer than those which flow up the dip. This would not be true in a rock of uniform hardness devoid of stratification. Such indications are more noticeable in beds containing hard and soft layers of rock.

Indurated Surfaces.—The surfaces of some porous beds of rock which are exposed on the sides of cuts opposite the direction of dip become indurated by the more or less constant evaporation of water containing minerals in solution. These minerals left behind fill the pores of the rock and unite the individual grains of the rock, thus hardening the surface. The rocks on the opposite side of the cut may lack this degree of induration because, since the dip is away from the outcrop, the greater part of the water is drained away from the surface and the amount evaporated at this point is small.

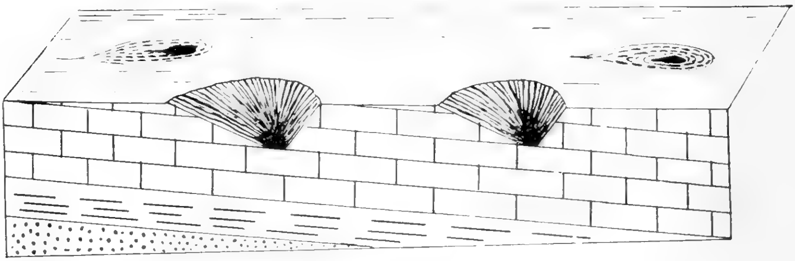

Fig. 7. Cross-section and horizontal section of strata containing sink holes. Note longer axis of holes parallel to the direction of dip.

Deposition of Sediment.—On the surfaces of layers of hard rock which are inclined either in quarries or stream beds the deposition of sediment may indicate the direction of dip. The thicker accumulation of sediment will occur in the direction of the dip. In the case of quarry floors which are formed on the stratification planes the distribution of rock dust and other forms of debris by running water will reveal the direction of the dip.

Distribution of Vegetation.—In inclined beds which outcrop, vegetation is sometimes more abundant on the side of the outcrop opposite the direction of dip. This greater abundance when it does occur is due to the increased amount of moisture and its almost constant supply to the surface of the outcrop through the porous layers which are draining down the dip.

Brief Notes on Field Methods Used in Geological Work of Mid-Continent Oil Fields.

Louis Roark—Indiana University.

In writing this article the writer is not attempting to make an elaborate discussion of the various methods nor is he attempting to suggest new methods of doing field work, but instead is endeavoring to bring together in a compact form, various methods commonly used, for the benefit of the young geologist who has not had an opportunity to learn them by actual experience.

No doubt many will take issue with me in regard to the value of some of these methods. However the writer has found them quite satisfactory under certain conditions and within certain limitations.

The geological work as conducted by the different oil companies of the mid-continent field is based upon one fundamental principle, namely, the location of structure favorable to the production of oil. The favorable structure as all know is the anticline. Therefore the geologist is continually searching for the anticline.

The geologist meets with many and varied difficulties in this work. He must follow the outcrops of the various rock strata and obtain elevations at intervals of at least one quarter mile and oftener if necessary. He must also measure the vertical interval between the different strata whenever the two horizons outcrop close together, thus presenting an opportunity to make such measurement. This vertical interval should be measured frequently in order to catch any variation in the interval. These elevations and intervals are used as a basis for drawing the structural contours, thus enabling the geologist to select the most favorable locations for drilling.

The following methods are used to obtain the elevation of outcrops.

1. Plane Table and Stadia Traverse, Using Telescopic Alidade.
2. Setting Bench Marks with Plane Table and Stadia. Geologist Using Aneroid Barometer.
3. Using Aneroid Barometer with Stationary Barograph.

4. Setting Bench Marks with Aneroid Barometer.

5. Reconnaissance (Scouting) Using Aneroid Barometer and Hand Level.

Method No 1.

For close detail work the plane table and stadia traverse is by far the most accurate method and no doubt favored by all geologists.

With this method the party consists of a geologist in charge and an instrument man. The geologist carries the stadia and follows the outcrop, giving stadia readings for location and elevation as frequently as he deems necessary. Between stations the instrument man sketches the drainage, roads and any and other features necessary to make a complete geological map.

At intervals of an hour or an hour and a half the geologist should return to the plane table and sketch the various outcrops on the map and record the vertical interval between the different strata he has mapped.

At night the day's work is inked in and that portion of the map is complete with exception of the structural contours.

This method is favored for open country and areas free from timber growth, and is fairly rapid.

The small telescopic alidade used by the United States Geological Survey is commonly used. The size of plane table depends upon horizontal scale used, varying from 15 inches to 24 inches square.

Method No. 2.

The second method used is not as accurate as first but is much more rapid for use in timber-covered areas.

With this method an instrument man with plane table, stadia and a rodman are sent into the particular area to be mapped. They run a stadia traverse along the roads, establishing bench marks at the corners and other conspicuous places, at least every one-half mile. If the roads are few the bench marks should be established at the end of spurs that extend toward the main stream between tributary valleys. A key system being used to mark the bench marks, the rodman paints the bench marks according to the key used. The elevation and number or key is recorded on the map for use of the geologist.

The geologist now takes the level sheet from the instrument man and by use of the aneroid barometer carries the elevation along the outcrop of rock strata. For the results obtained with the barometer to be of any value care should be taken that the barometer is checked frequently.

The method ordinarily used is to set the aneroid barometer at same elevation as bench mark from which start is made also noting time barometer was set, which is essential. Whenever an elevation reading is made on the outcrop the time of reading should be noted. The barometer must be checked at a known elevation every forty or forty-five minutes and should not be more than an hour between checks for accurate results. The barometer must not be changed after being set at first station in the morning.

At night, plot a curve showing amount of variation of barometer from normal during day. By means of the curve correct all readings for elevations made during the day by adding or subtracting the difference from normal, to the reading to be corrected.

Example: Suppose correction curve shows aneroid barometer was reading 22 feet high at 10:15 and elevation reading on outcrop was 953 feet at same time. To get correct elevation of that point subtract 22 feet from 953 feet which gives 931 feet, the correct elevation. If aneroid barometer was reading low at 10:15 the 22 feet should be added to give correct elevation which would be 975 feet, etc.

While geologist is walking the outcrop, he should sketch the drainage, roads, trend of outcrop of rock strata and other features necessary to make a complete geological map.

After making correction of barometer readings the day's work should be inked as finished, so that the work will not be lost by erasure during work the next day. The inking should be up to date at all times.

The aneroid barometer most commonly used is 2½ inches in diameter graduated to record elevation of 3,000 feet with 10 feet divisions. Frequently larger instruments are used, some as much as 6 inches in diameter. The larger aneroids are the more accurate.

Method No. 3.

The third method is not as accurate as either of the first two, but much more rapid, and can be carried on with less expense, as the plane table and operator are eliminated. With care accurate results can be accomplished with this method.

If a geologist is sent into a field to do a rapid piece of work and time available for doing the work or character of the work would not pay to employ the use of plane table and stadia this method is the most satisfactory one to use. The reader must keep in mind that the element of time is important to the oil geologist. He must finish his work and get report to the chief geologist to pass upon, before another company has an opportunity to obtain lease on valuable acreage that he is likely to report favorable.

In this method a barograph can be used to an advantage in connection with the ordinary aneroid barometer. Set the barograph at some place near center of area to be worked and proceed with aneroid barometer as in Method No. 2, noting time all readings are made. At night, instead of plotting curve as before, use curve of barograph and proceed in same way to make correction for elevations.

If a barograph is not available use two aneroid barometers, one to be stationary and the other carried by geologist. In case two aneroids are used the one stationary should be read every 15 or 20 minutes throughout the day and a curve plotted from these readings. Proceed as before in making corrections for elevations.

Method No. 4.

The fourth method can be used in case it is desirable to detail a small area and neither a plane table, barograph or extra aneroid barometer is available and time is short for completing the work.

The geologist uses his aneroid to establish his own bench marks. An elevation at a certain point may be assumed. Set aneroid at this assumed elevation, noting the time. Drive in a circle making readings at points where bench marks are desired, noting time of readings. Return to starting point within 45 minutes or an hour from time of start. Repeat circuit, checking previous readings. Now these points can be used as bench marks, making circuits from these points establishing bench marks farther out, checking and rechecking the points to be used as bench marks. Continue this until bench marks have been established over area to be detailed. Plot curve and make corrections for elevations of points to be used for bench marks. After the bench marks have been established the method of procedure is same as in Method No. 2 in all respects.

This method is very good and quite accurate for obtaining quick results.

Method No. 5.

The fifth method is simply reconnaissance work, or scouting, as it is frequently called.

With this method the geologist drives over the country observing the dip of the rock strata by use of the hand level, aneroid barometer or eye.

Wherever an exposure of rock is observed the hand level is used to determine the approximate amount of dip in any distance. The direction of dip may be obtained by use of the compass. The geologist must always know the height of his eye from the ground.

Example: Suppose strata is dipping west and in a distance of one-quarter mile the geologist finds the dip to be five times the height of his eye which is 5 feet 6 inches, therefore the rock would be dipping 27 feet 6 inches in one quarter mile, etc.

The aneroid barometer may be used in scouting to determine approximate amount of dip for short distances. Read elevation of outcrop, then follow strata for distance exposed, with occasional readings, noting amount of variation from first reading. This gives the amount of dip.

Example: If aneroid reads 700 feet at a given point and outcrop is followed east one-quarter mile and then reads 670 feet, showing strata dips east 30 feet in one quarter mile. Supposing second reading was 732 feet then strata dips west 32 feet in one quarter mile, etc.

An experienced geologist should be assigned to scouting work. The greatest value of this method is that it permits a large territory to be covered rapidly and a great part eliminated. An experienced man will be able to find most of the structure. Later, if deemed advisable, the various structures reported by the scout can be worked in detail by either of the first two methods.

An Improved Form of Mercury Vapor Air Pump.

Chas. T. Knipp—University of Illinois.

(Abstract.)

The mercury vapor pump described in this paper retains the same simple valve arrangement described recently by the writer,* but on the other hand replaces the umbrella that deflected the mercury vapor downward through an annular throat by the commonly used aspirator nozzle through which the vapor issues vertically upwards. This necessitates an interchange of connections leading to the supporting pump and the vessel to be exhausted.

This pump, single stage, will operate on any oil supporting pump of the grade of the Nelson pump. In addition to its speed, its simplicity of design and ease of construction are important points, and when constructed of pyrex glass is durable.

The paper also gives the data obtained when several of these pumps are placed in tandem. Again, a three-stage pump retaining the same general principle is described, designed to operate on a poorly working water aspirator as a supporting pump. The mercury vapor for each stage is supplied from the same boiler, yet at different pressures, the highest pressure to the first stage exhausting into the aspirator. Sample pumps and sketches were exhibited.

* Phys. Rev., N. S. IX, No. 3, March, 1917.

A Possible Standard of Sound.

Chas. T. Knipp—University of Illinois.

(Abstract.)

The paper as presented described a source of sound recently brought to the writer's attention, while blowing a mercury vapor trap of pyrex glass, that bids fair to furnish a standard of sound of any desired pitch with no other apparatus than the trap and a bunsen burner. In its simplest form the apparatus is an ordinary trap as shown in Fig. 1, having the usual ring seal at M.

To operate, close A with a sliding piston of cork, let C remain open, and apply a bunsen burner (adjusted to give a fairly hot flame) at B. The tube AB should be held in the flame at an angle so that the central portion M is not unduly heated. When B begins to glow, a pure tone that is readily audible over a large room is emitted at C. The pitch of the sound is dependent upon the length of the vibrating column AB and also upon the length of the side tube MC. Attaching a horn at C intensifies the sound many fold. The only opening is at C, yet a candle placed at this point is instantly blown out. On closer examination it was noticed that a current of air *enters* the tube C around its edge, and another at the same time *escapes from it* along its axis.

There are other conditions that affect the pitch. Those noted thus far are: That heating the region about M destroys the sound; but on the other hand if the flame is removed from B, then C stopped and A opened, the tube will again operate on *heating M to redness;* that the pitch is raised by the addition of extra side tubes fused to the vibrating column at M, and is instantly lowered when these extra branches are in turn stopped.

Tubes having different dimensions were constructed. These can be adjusted over wide ranges—each an octave or more—and all give, apparently, clear tones particularly free from overtones. By supplying heat to the end B at a constant rate (as by an electric furnace) the pitch may be kept constant for an indefinite length of time. The apparatus should therefore furnish a standard source of sound.

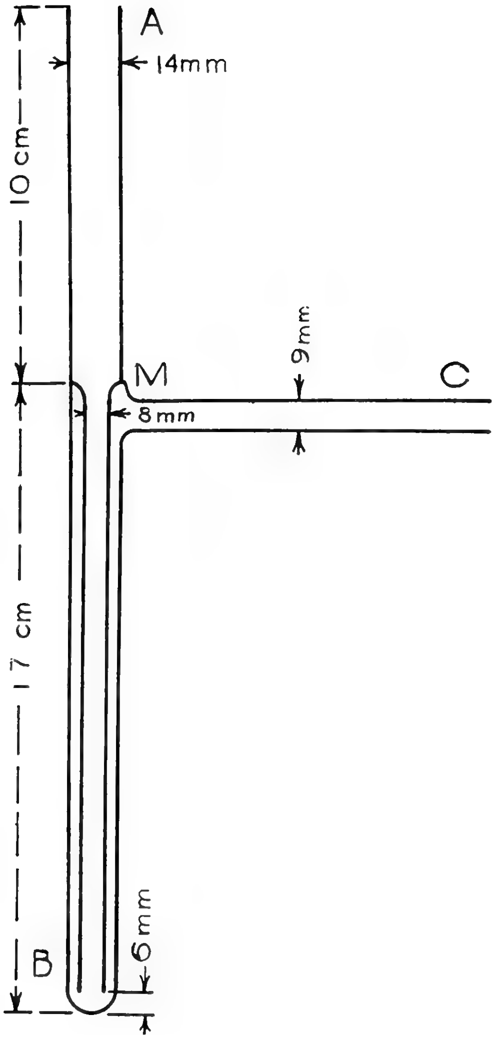

FIG. 1. A possible standard of sound.

Energy Losses in Commercial Hammers.

Edwin Morrison and Robert L. Petry—Earlham College.

It is a well-known principle of mechanics that, in case a moving object impinges against another object, that the total momentum before impact is equal to the total momentum after impact. In other words, "That momentum is conserved in all impacts, be it between elastic or inelastic objects." This law does not permit us to infer, however, that there are no energy losses in impacts. In fact the kinetic energy is always less after impacts than before impacts of two impinging objects. By testing this out by ordinary laboratory methods we find these energy losses to vary from as high as eighty per cent in case of inelastic impacts to as low as two per cent in elastic impacts.

In teaching this subject I have for a number of years attempted to illustrate and fasten these principles in the mind of the student by such questions as the following: Suppose a carpenter is employing a number of men in a mechanical process, such as the driving of nails with a hammer, would it be of importance for him to look into the grade of hammers used? Or again: Suppose a railroad company is retracking its line and it is necessary to drive thousands of spikes, does it matter whether the sledge hammers used are made of cast iron or a high grade of steel?

It so happened that my present class inquired as to whether it would be possible to try these conditions out in an experimental way. After a moment's reflection I informed them that it would be a very simple matter to make tests by substituting a hammer for one of the steel spheres in our impact machine. This has been done in the case of four hammers with considerable care.

The apparatus used was similar to that employed in Experiment 6, page 62, in Millikan's Mechanics, Molecular Physics, and Heat. One of the steel spheres was removed and the hammer to be tested was substituted in its place as shown in Fig. 1. In order to support the different hammers as nearly as possible under the same conditions, a frame was suspended by four adjustable cords, to which the hammers could be rigidly bolted. The experiment consists in displacing the hammer to a certain angular position to one side the normal position and allowing it to drop and impinge upon the steel sphere, noting the maximum angular displacement of both the steel sphere m_1 and the hammer after impact.

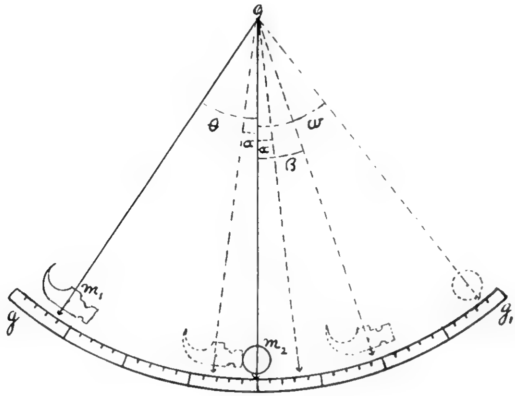

Fig. 1.

The following equations are applicable:

$$\text{The Coefficient of Restitution} = \xi = \frac{\sqrt{(1 - \cos \omega)} - \sqrt{(\cos \alpha - \cos \beta)}}{\sqrt{(\cos \alpha - \cos \theta)}}, \quad (1).$$

The percentage loss of K.E. $= 1 = (1 - \xi^2) \cdot \dfrac{m_2}{m_1 - m_2}$, (2) The values of α, β, θ, and ω are measured directly upon the graduated scale gg_1.

TABLE I.

	Mass of Sphere. m_2	Mass of Hammer.	Mass of Suspending Frame.	Total Mass. m_1.	α In Deg.	β In Deg.	θ In Deg.	ω In Deg.	ξ From Equation 1.	1 From Equation 2.	Average 1.
No. 1	232.9	659.0	123.3	782.3	2.97	6.08	10.0	14.4	.9539	2.063	......
No. 1	232.9	659.0	123.3	782.3	2.97	6.63	11.0	15.9	.9405	2.645	2.354
No. 2	232.9	518.8	123.3	634.1	3.27	5.82	10.5	13.8	.8981	5.193	......
No. 2	232.9	518.8	123.3	634.1	3.27	6.29	11.5	15.2	.8945	5.364	5.297
No. 3	232.9	332.6	123.3	455.9	3.00	4.70	9.9	11.8	.8618	8.693	......
No. 3	232.9	332.6	123.3	455.9	3.00	5.71	13.0	15.5	.8406	9.921	9.307
No. 4	232.9	245.6	123.3	368.9	3.02	5.95	15.0	15.2	.6829	20.65	......
No. 4	232.9	245.6	123.3	368.9	3.02	4.91	12.0	15.3	.7265	18.27	19.46

Hammer No. 1 was a high-grade machinist hammer.

Hammer No. 2 was a claw hammer purchased as a high-grade tool.

Hammer No. 3 was a lower-grade machinist hammer.

Hammer No. 4 was a cast-iron hammer purchased at a five and ten cent store.

The steel sphere used in the above experiment, when tested with a similar sphere, gave an average of approximately two per cent energy loss.

Conclusion: The experiment justifies the conclusion that high-grade steel hammers conserve to a much larger degree the kinetic energy of a blow than low-grade cast-iron hammers.

The Effect of Artificial Selection on Bristle Number in Drosophila ampelophila.

Fernandus Payne—Indiana University.

The following brief abstract gives a summary of the results obtained in an experiment designed to test the effect of artificial selection on bristle number in Droscphila ampelophila, and to find out in what way selection is active.

The normal number of bristles on the scutellum is four. In a mass culture which had been bred in the laboratory about three months, a female was found with one extra bristle, or five in all. This female was mated to a male from the same mass culture. Of the F offspring, two females had five bristles. These two females were mated to their normal brothers, and gave in F^2, 935 normal flies, thirty-nine with five bristles, and four with six bristles. The flies with extra bristles were again mated and this method of selecting the high-grade parent has been continued throughout the experiment. The per cent of extra bristled flies and the mean bristle number have been gradually increased until in the last generations of selection no normal flies were found and the mean reached 9.089 in the twenty-eighth generation. From the twenty-eighth to the thirty-eighth generations, the mean remained practically the same. A back selection line started from the eleventh generation was without effect.

Selection then has produced decided results. The larger question is, how have the results been produced? Have they been produced by selecting somatic variations, by selecting the variations of the gene which stands for bristle number, or have they been produced by piling up or getting rid of modifying factors? The first possibility can be dismissed without much consideration, as any character which is inherited must be germinal. Of the other two possibilities, my evidence is in favor of the latter. It shows quite conclusively, I think, that there is a factor in the X-chromosome and also one in the third chromosome which modifies bristle number. There may be more than two such factors. One was no doubt present at the beginning of the experiment. The others probably occurred as mutations during the course of selection.

The Unionidæ of Lake Maxinkuckee.

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and
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During the physical and biological survey of Lake Maxinkuckee carried on by the writers at intervals from 1899 to 1913, under the auspices of the United States Bureau of Fisheries, considerable attention was devoted to the freshwater mussels or clams (Unionidæ) inhabiting that lake. This was justified by the rapid and astonishing development of the pearl button industry in America, which is dependent upon the shells of the mussels for its raw material. The recent development of methods whereby several species of Unionidæ are now successfully propagated artificially adds special interest to the study of these mollusks.

Lakes and Ponds as the Home of Mussels.

Generally speaking, lakes and ponds are not so well suited to the growth and development of mussels as rivers are; the species of lake- or pond-mussels are comparatively few, and the individuals usually somewhat dwarfed. Of about 84 species of mussels reported for the State of Indiana, only about 24 are found in lakes, and not all of these in any one lake, several of them but rarely in any. Of the 24 species occasionally found in Indiana lakes, but 5 are reported only in lakes, and only 3 or 4 of the species common to both lakes and rivers seem to prefer lakes.

In rivers, the essential feature favorable to the development of mussels is the current; and in rivers the mussel beds reach their best development on riffles, where the current is strongest. The importance of the current to the well-being of the mussels is indicated by the position these mollusks naturally assume in the beds, the inhalent and exhalent apertures of the creatures being upstream against the current. The importance of the current is not merely as a bringer of food; examinations show that the mussels of the plankton-rich lakes and ponds usually contain more food material than those of the rivers. The current gives the river-mussels the advantage of a constant change of water, which means a more abundant supply of oxygen, and doubtless a more varied supply of mineral matter, from the various sorts of soil through which the river flows. The current is also probably of considerable importance in assisting in the fertilization of mussels, one of its results being the conveyance of sperm from mussels in upper portions of the bed to other mussels below. In places where there is no current, fertilization must be more largely a matter of chance.

Although the majority of species of mussels prefer a river where there is a good current, some are more fitted to the quieter parts of streams, or to ponds. These are chiefly thin-shelled species with weakly developed or undeveloped hinge-teeth, best represented by the genus *Anodonta.* In some places Anodontas are known as pond-mussels, to distinguish them from the heavier sorts, or river-mussels.

The distinction between lakes and rivers is not constant in degree; we have all sorts of gradations from the extreme form of lakes—isolated bodies without outlet—through lakes with relatively large, important outlets, to such lakes as are simply expansions of a river-bed, examples of the latter type being Lake Pepin, Minn., of the upper Mississippi, and the former English Lake in Indiana, an expansion of the Kankakee. As a usual thing, the more fluvatile a lake is, or the larger and more river-like its outlet, the more river-like will be its mussel fauna, both in abundance and species. In such lakes the mussels retain a vital continuity with the mussel beds of the river. In the less fluvatile lakes the mussels are more isolated, and there is more inbreeding. The large number (24) of lake-dwelling species recorded for Indiana is due to the fact that some of the lakes of Indiana are more or less fluvatile, and contain several species of river shells.

Origin and Character of the Maxinkuckee Mussels.

Lake Maxinkuckee, having a long, narrow, and relatively unimportant outlet, is a representative of one of the less fluvatile types of lakes, forming a pretty well marked contrast to the various lakes cited above, and bearing a pretty close resemblance to the neighboring lakes, such as Twin Lakes, Pretty Lake, Bass Lake, etc.

The Maxinkuckee mussels are doubtless derived from ancestors brought up the Outlet from the Tippecanoe River by ascending fishes. It is doubtful whether any have been introduced by the numerous plants of fish in the lake, though such a thing is possible. During various times the lake was visited, a few Tippecanoe River mussels were planted in the thoroughfare between the lakes, and a few Yellow River and Kankakee mussels were planted in the main lake.

The Outlet of Lake Maxinkuckee is now a narrow, shallow, winding stream, straightened in places by ditching, and bordered on each side by a flat sedgy plain which indicates the former breadth and importance of the stream. The colonization of the lake with mussels was probably effected chiefly during the period when the Outlet was a broad and relatively important stream. The situation has been carefully considered and seems to show that the mussels of the river and lake are isolated from each other and that there is no longer any vital connection between them. The strongest indication of the independence of the lake and river mussel faunas is the appearance of the Maxinkuckee mussels themselves; these are lake-mussels, easily distinguished for the most part from the river-mussels of the same species, and many of them are distinguishable also from the mussels of the neighboring lakes.

The Tippecanoe River is fairly well supplied with mussels. Although the number of species is considerably fewer, and the size of the individuals is generally smaller than those of the Wabash into which it flows, it compares very favorably with rivers of its size. At Delong, Ind., a short distance above the mouth of the Outlet of Lake Maxinkuckee, specimens were obtained in one bed representing twenty-four species of mussels, or about twice the number of kinds found in Lake Maxinkuckee.

Our knowledge of the extent and importance of migrations of fishes from the Tippecanoe River up to the lake and from the lake down to the river—a question which has a marked bearing upon the relationship of the mussel faunas—is not as complete as it should be, but indications are that they are not important or extensive. Inasmuch as the geographic distribution of a given species of mussel is coextensive with that of the species of fish which serves as its host, this question is worthy of careful consideration. There are several species of fishes of the Tippecanoe River (*Etheostoma camurum, Hadropterus evides, Hybopsis amblops,* etc.), which were not found either in the Outlet or in the lakes, and other species (*Hadropterus aspro, Ericymba buccata, Diplesion blennoides*) which have pushed half way up the Outlet, but were found no further up.

In this connection, the mussel fauna of the Outlet is worthy of consideration, and on various occasions, but especially on a trip down the Outlet September 30, 1907, particular attention was paid to this feature.

The Outlet is not particularly well suited to the growth and life of mussels. The bottom is either a firm peaty soil or fine shifting sand; moreover, the course has been artificially changed in some places and the stream has naturally shortened its length in others by making cutoffs. In addition to this the mussel fauna of such a narrow shallow stream would be the prey of muskrats, minks, etc., the entire length and width of the beds.

On the trip mentioned above, about a mile below Lost Lake a fine example of *Lampsilis iris* was found. This is the farthest up stream any species of mussel was obtained, and as this species is fairly common in both lakes and abundant in the Tippecanoe River, we have here the nearest approach to a continuous fauna. Some dead shells but no living examples of *Quadrula undulata* were found a little farther down. Farther down stream from a quarter to half a mile, a short distance above the second cross-road south of the lake, was found a small mussel-bed of about forty or fifty mussels, the great majority of which were *Quadrula undulata.* A few living *Lamrsilis iris*, two dead *Symphynota compressa,* one living *Symphynota costata* (gravid) and a few dead shells of *Quadrula coccinea,* complete the list. Below this point no mussels were found until near where the Outlet joins the Tippecanoe. Here, a few rods up the Outlet, a fair bed of *Quadrula coccinea* was found. Of the five species of mussels found in the Outlet, only two, *L. iris* and *Q. coccinea*, are found in the lake, the latter but rarely. The form and general appearance of the *Q. undulata* of the Outlet is quite peculiar and they can be picked out at once from collections from the various rivers of the country. They are unusually elongate, in this respect resembling some of the Tippecanoe mussels but differing from them in being thinner, and in having the furrows between the plicæ unusually deep and sharp. The costæ on the posterodorsal slope are very marked, and the epidermis is jet black. The umbones are considerably eroded.

Distribution of Mussels in the Lake.

In rivers, where there is a great variety of conditions, such as differences of current, bottom, etc., one finds the different species of mussels inhabiting different localities and different situations. In the lakes, where we have comparatively few species of mussels and not such important differences of environment, the distribution of the various species is much the same. The same conditions, such as rather shallow water and moderately firm bottom, are equally suitable for all. A few important exceptions may be noted, as for example, the less common species of the lakes are often more or less local in distribution. The only well-marked bed of *Quadrula rubiginosa* in the lakes is in the Lost Lake mussel-bed below the Bardsley cottage, and this is the only place where *Lampsilis subrostrata* can be collected in any considerable numbers. *Lampsilis glans* has a marked preference for the shallow water at the edge of the thoroughfare between the lakes; occasional examples can, however, be picked up almost anywhere along the shore, and it appears to be increasing considerably along shore at Long Point. *Anodonta grandis footiana,* which can live in softer bottom than the other mussels, has a considerably wider distribution, and was dredged in deeper water than any of the other mussels.

The mussels are to be found almost anywhere in water from 2 to 5 or 6 feet deep where the bottom is more or less sandy or marly. The beds are composed chiefly of the three principal species of the lake, *Lampsilis luteola, Unio gibbosus* and *Anodonta grandis footiana,* with the less common species sparsely interspersed. Especially good mussel beds occur at Long Point, along shore by Farrar's and McDonald's, along the depot grounds in Aubbenaubee Bay out from the Military Academy, and in the shallow water just beyond the mouth of Norris Inlet. Mussels are fairly well scattered from Long Point more or less continuously all the way southward to beyond Overmyer's hill, and from a little north of the ice-houses all the way around to the Military Academy. They are quite abundant in the neighborhood of Winfield's in shallow water, and occur scattered along the east side of the lake a little way out from the shore. A good mussel bed is found in Lost Lake along the east shore, extending from a little south of the Bardsley cottage to where the bullrushes and water lilies grow thickly in the soft black muck near the shore.

Movements.—Closely connected with the question of distribution is that of movement. The greater number of mussels of the lake, especially in the deeper water, spend their lives in a state of quiescence. Young mussels appear to be more active than older ones. The mussels retain the power of locomotion during all their lives, but after they have got well settled down, they only occasionally use this power. The mussels in shallow water near the shore move into greater depths at the approach of cold weather in late autumn or early winter and bury themselves more deeply in the sand. This movement is rather irregular and was not observed every year. It was strikingly manifest in the late autumn of 1913, when at one of the piers off Long Point a large number of furrows was observed heading straight into deep water, with a mussel at the outer end of each. The return of the mussels to shore during the spring and summer was not observed. Many of them are probably washed shoreward by the strong waves of the spring and summer storms, and some are carried shoreward by muskrats and dropped there. Occasional mussels were observed moving about in midwinter, even in rather deep water. During the winter of 1900-1901, an example of *Lampsilis luteola*, in rather deep water in the vicinity of Winfield's, was observed to have moved about 18 inches in a few days. Its track could distinctly be seen through the clear ice.

As a result of the quiescence of the lake mussels, the posterior half or third of the shells, which projects up from the lake bottom, is usually covered by a thick marly concretion which appears to be a mixture of minute algæ and lime. This marly concretion grows concentrically, forming rounded nodules, its development increasing with the age and size of the shell. This concretion, though most abundant on shells, is not confined entirely to them, but grows also on rocks that have lain undisturbed on the bottom. When growing on shells, it adheres to them very closely; and upon being pried loose sometimes separates from them much as the matrix separates from a fossil, and leaves the epidermis of the mussel clean. In other cases it adheres more closely and is difficult to scrape off clean. On this marly growth, colonies of *Ophrydium*, much the size, color, and general appearance of grapes with the skin removed, are often found growing, and in the cavities and interstices of the marl, a handsome little water-beetle, *Stenelmis sulcatus* Blatchley, and its peculiar elongate black larvæ, lives in considerable numbers but apparently has nothing to do with the mussels. Various species of hydrachnids, one of them strikingly handsome with its green body sprinkled with bright red dots, also live in the cavity of the marl, and offer some suggestion as to how the parasitic mite *Atax* went a step farther and took up its habitation within the mussel itself.

Food and Feeding.—An examination of the stomach and intestinal contents of the various species of mussels of the lake showed no noticeable difference between the food of the different species. Enough of the bottom mud is generally present to give the food mass the color of the bottom on which the mussels are found. Thus the stomach-contents of the mussels found in the black bottom of Lost Lake were usually blackish, while that of those found in the lighter bottom at Long Point were grayish. Intermixed, however, with the whole mass was always enough algæ to give it a somewhat greenish tinge, this green being usually intermixed more or less in the form of flakes. A striking contrast between the stomach contents of mussels inhabiting lakes and those found in rivers is the much greater preponderance of organic matter in the food of the lake mussels. The stomach contents of river-mussels is generally chiefly mud, with a few diatoms, desmids, *Scenedsmus* and *Pediastrum* intermixed, as said above. Those of the lake mussels are almost always full enough of algæ to be more or less flecked with green and sometimes the whole mass is decidedly greenish. On being placed in a vial of preserving fluid (3 per cent formalin was generally used) and shaken, the material from the river mussels always retains the uniform appearance of mud; that from the lake mussels separates, the mud settling to the bottom and the organic material settling as a light flocculent mass above the more solid portion. This top layer is composed of the various plankton elements of the lake, and was found to vary considerably in different lakes. In the Lake Maxinkuckee mussels it was found to consist chiefly of such species as *Mi-*

crocystis æruginosa, *Botryoccus braunii*, *Cœlosphærium kuetzingianum*, various diatoms, such as species of *Navicula*, *Rhoicosphenia*, *Gomphenema*, *Cyclotella*, and *Cocconema*, various forms of desmids, especially *Cosmarium* and *Staurastrum*, various forms of *Scenedesmus*, considerable *Peridinium tabulatum*, and short filaments of *Lyngbya*. *Pediastrum*, both *boryanum* and *duplex*, are here, as almost everywhere, rather common objects encountered in the intestines of mussels. Casts of the rotifer *Anuræa cochlearis*, and one of the small entomostracan, *Chydorus*, were occasionally encountered. In one of the Lost Lake mussels, *Dinobryon*, an exceedingly frequent element of the mussel-food in Lake Amelia, Minn., but rare here, was found.

No opportunities were had to study the stomach contents during the winter, the mussel work having not been taken up to any extent during the earlier part of the survey. Mussels obtained quite late in autumn contained much the same material as in summer. The open and apparently active inhalent and exhalent apertures noted throughout the winter in some individuals would indicate that the mussels—at least some of them—do not hibernate, but carry on life processes more or less actively the year round. The presence of pretty well-marked growth rings would indicate, however, annual rest periods. As diatoms appear to be much more abundant in the water during the winter, it is probable that they enter more plentifully into the mussel's bill-of-fare during the late autumn, winter, and early spring, than during the summer. In considering the mussels as feeders on plankton elements, it is worth while to investigate whether these are not of benefit to the lake as reducers of the excessive amounts of such undesirable elements as *Lyngbya*, *Anabæna* and *Microcystis*, and whether a considerable increase in the mussel population by means of artificial propagation would not clear up the lake to a considerable extent.

The following studies of stomach contents and table of mussel food are by no means exhaustive, but represent hurried examinations and a record of the more easily recognized forms out of a mass of doubtful material. They are intended to be simply suggestive.

Closely connected with the question of food and nutrition is that of the size of the mussels. A marked feature of the mussels of Lake Maxinkuckee, as well as of the neighboring lakes, is the dwarfing of many of the species, and this is rather difficult to explain when one considers the large amount of organic material they ingest. The mussels of a few northern lakes examined were thick-shelled and large. So this dwarfing may not be necessarily associated with lake conditions, that is, absence of current. A possible explanation is that of close inbreeding, there being no admixture of new blood with other distant colonies, such as is possible where the lake is in close connection with a large river and its mussel beds.

Breeding Habits, Reproduction, etc.—The reference to inbreeding above leads to a consideration of breeding and breeding habits. At first glance it would appear that lakes, having no, or only feeble, currents, would make fertilization of the ova of the female mussels largely a question of chance. It is not possible, with the data at hand, to make precise comparisons between number of gravid females of the mussels of lakes and rivers during the proper seasons, but the general impression gained from having examined the various mussels of numerous lakes and rivers through the different seasons is that there are fewer of the mussels of the lake that succeed in having their ova fertilized. Gravid mussels are indeed not rare in the lake at proper seasons, but they seem to be much fewer than one might expect. On October 17, 1907, for example, of 252 *Lampsilis luteola* examined, 41 were of the characteristic female form but only 25 were gravid. Likewise, of 18 Anodontas examined on the same date, only 2 were gravid. This is a considerably lower percentage than one would expect in rivers at this date. There are other indications that the functions of reproduction are much less prominent in the lake than in rivers. In the height of the spawning season certain species of mussels, especially *Lampsilis ventricosa* and *L. multiradiata*, exhibit, in the neighboring rivers, a very striking appearance, due to the excessive development and high coloration of portions of the mantle near the inhalent aperture. Though both these species are found in the lake, none was observed in this condition. In some rivers in densely crowding beds, moreover, one frequently encounters precocious individuals; small shells, usually apparently only 2 or 3 years old but gravid with the characteristic female contour markedly developed. This is possibly related to opportunities of fertilization of ova, and is most frequently observed in *L. ventricosa* and *L. luteola*. No such precociously developed mussels were found in the lakes.

A large and well developed female *Lampsilis ventricosa* was transplanted from Yellow River into Lake Maxinkuckee. On being examined two years later in the autumn, when this species is usually gravid, it was found to be sterile.

The natural infection of fishes of the lake with the glochidia of the mussels does not appear to be common. The gills of an immense number of fishes were examined for parasites, but no glochidia were noted. Some young bluegills and redeyes, exposed to the glochidia of *L. luteola* in the autumn of 1912, took very readily.

The young mussels were either few, or very difficult to find. Diligent search was made for them, especially in the sandy bottom near Long Point, the sand being scooped up and seived through fine-meshed seives. Numerous and varied forms of life were thus obtained, such as *Sphærium*, *Pisidium*, caddis cases, etc., and rather small but by no means minute examples of *L. luteola* found. These young shells were remarkably brightly rayed. Half-grown *Q. rubiginosa* were fairly common in the beds of Lost Lake.

Proportion of Various Species in the Lake.—Of a collection of 340 living mussels collected October 17, 1907, at Long Point, 252 were *Lampsilis luteola*, 41 *L. ventricosa*, 21 *Unio gibbosus*, 18 *Anodonta grandis footiana*, 5 *Strophitus edentulus*, and 3 *Lampsilis subrostrata.* In deep water *U. gibbosus* and *Anodonta* would have given a higher percentage, and in the Lost Lake beds *Quadrula rubiginosa* would be present in considerable relative abundance.

Parasites, Enemies, and Diseases.—As a general rule the mussels of lakes, ponds and bayous are more heavily infested with parasites than those of the swiftly flowing rivers, the probable reason being that in still waters the parasites can migrate more easily from one mussel to another than where there is a swift current. The mussels of the lake are not nearly so badly parasitized as those of the sloughs of the Mississippi, the dead waters in the Maumee above the dams, or those of the Twin Lakes a few miles to the north. The parasites will be taken up more fully in consideration of the various species of mussels. Several species of *Atax*, and *Cotylaspis insignis* are the most common parasites. Unlike the mussels of most of our rivers, the mussels of the lakes are comparatively exempt from destruction by man. A few are killed and used for bait, and now and then a mild case of pearl fever appears at the lake, but it is soon cured by the examination of a bushel or two of mussels. On September 22, 1907, a man was seen at the south end of the lake with about a peck of shells which he had opened in a vain search for pearls; on October 8 of the same year, a pile of about a half bushel of shells, which had evidently been opened by pearlers, was found in Overmyer's woods. Another pearler was seen in 1907 who had collected a few slugs of almost no value. One of the citizens of Culver, in 1906, submitted a small vial of lake baroques for valuation, but they had no worth whatever. The greatest enemy of the lake mussels is the muskrat, and its depredations are for the most part confined to the mussels near shore. The muskrat does not usually begin its mussel diet until rather late in autumn, when much of the succulent vegetation upon which it feeds has been cut down by the frost. Some autumns, however, they begin much earlier than others; a scarcity of vegetation or an abundance of old muskrats may have much to do with this. The rodent usually chooses for its feeding grounds some object projecting out above the water, such as a pier or the top of a fallen tree. Near or under such objects one occasionally finds large piles of shells. The muskrat apparently has no especial preference for one species of mussel above another, but naturally subsists most freely on the most abundant species. These shell piles are excellent places to search for the rarer shells of the lake.

On September 24, 1907, about a bushel of shells, recently cleaned out by muskrats, was found at Long Point where a pier had been removed not long before. The shells were all of rather small size and were in about 18 inches of water. About half were taken and examined. Of these shells, 358 were *Lampsilis luteola*, 167 *Unio gibbosus*, 6 *Lampsilis iris* and 1 *Lampsilis multiradiata*. In the autumn of 1913 freshly opened shells of *Lampsilis glans* were common along shore at Long Point. The first shells killed are rather small and are probably killed by young muskrats.

In the winter after the lake is frozen, great cracks in the ice extend out from shore in various directions, and this enables the muskrat to extend his depredations some distance from shore in definite limited directions. During the winter of 1904 a muskrat was observed feeding on mussels along the broad ice-crack that extended from the end of Long Point northeastward across the lake. The muskrat was about fifty feet from the shore. It repeatedly dived from the edge of the ice-crack, and reappeared with a mussel in its mouth. Upon reaching the surface with its catch, it sat down on its haunches on the edge of the crack, and, holding the mussel in its front feet, pried the valves apart with its teeth and scooped or licked out the contents of the shell. Some of the larger mussels were too strong for it to open, and a part of these were left lying on the ice. The bottom of the lake near Long Point, and also over by Norris's, is well paved by shells that have been killed by muskrats. Muskrats do not seem to relish the gills of gravid mussels; these parts are occasionally found untouched where the animal had been feeding.

Species of Mussels Occurring in Lake Maxinkuckee.

1. *Quadrula coccinea* (Conrad).

Rare at the lake; this is a river rather than a lake shell and would be expected in abundance only in fluviatile lakes, or lakes with broad short outlets and vital connection with river faunas. The few living mussels of this species found in the lake would probably represent a vanishing remnant of a fauna introduced when the lake had a broader outlet than at present and communication with the river below more active. A few dead shells were found along the north shore at various times. On October 25, 1907, a shell 1.75 inch long was found near the railroad bridge at Culver, and in 1909 another small shell was found along shore at Aubeenaubee Bay. Some fine large examples, brought up from the Tippecanoe were planted in the thoroughfare below the railroad bridge, but they have probably been covered and suffocated by sand.

2. *Quadrula rubiginosa* (Lea).

More common in Lake Maxinkuckee than *Q. coccinea*, but nevertheless rather rare, only a few dwarfed shells having been found. In Lost Lake below the Bardsley cottage it was a fairly common species. None of the shells found was of large size, but all were well-formed and handsome. The older shells are almost jet black and peculiarly elongate, with the umbones markedly anterior in position. They look considerably unlike those of either the Tippecanoe or Yellow River, but a form much like the Lost Lake shells was found in the lower course of the Kankakee. No gravid examples were found in the lake. Half grown examples are rather common in Lost Lake, but as they are usually buried considerably deeper in the sand than the older shells, they are harder to find. These half-grown shells are of a peculiarly beautiful golden yellow color with a satiny epidermis, and are of the same shape as those found in the neighboring rivers, that is, the normal or usual shape of the species. The peculiar elongate form of the adult is therefore evidently the product of local influences. The young shells are very iridescent and translucent, much more so than those found in rivers.

Q. rubiginosa is at its best a very fair button shell, but the lake shells are too small to work up well. This species appears to be rather rare in lakes. The only lake examples of this species with which the Lost Lake shells were compared were some obtained in Lake Erie. The Lake Erie shells are much more dwarfed, but very solid.

Food.

The following is the result of an examination of the material found in the intestines of *Q. rubiginosa* from Lost Lake.

Sample 1. August 2, 1908. Mass fine flocculent rather brownish green material, cohering somewhat in cylinders; looks as if chiefly organic; not gritty to touch. Organisms present: *Scenedesmus, Fragilaria, Tetraedron, Navicula, Peridinium tabulatum, Anuræa,* and *Botryococcus braunii.*

Sample 2. August 20, 1908. A large amount of material. Appearance in vial: bottom black, top a fine flocculent sediment. In the top material are *Tetraedron, Scenedesmus, Microcystis æriginosa* and many disassociated minute cells. Black bottom composed of *Anuræa, Lyngbya æstuarii,* a long filament; *Scenedesmus,* many *Peridinium tabulatum, Tetraedron, Epithemia turgida, Merismopœdia,* cast of *Cyclops, Melosira crenulata, Glœocapsa, Staurastrum, Pediastrum boryanum, Gomphonema, Chætophora, Cosmarium,* sponge spicule, *Gomphosphæria aponina,* and *Botryococcus braunii.*

Sample 3. August 20, 1908. A small amount of flocculent brownish material. *Microcystis æruginosa, Peridinium tabulatum* many, and a good many empty cuirasses, *Chydorus, Eudorina,* a few; *Scenedesmus,* common; Diatoms, *Pediastrum duplex.*

Sample 4. August 20, 1908. Fine blue-green flocculent material. *Lyngbya æstuarii,* several filaments; *Microcystis æruginosa,* common;

Cœlosphærium kuetzingianum, Peridinium tabulatum, very abundant; *Chydorus, Anuræa, Botryococcus braunii, Cœlastrum, Staurastrum* 1, small. Naviculas, several.

Sample 5. August 20, 1908. Fine bluish-green material. *Peridinium tabulatum,* abundant; *Cocconema cymbiforme, Navicula,* a few; *Anuræa cochlearis, Microcystis æruginosa, Chydorus,* 1 entire, and other fragments; *Pediastrum duplex, Cœlosphærium kuetzingianum; Cosmarium, Coscinodiscus, Scenedesmus,* very common; *Merismopœdia glauca.*

Sample 6. August 20, 1908. A small amount of flocculent grayish material. *Peridinium tabulatum,* abundant, agglutinated in masses; *Microcystis æruginosa,* very common; *Navicula, Staurastrum, Cosmarium,* several; *Chydorus,* fragment; *Scenedesmus,* small forms, common; *Pediastrum boryanum, Cocconema cymbiforme, Tetraedron,* common; various diatoms; *Rotifer,* an elongate species; *Merismopœdia glauca; Cœlastrum,* Desmids.

Sample 7. August 21, 1908. A small amount of rather coherent fine flocculent greenish material. *Peridinium tabulatum,* very common; *Anuræa cochlearis,* a few; *Microcystis æruginosa,* frequent; *Lyngbya æstuaria,* short filament; *Pediastrum boryanum, Cocconema cymbiforme, Cymatopleura, Epithemia argus, Gomphonema, Synedra, Tetraedron, Scenedesmus,* occasional; *Dinobryon, Staurastrum,* rather slender form.

Sample 8. August 20, 1908. A small amount of flocculent bluish material. *Peridinium tabulatum,* most abundant; *Cœlosphærium kuetzingianum; Pediastrum duplex, Microcystis æruginosa, Anuræa cochlearis,* Sponge spicule, Diatoms (*Navicula, Cocconema,* etc.), *Scenedesmus.*

Sample 9. August 20, 1908; a fair amount of flocculent grayish brown material with a greenish cast. *Peridinium tabulatum,* most abundant; *Microcystis æruginosa, Anuræa cochlearis, Staurastrum, Pediastrum duplex, Botryococcus braunii; Tetraedron minimum, Cœlosphærium kuetzingianum; Pediastrum boryanum, Chydorus, Lynbya æstuarii, Gloeocupsa,* Diatoms—*Cocconema cymbiforme, Navicula.*

3. *Unio gibbosus* Barnes.

This mussel, known among clammers as the "spike" or "ladyfinger" is, next to *Lampsilis luteola,* the most abundant shell in the lake.

It is found wherever the other mussels are; that is, in sandy or somewhat marly bottom in rather shallow water most of the way around the lake, and in the shell-bed in Lost Lake below Bardsley's. In Lake Maxinkuckee one of the best beds is at Long Point. It is abundant also at Norris Inlet, and by McDonald's and Farrar's.

No very young of this species were found in the lake; they are, however, hard to find in numbers anywhere, even in rivers where the species is abundant—except in cases where portions of the river go almost dry, and this of course never happens to the beds in the lake. The half-grown examples are solid, rather cylindrical shells, the same neat form that is known as the "spike" among the clammers. The old shells develop into a peculiar form, being flattened, arcuate along the ventral border and very thin posteriorly, so that they usually crack badly in drying; they represent the form described by Simpson as var. *delicata*. In general outline they remind one somewhat of *Margaritana monodonta*. This form is not strictly confined to the lake; some similar shells were collected in the Wabash near Terre Haute.

As found in the lake, *Unio gibbosus* is very constant in its characters, the only noteworthy difference between individuals being the change in shape already referred to as being due to age. In rivers this shell exhibits considerable variation in shape, size, color of nacre, etc., but the shells of the lake are quite constant in almost every respect. The nacre is a deep purple, never varying to pink or white as it frequently does in rivers.

Like *Lampsilis luteola* this species is frequently preyed upon by muskrats and the cleaned out shells are common where these rodents have had their feasts.

Although *U. gibbosus* of the Tippecanoe River near the mouth of the Outlet are very commonly infested with a distomid parasite along the hinge-line which brings about the formation of irregular baroques, this parasite does not occur in the lake so far as known. Small species of *Atax* are common parasites of this species in the lake, and in 1909 one was found affected by the large *Atax ingens*.

Even the large strong river shells of *Unio gibbosus* have as yet no value in the manufacture of buttons because of their purple color, and lack of luster. (The white-nacred shells are sometimes used.)

The only other lake examples with which the Lake Maxinkuckee specimens of this species have been compared, are some collected in Lake Erie at Put-in-Bay. The Lake Erie shells are much unlike the Maxinkuckee specimens, being short, humped and remarkably solid and heavy. Similar shells to those of Lake Erie are found in some of the small southern rivers.

We have no notes referring to gravid examples in the lake. This was probably because the most active work in collecting and examining mussels was carried on in the autumn, and the breeding period of this species is in early summer.

4. *Alasmidonta calceola* (Lea).

Judging from the dead shells found scattered along shore, this is not a particularly rare species in the lake. The shells were found most abundantly along the north shore of the lake, although they were also found along the east and southeast portion and were not infrequent between Arlington and Long Point. No living examples were found. On account of its small size and its habits, this is a rather difficult species to find, even where common, except under favorable conditions such as exceptionally low water, when the mussels move about more or less. Nothing was therefore learned of its habits in the lake. In the Tippecanoe River near Delong, Ind., this species was rather common in stiff blue clay near shore, and it is fairly abundant in Yellow River at Plymouth. Here, although the dead shells were common, the living examples were difficult to find until, during a period of very low water, they began actively moving about and could be tracked down. The species, which reaches an unusually large size in Yellow River, was there found gravid in autumn (September and October). The glochidia are of the Anodonta type, chestnut-shaped or rounded-triangular in outline, with large hooks at the ventral tips of the valves.

5. *Anodonta grandis footiana* (Lea).

Although the genus *Anodonta* is generally regarded as the "Pond-mussel" *par excellence,* the species of which might naturally be expected to be at home in lakes and ponds and thrive in such places even better than in rivers, the Anodantas of Lake Maxinkuckee show, along with the river species proper, the dwarfing influence of the lake. Moreover, *Anodonta* is not as one might naturally expect, the most abundant mussel in the lake, but is outnumbered, in some beds at least, by both *Lampsilis luteola* and *Unio gibbosus*. Its relative scarcity in some of the shore beds is in part made up by its wider distribution in the deeper waters of the lake than the others reach, and on its presence on the isolated bars, where it was occasionally taken up by the dredge.

On account of the great variability of *Anodonta grandis* and the difficulty in distinguishing the various forms, particular attention was paid to this species as found in the lake, and the lake specimens were compared with numerous examples from the neighboring lakes and river. No Anodontas were found in the Tippecanoe River near Lake Maxinkuckee Outlet, and we were therefore unable to compare our lake specimens with the form that would be most interesting in this connection.

The mussels of Tippecanoe Lake at the head of Tippecanoe River were examined in this connection. Blatchley (Indiana Geological Report for 1900, p. 190) has reported *Anodonta grandis* as common, and the subspecies *footiana* as frequent in Tippecanoe Lake. The Anodontas of that lake differ markedly both in the size and shape of the individuals from those of Lake Maxinkuckee. The difference in size can be easily explained by the more favorable conditions in Tippecanoe Lake. This body of water is more fluviatile than Lake Maxinkuckee, being directly connected with the Tippecanoe River, which is already a fairly large stream when it leaves the lake, and the mussel beds of the lake and river are continuous. The upper part of Tippecanoe Lake is exceptionally favorable for Anodontas; the living mussels are large and abundant, and the dead shells almost pave the bottom near shore, several dead shells often being telescoped within each other. Some of the shells reached a size not often surpassed in the neighboring rivers; one example measuring 172.5 mm. long, 95 mm. high and 65 mm. in diameter. A few were thickened with a tendency to form half pearls, or "blisters", but most were thin. A number of the shells approached *Anodonta corpulenta* in general form, and one flattened, rounded shell resembled *A. suborbiculata*. The Anodontas from other lakes of the Tippecanoe River system, such as Center Lake and Eagle Lake near Warsaw, resemble those of Lake Maxinkuckee, but are generally smaller and shorter.

The Anodontas of Lake Maxinkuckee were also compared with those of Yellow River a few miles to the north, and with the various lakes of the Kankakee system, including Upper Fish Lake, Lake of the Woods (Marshall Co.) Pretty Lake, Twin Lakes, Bass Lake and Cedar Lake. Some of the Yellow River Anodontas were normal, oval shells such as are common in the rivers of Northern Indiana; a few were exceptionally thin and exceedingly inflated, resembling *A. corpulenta.* Those of Upper Fish Lake—originally a fluviatile lake containing other fluviatile shells such as *Q. undulata*—were large shells like those of Tippecanoe Lake. The Anodontas of each of the other lakes differed more or less from those of the others, though all probably had a common origin. The only lake of this group the Anodontas of which closely resembled those of Lake Maxinkuckee is Bass Lake, and even there the shells were somewhat different, being smaller and with the epidermis more deeply stained. Even the Anodontas of Lost Lake differ slightly from those of Lake Maxinkuckee, being somewhat more inflated and with the epidermis green rather than brown, and in having the shell usually somewhat thinner. Some of the shells near the outlet of Lost Lake are exceedingly thin, some of them so much so that ordinary print can easily be read through them; they are so fragile that it is almost impossible to keep them.

Of the collection from Lake Maxinkuckee, mostly from Long Point, 26 examples were carefully compared. The smallest measured 68 mm. long, 38 mm. high and 24.6 mm. in diameter, and the largest 93.5 mm. long, 50 mm. high and 37 mm. in diameter. Among variant forms was one female, gravid when collected, which was unusually elongate, its measurements being 86 mm. long, 43.5 mm. high and 32.5 mm. in diameter. In outline this shell closely resembled *Anodontoides ferussacianus subcylindraceus.*

Some of the larger specimens are rather humped and arcuate, the ventral margin of one being somewhat concave. This is a variation which is quite likely to occur in old shells of any species.

Although gravid Anodontas were found rather frequently during the late autumn, no infected fishes were seen, and no young were found.

The Anodontas of the lake are fairly free from parasites, a few *Atax* and *Cotylaspis* and occasionally a few distomids on the mantle next to the umbonal cavity being the only ones present in any numbers. In some of the other lakes the Anodontas were very badly infested; a colony found in one of the Twin Lakes being infested to a remarkable degree by a distomid which formed cysts in the margin of the mantle.

Food and Parasites of Various Examples.—The following is the result of the examination of various examples of Anodontas: Sample No. 10. Vial containing intestinal contents of *Anodonta grandis footiana,* Lost Lake, September 7, 1908. The vial contains a considerable amount of material (in formalin) which was separated into black fine mud below and fine flocculent light green above. Upper portion—*Microcystis æruginosa,* most common; *Peridinium tabulatum,* some; *Pediastrum boryanum; Melosira crenulata,* a few filaments; *Cœlastrum microporum, Botryococcus braunii* and *Scenedesmus.* Bottom layer—*Lyngbya æstuarii, Microsystis æruginosa,* very common; *Peridinium tabulatum, Anuræa cochlearis, Cocconema cymbiforme* and *Navicula.*

Sample No. 11. Food of *Anodonta grandis footiana,* Lake Maxinkuckee, near Norris Inlet, August 20, 1908. A good mass of flocculent fine green material; no mud.

Microcystis æruginosa, most common, *Melosira,* filament, *Oscillatoria,* short filament; *Anuraea cochlearis,* several; *Cocconema cymbiforme; Gomphosphæria aponina; Peridinium tabulatum; Cœlosphærium keutzingianum, Lyngbya æstuarii, Epithemia argus, Chydorus,* and what appears to be fragments of *Ceratium hirundinella.*

Sample No. 12. *Anodonta grandis footiana,* near Norris Inlet, Lake Maxinkuckee, August 20, 1908; a small mass of flocculent blue material.

Microcystis æruginosa most abundant; *Lyngbya æstuarii, Melosira, Epithemia, Anuræa cochlearis, Pediastrum boryanum, Cosmarium intermedium* and a few others, *Staurastrum* sp?, *Spirulina* and *Pediastrum duplex.*

Sample No. 13. *Anodonta grandis footiana,* 97 mm. long. Edge of Lake Maxinkuckee east of Norris Inlet, August 29, 1908.

Parasites; 9 *Atax,* free among gills. Mussel gravid, with anterior end of shell indented and with some brown spots on the nacre. Food mass fine golden brown, abundant in quantity, containing *Anuræa cochlearis,* many; *Microcystis æruginosa,* most abundant element; *Lingbya æstuarii,* frequent; *Scenedesmus,* a few; *Botryococcus braunii,* frequent; *Cocconema cymbiforme; Staurastrum, Navicula; Fragilaria; Chydorus,* a few; *Cœlosphærium kuetzingianum;* the diatoms are not abundant.

Sample No. 14. *Anodonta grandis footiana* apparently old, 90 mm.

long, near Norris Inlet, Lake Maxinkuckee, Ind., August 29, 1908, the shell stained somewhat brown inside, with one steel-blue stain on the right valve anteriorly.

Parasites; *Atax* 7, large, full of eggs, one small, one very small, these all free among the gills; *Cotylaspis insignis* 1, in axil of gill.

Food abundant; *Microcystis æruginosa*, abundant; *Lyngbya æstuarii*, common; *Pediastrum duplex*, *Botryococcus braunii*, a few; *Cosmarium; Anuræa cochlearis*, several; *Scenedesmus; Ankistrodesmus*, and many diatoms, among which are *Cocconeis pediculus*, *Melosira*, *Gomphonema*, *Navicula*, *Epithemia turgida*, etc.

Sample No. 15. *Anodonta grandis footiana*, 101 mm. long, Lake Maxinkuckee, near shore, by Norris Inlet. August 29, 1908.

Parasities; 5 *Atax*, free in gills, some full of eggs, 2 smaller in size, larval *Atax* (black) scattered in gills. *Cotylaspis insignis*, 2, axil of inner gill.

A large amount of food material in intestines, very fine, of a yellowish brown color.

Microsystis æruginosa, *Anuræa cochlearis*, *Lyngbya æstuarii*, *Botryococcus braunii Cœlosphærium keutzingianum*, *Cosmarium*, *Navicula*, an elongate form, *Cocconema cymbiforme*, *Pediastrum duplex*, *P. boryanum;* red cysts apparently of *Peridinium*.

Sample No. 16. *Anodonta grandis footiana*, 90 mm. long, sandy bottom of Lake Maxinkuckee near Norris Inlet. August 29, 1908. Mussel gravid. Parasites: *Atex*, 3, free among gills, *Atex* embryos scattered through gills.

Food material scarce, fine golden brown in mass, consisting of *Microcystis æruginosa*, abundant; *Cœlosphærium keutzingianum*, abundant; *Lyngbya æstuarii*, a few filaments; *Anuræa cochlearis* and another rotifer; *Botryococcus braunii; Sorastrum*, *Cœlastrum*, *Scenedesmus*, *Pediastrum duplex*, *Navicula*, several; *Melosira tabulata*, *Synedra*, *Epithemia turgida*, *Cocconema cymbiforme;* and other small diatoms rather numerous. *Cosmarium*, a few.

Sample No. 17. *Anodonta grandis footiana*, 93 mm. long, sandy bottom of Lake Maxinkuckee near Norris Inlet, August 28, 1908. Mussel gravid. Parasites: 1 *Atax*, free among gills. Intestines almost empty. *Microcystis æruginosa*, one of most abundant elements; *Lyngbya æstuarii*, *Cœlosphærium kuetzingianum*, *Botryococcus braunii;*

Cosmarium, Pediastrum, Cocconeis pediculus, Epithemia turgida; Navicula (1 actively moving), *Gomphonema, Melosira tabulata, Anuræa cochlearis, Chydorus.*

Sample No. 18. *Anodonta grandis footiana,* 95 mm. long. Lake Maxinkuckee near Norris Inlet, August 29, 1908. Mussel gravid. Parasites: 6 *Atax* free among gills, one a minute red species. Many young Atax embryos in inner side of mantle, not in gills.

Food material golden brown, with some green intermixed, very fine. *Microcystis æruginosa,* common; *Lyngbya æstuarii,* a few filaments; *Cœlosphærium keutzingianum; Botryococcus braunii; Pediastrum duplex; Anuræa cochlearis* a few; *Epithemia turgida; Navicula,* common; *Cocconema cymbiforme; Cocconeis pediculus,* several; *Cosmarium; Chydorus.*

Sample No. 19. *Anodonta grandis footiana,* Lake Maxinkuckee, near Winfield's. Mussel gravid. Parasites: Young *Atax* in gills; Distomids on mantle (a slug pearl near hinge.)

Food: *Botryococcus braunii; Microcystis æruginosa; Lyngbya æstuarii, Cœlosphærium kuetzingianum, Pediastrum duplex, Navicula, Cocconema cymbiforme.*

Sample No. 20. *Anodonta grandis footiana.* Lost Lake. Young transparent shell, gravid, length 77 mm., height 41 mm., diameter 30 mm., live weight 1 oz., shell 1-4 oz. Parasites, several *Cotylaspis insignis* in axil of gills, food chiefly *Microcystis æruginosa;* considerable *Botryococcus braunii.*

Sample No. 21. *Anodonta grandis footiana,* Lost Lake. Parasites: 1 young *Atax* in gill; *Cotylaspis insignis* in axil of gill. Food chiefly *Microcystis æruginosa,* a little *Botryococcus braunii, Lyngbya æstuarii* and *Pediastrum boryanum.*

6. *Strophitus edentulus* (Say). Squawfoot.

Not very common in the lake. Occasional shells can be picked up along shore, especially between Long Point and Arlington, and along the north shore. Living examples were also taken in small numbers from the mussel bed at the mouth of Norris Inlet, and at Long Point. In a collection of about 300 living mussels collected at the latter place in the autumn of 1907, only three were of this species.

As found in the various rivers of the country, this is one of the most variable of shells, and the exact limits of the species and its various forms are not yet well worked out. The lake examples, though differing considerably from those of the neighboring rivers and from river shells in general, do not exhibit a very large range of variation. They are all markedly dwarfed, the average length being about 2 1-2 inches or 63.5 mm. All have a well-developed rounded posterior ridge. The epidermis is deeply stained, that of the exposed portion of the shell being a rich yellowish brown, while the anterior portion, in the living shell buried in the soil of the bottom, is a deep shining brown black. The anterior margin is not nearly so heavy and produced as one frequently finds it in river examples. The beaks of the lake shells are not so angular as they usually are in river shells, and the high wavy ridges are more numerous and pronounced. In the Maxinkuckee shells, also, a number of fine hair-like lines or ridges, much like growth lines, extend along the posterior border of the umbone, parallel with the posterior ridge of the earlier stages of the shell.

The nacre of the lake shells is a rich rosy salmon. Unlike the salmon color of "*Anodonta salmonea*", this is a natural color, not due to diseased conditions; the nacre surface is very smooth and the color extends deeply into the shell. In some cases the inner nacreous surface appears to be a secondary thickening of the shell, laid on the older portions like an enamel. Below this extra nacreous deposit the growth lines are very distinct on the inner surface of the shell. The rest periods are distinct black lines, often plainly visible through the translucent shell when held up to the light. Rays are always invisible by reflected light in the lake shells, but in some examples they were visible by transmitted light. The animal has orange-colored flesh. The few living examples examined indicate that parasites are common; one contained three old *Atax ypsilophorus*, and several young.

One gravid example was found, October 17, 1907. The youngest example found was 42 mm. long and exhibited four rest periods.

7. *Lampsilis glans* (Lea).

Fairly common in the main lake; dead shells are often found along shore, and occasionally the living mussels are to be seen in shallow water at the various mussel beds at the lake. It is quite abundant along the edges of the thoroughfare joining the lakes, and is common in Lost Lake.

The examples found in the thoroughfare and Lost Lake were of unusually large size; this is one of the few species of mussels which are as large or larger in the lake than in the neighboring rivers. *L. glans* appears to prefer shallow water along shore. A good number of shells recently cleaned out by muskrats was found near the water's edge at Long Point in the late autumn of 1913.

In the Tippecanoe River at Delong this was a very abundant species in the greasy whitish blue clay along shore, and was here one of the favorite morsels of the muskrat. With the exception of *Micromya fabalis* this is the smallest species of mussel found in the lake. It can be easily recognized by its black epidermis, small size and purple nacre.

8. *Lampsilis iris* (Lea).

Rather common in the lake in shallow water near shore, found scattered among the other species in the various shell-beds. There is a good colony in the Lost Lake bed, and it is fairly abundant off the Depot grounds, by Kruetzberger's pier, at Long Point, and at the bed near the mouth of Norris Inlet.

The lake shells differ markedly from those of the neighboring rivers so much that it is easy to separate the lake and river shells at a glance. The lake shells are considerably more elongate, and the epidermis is stained a deep brown, mostly concealing the rays; when these are visible they are brownish rather than green, and the umbones are rather eroded. The shells, indeed, resemble somewhat the males of *L. subrostrata*, with which they are associated. The lake shells exhibit a tendency to have their posterior margin somewhat broader than the river shells, and the shells are flatter at the posterior tip, becoming somewhat produced. The river shells are more solid and heavy.

Lampsilis iris is one of the few species of mussels which does not show a marked decrease of size in the lake; indeed, some of the larger lake examples run actually larger than those from the neighboring rivers. Some of the largest lake shells examined have the following dimensions:

No.	Length mm.	Alt. mm.	Diam. mm.
1	69.6	37.3	21.0
2	65.9	34.9	21.0
3	68.0	34.6	22.0

No.	Length mm.	Alt. mm.	Diam. mm.
4	64.9	35.8	22.7
5	67.0	36.8	20.9
6	67.7	33.8	21.5

No young shells were found, even the smallest appear rather old. The smallest three measure:

Length mm.	Alt. mm.	Diam. mm.
41.4	21.2	12.5
38.9	21.5	12.5
37.0	20.0	12.3

For comparison with the lake shells, the dimensions are given of the largest two shells found in Yellow River:

No.	Length mm.	Alt. mm.	Diam. mm.
1	67.0	34.5	22.9
2	64.0	33.5	21.0

Only one gravid example was found; this was obtained at Lost Lake bed September 7, 1908.

Of all the species of mussels in the lake, *L. iris* has the best connection, through scattered individuals along the Outlet, with the shells of the Tippecanoe River, a few shells having been found almost through the whole length of the Outlet. The Outlet shells, like those of the rivers, are brightly rayed. The species is abundant in the Tippecanoe River at Delong. A number of examples were noted in spawning condition there in late August and early September in 1908. Observations in the Maumee River indicate that this species, *L. parva* and *L. multiradiata*, do not have exactly the same breeding season as many other species of *Lampsilis* (*luteola, recta, ligamentina,* etc.), but are sometimes fertilized in July, spawning in August and September. Being small and an early developing species, it is probable that they have somewhat different habits; indeed, it is possible that they have more breeding seasons per year than the other species.

The Tippecanoe mussels of this species were a favorite food of the muskrat, and were killed in great numbers every autumn, the dead shells being thickly strewn along the bank, or piled in heaps at the bases of rocks which the rodent used as a feeding place.

Lampsilis iris has a well marked tendency in the lakes and Outlet to produce pearls and baroques; but these are too small to be of any value.

9. *Lampsilis subrostrata* (Say).

Lampsilis subrostrata reaches its best development along the muddy shores of lagoons, not being perfectly at home either in swiftly flowing streams or in perfectly quiet lakes, although occasional examples may be found in either. It is considerably more abundant in Lake Tippecanoe and Upper Fish Lake than in any other Indiana lakes examined. Along the edges of the Mississippi sloughs it is fairly common and reaches a large size, often distinguished with difficulty from *Lampsilis fallaciosa* except for the thinness of the shell and the black epidermis. It is rare in Lake Maxinkuckee, only a few examples having been obtained from the mussel bed near Norris Inlet. It is much more common in Lost Lake in the large bed along shore south of the Bardsley cottage. Mr. Blatchley, in a short report on the mollusks of the lake (25th annual report, Department of Geology and Natural Resources of Indiana, 1900, p. 250), says of this species: "Not common in the main lake; more so in the muck and mud along the margins of Lost Lake, where a well-marked variety, with a larger and broader beak, was taken. A specimen of this was sent, among others, to Mr. Chas. T. Simpson, of the Smithsonian Institution, for verification. In his reply he says: 'The variety of *subrostratus* which you send is, so far as I know, confined to northern Indiana. It is quite remarkable, and would seem to be almost a distinct species. I have seen quite a number of specimens of it, and at first thought it a variety of *U. nasutus*, but there seem to be intermediate forms connecting it with *U. subrostratus*.' "

With the exception of the differences due to sex, all the Maxinkuckee and Lost Lake shells are very uniform in appearance, much more so than *L. luteola*, and are hardly distinguishable from examples from Lake Tippecanoe, Upper Fish Lake, or a specimen collected in the Wabash River at Terre Haute by Dr. J. T. Scovell. They are dark brown in color with very faint rays. The species appears to be rare in the Tippecanoe River at Delong. One example was obtained there, which is somewhat shorter and stouter than those of the lake, and not so badly stained; it shows faint rays posteriorly. The Lost Lake shells are somewhat larger than those found at the other lakes. No young were found, the smallest shell obtained being a half-grown example. One gravid specimen was found at Lost Lake September 7, 1908. The marsupium closely resembles that of *L. iris*, being a kidney shaped mass filling the hinder portion of the outer gill, this mass marked into segments by rather deep radiating furrows. The very edge of the marsupium is white, beyond the dusky submarginal area, the white making a chain-like area at the edge of the gill. Like *L. iris*, this species has a tendency to form pearls, but they are too small to be of any value.

Food of individuals: The following is the result of the examination of the contents of the intestines of *L. subrostrata* from Lost Lake at various dates.

Sample 22. August 20, 1908. A small amount of flocculent bluish-gray material. *Peridinium tabulatum*, abundant; *Microcystis æruginosa*, abundant; *Anuræa cochlearis; Pediastrum boryanum;* Diatoms—*Synedra; Cocconema cymbiforme.*

Sample 23. August 20, 1908. A very small amount of flocculent grayish material. *Peridinium tabulatum*, a few; *Microcystis æruginosa*, a little; *Pediastrum boryanum; Cosmarium; Tetraedron minimum; Scenedesmus; Euglyphia alveolata; Peridinium*, a small, sharp-spined form. Diatoms make up the greater part, including *Cocconema cymbiforme; Navicula; Fragilaria; Coscinodiscus;* and *Epithemia.*

Sample 24. September 7. A large amount of material, black mud below, greenish flocculent material above. The upper portion contains chiefly *Botryococcus braunii* and *Microcystis æruginosa.* Bottom portion—*Microcystis æruginosa*, common; *Botryococcus braunii; Peridinium tabulatum; Peridinium*, a small-spined species; *Scenedesmus*, frequent; *Staurastrum; Pediastrum duplex; Cœlastrum*, a few; *Anuræa cochlearis; Tetraedron; Docidium; Cœlosphærium kuetzingianum;* Sponge spicule; *Lyngbya æstuarii;* Diatoms, *Synedra; Navicula; Gomphonema;* etc.

10. *Lampsilis luteola* (Lamarck). Fat Mucket.

Lampsilis luteola is the most widely distributed of the American *Unionidæ*, its range extending over nearly all of North America east of the Rocky Mountains. It lives and thrives under a great variety of conditions, being frequent in both lakes and rivers.

In Lake Maxinkuckee this is the most common mussel, being found almost everywhere in water from 2 to 5 or 6 feet deep where the bottom is suitable. It prefers a rather solid bottom with some admixture of sand or gravel, but occurs also even where the bottom is of a rather firm peaty nature as in some places in Outlet Bay. It is, however, rather scarce and widely scattered in such localities. The best beds are found at Long Point, at Farrar's, in front of McDonald's, by the old Kruetzberger pier, and in Aubeenaubee Bay off from the Military Academy. In Lost Lake it was abundant in the large mussel bed below the Bardsley cottage, and a few shells were found in the north end of the lake.

The Lake Maxinkuckee shells are smaller and thinner than those of the rivers; they closely resemble those of most of the neighboring lakes with which they were compared, such as Twin Lakes, Pretty Lake, Bass Lake, etc. The *L. luteola* of Upper Fish Lake are much larger and more like river shells. Compared with specimens of more remote lakes, those of Lake Erie are much smaller, more solid and not stained, the rays being quite distinct. The *L. luteola* of Lake Pokegama, Minn. are unlike any of those above cited, being large, thick and heavy, furnishing excellent button material.

Lampsilis luteola is represented in Lake Maxinkuckee and Lost Lake by two forms; although these forms are well connected by intergrades the extremes are pretty markedly distinct.

The colony in Lost Lake is composed of compressed, elongate shells, almost as large as those found in rivers, but considerably thinner. It is in the females of this group, and only in part of them, that the greatest variation occurs. The males are not much unlike the ordinary well-known form of the neighboring rivers. The most strongly aberrant females are markedly compressed, and flare out broadly in the post-basal region. The umbones are far forward and they remind one somewhat in contour of the marine species, *Modiola plicatula*. Some of them closely resemble *Lampsilis radiata* of the Atlantic drainage. The Lost Lake mussels of this species are stained a peculiar attractive ash-gray which does not greatly obscure the rays. They are not so heavily encrusted with marl as are those in the Lake Maxinkuckee beds. Typical Lake Maxinkuckee specimens are dwarfed and stained a deep brown, which obscures the rays. Most of them are thickly-coated posteriorly with incrustations of marl. It is principally this species which has associated with it the little water-beetle, *Stenelmis sulcatus* Blatchley. At Long Point, where *L. luteola* is the most common mussel, examples of the peculiar Lost Lake form are rather frequent. In comparing sets of shells from the various mussel beds of the lake, Long Point, Farrar's and the Norris Inlet beds, it was noted that the mussels of each bed, as one approached the upper portions of the lake, averaged somewhat smaller.

As regards food, movements, reproduction, etc., *L. luteola* does not differ greatly from the other mussels of the lake with the exception that it appears to be considerably the most active species in the lake. A few more were observed moving about during the winter of 1900-1901. The deep water individuals rarely move about at all. In the autumn of 1913 the migration of those near shore into deep water was strikingly shown in a series of numerous furrows, with a mussel at the deep water end and extending from shore outward near Long Point.

As with the other mussels of the Lake, reproduction is a rather inconspicuous phenomenon, not attended with the marked display common in the larger river examples. Of 252 examples collected at Long Point, October 17, 1907, 25 contained glochidia in the gills, some being very full and much distended. One was found gravid May 24, 1901, and on August 22, 1906, some in Lost Lake appeared to be about ready to spawn.

The young of this species were found rather frequently in the lake, much more frequently, indeed, than any other kind. The smallest examples were obtained while seiving sand for Sphæriums at Long Point. These young mussels live buried in the fine sand near shore. Specimens up to about a half-inch long are very crinkly, being covered with narrow elevated parallel ridges, generally five in number, each consisting of two open loops placed end to end, the sides of the loops being roughly parallel with the ventral margin of the shell; the ends where they join form a sharp curve upward toward the umbone. These double loops are followed by a number of broken irregular ridges. The markings just described persist on the umbones of the older shells until eroded away. The half grown shells are beautifully rayed with green on a whitish background. As the shells grow older they become gradually stained a deep uniform brown, obscuring the rays.

Most of the mussels of the lake are slightly parasitized, none abundantly; they contain a few examples of a small reddish *Atax*, and a few *Cotylaspis insignis.* A small round worm, somewhat like a vinegar eel, was found very active in the intestine of one specimen; it was probably parasitic.

Small irregular pearls or slugs are produced but they are of no value. In some rivers this species produces an abundance of small round pearls. Some of the pearl-bearing river specimens were planted in the lake in 1912 to see if they would infect the lake shells.

The *Lampsilis luteola* of the rivers is a fair button shell, but the Lake Maxinkuckee shells are too small and thin to have much value. It is a remarkable fact that in Lake Pokegama, Minn., *L. luteola* grows abundantly in shallow bottom among the weeds, and there produces a handsome thick heavy shell, one, indeed, concerning which the pearl button manufacturers are very enthusiastic, so much so that the shells at that distant point from the market brought $22.00 per ton; in the summer of 1912, two carloads of these shells were shipped to Europe.

Just why the Lake Maxinkuckee shells are not like the excellent ones of Lake Pokegama remains as yet unanswered, but seems to be largely a question of breed. It would certainly be worth while to introduce the Lake Pokegama breed into Lake Maxinkuckee.

Following is the results of the examination of various individuals of the Maxinkuckee and Lost Lake shells:

Sample 25. *L. luteola.* Lost Lake, September 7, 1908. Mussel gravid. Length 100 mm., altitude 62 mm.; diameter 33 mm. Live weight 2½ oz.; shell 1¾ oz. Parasites: 7 free *Atax* among gills, young *Atax* in gills and numerous *Atax* eggs on interior surface of mantle. Food chiefly *Microcystis æruginosa; Botryococcus braunii, Lyngbya æsturaii; Melosira; Navicula.*

Sample 26. *L. luteola.* Lost Lake, September 7, 1908: Mussel gravid: Length 95 mm., alt. 60 mm., diam. 38 mm. Live weight 3¾ oz.; shell 1¾ oz. Parasites: 7 free *Atax* in gills, and *Atax* eggs in the mantle. Food, chiefly *Microcystis æruginosa;* also *Botryococcus braunii; Navicula; Lyngbya æstuarii;* and *Anuræa cochlearis.*

Sample 27. *L. luteola.* Lost Lake by Bardsley's September 7, 1908. Live weight 3¼ oz.; shell 1½ oz., length 97 mm., alt. 54 mm., diam. 33

mm. Parasites: 7 free *Atax* among gills. Many small red eggs of *Atax* on inner surface of mantle. Food chiefly *Microcystis æruginosa; Botryococcus braunii;* and *Navicula.*

Sample 28. *Lampsilis luteola.* Lost Lake, September 7, 1908. Live weight 3¾ oz.; length 104 mm., alt. 54 mm., diameter 33 mm. Parasites: *Atax* 6, free among gills, eggs of *Atax* on inner side of mantle, young in pits on side of foot. Food, *Microcystis æruginosa*, most common; *Lyngbya æstuarii; Navicula; Melosira; Anuræa;* and *Cocconema.*

Intestinal contents of two examples of *L. luteola* obtained in Lake Maxinkuckee August 27, 1908, near the shore just north of the ice office gave the following results:

Sample 29. *Microcystis æruginosa*, main mass; *Anuræa cochlearis*, a few; *Botryococcus braunii*, rather common; *Cocconema cymbiforme*, one; *Lyngbya æstuarii*, 1 filament; *Navicula*, 2 examples; *Synedra*, a few.

Sample 30. *Microcystis æruginosa*, main mass; *Botryococcus braunii*, very common; *Lyngbya æstuarii*, several filaments; *Anuræa cochlearis*, a few; *Synedra*, some; *Navicula*, one example very lively; *Cosmarium*, one; Round worm like vinegar eel, very lively.

Sample 31. Lost Lake, 1908. A good mass of material, blackish below, flocculent greenish above. *Lyngbya aestuarii*, a few filaments, *Microcystis æruginosa*, quite abundant; *Anuræa cochlearis;* sponge spicule; *Pediastrum duplex; Staurastrum; Botryococcus braunii; Peridinium tabulatum*, a few; *Peridinium*, a small spiny species 1; *Pediastrum boryanum;* several diatoms—*Navicula; Coscinodiscus; Melosira; Cocconema cymbiforme; Microcystis*, is the most abundant element; *Peridinium* is rather scarce.

Sample 32. Lake Maxinkuckee, August 27, 1908: A small amount of brownish green flocculent material. *Anuræa cochlearis*, quite frequent; *Lyngbya æstuarii*, short filament; *Peridinium tabulatum*, a few; *Cœlastrum microporum; Cœlosphærium kuetzingianum; Pediastrum boryanum; Scenedesmus*, very few; *Chydorus*, fragment. Diatoms, *Epithemia turgida; Navicula; Cocconema cymbiforme; Gomphonema; Coscinodiscus.*

Sample 33. Lake Maxinkuckee, August 27, 1908: A fair amount of brownish green material, muddy below, flocculent green above. The green top material consisting chiefly of *Microcystis æruginosa;* with some *Anuræa cochlearis; Lyngbya æstuarii, Microsystis æruginosa; Bulbochæte,* bristle; *Cœlastrum microporum; Merismopœdia glauca; Pediastrum boryanum;* Diatoms—*Navicula, Coscinodiscus;* etc.

Measurements:—

The following is a series of measurements of Lost Lake examples:

Measurements in mm.

No.	Date, 1908.	Length.	Alt.	Diam.	Remarks.
1189	Aug. 20.	85.	54.	32.	Fanshaped female.
1260	Sept. 7.	97.4	55.	31.	Fanshaped female gravid.
1215	Aug. 20.	87.	46.	35.6	Fanshaped female.
1224	Aug. 20.	98.	56.	26.	Fanshaped female.
1245	Aug. 20.	90.	51.	32.8	Fanshaped female.
1235	Aug. 20.	98.	48.9	36.3	Male.
1188	Aug. 20.	102.	53.	36.	Male.
1221	Aug. 20.	100.	51.	37.	Male.
1223	Aug. 20.	96.	51.4	34.8	Male.
1228	Aug. 20.	102.3	53.7	33.	Male.
					Most of these shells. blistered posteriorly.

The males are fairly like those of river examples; the females are more fan-shaped. Weight of the 10 shells, 15 oz.; only a few are rayed

11. *Lampsilis ventricosa* (Barnes). Pocket-book.

Rather common at the Long Point mussel bed; a few found in the bed by Farrar's and a few in Lost Lake. The species as found in the lake is markedly dwarfed and quite different in appearance from the usual river form. There are two types in the Long Point bed, one consisting of females and having the post-basal inflation of the shell characteristic of that sex, not exactly as in the river form, however, but somewhat more restricted; this feature, along with a peculiar stain of the epidermis which conceals the normal coloring of the shell, causes them to resemble very closely a short female *L. luteola.* The other type, an oval shell without the post-basal inflation, was at first taken to represent the males, but some of them were found to contain glochidia. These, too, bear a marked resemblance to *L. luteola,* and the only way to distinguish the two species, as they occur in the lake, was by an examination of the umbonal sculpture. This in *ventricosa* consists of a a few coarse parallel ridges; in *luteola* the sculpture is of numerous fine wavy lines.

The lake *L. ventricosa* was so markedly different from the species as usually known that it was compared with a large series of both lake and river forms. Of river shells only a few from the central part of the Maumee, where for some reason the shells are markedly dwarfed, bore any close resemblance to it. None was found in any of the neighboring lakes with which to compare them. In some of the small lakes of Michigan where Dr. Robert E. Coker had collected he had experienced a similar difficulty in distinguishing between *L. ventricosa* and *L. luteola* and had sent sets of critical specimens to Mr. Bryant Walker of Detroit, Mich., who identified the shells with a few coarse straight undulations on the beaks as *Lampsilis ventricosa canadensis* and the others as *L. luteola*.

The Maxinkuckee specimens were also compared with *L. ventricosa* from Lake Champlain, and were found to be much like them. The Champlain examples which were free from staining of the epidermis more closely resembled in color the *ventricosa* of the rivers.

The specimens of *L. ventricosa* differed considerably in the different beds. Lost Lake examples are usually rather small, and are stained a peculiar ashy-gray. Those from the beds near Farrar's are mostly small and apparently young and are rather well rayed; they resemble river forms more closely than any others in the lake.

The large oval *L. ventricosa* of Long Point are the heaviest shells of the lake. A peculiarity of several of these shells is a conspicuous rib-like thickening on the inside, extending from near the umbonal cavity postero-ventrally. The nacre is soft satiny in luster, and not very iridescent. This oval form of *ventricosa* found at Long Point furnishes the only shell in the lake that could be used to any advantage in the manufacture of buttons, and even it produces rather inferior material. Some of these shells were sent away to a button factory at Davenport and buttons were made of them. The following is a set of measurements of these large shells:

No.	Date, 1907.	Lgth. mm.	Alt. mm.	Dia. mm.	Remarks.
1	Sept. 24.	114.	74.8	53.	Female gravid.
2	Oct. 30.	107.6	65.5	54.8	
3	Oct. 2.	105.2	63.7	52.5	
4	Oct. 30.	92.5	60.4	53.7	Female gravid.
5	Oct. 30.	103.7	67.3	49.3	Dorsal baroques.
6	Oct. 17.	98.6	60.2	55.5	Arcuate, baroque found.
7	Oct. 20.	101.7	63.6	52.2	
8	Oct. 30.	94.6	58.4	53.2	Nacre diseased and blistered.
9	Oct. 17.	95.6	55.7	49.	
10	Oct. 17.	91.5	60.4	49.5	

Although the reproductive phase of *L. ventricosa* of the Lake is much less conspicuous than in the river mussels, most of them apparently succeed in reproducing themselves. Most of the females found later in autumn have more or less numerous glochidia in the gills. No infected fishes or very young mussels of this species were seen.

The most common parasite is *Atax,* and it is not particularly abundant. Of 6 examples collected near Farrar's July 24, 1909, the first contained 9 of the mites, the second 4, the third 15, with *Atax* eggs in mantle and body, the fourth 12 *Atax* and numerous eggs of the mite on the inner surface of the mantle, the fifth 3 *Atax* with eggs, and the sixth 7 *Atax* with eggs and egg scars. No other parasites were noted. No pearls were found, only a few irregular slugs.

In 1906 some of the immense *L. ventricosa* of Yellow River were planted in the lake near shore not far from the old ice office. A few died shortly after planting but near the same place two years later some of the mussels were found alive and apparently thriving. Two of the large females were killed and examined. Although this was at a time when this species is usually gravid, one of these individuals was sterile, apparently having failed to become impregnated. The influence of its residence in the lake was marked by a dark stain which covered the exposed portion of the shell. The other had a few eggs in the gills, and numerous marginal cysts in the mantle. About 10 *Atax* among the gills, and numerous distomids on the outside surface of the mantle in the umbonal cavity.

12. *Lampsilis multiradiata* (Lea).

Not abundant in the lake; occasional shells are found along shore, and now and then they are encountered in the piles of shells where muskrats have been feeding. A few living examples were found in the mussel bed near the mouth of Norris Inlet and a few at Long Point bed. In all hardly a dozen living examples were secured; of 563 shells taken from a pile left by a muskrat at Long Point in 1907, only one was of this species. This mussel, as it occurs in the lake, is not nearly so attractive as river specimens, being dwarfed, and so deeply stained that the rays are inconspicuous, being usually black or dull brown instead of green.

This species was found in unusual abundance in the Tippecanoe River at Delong, and a considerable number was observed spawning during the autumn of 1908. While spawning, this mussel is very conspicuous in its habits. It lies either on its back, or more usually with the posterior end directly upward, and the showy edges of the mantle, which are of a yellowish brown color, and cross-barred with narrow lines which are continuous with the fine rays of the epidermis, look a good deal like a small darter lying on the bottom. Long waving pennant-like flaps, with showy black spots at the base of each are developed, and this portion of the mussel is made still more conspicuous by reason of periodic violent spasmodic contractions.

In the Tippecanoe River near Delong this is one of the favorite foods of the muskrat, and it must be difficult for them to hold their own against that rodent.

13. *Micromya fabalis* (Lea).

Rare; previous to 1913 only one shell had been found; this was picked up on the north shore of the lake in 1907. In 1913 several shells, recently cleaned out by some animal, probably a muskrat, were found at the wagon bridge. This species is fairly common in Tippecanoe Lake and still more so in the Tippecanoe River at Delong, where it was collected in shallow water near shore in rather stiff blue clay. It is the smallest of our Unionidæ. The white or bluish white nacre has an exceedingly brilliant luster.

Several other species of mussels have been recorded for the lake, among them *Quadrula lachrymosa* (Lea), *Margaritana marginata* Say, *Unio pressus* Lea, *Anodonta subcylindracea* Lea, *Anodonta imbecillis* Say, *Unio phaseolus* Hildreth, *Unio circulus* Lea, *Unio parvus* Barnes, and *Lampsilis gracilis* (Barnes). We have seen representatives of none of these species from the lake, and while some, such as *Anodonta imbecillis** and *A. subcylindracea* are very probably present, the presence of the others is very improbable.

* Since the above was written a single specimen of *Anodonta imbecillis*, from Lost Lake, has been seen.

Further Experiments with the Mutant, Scarlet, from Drosophila Repleta.

Hobart Cromwell.

The mutant, scarlet, from Drosophila repleta, was first described by Hyde in the American Naturalist, 1914, Vol. 49, p. 183. This new eye-color was found to be a recessive Mendelian unit, giving a ratio of 3 to 1 in the F_2 generation. In order to familiarize myself with Mendelism, I undertook to determine whether or not the black-eyed flies of the F_2 generation were in the ratio of one homozygous to two heterozygous as the Mendelian formula demands.

The following tables give the results of the crosses between scarlet and the wild stock. All the F_1 flies had black eyes like those of the original wild parents. These were then inbred in mass culture, as is shown in Tables I. and II.

TABLE I.

F_2 Flies of the Cross, Scarlet Female by Wild Male.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	187	202	64	59
2	425	418	123	128
3	410	410	124	90
4	211	200	67	70
5	123	152	52	38
6	190	175	64	40
7	200	210	61	58
8	115	115	43	31
Total	1,861	1,982	598	534

TABLE II.

F_2 Flies of the Cross, Scarlet Male by Wild Female.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	447	456	120	146
2	714	692	186	203
3	284	292	68	92
4	445	415	108	123
5	193	171	64	65
6	215	220	75	77
7	122	110	32	38
8	562	462	155	142
9	326	304	108	112
10	228	262	105	69
11	195	178	66	63
12	149	157	51	53
13	341	302	87	116
Total	4,221	4,021	1,225	1,299

In the F_2 generation from the scarlet female (Table I), there was a total of 3,843 wild type flies and 1,132 scarlet, which is approximately a ratio of 3 wild type to 1 scarlet. In the F_2 generation from the scarlet male (Table II), there were 8,242 of the wild type and 2,524 of the scarlet, which makes a ratio of 3.22 wild type to 1 scarlet. The extracted scarlets have since bred true.

Crosses were made to scarlet with the F_2 wild type flies from both the original cross and its reciprocal. To insure virgin flies the sexes were separated every twelve hours. These back-crosses were made in pairs to determine how many of the flies of this generation were homozygous and how many were heterozygous. If the scarlet eye-color is a simple recessive unit, all the homozygous blacks mated to scarlet should give only wild type offspring, while the heterozygous blacks mated to scarlet should give equal numbers of blacks and scarlets. The results of these crosses are shown in Tables III to VI.

Table III gives the results of back-crossing to scarlet the F_2 female wild type flies from the original parents, scarlet female by wild male. This table shows that 82 such matings were made. Of these 82 females, 27 proved to be homozygous and 55 heterozygous, a ratio of two to one. Table IV, showing the reciprocal cross of Table III, gives 18 homozygous and 59 heterozygous. Table V gives the results obtained by back-crossing to scarlet the F_2 wild type female from the original parent cross scarlet male by wild female. Of these females, 25 proved to be homozygous and 39 heterozygous. Table VI, the reciprocal cross of Table V, shows a result of 14 homozygous and 16 heterozygous males.

A sum total of all the results of Tables III-VI gives 84 homozygous F_2 flies and 169 heterozygous, making a ratio of one to two, which agrees with the calculated ratio.

I am indebted to Dr. R. R. Hyde for material and helpful suggestions.

TABLE III.

P_1. Scarlet Female by Wild Male. Results of Crossing Wild Type F_2 Female Flies to Scarlet Males.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	8	9	6	9
2	17	8	...	...
3	17	15	13	15
4	24	31	19	16
5	21	17	25	17
6	17	8	...	...
7	31	22	13	30
8	31	22	28	14
9	43	19	22	41
10†	...	...	...	...
11	83	82	...	
12	102	94		
13	10	6		
14	28	14	12	20
15	27	36	35	40
16	52	38	37	30
17	19	9	15	8
18	48	33	30	35
19	23	21	19	26
20	78	76	...	...
21	18	15	13	18
22	14	16	16	11
23	15	17	8	15
24	37+	37+	28+	28+
25	25	22	16	11
26	62	63		
27	37	30	...	...
28	46	48	...	...
29	61	69	...	...
30	7	15	...	
31	30	35	...	...
32	44	40	18	27
33	24	16	14	22
34	40	49	32	38
35	38	38	43	31
36	78	79	...	...
37	30	22	20	29
38	58	35	30	29
39	34	32	39	39
40	26	31	24	34
41	39	33	23	27
42	78+	78+	...	...
43	20	18	16	10
44	44+	44+	40+	40+
45	23+	23+	11+	11+
46	23+	23+	25+	25+
47	38+	38+	35+	35+
48	24+	24+	21+	21+
49	75+	75+	...	...
50	19	19	...	...
51	10+	10+		

TABLE III—Continued.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
52	46+	46+	......	......
53	37+	37+	27+	27+
54	12	10	8	7
55	25	19	27	15
56	6	5	3	8
57	16	13	13	16
58	67	55	......	......
59	17	17	17	22
60	18	20	25	21
61	23	18	16	18
62	8	4	3	8
63	33	33	......	......
64	12	13		......
65	5	2	2	......
66	4	3	2	3
67	7	5	8	5
68	19	13	......	......
69	89	90	......	......
70	56	56	......	......
71	73	65	......	......
72	18+	26+	18+	26+
73	42	28	28	15
74	23	31	19	21
75	24	22	17	25
76	63	63	......	......
77	27	33	40	25
78	29	25	27	15
79	49	57	......	......
80	29	34	23	35
81	43	39	44	35
82	20	23	24	15

Total: 27 homozygous and 55 heterozygous.

†Heterozygous.

TABLE IV.

P_1 Scarlet Females by Wild Males. Results of Crossing Wild Type F_2 Males to Scarlet Females.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	2	4	2	4
2	13	4	9	4
3	17	3	12	3
4	24	25	10	6
5	14	23	17	14
6	52	41	30	50
7	64	64	......	......
8	52	40	18	16
9	31	36	34	29
10	47	34	39	55
11	20	27	25	20
12	56	40	53	60
13	28	34	27	26
14	22	28	18	11
15	39	58	61	51
16	63	39	100	63
17	30	25	33	34
18	40	53	19	21
19	28	30	28	22

TABLE IV—Continued.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
20	86	92	......	......
21	136	149	......	......
22	24	42	31	22
23	94	105	......	......
24	24	37	......	......
25	20	19	20	21
26	23	31	19	24
27	24	29	32	40
28	36	31	40	43
29	85	123	43	46
30	46	34	41	45
31	43	38	33	34
32	54	40	39	55
33	55	71	28	39
34	77+	77+	......	......
35	20	15	16	21
36	45	45	41	47
37	63	23	23	26
38	55	14	20	24
39	47	57	59	37
40	134	107	......	......
41	27	32	21	26
42	52+	52+	55	47
43	102	95	......	......
44	20	22	35	26
45	120	91	......	......
46	22	19	21	22
47	120+	120+	......	......
48	26	22	19	24
49	93	96	......	......
50	43	37	32	32
51	62	52	......	......
52†	......	......	......	......
53	83	71	......	......
54	53	36	......	......
55	55	55	41	43
56	24	29	22	21
57	52+	52+	35+	35+
58	46+	46+	50+	50+
59	42	43	25	22
60	41	44	30	51
61	38+	38+	26+	26+
62	6	7	......	......
63	15	7	9	7
64	7	19	2	14
65	9	8	8	13
66	29	30	13	14
67	21	24	23	11
68	23	12	10	5
69	39	11	......	......
70†	......	......	......	......
71	26	25	20	9
72	27	29	16	14
73	40	23	......	......
74	20	15	13	10
75	9	6	5	5
76	5	7	8	14
77	18	23	......	......

Total: 18 proved homozygous and 59 heterozygous.

†Noted as heterozygous, but no count made.

TABLE V.

P₁ Scarlet Male by Wild Female. Result of Crossing Wild Type F_2 Male to Scarlet Female.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	50	52		
2	61	49	44	49
3	74	63		
4	5	10	6	5
5	27	10	20	12
6	26	28		
7	86	65		
8	93	83		
9	21	15		
10	34	30	40	43
11	19	14	16	15
12	11	10	13	12
13	45	53	33	40
14	42	48	54	54
15	46	49	37	41
16	29	21		
17	14	15		
18	28+	28+		
19	51	36	34	32
20	61	47		
21	2	9	12	11
22	17	19		
23	17	11		
24	87	88		
25	22	28	20	25
26	16	10	10	11
27	37	27	31	28
28	45	36		
29	31	38	31	27
30	38	26	26	31
31	20	16	19	21
32	78	70		
33	42	51		
34	34	46	39	38
35	84	72		
36†				
37	20	23	13	22
38	7	8	65+	65+
39	46	68	38	30
40	70	74		
41	31	35	32	41
42	38	23	21	12
43	10	6	5	5
44	32	41	17	28
45	3	4	6	4
46	10	12	18	6
47	30	7	19	10
48	23	20	22	18
49	7	3	6	3
50	3	2	8	4
51	60	66		
52	84+	84+		
53	24	21		
54	27	25	28	20
55	21	20	21	19
56	11	12		
57	14	11	10	9
58	5	1	2	5
59	14	5	6	4
60	25	34		
61	15+	15+	16+	16+
62	10	8		
63	15	13		
64	5	2	2	3

Total: 25 homozygous and 39 heterozygous.

†Noted as heterozygous, but no accurate count made.

TABLE VI.

P_1 Scarlet Male by Wild Female. Results of Crossing Wild Type F_2 Female to Scarlet Male.

Culture Number.	Wild Type, Females.	Wild Type, Males.	Scarlet, Females.	Scarlet, Males.
1	89	89		
2	49	48	23	36
3	51	50		
4	111+	111+		
5	25	20	15	14
6	45	40	62	50
7	88	75		
8	10	17		
9	31	31	17	26
10	71	79		
11	49	46		
12	54	56		
13	19	29	21	24
14	71	75	25	17
15	12	14		
16	50	41		
17	17	22	27	19
18	53	50		
19	28	34	37	29
20	50	39	46	41
21	7	13	4	6
22	19	19	14	21
23	13	23		
24	29	30	23	18
25	35	36		
26	56	52	20	31
27	68	40		
28†				
29	30	31	21	26
30	26	24	21	23

Total: 14 homozygous and 16 heterozygous.

†Noted as heterozygous, but no accurate count made.

A Seasonal Study of the Kidney of the Five-Spined Stickleback, Encalia Inconstans Cayuga Jordan.

Walter N. Hess—DePauw University.

During the greater part of the year the male kidney is an excretory organ. At the breeding season, however, the kidney tubules, for about one-third of their extent, as well as the urinary ducts, the bladder and the common urinary duct become modified for the purpose of producing slime. This secretion, which is used by the fish in constructing its nest, is produced entirely by the male kidneys and only at the breeding season.

In the process of slime secretion, the behavior of the nuclei is such that they evidently pour into the cell bodies certain products, in the form of secretion granules, which function in breaking down the granular cytoplasm of the cells, and thus form the secretion. These secretion granules appear to be produced from certain products of the karyoplasm, as this substance gradually diminishes in amount during this process. Since the nuclei become irregular and flattened, it is possible, but not probable, that the nucleolus functions in this process.

Only one kind of secretion is produced for constructing the nest. This material is not silk, nor is it composed of fine fibrils, but appears as a fine granular slime-like substance. It is sometimes exuded in ribbon-like masses, but it probably functions more as an adhesive substance, than as a string, in binding the materials of the nest together.

At the end of the breeding season the cytoplasmic granules are regenerated. They begin to appear on all sides of the nucleus at the time that the nucleus begins to enlarge and become spherical. Since they form about the nucleus and wander into the other parts of the cell it would seem that the nucleus must be the active agent in their formation.

During the resting or winter stage the cells which form the slime during the spring appear much like the cells near the glomeruli which secrete urine, except that their nuclei are much smaller and they contain only one nucleolus. At this season the nuclei of the urinary secreting cells are very large, often occupying at least half of the cell contents.

This investigation justifies the conclusion that the whole kidney is not transformed periodically into a silk or slime producing gland, as is maintained by certain authors, but that the process of slime secretion is due to the activity of the epithelial cells of various ducts and tubes of the system not engaged in the excretory function. It is comparable to the secretion of slime by the genital ducts of Amphibia during the breeding season.

The Erdmann New Culture Medium for Protozoa.

C. A. Behrens and H. C. Travelbee—Purdue University.

It is a well-known fact that the first culture *in vitro* of a pathogenic trypanosome (Tryponosoma Brucei) was obtained by Novy and MacNeal[1] in 1903. The medium used was a meat extract agar plus two parts of defibrinated rabbit's blood. Of fifty animals tested only 4, or 8% positive cultures resulted. In 1905 Smedley[2], using a similar medium, found that three out of ten attempts, or 30%, were successful.

Because of the inconsistent results we deemed it advisable to attempt an improvement of the medium. The first attempts along these lines were in 1909[3]. The media with their per cent. of positive growths are as follows:

1	Novy MacNeal blood agar	25%
1A	Novy MacNeal blood	0%
2	Bean and pea extract blood agar	53%
2A	Bean and pea extract blood	0%
3	Nicolle blood agar	48%
3A	Nicolle blood	0%
4	Dialyzed meat extract blood agar	80%
4A	Dialyzed meat extract blood	0%
5	Dialyzed meat extract dilute serum agar	100%
5A	Dialyzed meat extract dilute serum	0%
6	Dialyzed meat extract inactivated serum agar	100%
6A	Dialyzed meat extract inactivated serum	0%
7	Dialyzed meat extract dilute red blood cells agar	38%
7A	Dialyzed meat extract dilute red blood cells	0%
8	Dialyzed meat extract Ascitic fluid agar	0%
8A	Dialyzed meat extract Ascitic fluid	0%
9	Veal extract blood minus white blood cells agar	100%
9A	Veal extract blood minus white blood cells	0%

[1] Jour. Amer. Med. Assn., 1903, 41, p. 1266; Jour. Infect. Dis., 1904, 1, p. 1.
[2] Jour. Hyg., 1905, 5, p. 38.
[3] Jour. Infec. Dis., 1914, 15, 1, p. 4.

The above table indicates that successful cultures ranging from 25 to 100 per cent. are obtained when the solid type of medium is employed and that in every case where the liquid medium is used negative results occurred. In the successful cultures growth always resulted in the water of condensation after a period of incubation from one to four weeks at a temperature ranging from 25° to 28° C.

We therefore naturally were very much interested when in 1914 Rh. Erdmann[4] announced a new liquid culture medium for Trypanosoma Brucei. Erdmann states that by using the plasma of the host as the medium she grew Trypanosoma Brucei in hanging-drop cultures and kept them in normal condition for an indefinite period. The technique employed in brief was as follows: The plasma was obtained by the method of Harrison[5], Burrows[6], and Walton[7]. "The blood from the infected rat was taken and put into a small drop of plasma on a cover-glass and then this was further diluted with plasma in order to reduce the number of blood corpuscles in the hanging-drop which was taken from this." The cover glass with hanging-drop was either placed on a depression or regular slide and sealed. Precautions to secure aseptic conditions were taken.

We attempted to follow the technique thus outlined as nearly as possible. These cultures showed no signs of bacterial contamination at the end of forty-five days. In only a few instances were actively motile survivals in evidence for more than five days when kept at 10°C. In preparations incubated at 20°C, or above no survivals were observed after forty-eight hours.

In the course of an extensive series of attempts using heterologous and homologous sera under various conditions we found it impossible at any time to obtain a second generation by the Erdmann method. The homologous sera used were rat and guinea pig. The heterologous sera were human, horse, beef, sheep, pig, rabbit and chicken. These sera were used in a dilute one to one, inactivated, and normal form and the preparations were incubated at temperatures of 10, 15, 20, 25, 28, 30, 35, 37½, and 40°C. Ascitic fluid was also used without success.

It is true that trypanosomes will multiply and remain actively

[4] Soc. Exp. Biol. and Med., 1914, XII, p. 57.

[5] Proc. Soc. Exp. Biol. and Med., 1907, IV, p. 40; Jour. Exp. Zool., 1910, IX, p. 787.

[6] Jour. Amer. Med. Assn., 1910, LV; Jour. Exp. Zool., 1911, X, p. 63.

[7] Proc. R. S. L., Ser. B., 87, p. 452.

motile when first placed in a medium such as described by Erdmann. We have especially noticed this in connection with our work with solid media. Good survival forms of other pathogenic trypanosomes as those causing human sleeping sickness, dourine, and mal de caderas were observed as late as the twenty-eighth day, but in no case did these forms result in positive growth or second generation when transplanted to similar medium under similar conditions.

In summing up our work we can positively say that at no time, under no conditions were we able to obtain a positive culture using the Erdmann cultural medium. As a matter of fact the easily cultivated trypanosome of Lewis would not develop successfully on this medium.

Disposition and Intelligence of the Chimpanzee.

W. Henry Sheak—Philadelphia, Pa.

I shall not, in this brief paper, attempt to prove aught of the disposition and intelligence of *Anthropopithecus troglodytes* by force of argument. I shall merely set forth a few of my own personal observations. You may draw your own conclusions.

The chimpanzee is a native of tropical Africa, ranging from about twelve degrees north of the equator to ten degrees south of this line, and from the Atlantic Ocean on the west, to the Blue Nile on the east. But these interesting animals seem to be much more abundant in the western part of their range than in the eastern; at least, most of the specimens we get in captivity come from near the Atlantic. The chimpanzee is not nearly so large as the gorilla, and possibly not quite so large as the orang-utan, but there is not much difference in size between the chimpanzee and the orang. The adult males reach a height of about four feet five inches and a weight of from one hundred and forty to one hundred and sixty pounds. The females are not quite so large. The color is black, both the hair and skin being black. In some specimens, however, the face is quite light in color, and in others there may be found considerable ashy-gray hair among the black.

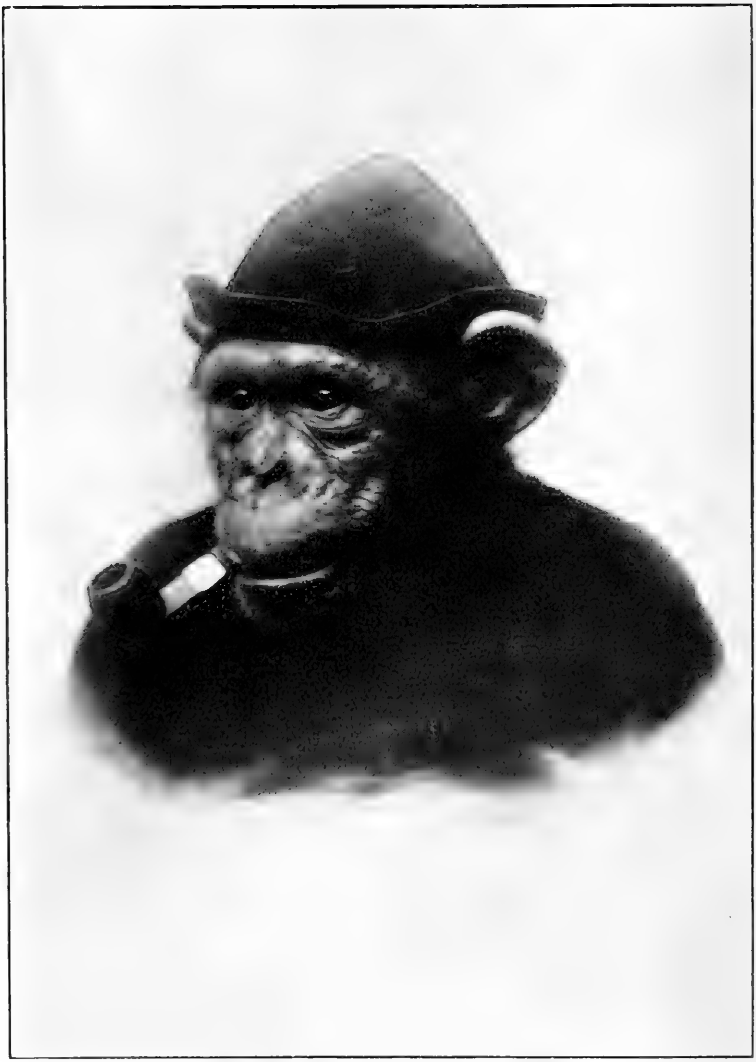
The chimpanzee is the most friendly and docile of the great apes, differing in this way from his near relative, the gorilla, which is savage and morose, refusing to make friends with man. I have seen a young chimpanzee fresh from the jungles, on being taken from the shipping box in which he came to America, throw his arms about a man's neck he had never seen ten minutes before, and hug him affectionately. To me, one of the most interesting things about these great apes is that they know how to express affection and gratitude by hugging and kissing without being taught. A few years ago I had a big chimpanzee called Mike, who insisted on kissing me, and kissing me on the lips, whenever I came near him. This was not the most delightful of experiences, because Mike's lips were not always clean. Joe, a smaller specimen,

Skeleton of a Chimpanzee, showing close resemblance in structure to man.

very intelligent and affectionate, and my special pet, would often cuddle up close to me, and if I did not voluntarily put my arm about him, he would take hold of my arm and fold it about his shoulders or waist.

When Joe was only a baby, he fell into the habit of pulling my hand to his mouth and biting my fingers, while I was talking to the people about him. He was only playing and did not intend to hurt me; but often, in his efforts to get my hand to his face and in snapping at my fingers, he would bite harder than he intended. Then, too, it was tiresome to have him pulling on me when I was trying to talk. One morning I got tired of his pulling and biting. I was carrying a small stick and gave him a light tap on the bare arm. He stopped instantly, lifted his pretty brown eyes to mine with an expression of pained surprise and incredulity upon his face, as if he could not believe I would hit him. After looking at me thus intently for fully half a minute, he put up his hands, folded his little black arms about my neck, and hugged me, three times, before he would let me go. This display of wounded feeling and tender affection almost brought tears to my eyes.

The chimpanzee is also affectionate towards members of his own species and towards other animals, especially his nearest relatives, the simians. Recently we had three chimpanzees in our collection, Mike and Joe, already mentioned, and Jerry, a baby about thirteen months old. Joe and Mike were both devoted to the baby and were always ready to fight for him. Mike usually mothered the little fellow, keeping him under his especial care, and was jealous of Joe. One morning Joe appropriated the baby and sat on the floor holding him on his lap, much the same way that a very small boy holds his very big baby brother. Mike wanted the baby and insisted upon having him. The two almost came to blows (or bites) over the youngster. Mike was itching for a fight but knew that sure and condign punishment awaited him if he hurt his smaller companion. First, he took a handkerchief and tried to strike Joe with it, much in the spirit of the young man who wanted to fight, but was afraid, and exclaimed, "I'm so mad at you I could chew paper." Then he doubled up his fist and commenced a fusillade of very light taps, delivered in very rapid succession about the neck and shoulders of his rival, just to show him what he would like to do, if he dared.



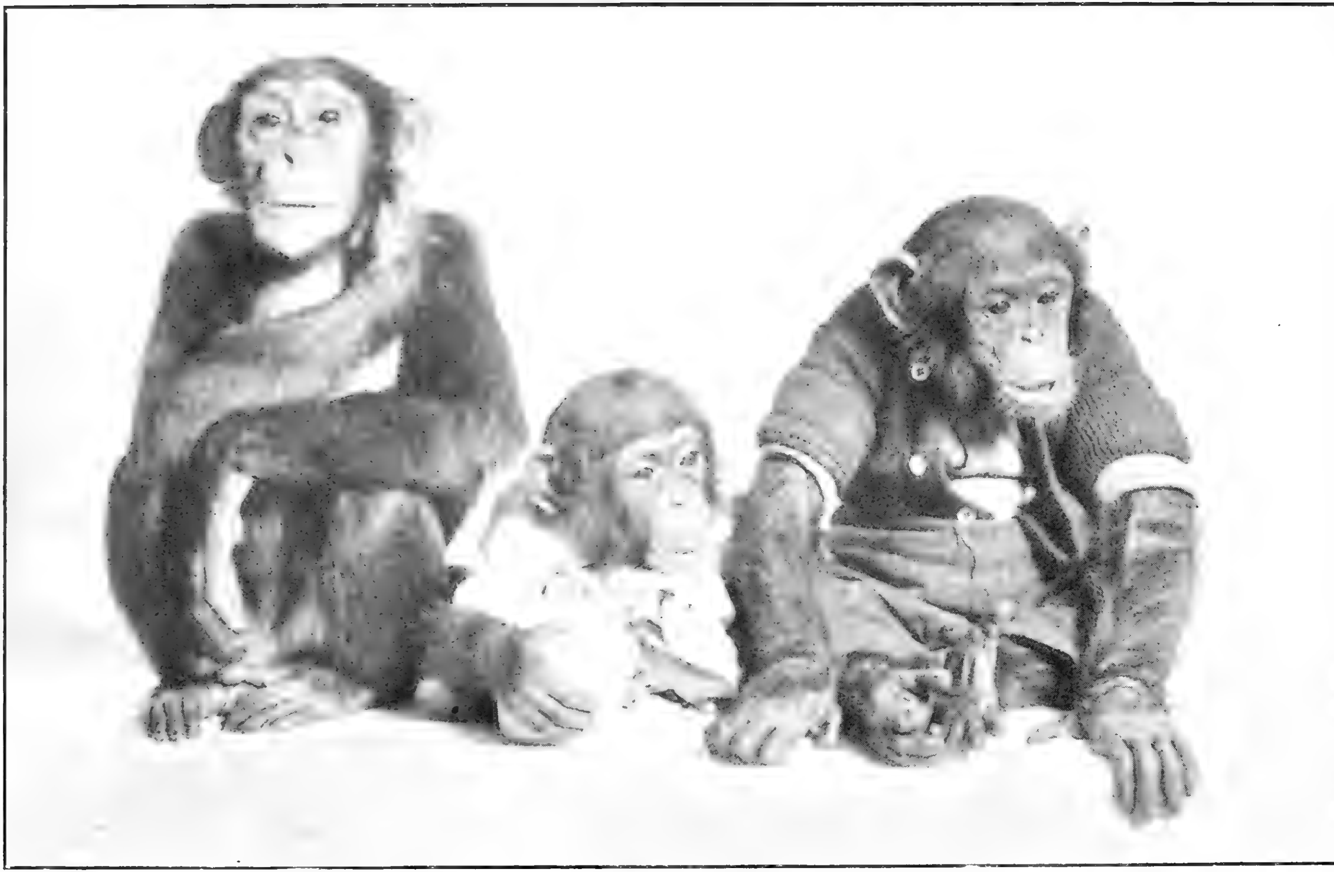
Fresh from the Old Sod—A big Chimpanzee.

One day baby Jerry was on top of a cage, when he caught hold of a large wooden ring suspended from a rope, and swung off. He was now quite a distance from the floor, and was afraid to drop. He could not swing back to the cage. Mike saw his dilemma, got on top of the cage, reached out, caught the baby, folded him in his arms, and carried him in safety to the floor. The keepers had always to be on their guard when handling Jerry, for fear Mike would mistake their intentions and attack. One evening, in Rochester, N. Y., a little girl came behind the guardrail, attracted by the cunning antics of the baby, when Mike hit her a blow in the face that brought the blood.

When Jerry died, Mike, who had been sleeping with him, went into the box and felt all over the body. When the body was taken in to the basement, Mike insisted on following, and had to be driven back with a shovel. He went to bed, but when he found out Jerry was not there, he got up and came out again. He then sat about for an hour or more, grieving and crying in the strangely human-like voice of his species. For several days he was listless and spiritless.

After years of experience in studying these animals and living with them, I have come to the careful and deliberate conclusion that, up to about four years of age, the chimpanzee babe is not only more precocious, but more intelligent than a human child of the same age. But after about four years the chimpanzee babe begins to fall behind and the human child to go ahead.

Joe learned to brush his hair with a hairbrush, to dust his clothes with a whiskbroom, to wipe his nose with a handkerchief, to eat out of a cup with a spoon as well as any human child, to bore holes with a brace and bit, to use a handsaw quite dexterously, to take screws out of the guardrail with a screwdriver, to drive nails with the hammer and pull them out again with the claw of the hammer, to play on a toy piano, and to play on a mouthharp. This last is a very difficult trick to teach an animal. You can not tell him to expel the air from his lungs and you can not show him how to do it. He must pick it up himself. I have known two or three elephants to learn this trick, but, aside from these, Joe was the only other I ever knew to accomplish the feat. All these tricks he learned with little or no teaching. He was a very close



Mike. Jerry. Joe.

Three of the Chimpanzees frequently mentioned in the context.

observer, and whatever he saw his human friends do, he would try himself, until he had acquired a long string of accomplishments.

In Chicago an employe of the menagerie brought from a Chinese restaurant a menu card printed in red ink. Joe seemed much interested in this and carefully kept it for a week or ten days. With considerable deliberation he would spread it out on the floor, then follow the lines slowly with his finger, as if reading. I have observed that most chimpanzees are right-handed, but Joe was left-handed. He always used a hammer or saw in his left hand, and in studying this menu card he would follow the lines with the index finger of his left hand.

Like human children, chimpanzees are fond of candy. But sweets are forbidden the menageries, owing to the fact that the chimpanzee stomach will bear but little sugar. In spite of the printed placards, however, well-meaning but unwise visitors would often throw them candy. One afternoon Joe was enjoying to the full a morsel of the proscribed dainty, when he saw his master approaching. He cunningly ducked his head under a blanket so the cruel tyrant, as he doubtless considered his humanu persecutor, could not see what he was eating. His cleverness was awarded by telling him to eat the candy. Joe dearly loved to tease a small Mexican hairless dog, called Harry, which usually slept on the stage near the chimpanzee cage. He would reach through the bars, give the dog a punch, pinch him, or pull his tail, then jerk his hand before Harry could nip him. In this way he kept the dog irritated much of the time, and he was always ready to bite him. One morning the manager came in with some oranges, a fruit of which the chimpanzee is very fond. To see how Joe would solve the problem, he placed one of the oranges directly under the dog's nose.

Joe was puzzled at first, but he soon had an idea. He brought the hammer from the other end of the cage, and with this in his right hand began punching at Harry. The dog was ready for a fight, as usual, and began biting at the hammer handle. In this way he gradually enticed him away from the orange, then he reached out with his left hand and took the fruit.

While exhibiting our animals in Kansas City, we kept the chimpanzees in a big cage, almost as large as an ordinary bedroom. To the top of the cage we had several ropes attached by means of bolts, with a ring for a head. The chimpanzees would swing on these ropes, chasing each other from end to end of the cage. We found that the more exercise they took, the longer they would live in captivity. One day one of the bolts came loose and fell to the floor. The manager got into the cage, picked up the bolt and handing it to Joe, told him to put it up there in place, pointing to the hole, and hold it until he could make it fast. Joe took the bolt, climbed to the top of the cage, put it into its proper hole and held it there until the manager got on top and fastened it. The head keeper was standing near, and exclaimed, "By George, that's going some." His words expressed the thought of all us. It was the strongest manifestation of intelligence I had ever seen from an animal.

One Christmas morning a gentleman with a Great Dane came into the room. Mike and Joe were much excited and not a little afraid of the dog. Joe climbed over the senior partner's back. Mike got a piece of board into which Joe had been driving nails, and made desperate attempts to throw it. He would swing his arm back and forth, but did not seem to understand just when to let go, and the board was just as likely to go back over his shoulder as toward the dog. But now and then he came very near the dog and hit him a telling blow. Mike kept practicing at throwing till he became expert. He got into the infamous habit of throwing the hammer out among the people in front of the stage, and we had to keep it out of his reach. The wife of the manager came out of the kitchen with a half head of cabbage and cast it over the bars onto the stage, there being no top on to the chimpanzee cage at that time. Mike picked up the cabbage and tossed it back to her with just as much dexterity and precision as she had used.

We once had a very intelligent chimpanzee called Sallie. A negro connected with the menagerie had a needle and thread with which he mended his clothes. Sallie watched the operation very intently. A little later she was noticed with a string trying to find an eye in a nail. She was given a small darning needle, and a heavy cotton thread, and at once threaded the needle, just as she had seen the negro do. After that she could not be deceived. When given a nail or piece of wire, she would look for an eye and, if there was none, she would throw away the counterfeit. She would begin by wetting the end of the thread in her mouth, would place the eye of her needle in line with her eye, insert the thread from behind forward, then pull the thread the remainder of the way with her lips. She often tried to tie a knot, too; but in this she was never successful. She always tried to make the knot in the thread up next to the needle. After a number of successful attempts at this, she would go to work on her dress, and sew, and sew, and sew, pulling the thread clear at every stitch. Sometimes she would amuse herself in this way for half an hour.

I often wondered if these very intelligent animals really understood the meaning of words, or whether they only comprehended a sentence or phrase as a whole or got the idea from my gestures or the order of the performance. One morning I saw an opportunity to test the matter. We had a little hat which I would hand to Sallie and tell her put on her "five dollar" hat. This she would generally do very neatly and skillfully, but sometimes in the morning, when she had just gotten out of bed, or at night, when she was tired and sleepy, she would respond very indifferently, either getting the hat on one side or missing her head altogether. I always had her put on her hat immediately after shaking hands at the beginning of the lecture. On the morning in question, the hat had fallen to the stage floor near her feet. Shortly after the lecture commenced, as I was finishing the talk, I said to her without changing my tone or looking toward the hat, "Sallie put on your five dollar hat." Without the slightest hesitation, she reached down, picked up the hat, and put it on her head.

Joe learned the order of the performance, and when I got through describing his hand to the audience, he would proffer his foot. He seemed, too, to understand the meaning of "posterior limb," for, although I might change the order of the lecture, the instant I sad "posterior limb," he would put up his foot.

One afternoon, in Detroit, some one had given Mike something to eat in a common earthenware bowl. When I came up, he had almost emptied the vessel. I knew he would throw it to the floor and break it, so I stepped behind the guardrail and said, "Mike, hand me that bowl." Immediately he set down the bowl and put out his hand. I saw at once that I, not he, had blundered. The word "bowl" was new to him, he had never heard it before; but as I had told him to hand me the bowl, he set down the vessel and offered me his hand. So I changed the form of the command, "Give me that cup." He was perfectly familiar with the word "cup", as he kept one on the platform and, when he was thirsty, gave it to the keeper to fetch him a drink of water. Without hesitation he picked up the bowl and gave it to me, doubtless considering it merely a cup of larger size.

One day, when our Joe was a little fellow, he and one of the keepers got into an argument. The keeper wanted Joe to sit on his chair, but he refused to do so. Bad temper and angry passions were prevailing on both sides. The keeper had a whip and was threatening to strike. Joe was showing his teeth and threatening to bite. I stepped behind the guardrail and sent the keeper on an errand out of the room. I spoke a few soothing words to Joe. He stopped screaming and got up on his chair. In a moment he had forgotten his trouble. A bystander wanted to know the secret of my influence over the animal. It was kindness and love.

THE UREDINALES OF DELAWARE.[1]

H. S. JACKSON—Purdue University.

The following account of the Uredinales of Delaware is the result of a study of the rust flora of that State begun in 1906, during the time when the writer was connected with the Delaware College and Experiment Station. A preliminary manuscript was prepared at that time and has since been revised and amplified at various times and finally rewritten in the present form in the winter of 1916-1917. A few changes and additions have since been made to bring the notes up to date.

The records include all the material in the Herbarium of the Delaware College Agricultural Experiment Station, together with the collections made by the writer during a period of three years, and most of the collections made by the late Mr. A. Commons of Wilmington, Delaware.

Mr. Commons made a very extensive collection of the Phanerogams and Fungi of the State, largely during the period from 1885 to 1895. Most of the fungi were determined by Mr. J. B. Ellis and duplicates of the specimens are now in the herbarium of the New York Botanical Garden. A manuscript list of the fungi was prepared by Mr. Commons, but never published.

The writer enjoyed the privilege of a conference with Mr. Commons in 1907 and was permitted to make a record of the rusts from his manuscript list. His collection was not available for consultation at the time, having been stored in boxes in a garret in Wilmington. Duplicates of most of the specimens, however, have been found and examined in the Ellis herbarium at the New York Botanical Garden. Only those specimens which the writer has seen are included in the present account.

A total of 129 species are recorded from the State, including the unconnected species of Aecidium and one uncertain Uredo. These are recorded on 232 different hosts. A total of about 450 collections are included, the greater number of which were made by the writer.

In recording the collections, the nearest postoffice is given, together

[1] Contribution from the Botanical Department of the Purdue University Agricultural Experiment Station.

with the date and name of the collector if made by another person than the writer. The numbers in parentheses following the date are the writer's accession numbers. Collections made at Seaford, July 9, 1907, at Clayton, July 24, 1907, and at Lewes, August 14, 1907, were made in company with Dr. M. T. Cook. In the case of collections made by Mr. Commons the numbers given are those of his manuscript list.

An attempt has been made to include in the notes a review of all the American culture work, together with some reference to similar work conducted by European workers.

A number of field observations which were made at the time of collecting the specimens have since been used by Dr. J. C. Arthur as the basis for successful culture work and have been recorded elsewhere. A considerable number of collections of material for culture work were supplied him, a number of special trips having been made primarily for this purpose, the expenses for which he provided from the funds of the Purdue University Agricultural Experiment Station. Many of the specimens collected, especially those on grasses and sedges, were identified by Dr. Arthur or his associates in rust work. Many others, originally determined by the writer, were sent him from Delaware for confirmation. Throughout the period of time when the collections were being made, a continuous correspondence was carried on with Dr. Arthur which proved very stimulating and the writer is under special obligations to him for this assistance. Acknowledgment is also gratefully made to any others who have in any way aided in the work.

COLEOSPORIACEAE

1. Coleosporium carneum (Bosc.) comb. nov.

Tubercularia carnea Bosc. Ges. Nat. Freunde Berlin Mag. 5:88. 1811.

Coleosporium Vernoniae B. & C. Grevillea 3:57. 1874.

Peridermium carneum Seymour & Earle, Econ. Fungi 550. 1899.

On Carduaceae: II, III.

Vernonia noveboracensis (L.) Willd., Lewes, Aug. 14, 1907, (1680); Collins Beach, Oct. 1, 1907, (1912); Newark, Oct. 25, 1907 (1978.)

Arthur (Mycol. 4:29. 1912), in 1910 proved that *Peridermium carneum* is genetically connected with *Coleosporium Vernoniae*. Successful infection, resulting in the formation of uredinia and telia was obtained by sowing aeciospores from *Pinus taeda* on *Vernonia crinita*, from Florida. These results were confirmed in 1911 by the same author (Mycol. 4:57. 1912), who obtained successful infection on *V. gigantea*, using aecial material from Mississippi; and again in 1913 and 1914 (Mycol. 7:80, 84. 1915), when infection of *V. fasciculata* was obtained from aecial material on *P. taeda* and *P. palustris* collected in Florida.

The type of *Tubercularia carnea* has not been seen, and presumably is not in existence. It seems desirable, if this name is to be retained at all, to restrict its use to the Vernonia combination or, in case it should later be found desirable to unite this species with *C. Elephantopodis*, for the combined species. Hedgcock & Long (Phytopath. 7:66-67. 1917) record culture work indicating that the two species may be identical. See also Phytopathology 8:321, 325. 1918.

2. COLEOSPORIUM DELICATULUM (Arth. & Kern) Hedgcock & Long, Phytopath. 3:250. 1913.

Peridermium delicatulum Arth. & Kern, Bull. Torrey Club 33:412. 1906.

ON CARDUACEAE: II, III.

Euthamia graminifolia (L.) Nutt., Newark, September 1888, F. D. Chester; Clayton, July 24, 1907, (1706); Felton, Sept. 5, 1907, (1746); Selbyville, Oct. 4, 1907, (1990).

This species until recently has been included with *C. Solidaginis*. The first suggestion leading to a true understanding of its relationship was made by Clinton in 1912 (Conn. Agr. Exp. Station Report 1912:352. 1913) who observed *P. delicatulum* on *Pinus rigida* in Connecticut associated in the field with Coleosporium on *Solidago graminifolia*. He pointed out a morphological correlation between the spore wall markings of the aeciospores and the urediniospores of the two forms but no cultures were attempted.

Hedgcock and Long in 1913 (l. c.) showed by infection experiments that this form is distinct and is connected genetically with *Peridermium delicatulum*. Uredinia developed on Euthamia when inoculated with aeciospores of *P. delicatulum* on *Pinus rigida*.

For a record of additional culture work see Phytopathology 8:321. 1918.

3. Coleosporium Elephantopodis (Schw.) Thüm. Myc. Univ. 953. 1878.

Uredo Elephantopodis Schw. Schr. Nat. Ges. Leipzig 1:70. 1822.

On Carduaceae: II, III.

Elephantopus caroliniana Willd., Greenbank, Aug. 24, 1886, A. Commons (318); Selbyville, Oct. 4, 1907, (1753).

Hedgcock & Long (Phytopath. 7:66-67. 1917) record culture work which indicates that this species is identical with *C. Vernoniae.* Further information regarding this situation is to be found in Phytopathology 8:321, 325. 1918.

4. Coleosporium Ipomoeae (Schw.) Burr. Bull. Ill. Lab. Nat. Hist. 2:217. 1885.

Uredo Ipomoeae Schw. Schr. Nat. Ges. Leipzig 1:70. 1822. *Peridermium Ipomoeae* Hedgc. & Hunt, Mycologia 9:239. 1917.

On Convolvulaceae: II, III.

Ipomoea hederacea (L.) Jacq., Lewes, Aug. 14, 1907, (1683); Selbyville, Oct. 4, 1907, (1982).

Ipomoea pandurata (L.) Meyer,—Faulkland, Sept. 18, 1885, A. Commons (219).

Ipomoea purpurea (L.) Roth.—Lewes, Aug. 14, 1907 (1694). Newark, Sept. 15, 1905 (1539).

Hedgcock & Hunt (Phytopath. 7:67. 1917) have shown that a previously undescribed foliicolous species of Peridermium, to which they give the name *P. Ipomoeae,* is the aecial stage of this species.

5. Coleosporium Pini Gall. Jour. Myc. 7:44. 1891.

Gallowaya Pini Arth. Result. Sci. Congr. Bot. Vienne 336. 1906.

On Pinaceae: III.

Pinus virginiana Mill.—Seaford, June 4, 1908, (2095).

This species represents the type of the genus Gallowaya Arth. which up to the present time remains monotypic. It is in its life history a short cycle Coleosporium bearing the same relation to that genus that Necium Arth. does to Melampsora Cast. and Chrysomyxa Ung. to Melampsoropsis (Schröt.) Arth., etc., as proposed in the revised classification of Arthur (l. c.).

Galloway (Bot. Gaz. 22:433-452. 1896) has made a very thorough investigation of the life history, pathological histology and the effect of this fungus on this host. A large series of inoculations were carried out proving conclusively that the fungus is autoecious and that telia only are included in the life cycle.

6. COLEOSPORIUM SOLIDAGINIS (Schw.) Thüm. Bull. Torrey Club 6:216. 1878.

Uredo Solidaginis Schw. Schr. Nat. Ges. Leipzig 1:70. 1822.

Periderminum acicolum Und. & Earle, Bull. Torrey Club 23:400. 1896.

Peridermium montanum Arthur & Kern, Bull. Torrey Club 33:413. 1906.

ON PINACEAE: I.

Pinus rigida Mill.—Seaford, June 5, 1908, (2066, 2094); Harrington, June 5, 1908 (2257).

ON CARDUACEAE: II, III.

Solidago canadensis L.—Newark, September, 1888, F. D. Chester; Seaford, July 9, 1907, (1644); Clayton, July 24, 1907, (1704); Lewes, Aug. 14, 1907, (1697, 1701).

Solidago rugosa Mill., Lewes, Aug. 14, 1907, (1698).

Aster paniculatus Lam. Newark, October, 1907, (2265, 2248).

The life history of this species was first worked out by Clinton (Science N. S. 25:289. 1907. Ann. Rep. Conn. Exp. Sta. **1906**:320. 1907; **1907**:375. 1908). He successfully infected *Solidago rugosa* with aeciospores of *Peridermium acicolum* on *Pinus rigida*. The aecial material used was collected in three localities in Connecticut and three trials were made, all of which resulted in the development of uredinia. Telia followed in two cases.

More recently Hedgcock (Phytopath. 6:65. 1916) and Wier and Hubert (Phytopath. 6:68. 1916) working independently, have shown that, in Montana, the species under discussion has for its aecial stage a Peridermium common in the west on the needles of various pines, known as *P. montanum* Arth. & Kern. Hedgcock sowed aeciospores collected on *Pinus contorta* in Montana on various hosts and obtained the development of aecia and telia on *Aster conspicuous.* Wier & Hubert also sowed aeciospores from the same host and State on a number of local hosts for Coleosporium and obtained infection resulting in aecia on *Solidago canadensis, S. missouriensis* and *Aster laevis geyeri.*

A review of the present knowledge with reference to this species can be found in Phytopathology 8:324. 1918.

7. CRONARTIUM CEREBRUM (Peck) Hedgcock & Long, Jour. Agr. Res. 2:247. 1914.

Peridermium cerebrum Pk. Bull. Buff. Soc. Nat. Sci. 1:68. 1873.

Aecidium giganteum Mahr. Wald. Nordam. 120. 1890.

Cronartium Quercuum Miyabe; Shirai, Bot. Mag. Tokyo 13:74. 1899.

Peridermium fusiforme Arth & Kern, Bull. Torrey Club 33:421. 1906.

ON PINACEAE: I.

Pinus virginiana Mills., Seaford, April 1908, (2250).

ON FAGACEAE: II, III.

Quercus coccinea Wang., Seaford, July 9, 1907, (1645).

Quercus digitata (Marsh.) Sudw., Seaford, July 9, 1907, (1641, 1642) (Barth. Fungi Columb. 2720); Lewes, Aug. 14, 1907, (2249).

Quercus marylandica Moench., Seaford, July 9, 1907, (1646, 1647, 1652), (Barth. Fungi Columb. 2719); Lewes, Aug. 14, 1907.

Quercus nigra L., Seaford, July 9, 1907, (1643).

The first record of culture work with this species was made by Shirai (Bot. Mag. 13:74. 1899). He successfully inoculated *Quercus serrata*, *Q. variabilis* and *Q. glandulosa* in Japan, with aeciospores of *Peridermium giganteum* (Mahr.) Tubeuf from native Pinus sp.

Shear (Jour. Myc. 12:89. 1906) was the first in America to report successful inoculation indicating the connection of *Peridermium cerebrum* with the American Cronartium on Quercus sp. He conducted out-of-door inoculation experiments in the vicinity of Washington, D. C., using aeciospores of *Peridermium cerebrum* on *Pinus virginiana* to infect *Q. coccinea*. The experiments resulted in the formation of uredinia followed by telia. He also records convincing field observations confirming the above mentioned culture work.

Arthur in the same year (Jour. Myc. 13:194. 1907) confirmed Shear's results under greenhouse control by obtaining successful infection on *Q. velutina* which resulted in the formation of uredinia and telia following sowings with aecial material furnished by Dr. Shear, on *Pinus virginiana*. These results were confirmed by the same author in 1910 (Mycol. 4:26. 1912) when infection was obtained on *Q. rubra* using aecia on *P. virginiana* from the same locality.

Hedgcock in 1908 (Phytopath, 1:131. 1911) infected *Q. lobata, Q. rubra* and *Q. densifolia echinoides* by sowing with aeciospores from *Pinus virginiana* and *P. echinata,* resulting in the formation of uredinia and telia on all hosts. He also records further inoculation experiments in 1909 and 1910 in which 14 additional species of Quercus were successfully infected as was also *Castanopsis chrysophylla.* Typical galls were produced on five species of pines by introducing teliospores from the oak into wounds on the limbs. Many cross inoculations are recorded between species of Quercus in which uredospores were used.

Later Hedgcock & Long (Jour. Agr. Res. 2:247. 1914) record further inoculation work extending as well as confirming the above results and also show by carefully conducted inoculation experiments that *Peridermium fusiforme* is a synonym of the species under discussion.

Arthur in 1913 (Mycologia 7:79. 1915) confirms Hedgcock and Long's findings with reference to *Peridermium fusiforme,* obtaining successful infection of *Q. rubra* and *Q. Phellos,* following sowings with aeciospores from typical galls of this species on *Pinus taeda* from Alabama.

A more recent view with reference to the relation of *Peridermium cerebrum* and *P. fusiforme* to the Cronartium on oaks will be found in Phytopathology 8:315-316. 1918.

8. CRONARTIUM PYRIFORME (Peck) Hedgcock & Long, Alt. Stage Peridermium pyriforme 3, 1914.

   Cronartium Comandrae Peck, Bot. Gaz. 4:128. 1879.

   Peridermium pyriforme Peck, Bull. Torrey Club 6:13. 1875.

   ON SANTALACEAE: II, III.

   Comandra umbellata (L.) Nutt., Harrington, June 6, 1908, (2070).

Orton & Adams (Phytopath. 4:25. 1914) record convincing field observations made in Pennsylvania which led to the conclusion that the aecial stage of this species was the much confused *Peridermium pyriforme* Pk. No cultures were attempted.

Hedgcock and Long (l. c.) were the first to conduct cultures. They succeeded in infecting *Comandra umbellata* by sowings with aeciospores from *Pinus ponderosa,* resulting in typical uredinia.

In a later publication (Bull. U. S. Dept. Agr. 247:5. 1915) the same authors discuss this fungus at considerable length and record in detail the results of infection experiments.

Kirkwood (Phytopath. 5:223-224. 1915) records field infection experiments conducted in 1912 in which *Comandra pallida* was infected by aeciospores from *Pinus ponderosa*. The results were inconclusive. In 1914 teliospores were inserted in incisions in the bark of young pine trees resulting in a development of mycelium in the tissues, which on histological examination resembled the condition found in trees known to be natually infected. Further field infections similar to those conducted in 1912 were carried out in 1914.

9. HYALOPSORA POLYPODII (DC.) Magn. Ber. Deuts. Bot. Ges. **19**:582. 1901.

Uredo Polypodii DC. Fl. Fr. 6:81. 1815.

ON POLYPODIACEAE:

Felix fragilis (L.) Und., Stanton, July 4, 1894, A. Commons (2466); Mt. Cuba, July 1894, A. Commons (Distributed in Ellis & Ev. Fungi Columb. 765).

The evidence at hand at the present time leads to the conclusion that this species and other members of the genus Hyalopsora are heteroecious. Bartholomew (Bull. Torrey Club 43:195. 1916) shows that the mycelium of this species is binucleate in all its forms on the above host. No clues to the alternate host have been suggested.

10. KUEHNEOLA UREDINIS (Lk.) Arth. Result. Sci. Congr. Bot. Vienne 342. 1906.

Oidium Uredinis Lk. in Willd. Sp. Pl. 6[1]:123. 1824.

Chrysomyxa albida Kühn, Bot. Centr. **16**:154. 1883.

Uredo Muelleri Schröt. Krypt. Fl. Schles. 3[1]:375. 1887.

Coleosporium Rubi Ellis & Holw. Sacc. Syll. Fung. **7**:759. 1888.

ON ROSACEAE:

Rubus nigrobaccus Bailey, Faulkland, Sept. 15, 1885, A. Commons (175), Oct. 1, 1886, A. Commons (175a) (type of *Coleosporium* Rubi Ell. & Holw. issued in Ellis & Ev. N. Am. Fungi 1878); Newark, Sept. 5, 1905 (1629).

Rubus frondosus Bigel. Newark, Sept. 1907 (2012).

11. MELAMPSORA BIGELOWII Thüm. Mitth. Forstl. Vers. 2:37. 1879.
Uredo Bigelowii Arth. Result. Sci. Congr. Bot. Vienne 338. 1906.
ON SALICACEAE: II, III.
Salix nigra Marsh., Wilmington, Oct. 4, 1889, A. Commons (1022); Newark, Oct. 6, 1905 (1634), Sept. 10, 1907 (1729).

Arthur in 1903 (Jour. Myc. 11:60. 1905) was the first to show that this American species, like certain European forms on Salix, develops its aecial stage on Larix. He obtained the development of aecia on *Larix decidua* by using for infection, telial material on *Salix amygdaloides,* from Wisconsin. These results were confirmed in 1906 (Jour. Myc. 13:194. 1907) when similar successful infection was obtained on *L. decidua* following exposure to germinating telia on Salix sp. from Indiana. Wier and Hubert (Phytopath. 6:372. 1916) used telia on *Salix Bebbiana* from Montana to successfully infect *L. occidentalis,* and on *S. cordata mackenzieana* from Idaho to infect *L. Europea.* Pycnia and aecia developed in abundance from both infections. (See also Phytopath 7:109. 1917; 8:326. 1918.)

12. PUCCINIASTRUM AGRIMONIAE (Schw.) Tranz. Script. Bot. Hort. Univ. Petrop. 4:301. 1895.
Caeoma Agrimoniae Schw. Trans. Am. Phil. Soc. II, 4:291. 1832.
ON ROSACEAE: II, III.
Agrimonia hirsuta (Mühl.) Bicknell, Newark, Sept. 19, 1905, (1547); Oct. 1907 (2235).

No culture work leading to the detection of the alternate form of the species has been conducted. The aecia, in common with other North American species of Pucciniastrum, doubtless occur on the leaves of Abies or Tsuga.

13. PUCCINIASTRUM MINIMUM (Schw.) Arth. Result. Sci. Congr. Bot. Vienne 337. 1906.
Uredo minima Schw. Schr. Nat. Ges. Leipzig 1:70. 1822.
Peridermium Peckii Thüm. Mitth. Forstl. Vers. Oest. 2:320 (24). 1880.
ON ERICACEAE: II.
Azalea viscosa L., Collins Beach, Oct. 1, 1907 (1910).

Fraser in 1910 (Mycol. 4:184. 1912) was the first to show that the alternate host for this species is *Tsuga canadensis.* He obtained successful infection, resulting in pycnia and aecia on leaves and cones of *Tsuga canadensis* (referred to *Peridermium Peckii*) by sowings with telial material from *Rhodora canadensis.*

A comparison of the morphology of all the spore stages of this species with the following, taken together with the close relationship of the hosts involved, strongly suggests that they should be united under one name.

See also Phytopathology 8:329-330. 1918.

14. PUCCINIASTRUM MYRTILLI (Schum.) Arth. Result Sci. Congr. Bot. Vienne 337. 1906.

Aecidium Myrtilli Schum. Enum. Pl. Saell. 2:227. 1803.

ON VACCINIACEAE: II.

Vaccinium vacillans, Kalm., Newark, Sept. 17, 1907 (2008); Selbyville, Oct. 4, 1907 (1989).

Clinton (Rep. Conn. Agr. Exp. Sta. **1909-1910**:719. 1911) was the first to show that the aecial stage of this species occurred on *Tsuga canadensis.* He successfully infected *Gaylussacia baccata* by sowing with aeciospores from Tsuga, resulting in the development of the typical uredinia of this species.

Fraser in 1912 (Mycol. 5:237. 1913) confirms Clinton's work by obtaining the development of aecia on the leaves of *Tsuga canadensis* following sowings from teliosporic material on *Vaccinium canadense.* The same author in 1913 (Mycol. 6:27. 1914) obtained aecia on *Tsuga canadensis* following sowing of teliosporic material from *Galussacia resinosa.* The aecia developed in these experiments are similar to those of *Peridermium Peckii* Thüm. but may represent an undescribed form.

15. PUCCINIASTRUM PYROLAE (Pers.) Dietel, in Engler & Prantl Nat. Pfl. **1,1****:47. 1897.

Aecidium Pyrolae Pers. Gmel. Syst. Nat. 2:1473. 1791.

ON PYROLACEAE:

Chimaphila maculata (L.) Parsh., Seaford, June 5, 1908. (2075).

16. PUCCINIASTRUM PUSTULARUM (Pers.) Dietel, in E. & P. Nat. Pfl. **1,1****:47. 1897.

Uredo pustulata Pers. Syn. Fung. 219. 1801.

Pucciniastrum Epilobii Otth. Mitth. Nat. Ges. Bern **1861**:72. 1861.

Pucciniastrum Abieti-Chamaenerii Kleb. Jahrb. Wiss. Bot. 34:387. 1900.

ON ONAGRACEAE: II.

Epilobium coloratum Muhl., Mt. Cuba, Sept. 20, 1893, A. Commons (2262).

Klebahn (Zeits. Pflanzenkr. 9:22-26. 1899) and other European investigators have shown that the aecial stage of the rust on species of Epilobium belonging to the section Chamaenerion occurs in Europe on *Abies pectinata.*

Fraser in 1910 (Mycol. 4:176. 1912) was the first in America to record successful cultural experiments with this species. He showed that the aecia were found on *Abies balsamea* using for infection telia from *Epilobium angustifolium* collected in Nova Scotia. The aeciospores thus produced were used to infect *Epilobium angustifolium* and the typical uredinia of this species resulted. Weir and Hubert (Phytopath. 6:373. 1916) using telial material from the same host collected in Idaho obtained development of pycnia on *Abies lasiocarpa.*

It will be noted that all the cultural work has been conducted with but one American species of Epilobium which belongs in the same group as those successfully cultured in Europe. It is probable that there are at least two distinct biological races involved. Sydow (Monog. Ured. 3:442-444. 1915) recognizes two species.

See also Phytopathology 8:328-329. 1918 for a review of more recent work.

17. UREDINOPSIS ATKINSONII Magn. Hedwigia 43:123. 1904.

ON POLYPODIACEAE:

Dryopteris Thelypteris (L.) A. Gray, Stanton, July 13, 1894, A. Commons (2471).

Fraser in 1912 (Mycol. 5:236. 1913) proved that this species has its aecial stage on *Abies balsamea* (*Peridermium balsameum* Pk. p. p.) by successfully infecting *Dryopteris Thelypteris* with aeciospores from *Abies balsamea* with production of uredinia.

18. UREDINOPSIS MIRABILIS (Pk.) Magn. Hedwigia 43:121. 1904.

Septoria mirabilis Pk. Ann. Rep. N. Y. Mus. 25:87. 1873.

ON POLYPODIACEAE:

Lorinseria areolata (L.) Presl., Selbyville, Oct. 4, 1907, (1755).

Onoclea sensibilis L., Newark, Oct. 1907, (2259).

Fraser in 1910 (Mycol. 4:189. 1912) conducted inconclusive culture experiments indicating that this species on *Onoclea sensibilis* had for its aecial stage a Peridermium on *Abies balsamea.* In 1912 (Mycol. 5:236. 1913), however, the same author demonstrated conclusively that such was the case. Teliosporic material on *Onoclea sensibilis* L. was used to successfully infect the leaves of *Abies balsamea* resulting in pycnia and aecia of *Peridermium balsameum.* In three trials using aeciospores from *Abies balsamea,* uredinia developed on Onoclea. In 1913 (Mycol. 6:25. 1914) the results of 1912 were repeatedly confirmed. The species of the genus Uredinopsis are separated on rather slight morphological characters. Fraser reports the results of experiments, however, that indicate that this species is at least biologically distinct.

PUCCINIACEAE.

19. Gymnoconia interstitialis (Schlecht.) Lag. Tromsö Mus. Aarsh. 16:140. 1894.

Caeoma interstitiale Schlecht. Horae Phys. Berol. 96. 1820.

Aecidium nitens Schw. Schr. Nat. Ges. Leipzig 1:69. 1822.

Puccinia Peckiana Howe; Peck, Ann. Rep. N. Y. State Mus. 23:57. 1872.

Puccinia tripustulata Peck, Ann. Rep. N. Y. State Mus. 24:91. 1872.

Gymnoconia Peckiana Trotter, Fl. Ital. Crypt. 1^{12}:338. 1910.

Kunkelia nitens Arth. Bot. Gaz. 58:504. 1917.

On Rosaceae: I.

Rubus allegheniensis Porter, Newark, May 1889, F. D. Chester.

Rubus villosus Ait., Newark, May 15, 1907, (1620), June 16, 1907, M. T. Cook, (1661).

Tranzschel (Hedwigia 32:257. 1893) was the first to report success in culturing this species. He succeeded in obtaining the development of *Puccinia Peckiana* Howe on *Rubus saxatilis* by sowing spores of *Caeoma nitens* Burrill.

In America Clinton (Bot. Gaz. 19:116. 1895) confirmed Tranzschel's work by successfully infecting *Rubus villosus* with production of telia. He used aecial material from the same host.

Kunkel (Bull. Torrey Club 40:361-366. 1913; Am. Jour. Bot. 1:37-47. 1914) has shown that *Caeoma nitens* on *Rubus frondosus* behaves like a short cycle telial form comparable to Endophyllum, since the so-called aeciospores germinate like teliospores. In a later study (Bull. Torrey Club 43:559-569. 1916) Kunkel concludes that there are two forms of orange rust of Rubus in North America. He found that in certain collections the spores germinate as aeciospores with germ tube, while in others they germinate as teliospores. Arthur (l. c.) concurs in this view and establishes the genus Kunkelia for the short cycled form. Atkinson (Am. Jour. Bot. 5:79-83. 1918) presents evidence in support of the contention that only one species should be recognized and that it represents a form whose life history is unstable and that the spores may germinate either as aeciospores which on infection develop teliospores of *Puccinia Peckiana*, or as teliospores which, following infection, result in a repetition of the caeomoid aecial form. He considers that the behavior of the spores is dependent on certain conditions, the most important of which is temperature. Until more evidence is available it seems best to continue to list this species under the old name.

20. GYMNOSPORANGIUM BOTRYAPITES (Schw.) Kern, Bull. Torrey Club 35:506. 1908.

Caeoma Botryapites Schw. Trans. Am. Phil. Soc. II. 4:294. 1832.

Gymnosporangium biseptatum Ellis, Bull. Torrey Club 5:46. 1874.

ON JUNIPERACEAE: III.

Chamaecyparis thyoides (L.) B.S.P., Seaford, April 14, 1908.

Dr. W. G. Farlow (Anniv. Mem. Bost. Soc. Nat. Hist. 35:1880) was the first to attempt infection experiments with this species. He reports success in obtaining pycnia on *Crataegus tomentosa.* It is noteworthy that later studies have not confirmed the occurrence of the species on Crataegus. Later (Proc. Am. Acad. Nat. Sci. 12:313. 1885) spermogonia were obtained on leaves and stems of *Amelanchier canadensis.* Dr. R. Thaxter (Proc. Am. Acad. Nat. Sci. 14:263. 1887) obtained the development of aecia on *Amelanchier canadensis* which were recognized to be *Roestelia Botryapites* (Schw.) C. & E. These results were later repeatedly confirmed (Conn. Agr. Exp. Sta. Bull. 107:4. 1891).

Dr. J. C. Arthur (Mycol. 1:240. 1909) records successful infection of *Amelanchier intermedia* from telial material collected by the writer at Newfield, N. J., pycnia only resulting.

Dodge (Torreya 15:133-134. 1915; Bull. Torrey Club 42:519-542.

1915) conducted an extensive investigation of this species in comparison with *G. transformans.* In connection with this work he repeatedly obtained infection by using telia from galls on *Chamaecyparis thyoides,* on *A. canadensis, A. intermedia* and *A. Amelanchier* which resulted in the development of *Roestelia Botryapites.* (c. f. 27). He failed to obtain any infection on Aronia.

21. GYMNOSPORANGIUM CLAVARIAEFORME (Jacq.) DC. Fl. Fr. 2:217. 1895.

Tremella clavariaeformis Jacq. Coll. 2:174. 1788.

ON MALACEAE: I.

Amelanchier canadensis (L.) Medic., Felton, June 8, 1893, F. D. Chester.

The alternate host for this species occurs on *Juniperus communis* L. and *J. sibirica* Burgsd.

Oersted (Overs. Vid. Selsk. Forh. 210, 1867; Bot. Zeit. 222, 1867) was the first to carry out infection experiments with this species. He successfully infected *Crataegus oxycantha* following sowings with telial material. This species has since been frequently cultured by European investigators and the results have been fully summarized by Klebahn (Die Wirtswechselden Rostpilze 339-345. 1904).

In America, Thaxter (Proc. Am. Acad. Sci. 22:262. 1887; Bot. Gaz. 14:166. 1889) was the first to conduct definite cultures. He succeeded in obtaining the development of an abundance of pycnia and aecia on *Crataegus tomentosa* and *Amelanchier canadensis.*

Dr. J. C. Arthur (Jour. Myc. 14:19. 1908) in 1907 succeeded in obtaining infection of *Amelanchier intermedia* following sowings of sporidia from *Juniperus sibirica* with development of pycnia only. In 1908 (Mycol. 1:239. 1909) aecia were obtained on *Amelanchier erecta* following sowings of sporidia from *J. sibirica* from Colorado. In 1910, (Mycol. 4:24. 1912) using similar infection material, the same author succeeded in obtaining pycnia and aecia on *Amelanchier erecta* and pycnia on *Crataegus punctata.* In 1911 (Mycol. 4:56. 1912) the same results on *Amelanchier erecta* were obtained as in 1910, using telial material from the same locality. In 1913 (Mycol. 7:79. 1915) pycnia were obtained on *Crataegus cerronus,* following inoculation with telia from Colorado on *Juniperus sibirica.*

22. GYMNOSPORANGIUM GERMINALE (Schw.) Kern, Bull. Torrey Club 35:506. 1908.

Caeoma germinale Schw. Trans. Am. Phil. Soc. II. 4:294. 1832.

Gymnosporangium clavipes Cooke & Peck; Cooke, Jour. Quek. Club 2:267. 1871.

Roestelia aurantica Pk. Bull. Buffalo Soc. Nat. Sci. 1:68. 1873.

ON MALACEAE: I.

Cydonia vulgaris (L.) Pers., Smyrna, July 15, 1895, comm. J. C. Stockley; Felton, Aug. 1897, F. D. Chester.

ON JUNIPERACEAE: III.

Juniperus virginiana L., Iron Hill, May 1897, F. D. Chester; Seaford, April 14, 1908, (2252).

Dr. W. G. Farlow was the first to conduct culture experiments with this species. In 1883 (Proc. Am. Acad. Sci. **20**:313. 1885) using telia from *Juniperus virginiana* he succeeded in obtaining the development of pycnia on leaves of *Malus Malus, Aronia arbutifolia* and *Amelanchier canadensis,* but aecia did not develop.

Dr. R. Thaxter (Bot. Gaz. **11**:236. 1886; Proc. Am. Acad. Sci. **22**:264. 1887) conducted similar cultural work obtaining well developed aecia on *Amelanchier canadensis* and pycnia on *Malus Malus.*

Dr. J. C. Arthur in 1907 (Jour. Myc. **14**:18. 1908) using material on *Juniperus sibirica* from Illinois secured infection on leaves of *Amelanchier intermedia* and on fruit of *A. erecta* with development of pycnia only. In 1908 the same author (Mycol. **1**:239. 1909) using telial material from *J. virginiana* from Kentucky succeeded in developing pycnia and aecia on Crataegus sp. In 1909 (Mycol. 2:229. 1910) successful infection of *Amelanchier erecta* with development of aecia in abundance and of *Crataegus punctata* with development of pycnia only was obtained. Telial material from *J. sibirica* from Michigan was used in these experiments. In 1910, (Mycol. 4:24. 1912) using telial material from Wisconsin on *J. sibirica,* successful infection of *Amelanchier erecta* and *Crataegus tomentosa* was obtained resulting in abundant aecia in both cases. Aeciospores from the Amelanchier were used in June 1910 to inoculate *J. sibirica* resulting in the development of telia the following spring.

23. GYMNOSPORANGIUM GLOBOSUM Farl. Anniv. Mem. Boston Soc. Nat. Hist. 18. 1880.

ON MALACEAE: I.

Crataegus phaenopyrum (L. f.) Medic., Newark, Oct. 1888, F. D. Chester.

Dr. W. G. Farlow (Anniv. Mem. Boston Soc. Nat. Hist. **34**:1880 and Proc. Am. Acad. N. S. **12**:312. 1885) was the first to conduct infection experiments with this species. He succeeded in obtaining pycnia only on *Crataegus tomentosa, C. Douglasii, C. oxyacantha,* following sowings with telial material from *J. virginiana.* Dr. R. Thaxter (Proc. Am. Acad. Sci. **22**:263. 1887; Bot. Gaz. **14**:167. 1889) succeeded in obtaining infection resulting in aecia on *Crataegus coccinea* and *Malus Malus* and spermogonia on *Sorbus americana* and *Cydonia vulgaris.*

In a later report (Conn. Agr. Exp. Sta. Bull. **107**:4. 1891) additional work is recorded confirming the previous results on *Malus Malus* and recording successful infection of *Sorbus americana* resulting in the development of aecia.

Dr. J. C. Arthur in 1906 (Jour. Myc. **13**:200. 1907) using a telial material from *Juniperus virginiana* from Indiana obtained aecia on *Crataegus Pringlei.* Similar material from West Virginia gave aecia on *Sorbus americana* and pycnia on *Crataegus Pringlei* and *Malus coronaria.* In 1907, (Jour. Myc. **14**:18. 1908) infection from telial material from Indiana resulting in aecia, was secured on *Malus Malus.* In 1908 (Mycol. **1**:239. 1909) infection resulting in aecia was obtained on *Crataegus Pringlei,* using telial material from Massachusetts. Pycnia were also obtained on Crataegus sp. using telial material from Kentucky. In 1909 (Mycol. **2**:229. 1910) successful infection resulting in aecia was obtained on *Crataegus coccinea* using infecting material from North Carolina.

24. GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE Schw. Schr. Nat. Ges. Leipzig **1**:74. 1822.

Gymnosporangium macropus Lk. in Willd. Sp. Pl. **6**[2]:128. 1825.
Aecidium pyratum Schw. Trans. Am. Phil. Soc. II. **4**:309. 1832.
Roestelia pyrata Thax. Proc. Am. Acad. **22**:269. 1887.

On Malaceae: I.

Pyrus coronaria L., Wilmington, Aug. 26, 1886, A. Commons.
Pyrus malus L., Felton, Sept. 5, 1907 (1737).

On Juniperaceae: III.

Juniperus virginiana L., Georgetown, May 18, 1892, F. D. Chester; Lincoln City, May 1906, H. S. Jackson.

The species recorded above is the common cedar-apple rust known throughout the eastern United States and is one of the serious apple diseases often, in epidemic years, causing enormous losses. An account of this disease in Delaware with a list of susceptible and immune varieties has been prepared by Chester (Del. Exp. Sta. Rep. 8:63-69. 1896).

Farlow in 1877 and 1883 (Aniv. Mem. Boston Soc. Nat. Hist. 35:1880; Proc. Am. Acad. **20**:313, 314. 1885) was the first to attempt culture work with this species. He obtained incomplete proof of the life history. In 1886 Thaxter (Proc. Am. Acad. 22:257. 1887) first conducted cultures establishing the genetic relation of the common apple rust (*Roestelia pyrata*) and *G. macropus*. He succeeded in obtaining aecia on *Pyrus malus* following sowing of teliospores from *J. virginiana*. The results were repeated and confirmed in 1887 (Bot. Gaz. **14**:166. 1889). Halsted in 1886 (Bot. Gaz. **11**:190. 1886; Bull. Iowa Agr. Coll. Dept. Bot. 59. 1886) obtained infection on *Pyrus Iowensis* resulting in aecia.

Stewart and Carver in 1896 (Rep. N. Y. (Geneva) Exp. Sta. **14**:535. 1896) conducted culture experiments in New York and Iowa and obtained infection of apples in New York using telia collected in Iowa as well as locally, with successful development of aecia on some varieties. In Iowa infection could only be obtained on wild crab when either New York or Iowa telia were used. The results are recorded in considerable detail and are exceedingly interesting and difficult of explanation.

In 1901 Pammel (Bull. Iowa Exp. Sta. 84:24. 1905) conducted cultural experiments and reports infection of *Pyrus Iowensis* and *Crataegus mollis* and *C. pinnatifida* with development of aecia using telial material from both New York and Missouri.

Arthur in 1905 (Jour. Myc. 12:13. 1906) using telial material from Iowa and North Carolina obtained infection resulting in abundant pycnia on the apple from both sources. In 1906 and 1907 and 1910 (Jour. Myc.

13:200. 1907; **14**:17. 1908; Mycol. 4:24. 1912) pycnia were again obtained on apple following sowings from telial material from Indiana.

In 1915 Reed and Crabill (Tech. Bull. Va. Exp. Sta. 9:43-45. 1915) report the results of numerous infection experiments on different varieties of cultivated apples. Their experiments bring out strongly the well established fact that some varieties are susceptible and other relatively or totally immune. They also show that only young leaves are susceptible.

25. GYMNOSPORANGIUM MYRICATUM (Schw.) Fromme, Mycol. 6:229. 1914.

Caeoma (Aecidium) Myricatum Schw. Trans. Am. Phil. Soc. II. 4:294. 1832.

Podisoma Ellisii Berk. Grevillea 3:56. 1844.

Gymnosporangium Ellisii Farl., Ellis N. A. Fungi 271. 1879.

ON MYRICACEAE: I.

Myrica cerifera L., Seaford, July 9, 1907 (1648).

ON JUNIPERACEAE: III.

Chamaecyparis thyoides (L.) B. S. P., Seaford, April 14, 1908 (2251).

Fromme (l. c.) has shown by infection experiments and field observations that the well known *Gymnosporangium Ellisii* has for its aecial stage *Aecidium Myricatum.* This is especially remarkable since only one other Gymnosporangium *(G. Blasdaleanum)* has been definitely shown by infection experiments to have aecia of the cupulate type, and since no other species of Gymnosporangium is known to have an aecial host in other than the Rosales.

26. GYMNOSPORANGIUM NIDUS-AVIS Thaxter, Bull. Conn. Exp. Sta. **107**:6. 1891.

ON JUNIPERACEAE: III.

Juniperus virginiana L., Lewes, April 15, 1908 (2243).

This species produces largely "witches' brooms" on the red cedar.

Thaxter conducted culture experiments in 1886 and in 1887 (Proc. Amer. Acad. 22:264. 1887; Bot. Gaz. **14**:167. 1889) in which he infected *Amelanchier canadensis* with production of pycnia and aecia in abundance using sporidia of the above species, at that time undescribed, but referred to *G. conicum.* In 1891 Thaxter (l. c.) stated "infections with this species have been conducted every year since the spring of 1886 . . . and the results in all the cultures were identical."

Arthur in 1907 (Jour. Myc. 14:19. 1908), using sporidia from *J. virginiana* collected in Illinois, obtained successful infection of *Malus Malus* with production of pycnia followed by aecia, but failed to obtain infection of *Amelanchier intermedia.* In 1909 (Mycol. 2:230. 1910) successful infection of *Crataegus Pringlei* with production of pycnia only, and of *Malus Iowensis* with development of aecia was obtained, but without infection on *Amelanchier canadensis.* In 1910 (Mycol. 4:25. 1912) infection of *Cydonia vulgaris* and *Amelanchier vulgaris* with production of pycnia only is recorded. In 1911 (Mycol. 4:56. 1912) using sporidia from New Jersey successful infection of *Amelanchier erecta* resulted in the production of aecia on fruits; using sporidia from Nebraska successful infection of *Malus coronaria* with production of pycnia only is recorded. In 1914 (Mycol. 7:83. 1915) *Amelanchier vulgaris* was inoculated with telial material from Massachusetts and abundant production of pycnia and aecia resulted.

27. GYMNOSPORANGIUM TRANSFORMANS (Ellis) Kern, Bull. N. Y. Bot. Gard. 7:463. 1911.

Roestelia transformans Ellis; Peck, Bull. Torrey Club 5:3. 1874.

Gymnosporangium fraternum Kern, Bull. N. Y. Bot. Gard. 7:439. 1911.

ON MALACEAE: I.

Aronia arbutifolia (L. f.) Ell., Seaford, June 1908 (2262).

The above collection is of pycnia only.

Dodge (Torreya 15:133-134. 1915; Bull. Torrey Club 42:519-542. 1915) has studied the foliicolous form occurring on *Chamaecyparis thyoides* which until Kern's monographic study (l. c.) had been considered a form of *G. biseptatum.* His work clearly shows that this leaf form has for its aecia *Roestelia transformans* on Aronia having repeatedly obtained infection followed by development of aecia on *A. arbutifolia* and *A. nigra.* He also claims to have obtained infection with the leaf form on *Amelanchier intermedia, A. canadensis* and *A. Amelanchier,* resulting in the development of aecia having the morphology of *R. Botryapites* which has been repeatedly shown to go to the branch form known commonly as *G. biseptatum.* The young infections of *G. bisep-*

tatum which occur on the young twigs may easily be confused with the leaf form unless microscopically examined, and might have been mixed with the material of *G. fraternum* used in the infection experiments.

28. PHRAGMIDIUM AMERICANUM Diet. Hedwigia 44:124. 1905.

ON ROSACEAE:

Rosa Carolina L. Collins Beach, Oct. 1, 1907.

Rosa humilis Marsh., Seaford, June 4, 1908 (2050); Lewes, Aug. 14, 1907 (1685).

29. PHRAGMIDIUM DISCIFLORUM (Tode) J. F. James, Cont. U. S. Nat. Herb. 3:276. 1895.

Ascophora disciflora Tode, Fungi Meckl. 1:16. 1790.

ON ROSACEAE:

Rosa sp. (cultivated), Newark, September 1888, F. D. Chester.

30. PHRAGMIDIUM DUCHESNEAE (Arth.) Sydow, Monog. Ured. 3:93. 1912.

Kuehneola Duchesneae Arthur, N. A. Flora 7:185. 1912.

Frommea Duchesneae Arthur, Bull. Torrey Club 44:504. 1917.

ON ROSACEAE:

Duchesnea Indica (Ards.) Focke, II, Newark, May 1908, H. S. Jackson; III, Wilmington, Nov. 1, 1890, A. Commons (1686).

This species and the following possess only uredinia (primary and secondary) and telia in their life cycle differing from the commoner species occurring on Rubus and Rosa in the absence of any Caeoma stage. As suggested by Arthur (Phytopath. 6:100. 1916; Bull. Torrey Club 44:501-511. 1917) their affinities are with Phragmidium rather than with Kuehneola which doubtless belongs in the Uredinaceae. In the classification of the Uredinales based on the length of life cycle, proposed by Arthur (Result. Sci. Congr. Bot. Vienna in 1906) these species would represent a genus in the Phragmidiatae bearing the same relation to Phragmidium and Earlea that Bullaria does to Dicaeoma and Dasyspora in the Dicaeomatae. Frommea Arthur (l. c.) has been proposed as the name of this genus.

31. PHRAGMIDIUM TRIARTICULATUM (B. & C.) Farl., Bull. Bussey Inst. 1:433. 1876.

Aregma triarticulatum Berk. & Curtis; Berk. Grevillea 3:51. 1874.

Kuehneola obtusa Arthur N. A. Flora 7[3]:185. 1912. p. p.

Phragmidium Potentillae-canadensis Diet. Hedw. Beibl. 42:179. 1903.

Frommea obtusa Arth. Bull. Torrey Club 44:503. 1917.

On Rosaceae:

Potentilla canadensis L., Newark, September 1907 (2004).

32. Pileolaria Toxicodendri (Berk. & Rav.) Arth. N. A. Flora 7^2:147. 1907.

Uromyces Toxicodendri Berk & Rav. Grevillea 3:56. 1874.

On Sapindaceae:

Rhus radicans L., Stanton, Sept. 10, 1885, A. Commons (184).

33. Polythelis fusca (Pers) Arth. Result Sci. Congr. Bot. Vienne 341. 1906.

Aecidium fuscum Pers. Linn. Syst. Nat. 2^2:1873. 1791.

Puccinia fusca Wint. Rabh. Krypt. Fl. 1:199. 1884.

On Ranunculaceae:

Anemone quinquefolia L., Newark, April 13, 1908, (2255).

The mycelium of this species is perennial as first shown by DeBary (Monatsber. K. Akad. d. Wiss. Berlin 1865). Plants affected by this rust are deformed, slightly dwarfed and seldom if ever flower. The leaves are paler and narrower than normal and are considerably thickened.

34. Puccinia Agropyri E. & E. Jour. Myc. 7:131. 1892.

On Poaceae:

Agropyron repens L., Newark, August 23, 1907 (1716).

No successful culture work has been conducted with this sub-epidermal leaf rust on this host. It is indistinguishable from the normal form of *P. tomipara* Trel. on Bromus sp. and with other similar forms on various grasses described under a variety of names including *P. obliterata* Arth. on *Agropyron* sp., *P. alternans* Arth. on *Bromus* sp. and *P. cinerea* Arth. on Poa sp. Considerable culture work has been done by Arthur showing that these forms have aecia on Ranunculaceae and are probably identical. It is to be expected that aecia for leaf rust on *Agropyron repens* will also be found to be on Ranunculaceae. The most probable connection is with Clematis.

35. PUCCINIA ALETRIDIS B. & C. Grevillea 3:52. 1874.

ON LILIACEAE:

Aletris farinosa L., Newark, April 7, 1892, A. Commons (1924); Townsend, Oct. 9, 1896, A. Commons (2785); Selbyville, Oct. 3, 1907 (1756).

The specimen from Newark collected by Commons which is in the Ellis collection at the New York Botanical Garden is labeled as occuring on Chamalerion. The host is clearly Aletris.

No aecia are known for this rather rare species and its life history is in doubt. Only three other collections have been seen by the writer from Massachusetts, Florida and Mississippi.

36. PUCCINIA ANEMONES-VIRGINIANAE Schw. Schrift. Nat. Ges. Leipzig **1**:72. 1822.

ON RANUNCULACEAE:

Anemone virginiana L., Faulkland, Aug. 13, 1886, A. Commons (293).

The above collection was also issued in Ellis & Ev. N. A. Fungi 1847.

37. PUCCINIA ANDROPOGONIS Schw. Trans. Am. Phil. Soc. II, 4:295. 1834.

Aecidium Pentastemonis Schw. Schr. Nat. Ges. Leipzig **1**:68. 1822.

ON SCROPHULARIACEAE: I.

Melampyrum lineare Lam. (*M. americanum* Michx.), Seaford, June 4, 1908 (2051).

ON POACEAE: II, III.

Schizachyrium scoparium (Michx.) Nash (*Andropogon scoparius* Michx.), Lewes, Nov. 16, 1907.

This species on Andropogon was first cultured by Arthur in 1899 (Bot. Gaz. **29**:27. 1900) who succeeded in obtaining infection resulting in aecia on *Pentstemon pubescens* using telia from *A. scoparius* from Indiana. In 1904 and 1906 the same author (Jour. Myc. **10**:11. 1904; **13**:197. 1907) using telia of *A. scoparius* collected in Nebraska, obtained infection resulting in aecia on *P. hirsutus*. In 1910 (Mycol. 4:17. 1912) telia from *A. virginicus* from W. Virginia were successfully cultured on *P. hirsutus* and from *A. scoparius* from Colorado on *P. alpinus*. In 1903 Kellerman (Jour. Myc. 9:10. 1903) verified the results of Arthur by obtaining successful infection on *P. hirsutus* resulting in pycnia following sowing of telia from *A. scoparius* collected in Indiana.

This aecidium on Melampyrum included here is known on this host otherwise only from Connecticut and Massachusetts. It somewhat resembles *A. Melampyri* Kuntze & Schum., which has been shown by Juel (Obv. K. Vet. Akad. Föch 1894. 503) and Klebahn (Kulturv. VIII 402) to go to *Puccinia nemoralis* Juel on *Molina caerulea.* The American aecia differs however from the European in the larger thick walled aeciospores and in the character of the peridial cells and since no telial form referrable to the European species has yet been found in America it is probable that the Aecidium under discussion goes to some American grass or sedge rust. It is scarcely distinguishable from the aecia of *P. Andropogonis* Schw. which occur on other Scrophulariaceae in the same range and is tentatively referred here till positive cultures are conducted.

38. PUCCINIA ANGUSTATA Pk. Bull. Buff. Soc. Nat. Hist. **1**:67. 1873.

Aecidium lycopi Ger.; in Peck Bull. Buff. Soc. Nat. Hist. **1**:68. 1873.

ON BORAGINACEAE: I.

Lycopus virginicus L., Newark, May 25, 1908, (2236), Seaford, June 4, 1908, (2068).

ON CYPERACEAE: II, III.

Scirpus atrovirens Muhl. Newark, Oct. 4, 1905, (1635).

Scirpus cyperinus (L.) Kunth., Selbyville, October 4, 1907, (1812).

Scirpus georgianus Harper, Newark, September 1907, (1818, 1820).

This species has for its aecial stage *Aecidium lycopi* Ger. on Lycopus sp. as first shown by Arthur in 1899 (Bot. Gaz. **29**:273. 1900), who succeeded in infecting *Scirpus atrovirens* with aeciospores from *Lycopus americanus.* These results were confirmed in 1901, 1903, 1904, 1906 and 1907 (Jour. Myc. **8**:53. 1902; **11**:58. 1905; **13**:196. 1907; **14**:14. 1908) by sowing teliospores from *Scirpus atrovirens* on leaves of *Lycopus americanus* resulting in each case in the development of aecia. Kellerman in 1903 (Jour. Myc. **9**:226. 1903) confirms Arthur's results using the same hosts, collecting his telial material in Ohio. In 1908 (Mycol. **1**:234. 1909) Arthur infected *Lycopus communis* and *L. americanus* by sowing with teliospores from *Scirpus cyperinus.* In 1910 (Mycol. **4**:17. 1912) the results of 1901-1907 were confirmed and in 1911 (Mycol. **4**:54.

1912) the results of 1908 were confirmed in part. In 1912 (Mycol. 7:70. 1915) infection resulting in the development of aecia was again obtained on *L. americanus* using telial material on *S. atrovirens* from Indiana and Ontario.

39. Puccinia Anthoxanthi Fckl. Symb. Myc. Nachtr. 2:15. 1873.
On Poaceae:
Anthoxanthum odoratum L., Newark, June 1908, (2244).

40. Puccinia Asparagi DC. Flora Fr. 2:595. 1805.
On Convallariaceae:
Asparagus officinalis L., Hare's Corners, October 1896, F. D. Chester; Smyrna, October 1904, C. O. Smith; Lewes, Aug. 14, 1907, (1681).

A discussion of the economic importance of this rust in Delaware will be found in Delaware Experiment Station bulletins 57 and 63.

Sheldon (Science N. S. 16:235. 1902) shows that this species is autoecious and that the urediniospores may carry the fungus over the winter. He also claims to have successfully infected *Allium cepa,* all three stages having been produced on that host.

41. Puccinia asperifolii (Pers.) Wettst. Verh. Zool.-Bot. Ges. Wein. 35:541. 1885.
Puccinia dispersa Erikss. Zeitsch. f. Pflanzkr. 4:257. 1894.
Aecidium asperifolii Pers. Obs. Myc. 1:97. 1896.
On Poaceae:
Secale cereale L., Newark, May 25, 1908, (2263).

DeBary (Monatsber. K. Akad. d. Wiss. Berlin 211. 1866) was the first to show the connection between the leaf rust of rye and *Aecidium asperifolii* Pers. by sowing sporidia on *Anchusa officinalis* L. and on *Lycopsis arvensis,* pycnia and aecia resulting. Uredinia and telia were obtained on rye following sowing of aeciospores from the above mentioned aecial hosts.

In America, Arthur (Mycol. 1:236. 1909) records successful infection experiments resulting in the production of pycnia on *Lycopsis arvensis* L. following sowings of sporidia from *Secale cereale* L. The Lycopsis plants were grown from seed secured in Europe. These cultures prove that the leaf rust of rye in Europe and America is identical.

42. PUCCINIA ASTERIS Duby, Bot. Gall. 2:888. 1830.

ON CARDUACEAE:

Aster paniculatus Lam., Newark, September 1905, (1636); September 10, 1907, (1728).

Aster salicifolius Lam., Newark, September 10, 1907, (1728).

43. PUCCINIA ASTERUM (Schw.) Kern, Mycol. 9:224. 1917.

Aecidium asterum Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.

Puccinia extensicola Plowr. British Ured. & Ust. 181. 1889.

Puccinia vulpinoidis Diet. & Holw.; Dietel, Bot. Gaz. 19:304. 1894.

Puccinia Caricis-Erigerontis Arth. Jour. Myc. 8:53. 1902.

Puccinia Caricis-Asteris Arth. Jour. Myc. 8:54. 1902.

Puccinia Caricis-Solidaginis Arth. Bot. Gaz. 35:21. 1903.

Puccinia Dulichii Syd. Monog. Ured. 1:684. 1903.

ON CARDUACEAE: I.

Erigeron annuus (L.) Pers., Newark, June 1907, (1669).

Euthamia graminifolia (L.) Nutt., Seaford, June 4, 1908, (2043, 2065).

Solidago altissima L., June 5, 1908, (2076).

Solidago rugosa Mill., Seaford, June 9, 1907, (2013, 2014).

Solidago sempervirens L., Seaford, June 4, 1908, (2086).

ON CYPERACEAE: II, III.

Carex albolutescens Schw., Selbyville, Oct. 4, 1907, (1808, 1809).

Carex festucacea Willd., Seaford, Nov. 15, 1907, (1759).

Carex Leersii Willd., Seaford, June 4, 1908, (2057a, 2061b).

Carex Muhlenbergii Schk., Lewes, Aug. 14, 1907, (1699).

Carex radiata (Wahl) Small, Newark, Sept. 1907, (1826).

Carex rosea Schk., Seaford, June 4, 1908, (2062a).

Carex stipata Muhl., Newark, Sept. 1907, (1821, 1827).

Carex straminea Willd., Seaford, Nov. 14, 1907, (1770), Nov. 15, 1907, (1859).

Carex vulpinoidea Michx., Lewes, Aug. 16, 1907, (1678); June 7, 1908, (2087); Collins Beach, Oct. 1, 1907, (1783); Newark, Aug. 23, 1907, (1717, 1725), Sept. 1907, (1733), April 5, 1908, April 11, 1908, Felton, Sept. 5, 1907, (1740, 1741); Seaford, April 23, 1908, (2032), June 4, 1908, (2077, 2080, 2081).

Dulichium arundinaceum (L.) Britt., Selbyville, Oct. 4, 1907, (1803, Barth. Fungi Columb. 2662); Seaford, Nov. 14, 1907, (1761).

In 1901 Arthur (Jour. Myc. 8:54. 1902) first began culture work showing that aecia which occur commonly on Aster, Solidago and related hosts are genetically connected with uredinia and telia on various species of Carex. The culture work conducted by Arthur is extensive and extends over a period of years from 1901-1914. In this series of culture work aecia have been produced on various species of Aster, Solidago, Erigeron, Leptilon and Euthamia, using telia from many species of Carex from various parts of North America and from Dulichium. (Jour. Myc. 8:54. 1902; 11:58. 1905; 12:15. 1906; 14:13. 1908; Bot. Gaz. 35:15, 21. 1903; Mycol. 1:233. 1909; 2:224. 1910; 4:15, 16. 1912; 7:70, 81. 1915). Fraser in 1911 (Mycol 4:181. 1912) confirms Arthur's results in part by successfully infecting *Aster acuminatus* using telial material from *Carex trisperma.*

This study has also shown that the species as here considered is a composite form made up of several distinct physiological races.

The species is separable from all other American species of Puccinia on Carex by the presence of two pores in the upper part of the rather small (12-19 by 16-23μ uredospores, and the medium sized (12-20 by 35-50μ) teliospores.

44. PUCCINIA BATESIANA Arth. Bull. Torrey Club 28:661. 1901.

ON CARDUACEAE:

Heliopsis helianthoides (L.) B. S. P., Newark, Oct. 4, 1905, (1510).

This species has not been recorded otherwise on this host but has been collected in Iowa, Minnesota and Nebraska on *Heliopsis scabra* Dunal.

45. PUCCINIA VERNONIAE Schw. Proc. Am. Phil. Soc. II. 4:296. 1832.

Puccinia bullata Schw. Schrift. Nat. Ges. Leipzig 1:74. 1822.

ON CARDUACEAE:

Vernonia noveboracensis (L.) Willd., Clayton, July 24, 1907, (1707).

This very common species is apparently confined to the United States and is the only one so far recorded north of Mexico. The name first proposed by Schweinitz was based on collections made at Salem, North Carolina, occurring "erumpent from the dried stems of various plants, e. g. Ambrosia, Chenopodium." In his later publication he cites it as occurring in Pennsylvania on *V. noveboracensis*. An examination of the material in the Schweinitz collection at the Philadelphia Academy of Science, made by Dr. J. C. Arthur, shows that there are three packets, containing in the aggregate 9 pieces, of similar stems bearing large sori up to 3 cm. long. The original packet reads "P bullata LvS. Salem & Beth. in caulibus varies." The stems all appear to be of Vernonia and the rust when examined microscopically does not differ from similar material on Vernonia stems (now interpreted as *V. altissima*) collected by L. M. Underwood at Fern, Putnam Co., Indiana, and distributed in Ellis & Ev. N. A. Fungi 2988 and other exsiccati under the name *P. Verncniae* Schw. No other rust with which this could possibly be confused is known to occur on the stems of Ambrosia or Chenopodium, or on any other host within the range of this species.

That the rust on the stems is the same as the more common, or at least more frequently collected, form on the leaves has been shown by Dr. Arthur who, in 1916, using telial material from the stems of Vernonia sp. collected by C. H. Crabill at Cliffview, Va., and communicated by Dr. F. D. Fromme, succeeded in obtaining the development of pycnia and uredinia on the leaves of Vernonia sp. This culture also demonstrates that this rust, whose life history has long been in doubt, is a brachy-form referrable to the genus Bullaria. Pycnia have not been observed in any field collections thus far studied.

46. PUCCINIA CANALICULATA (Schw.) Lagerh. Tromsö Mus. Aarsh. 17:51. 1894.

Sphaeria canaliculata Schw. Trans. Am. Phil. Soc. II, 4:209. 1832.

Aecidium compositarum Xanthii Burr.; DeToni in Sacc. Syll. Fung. 7:799. 1888.

ON CARDUACEAE: I.

Xanthium echinatum Murr., Seaford, June 4, 1908, (2049).

ON CYPERACEAE: II, III.

Cyperus esculentus L., Selbyville, Oct. 4, 1907, (1794).

Cyperus filiculmis Vahl., Felton, Sept. 5, 1907, (1742).

Cyperus lancastriensis Porter, Selbyville, Oct. 4, 1907, (1813).

Cyperus ovularis (Michx.) Torr., Felton, Sept. 5, 1907, (1744); Newark, Oct. 20, 1907, (2258).

Cyperus refractus Engelm., Newark, Aug. 23, 1907, (1718).

Cyperus strigosus L., Felton, July 30, 1906, (1618); Lewes, Aug. 14, 1907, (1693).

Cyperus Torreyi Britton (*C. cylindricus* (Ell.) Britton), Selbyville, Oct. 4, 1907, (1810).

Arthur (Jour. Myc. 12:23. 1906) conducted culture experiments in 1905 which showed that an aecidium on *Xanthium canadense* is connected with this species on various species of Cyperus. Following sowings of aeciospores from *X. canadense*, collected in Indiana, urediniospores developed on *C. esculentus*.

47. PUCCINIA CARICIS-STRICTAE Dietel, Hedw. 28:23. 1889.

Uromyces Caricis Pk. Ann. Rep. N. Y. State Mus. 24:90. 1872.

ON CYPERACEAE: II, III.

Carex stricta Lam., Seaford, Nov. 14, 1907, (1757, 1762, 1763, 1764, 1765, 1766).

48. PUCCINIA CHRYSANTHEMI Roze, Bull. Soc. Myc. Fr. 17:92. 1900.

ON CARDUACEAE:

Chrysanthemum sinense Sabine, Camden, September 1905, (1536); Wyoming, November 1907.

This rust causes considerable damage to cultivated chrysanthemums. The life history is somewhat in doubt. In America the rust exists only in the uredinial stage.

49. PUCCINIA CIRSII Lasch. in Rab. Fungi Eur. 89. 1859.

ON CARDUACEAE:

Carduus altissimus L., Faulkland, Oct. 20, 1886, A. Commons, 459; August 1887, A. Commons, 137.

The latter specimen was issued in E. & E. N. A. Fungi 2253 as *P. compositarum* Schlecht, f. *Cnici altissimi*. This is a brachy-Puccinia developing pycnia with the uredinia and occurs most commonly on the under surface of the leaves. It occurs throughout the United States on species of Carduus other than *C. lanceolatus*.

50. PUCCINIA CLAYTONIATA (Schw.) Peck, Bull. N. Y. State Mus. 6:226. 1899.

Caeoma (Aecidium) claytoniatum Schw. Tran. Am. Phil. Soc. II. 4:294. 1832.

Puccinia Mariae-Wilsoni G. W. Clinton, Bull. Buff. Soc. Nat. Sci. 1:166. 1873.

Allodus claytoniata Arth. Result. Sci. Congr. Bot. Vienna 345. 1906.

ON PORTULACACEAE:

Claytonia virginica L., Newark, May 2, 1907, I, (1578); May 29, 1907, III, (1658); April 19, 1908, I, (2241).

Orton (Mem. N. Y. Bot. Gard. 6:177. 1916) is the authority for the statement that this species has been cultured by Fromme. He sowed aeciospores from primary aecia on the same host and obtained the development of telia of the scattered type indicating that repeating aecia do not occur in this species. An examination of specimens in the Arthur herbarium has failed to reveal any collection of aecia not accompanied by pycnia.

51. PUCCINIA CNICI Mart. Fl. Mosq. 226. 1817.

Puccinia Cirsii-lanceolati Schroet. Pilze Schles. 1:317. 1887.

ON CARDUACEAE:

Carduus lanceolatus L., Newark, October 1907, (2009).

This species produces aecia of a peculiar character having a rudimentary aecidium. All stages occur most abundantly on the upper surfaces of the leaves.

Kellerman (Jour. Myc. 9:229. 1903) has shown through carefully conducted culture experiments that this species is an eu-Puccinia and autoecious. In America it is known only on the above host.

52. PUCCINIA CONVOLVULI (Pers.) Cast. Obs. Myc. 1:16. 1842.

Uredo Betae Convolvuli Pers. Syn. Fung. 221. 1801.

ON CONVOLVULACEAE:

Convolvulus sepium L., Wilmington, Aug. 17, 1886, III, A. Commons (302); Lewes, April 1908, I, (2260).

The collection by Commons was issued in E. & E. N. Am. Fungi 1857 as on *Ipomoea pandurata* (L.) Meyer. The host is certainly Convolvulus. Arthur (Bot. Gaz. 29:270. 1900) has shown that this species is autoecious. Teliospores from *C. sepium* were sown in the greenhouse on the same host with subsequent abundant development of pycnia and aecia.

53. PUCCINIA CRYPTOTAENIAE Pk. Rep. N. Y. State Mus. 25:114. 1873.

ON AMMIACEAE:

Deringia canadensis (L.) Kuntze, Wilmington, Nov. 14, 1888, A. Commons (909); Newark, May 1907, (1667).

This is a micro-Puccinia correlated with *Puccinia microica* Ellis which is an opsis form. The latter was originally reported as occurring on Sanicula sp., which was an error for *Deringia canadensis.*

54. PUCCINIA CYANI (Schleich.) Pass. Rabh. Fungi Eur. 1767. 1874.

Uredo Cyani Schleich. Pl. Helv. 95.

ON CARDUACEAE:

Centaurea cyanus L., Newark, May 20, 1913, C. O. Houghton.

55. PUCCINIA EATONIAE Arth. Jour. Myc. 10:18. 1904.

Aecidium Ranunculi Schw. Schr. Nat. Ges. Leipzig 1:67. 1822. (Not *A. Ranunculi* Schum. 1803.)

ON RANUNCULACEAE: I.

Ranunculus abortivus L., Newark, May 1, 1905, C. O. Smith. Issued as *A. Ranunculi* Schw. in E. & E. Fungi Columb. 2107. Newark, May 1, 1908, (2238).

ON POACEAE: II, III.

Sphenopholis pallens (Spreng.) Schrib., Newark, May 1, 1908, II, (2237), June 1, 1908, III (2234, 2239).

Sphenopholis nitida (Spreng.) Schrib., Newark, June 1908, (2269).

Arthur in Jour. Myc. 10:18. 1904, shows by culture that *Aecidium Ranunculi* Schw. has its telial stage on *Sphenopholis pallens* (*Eatonia pennsylvanica* (DC.) A. Gray), having obtained infection on *E. pennsylvanica* resulting in uredinia by inoculation with aeciospores from *Ranunculus abortivus.* Field observations made by the writer in connection with the collections listed above lend confirming evidence to the cultural results by Dr. Arthur. On May 1 the writer collected *Aecidium Ranunculi* Schw. (2238). Almost in contact were found the leaves of grass at that time not yet fruiting, bearing fresh uredinia (2237). The over-wintering leaves of this grass were found to bear telia. On June 1 at the same place this grass was found in fruiting condition bearing fresh telia (2239). The grass proved to be *Eatonia pallens*. Examination showed the rust to be that described by Arthur on *P. Eatoniae*.

56. PUCCINIA ELEOCHARIDIS Arth. Bull. Iowa Agr. College Nov. 156. 1884.

Aecidium compositarum Eupatorii DeToni in Sacc. Syll. Fung. 7:798. 1888.

ON CARDUACEAE: I.

Eupatorium perfoliatum L., Seaford, June 4, 1908, (2054, 2061a, 2074, 2079).

Eupatorium purpureum L., Seaford, June 4, 1908, (2058b, 2060, 2062b, 2067, 2072).

Eupatorium rotundifolium L., Seaford, June 4, 1908, (2055, 2069).

Arthur conducted culture experiments in 1905 (Jour. Myc. 12:23. 1906) showing that an aecidium resembling in every way the common one on Eupatorium species could be induced by sowings with teliospores from Eleocharis. He used teliospores on *Eleocharis palustris* from Wisconsin to successfully infect *Eupatorium perfoliatum*, with subsequent development of aecia—two trials. These results were confirmed in 1906 and 1908 by the same author (Jour. Myc. 13:197. 1907; Mycol. 1:233. 1909) when typical aecia were produced on *Eupatorium perfoliatum* following infection by teliospores from *E. palustris* collected in Kansas and Indiana.

57. PUCCINIA ELLISIANA Thüm. Bull. Torrey Club 6:215. 1878.

Puccinia americana Lagerh. Tromsö Mus. Aarsh. 17:45. 1895.

ON POACEAE: II, III.

Andropogon scoparius Mchx., Newark, Oct. 1907 (1830); March 30, 1908, (2246).

This species has been separated from *P. Andropogonis* by the possession of thick walled verrucose uredospores.

Long (Phytopath. 2:164. 1912) carried on successful experiments with this species in 1910, 1911, and 1912 reporting successful infection of *Viola fimbriatula, V. hirsutula, V. sagittata, V. papilionacea,* with development of aecia following sowings of teliospores from *A. virginicus.* Uredinia were produced on Andropogon when aecia were used for infection.

Arthur in 1912 (Mycol. 7:71. 1915) using telia from Andropogon sp. from North Dakota obtained the development of aecia on *V. cucullata* and *V. Nuttallii.*

In a later paper Long (Jour. Agr. Res. 2:303-319. 1914) presents the results of an extensive research dealing with this species and *P. Andropogonis* Schw. in which he claims to prove "that the ordinary Pentstemon rust *P. Andropogonis,* can be produced from the Viola rust *P. Ellisiana,* by simply passing the Viola rust through Pentstemon as an aecial host." Numerous culture experiments were conducted in support of the above conclusion.

58. PUCCINIA EMACULATA Schw. Trans. Am. Phil. Soc. II, 4:295. 1834.

ON POACEAE:

Panicum capillare L., Newark, Sept. 15, 1905, (1615); Felton, Sept. 5, 1907, (1750).

Successful cultures have never been conducted with this common rust though many attempts have been made. Morphologically it is very like *P. Pammelii* (Trel.) Arth. (*P. Panici* Diet.) and perhaps should be united with it. On account of the resemblance to that species the aecia should be looked for on Euphorbiaceous hosts. It is convenient, however, to retain it as a separate form till cultures establishing its relationship have been successfully carried out.

59. PUCCINIA EPIPHYLLA (L.) Wettst. in Verh. Zool.-Bot. Ges. Wien 35:541. 1886.

Lycoperdon epiphyllum L. Sp. Pl. 1653. 1753.

Aecidium Tussilaginis Pers. in Gmel. Syst. Nat. 2:1473. 1791.

Puccinia poarum Nielsen Bot. Tidsskr. III, 2:34. 1877.

ON POACEAE: II.

Poa annua L., Newark, June 1908, (2245).

Poa pratensis L., Seaford, June 4, 1908, (2053a, 2042); Newark, June 1908, (2268).

Nielsen was the first to show the relation between this rust and *Aecidium Tussilaginis.* He succeeded in infecting *P. annua, P. trivialis, P. nemoralis, P. fertilis* and *P. pratensis* by sowing aeciospores from

Tussilago farfara. He infected the aecial host by sowing with teliospores from *P. annua.*

Additional observations and culture work have been recorded by various European authors, which has been summarized by Klebahn (Die Wirtw. Rostpilze 290. 1904).

60. PUCCINIA FRAXINATA (Lk.) Arth. Bot. Gaz. 34:6. 1902.

Aecidium Fraxini Schw. Schr. Nat. Ges. Leipzig 1:66. 1822. (Not *A. Fraxini* Korn.)

Caeoma Fraxinatum Lk. in Willd. Sp. Pl. 6²:62. 1825.

Puccinia Sparganioides Ellis & Barth. Erythea 4:2. 1896.

ON OLEACEAE: I.

Fraxinus lanceolata Borck., Newark, 1897, F. D. Chester, June 17, 1907, (1663); May 1908: (2240).

ON POACEAE: III.

Spartina cynosuroides (L.) Roth (*S. polystachya* Ell.), Collins Beach, Oct. 1, 1907, (1784).

Spartina stricta (Ait.) Roth (*S. glabra* Muhl.), Lewes, Nov. 16, 1907, (1772, 1773, 1849, 1850a, 1851); Collins Beach, Oct. 1, 1907, (1785, 1786).

The Aecidium on Fraxinus known as *A. Fraxini* Schw. was first shown by Arthur (Bot. Gaz. 29:275. 1900) to have telia on *Spartina cynosuroides.* He obtained the development of aecia on *F. viridis* following sowings of telial material from Iowa and Nebraska. In 1904, 1905, 1907 and 1909 (Jour. Myc. 11:57. 1905; 12:16. 1906; 14:14. 1908; Mycol. 2:225. 1910) similar results were obtained on *F. lanceolata* using telia from Iowa, Kansas, Nebraska and North Dakota.

In 1908 the writer sent telial material collected at Lewes on *S. cynosuroides* and *S. stricta* to Dr. Arthur for culture work. Successful infection of *F. lanceolata* with development of aecia was obtained from cultures with telia from both hosts.

61. PUCCINIA HELIANTHI-MOLLIS (Schw.) Jackson, Brooklyn Bot. Gard. Mem. 1:250. 1918.

Aecidium Helianthi-mollis Schw. Schr. Nat. Ges. Leipzig 1:68. 1822.

Puccinia Helianthi Schw. Schr. Nat. Ges. Leipzig 1:73. 1822.

ON CARDUACEAE:

Helianthus annuus L., Newark, Sept. 1907, (2006).

Helianthus angustifolius L., Selbyville, Oct. 4, 1907, (1993).

Helianthus decapetalus L., Newark, Sept. 7, 1905, (1553, 1624), Aug. 23, 1907, (1724).

Carleton (Science **13**:250. 1901) was the first in America to record culture experiments showing that the species is autoecious. These results were confirmed by Arthur (Bot. Gaz. **35**:17. 1903) whose work indicates, however, that there may be biological races. Further evidence of this was obtained in 1903 (Jour. Myc. **10**:12. 1904) and in 1904 (Jour. Myc. **11**:53. 1905), on further evidence, the conclusion is made that "*P. Helianthi* Schw. is a single species having many races, for which *H. annuus* acts as a bridging host." Further cultural results were recorded in Jour. Myc. **12**:18. 1906.

62. PUCCINIA HIBISCIATUM (Schw.) Kellerm. Jour. Myc. **9**:110. 1903.

Caeoma Hibisciatum Schw. Trans. Am. Phil. Soc. II, **4**:293. 1834.

Aecidium Napaeae Arth. & Holw.; Arthur in Bull. Iowa Agr. Coll. **1884**:166. 1885.

Aecidium Callirrhoes Ell. & Kellerm. Jour. Myc. **2**:4. 1886.

Puccinia Muhlenbergiae Arth. & Holw. Bull. Lab. Nat. Hist. Univ. Iowa **5**:317. 1902.

Puccinia tosta Arth. Bull. Torrey Club **29**:228. 1902.

ON POACEAE: II, III.

Muhlenbergia sobalifera (Muhl.) Trin.,—Wilmington, Oct. 26, 1891, A. Commons (1867).

Muhlenbergia Schreberi Gmel. (*M. diffusa* Willd.),—Newark, Sept. 1907, (1817, 1828).

Kellerman (Jour. Myc. **9**:110, 232. 1903) was the first to conduct successful culture experiments leading to an understanding of the life history of this species. An extensive series of inoculations with telial material on *Muhlenbergia mexicana* from Ohio, in which many Malvaceous hosts were used, resulted in obtaining successful infection of *Hibiscus mocheutos* and *H. militaris* with production of typical aecia of *A. Hibisciatum* Schw.

Arthur in 1908 (Mycol. **1**:251. 1909) first showed that this species also has for its aecial stage, *A. Napaeae* A. & H. Infection of *Callirrhoe involucrata*, resulting in aecia, was obtained following sowings of teliospores from *M. mexicana* from Kansas. These results were confirmed in 1909 (Mycol. 2:226. 1910) using telial material on *M. glomerata* from Kansas and in 1910 (Mycol. 4:18. 1912) successful infection followed sowings with teliospores from *M. racemosa* collected in North Dakota.

In 1914 (Mycol. 7:80. 1915) Arthur also showed that *Puccinia tosta* on *Sporobolus asperifolius* has for its aecial stage, *Aecidium Sphaeralceae*. Successful infection of *Sphaeralcea incana* was obtained following sowings of telial material from New Mexico. Infection of *S. lobata* was also obtained when telial material from Texas was used. A comparison of the aecia and of the telia showed *P. tosta* to be inseparable from the form of Muhlenbergia.

63. PUCCINIA HIERACII (Schum.) Mart. Flora Mosq. 226. 1817.
Uredo Hieracii Schum. Enum. Plant. Saell. 2:232. 1803.
ON CICHORIACEAE:
Hieracium scabrum Michx., Newark, Sept. 5, 1905, (1623); Lewes, April 25, 1908, (2035).

64. PUCCINIA IMPATIENTIS (Schw.) Arth. Bot. Gaz. 35:19. 1903.
Aecidium Impatientis Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.
Puccinia perminuta Arth. Bull. Torrey Club 34:584. 1907.
ON BALSAMINACEAE: I.
Impatiens aurea Muhl., Newark, June 17, 1907, (1664).
ON POACEAE: II, III.
Agrostis hyemalis (Walt.) B. S. P., Seaford, June 4, 1908, (2045).
Agrostis perrenans (Walt.) Tuckerm. Woodland Beach, Aug. 1890, J. H. Holmes (Phan. spec. 312).
Elymus canadensis L., Newark, Aug. 23, 1907, II, (1722).

Arthur has shown that *Aecidium Impatientis* Schw. is connected with a telial form on *Elymus virginicus* L. which previously had been called *P. rubigo-vera* (Bot. Gaz. 35:18. 1903). He obtained the development of aecia on *Impatiens aurea* following inoculation with germinating teliospores on *Elymus virginicus* from Indiana. Further cultures made in 1903 and 1904 (Jour. Myc. **10**:11. 1904; **11**:57. 1905) gave identical results when telial material from Indiana and Wisconsin were used for inoculation. In 1909 (Mycol. 2:226. 1910) teliospores from *Elymus striatus* were used by Arthur to successfully inoculate *Impatiens* *aurea.* Uredinia were also obtained on *E. virginicus*, *E. canadensis*, and *E. striatus* following infection with aeciospores from *Impatiens aurea.*

65. Puccinia Iridis (DC.) Wallr. Rabh. Krypt. Fl. Ed. 1, 1:23. 1844.

Uredo Iridis DC. Encycl. 8:224. 1808.

On Iridaceae:

Iris versicolor L., Newark, July 24, 1906, (1565).

The life history of this common rust is still in doubt, only uredinia and telia are known.

66. Puccinia Lobeliae Ger. Bull. Buffalo Soc. Nat. Sci. 1:68. 1873.

On Campanulaceae:

Lobelia puberula Michx., Wilmington, Sept. 1893, A. Commons, (issued also in E. & E. Fungi Columb. 261); Newark, Sept. 8, 1893, A. Commons, (2213).

Lobelia syphilitica L., Lewes, Aug. 14, 1907, (1696), August, 1907, (2242).

67. Puccinia lysimachiata (Link) Kern, Mycol. 9:215. 1917.

Aecidium Lysimachiae Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.

Caeoma lysimachiatum Link, in Willd. Sp. Pl. 6^2:45. 1825.

Puccinia Limosae Magn. Amtl. Ber. Vers. Deutsch. Naturf. u. Aerzte 1877:200. 1877.

On Primulaceae: I.

Lysimachia terrestris (L.) B. S. P., Seaford, June 5, 1908, (2084).

Klebahn (Jahr. Wiss. Bot. 34:396. 1910) has shown that the European *A. Lysimachiae* Schlecht. is genetically connected with *P. Limosae* Magn. He succeeded in obtaining infection resulting in the development of urediniospores on *Carex limosa* following sowings with aeciospores from *Lysimachia thyrsiflora* and *L. vulgaris.* No cultures have been conducted in America, but since no essential morphological difference can be detected in the aecia and several collections on Carex have been recognized by Arthur which agree with European material referred to *P. Limosae*, there seems to be no good reason for considering the American form distinct from the European.

68. Puccinia macrospora (Pk.) Arth. Mycol. 1:244. 1909.

Aecidium macrosporum Pk. Ann. Rep. N. Y. State Mus. 23:61. 1873.

On Smilaceae: I.

Smilax rotundifolia Seaford, July 9, 1907, (1651); Lewes, Aug. 14, 1907; June 6, 1908, (2089); Townsend, June 11, 1890; A. Commons (1437); Newark, July 1891, A. Commons (Distributed in E. & E. N. A. Fungi 2708).

On Cyperaceae: II, III.

Carex comosa Boott, Lewes, Aug. 14, 1907, II, (1686), Nov. 16, 1907, III, (1853).

As noted above, on Aug. 14, 1907, the writer collected the uredo stage of a rust on Carex comosa at Lewes. Nearby was a vine of *Smilax rotundifolia* bearing aecia of *Aecidium macrosporum* Pk. *Aecidium Nesaeae* Ger. on *Decodon verticillata* was also collected at Lewes in the immediate vicinity of the rust on *Carex comosa.*

The material collected was sent to Dr. Arthur, who stated that the form on *Carex comosa* probably represented an undescribed species. A trip to the same vicinity was made at Dr. Arthur's request in November 1907 for the purpose of collecting this and other forms for culture work. Telia were collected on *Carex comosa* at that time, showing the form to be a Puccinia. The following spring Dr. Arthur (Mycol. 1:243. 1909) sowed this on various hosts, including *Smilax hispida* and the typical aecia of *Aecidium macrosporum* Pk. were produced.

69. Puccinia malvacearum Bert. Gay's Hist. de Chile 8:43. 1852.

On Malvaceae:

Althaea rosea Cav., Newark, Oct. 16, 1909, J. Taubenhaus.

Malva rotundifolia L., Newark, May 24, 1913, Julia Clark, May 25, 1916, C. O. Houghton.

70. Puccinia marylandica Lindr. Medd. f. Stockh. Hogsk. Bot. Inst. 4:(2). 1901.

On Ammiaceae:

Sanicula canadensis L., Collins Beach, Oct. 1, 1907, (1815).

71. Puccinia Menthae Pers. Syn. Fung. 227. 1801.

On Labiatae:

Koellia mutica (Michx.) Britt., Clayton, July 24, 1907, (1709).

Monarda punctata L., Seaford, July 9, 1907.

72. PUCCINIA MINUTISSIMA Arth. Bull. Torrey Club 34:587. 1907.

Aecidium Nesaeae Ger. Bull. Torrey Club 4:47. 1873. (Not *P. Nesaeae* E. & E. 1895.)

ON LYTHRACEAE: I.

Decodon verticillata (L.) Ellis, Seaford, July 9, 1907, (2256); Lewes, Aug. 14, 1907, (1690).

The Aecidium on Decodon was shown by Arthur in 1914 (Mycol. 7:86. 1915) to be the aecial stage of *P. minutissima.* Typical aecia were developed on Decodon, following inoculation with telial material on *Carex filiformis* from Ontario. The telial stage has not been found in Delaware and has apparently been collected but rarely. Species referred here in the Arthur herbarium occur on *C. teretiuscula, C. filiformis* and *C. aquatilis.*

73. PUCCINIA NESAEAE Ell. & Ev. Bull. Torrey Club 22:363. 1895. (Not *Aecidium Nesaeae* Ger. 1873.)

Aecidium Ludwigiae E. & E. Proc. Phil. Acad. 1893:155. 1893.

Puccinia Ludwigiae Holw. N. A. Ured. 1^3:72. 1907. (Not *P. Ludwigiae* Tepper 1890.)

Allodus Ludwigiae Orton, Mem. N. Y. Bot. Gard. 6:189. 1916.

ON ONAGRACEAE: I.

Ludwigia sphaerocarpa Ell., Ellendale, Sept. 1, 1892, A. Commons, (1983).

This collection is the type of *Aecidium Ludwigiae* E. & E. The name here used for this species was applied by Ellis and Everhart to a rust thought to be on Necium (Decodon). The host has been shown by Holway (l. c.) to be *Ludwigia polycarpa.* The name has frequently been misapplied to *Aecidium Nesaeae* Ger. on Necium which has been shown by Arthur (Mycol. 7:86. 1915) to be the aecial stage of *P. minutissima* (c. f. 67).

The rust is evidently an opsis form. Telia have been rarely collected, occurring in the Arthur herbarium only on *L. polycarpa* from Iowa and on *L. virgata* from Florida.

74. PUCCINIA NOLITANGERIS Corda, Icones 4:16. 1840.

Puccinia argentata Wint. Rabh. Krypt. Fl. 1^2:194. 1881.

ON BALSAMINACEAE: III.

Impatiens biflora Wald., Newark, Sept. 7, 1905; Sept. 15, 1906; Sept. 1907; (1552, 1535, 2005).

Bubak (Cent. Bakt. 10[2]:574. 1903) has shown by cultures that the European *P. argentata* has its aecial stage on *Adoxa moschatellina.* Arthur in 1910 (Mycol. 4:20. 1912) successfully infected *Impatiens aurea* by sowing with aeciospores from *Adoxa moschatellina* collected in Iowa, thus proving the American and European rusts are the same.

75. PUCCINIA OBTECTA Pk. Bull. Buffalo Soc. Nat. Hist. **1**:66. 1873.

Aecidium compositarum Bidentis Burrill; DeToni, in Sacc. Syll. Fung. **7**:799. 1888.

ON CYPERACEAE:

Scirpus fluviatilis (Torr.) A. Gray? Wilmington, Nov. 5, 1885, A. Commons (1076).

Scirpus americanus Pers., Wilmington, Oct. 11, 1889, A. Commons (1026).

Arthur in 1907 (Jour. Myc. **14**:20. 1908) has shown that *P. obtecta* Pk. has its aecial stage on Bidens. Successful sowings of teliospores from *A. americanus* collected in Indiana were made on *B. frondosa* and *B. comata.*

76. PUCCINIA ORBICULA Pk. & Curt. Ann. Rep. N. Y. State Mus. **30**:53. 1879.

ON CICHORIACEAE:

Nabalus sp., Newark, 1907, M. T. Cook.

77. PUCCINIA PAMMELII (Trel.) Arth. Jour. Myc. **11**:56. 1905.

Puccinia Panici Diet. Erythea **3**:80. 1895.

Aecidium Pammelii Trel. Trans. Wis. Acad. Sci. **6**:136. 1885.

ON POACEAE:

Panicum virgatum L., Selbyville, Oct. 4, 1907, (1789).

Stuart (Proc. Ind. Acad. Sci. **1901**:284. 1902) shows by cultures that *Aecidium Pammelii* on *Euphorbia corollata* is the aecial stage of *P. panici.* These results were confirmed by Arthur in 1904 and 1905 (Jour. Myc. **11**:56. 1905; **12**:16. 1906) by sowing telial material on *P. virgatum* from Indiana, on *E. corollata* with resulting infection and development of aecia. In 1907 (Jour. Myc. **14**:16. 1908) successful infection on *E. maculata* was obtained following sowings of teliospores from the same host collected in Nebraska. At the same time negative results were obtained on *E. corollata.* These results indicate the presence of physiological races in this species.

78. PUCCINIA PIMPINELLAE (Strauss) Mart. Fl. Mosq. Ed. II:226. 1817.

Uredo Pimpinellae Strauss, Wettst. Ann. 2:102. 1810.

Aecidium Osmorrhizae Pk. Ann. Rep. N. Y. State Mus. 24:92. 1872.

Puccinia Osmorrhizae C. & P.; Peck in Ann. Rep. N. Y. State Mus. 29:73. 1878.

ON AMMIACEAE:

Washingtonia brevistylis DC., Newark, May 2, 1907, I (1575), May 29, 1907, III, (1659).

79. PUCCINIA POCULIFORMIS (Jacq.) Wettst. Verhl. Zool.-Bot. Ges. Wien 35:544. 1885.

Lycoperdon poculiforme Jacq. Coll. Austr. 1:122. 1786.

Aecidium Berberidis Pers. in J. F. Gmel Syst. Nat. 2:1473. 1791.

Puccinia graminis Pers. Neues Mag. Bot. 1:119. 1794.

Puccinia Phlei-pratensis Erikss. & Henn. Zeit. f. Pflanzenkr. 4:140. 1894.

ON POACEAE:

Agrostis alba L., Newark, Aug. 23, 1907, (1715, 1713).

Phleum pratense L., Newark, Aug. 23, 1907, (1720).

Triticum vulgare L., Newark, Aug. 23, 1907, (1721).

DeBary (Monatsber. K. Akad. d. Wiss. Berlin 25. 1865) was the first to show that the well known *Puccinia graminis* developed its aecial form on Berberis. In 1864 he first sowed telia from *Agropyron repens* and *Poa pratensis* on leaves of Berberis resulting in the development of pycnia and aecia. He later (1865) infected *Secale cereale* by sowing aeciospores from Berberis. This is the first record of the connection of two stages of an heteroecious rust by inoculation. Since DeBary's first publication of the life history of this species a large number of mycologists in all parts of the world have conducted culture work confirming DeBary's results and adding to our knowledge of the species. For a review of this work see Klebahn (Die Wirtswechs Rostpilze Berlin 205-235. 1904).

In America the most important work has been conducted by Carleton (Div. Veg. Phys. & Path. U. S. D. A. Bull. 16. 1899; Bur. Pl. Ind. U. S. D. A. Bull. 63. 1904); Arthur (Jour. Myc. 8:53. 1902; 11:57.

1905; **12**:17. 1906; **13**:198. 1907; **14**:16. 1908; Mycol. **2**:227. 1910; **4**:18. 1912); Freeman & Johnson (Bur. Pl. Ind. U. S. D. A. Bull. 216. 1911); Stakman (Minn. Exp. Sta. Bull. 138. 1914; Jour. Agr. Research **4**:193-199. 1915); Stakman and Piemeisel (Jour. Agr. Research **6**:813-816. 1916; **10**:429-495. 1917).

80. PUCCINIA PODOPHYLLI Schw. Schrift. Nat. Ges. Leipzig **1**:72. 1822.

ON BERBERIDACEAE:

Podophyllum peltatum L., Newark, May 1890, F. D. Chester, May 15, 1906, I, (1621), June 19, 1907, III, (1660); Hockessin, May 5, 1913; C. O. Houghton.

81. PUCCINIA POLYGONI-AMPHIBII Pers. Syn. Meth. Fungi 227. 1801.

Aecidium Geranii-maculati Schw. Schr. Nat. Ges. Leipzig **1**:67. 1822.

Aecidium Sanguinolentum Lindr. Bot. Nat. **1900**:241. 1900.

ON GERANIACEAE: I.

Geranium maculatum L., Wilmington, June 29, 1893, A. Commons (2099).

ON POLYGONACEAE: II, III.

Persicaria muhlenbergii (S. Wats.) Small (*Polygonum emersum* (Michx.) Britton), Wilmington, Aug. 17, 1886, A. Commons (297).

Persicaria pennsylvanicum (L.) Small (*Polygonum pennsylvanicum* L.), Newark, Sept. 17, 1890, F. D. Chester.

Dr. Tranzschel first showed (Centr. f. Bakt. **11**^{2}:106. 1903) that this species on Polygonum was connected with *Aecidium Sanguinolentum* on Geranium sp. These results were confirmed in America by Arthur (Jour. Myc. **11**:59. 1905) who used aeciospores from *Geranium maculatum* to inoculate *Polygonum emersum.* Uredinia and telia developed from this culture. In 1905 (Jour. Myc. **12**:18. 1906) these results were confirmed by successfully sowing teliospores from *Polygonum emersum* on *Geranium maculatum* resulting in the typical aecia of *A. Sanguinolentum.* These results prove that the European and American rusts referred to this species are identical.

82. PUCCINIA POLYGONI-CONVOLVULI Hedw. f., Poiret. Encycl. Meth. Bot. 8:251. 1808.

Puccinia Polygoni A. .& S. Consp. Fung. 132. 1805. (Not *P. Polygoni* Pers. 1794.)

ON POLYGONACEAE:

Polygonum Convolvulus L., Lewes, Aug. 14, 1907, II, (1692).

83. PUCCINIA PUSTULATUM (Curtis) Arth. Jour. Myc. **10**:18. 1904.

Aecidium pustulatum Curtis; Peck, Ann. Rep. N. Y. State Mus. **23**:60. 1873.

ON POACEAE:

Schizachyrium scoparium (Michx.) Nash (*Andropogon scoparius* Michx.), Seaford, Nov. 15, 1907, (1760).

This species of Andropogon rust is difficult to separate from *P. Andropogonis* Schw. In the latter, however, the uredospore markings are finely verrucose-echinulate with the pores 3-4 scattered (rarely appearing equatorial) while in the form here considered the uredospore markings are of the echinulate type and the pores 4-6 scattered.

The life history of this heteroecious rust was first determined by Arthur in 1903 (Jour. Myc. **10**:17. 1904). He sowed germinating teliospores from *Andropogon furcatus* and *A. scoparius* collected in Indiana on *Comandra umbellata* and obtained the development of pycnia and aecia of *Aecidium pustulatum.* These experiments were successfully verified in 1905 and 1910 (Jour. Myc. 12:16. 1906; Mycol. 4:17. 1912) using telial material on *A. furcatus* from Indiana and Colorado.

84. PUCCINIA RECEDENS Syd. Monog. Ured. **1**:146. 1902.

ON CARDUACEAE:

Senecio aureus L., Naaman's Creek, July 28, 1893, A. Commons (2129).

This species has previously been confused with *P. Asteris* Duby.

It is a micro-Puccinia common on *Senecio aureus* in the northeastern United States. It is known on other hosts from the Atlantic to the Pacific in the more northern states.

85. PUCCINIA RHAMNI (Pers.) Wettst. Verhl. Zool-Bot. Ges. Wein. 35:545. 1885.

Aecidium Rhamni Pers. in Gmel. Syst. Nat. **2**:1472. 1791.

Puccinia coronata Corda, Icones **1**:6. 1837.

ON POACEAE:

Avena sativa L., Newark, July 17, 1903, C. O. Smith; Clayton, July 24, 1907, (1708).

This species is the common coronate spored rust and occurs throughout the United States on cultivated oats and on a great variety of native grasses. DeBary (Monat. Akad. Wiss. 211. 1866.) was the first to conduct culture experiments indicating the genetic connection with aecia on Frangula and Rhamnus in Europe. Since that time many European authors have conducted culture experiments, a summary of which has been made by Klebahn (Wirtw. Rostp. 254-262. 1904).

In America this species has been studied by Carleton (Div. Veg. Phys. & Path. **16**:48. 1899), who obtained uredinia on cultivated oats, *Arrhenatherum elatius* and *Phalaris caroliniana* by sowing aeciospores from *Rhamnus lanceolata.* Carleton also carried out extensive cross inoculations between oats and many native grasses. (See also Bur. Pl. Ind. Bull. **63**:15. 1904.)

At about the same time Arthur (Bull. Lab. Nat. Hist. State Univ. Iowa **4**:398. 1898) obtained infection on oats with aeciospores from *R. lanceolata.* In 1904 the same author (Jour. Myc. **11**:58. 1905) successfully confirmed the results of European and other investigators by sowing aeciospores from *Rhamnus cathartica, R. caroliniana, R. lanceolata* on *Avena sativa* resulting in the production of urediniospores in all cases. In 1910 the same author (Mycol. **4**:18. 1912) successfully infected *Rhamnus cathartica* by sowing teliospores from *Calamagrostis canadensis* from Nova Scotia.

86. PUCCINIA RUBELLA (Pers.) Arth. Bot. Gaz. **34**:15. 1902.

Aecidium rubellum Pers. in Gmel. Syst. Nat. **2**:1473. 1791.

Uredo Phragmites Schum. Enum. Pl. Saell. **2**:231. 1803.

Puccinia Phragmites Koern. Hedwigia **15**:179. 1876.

ON POACEAE:

Phragmites Phragmites (L.) Karst., Wilmington, Nov. 1, 1893, A. Commons (2364).

Winter (Hedwigia **14**:115. 1875) was the first to show the relation between *Puccinia Phragmites* and *Aecidium rubellum.* He successfully infected *Rumex hydrolapathum* with sporidia from Phragmites. He also infected the latter host, using aeciospores. These results have been confirmed by several European investigators. The summary of their results will be found in Klebahn (Die Wirtsw. Rostp. 283. 1904).

Arthur in 1899 (Bot. Gaz. 29:269. 1900) produced aecia on *Rumex crispus* and *R. obtusifolius* with sowings of teliospores from *P. Phragmites.* These results have been repeatedly confirmed by the same author and reported in Jour. Myc. 9:220. 1903; 14:15. 1908; and Mycol. 2:225. 1910; 4:54. 1912.

Bates (Jour. Myc. 9:219. 1903) made some interesting field cultures and observations on the natural occurrence of the aecial stage on Rheum and Rumex (3 species) lending confirmatory evidence to the results of previous investigators.

87. PUCCINIA SAMBUCI (Schw.) Arth. Bot. Gaz. 35:15. 1903.

Aecidium Sambuci Schw. Schr. Nat. Ges. Leipzig 1:67. 1822.

Puccinia Bolleyana Sacc. Am. Microsc. Jour. 169. 1889.

Puccinia Atkinsoniana Diet. in Atk. Bull. Cornell Univ. 3:19. 1897.

Puccinia Thompsonii Hume, Bot. Gaz. 29:353. 1900.

ON CAPRIFOLIACEAE: I.

Sambucus canadensis L., Seaford, July 9, 1907, (1650), April 23, 1908, (2022).

Sambucus pubens Michx., Newark, June 9, 1907, (1665).

ON CYPERACEAE: II, III.

Carex bullata Schk., Seaford, June 4, 1908, (2083).

Carex lurida Wahl., Newark, Aug. and Sept., 1907, (1719, 1819); Felton, Sept. 5, 1907, (1738); Collins Beach, Oct. 1, 1907, (1788); Seaford, Nov. 14, 1907, (1767, 1858); June 5, 1908, (2082).

Arthur in 1901 conducted culture experiments (Jour. Myc. 8:55. 1902) proving that *Aecidium Sambuci* on *Sambucus canadensis* was specifically connected with *Puccinia Bolleyana* on *Carex trichocarpa.* In 1902 further experiments were conducted (Bot. Gaz. 35:14. 1903) confirming the above results and showing that *Puccinia Atkinsoniana* on *Carex lurida* is also a synonym and has its aecial stage on Sambucus. See also the results of culture work in 1904 (Jour. Myc. 11:58. 1905) and 1905 (Jour. Myc. 12:14. 1906) and 1906 (Jour. Myc. 13:195. 1907) in which *Carex lupulina* and *C. Frankii* are definitely proven to bear telia of *P. Sambuci.* The results of 1902 were confirmed in 1908 (Mycol. 1:233.

1909). Kellerman (Jour. Myc. 9:7. 1903) confirmed Arthur's results as to the connection of *Aecidium Sambuci* with *P. Atkinsoniana* on *Carex lurida* and with *P. Bolleyana* on *C. trichocarpa.*

88. PUCCINIA SMILACIS Schw. Schr. Nat. Ges. Leipzig 1:72. 1822.
Aecidium Smilacis Schw. Schr. Nat. Ges. Leipzig 1:69. 1822.
ON SMILACEAE:
Smilax glauca Walt., Selbyville, Oct. 4, 1907, (1752).
Smilax rotundifolia L., Newark, October 1907, (2007); Collins Beach, Oct. 1, 1907, (1816); Selbyville, Oct. 4, 1907, (1754).

This is an autoecious long cycle rust common throughout the eastern United States. No aecial collections have been made in Delaware. The aecia may be distinguished from the aecia of *Puccinia macrospora* (Pk.) Arth., which occur on Smilax in the same range, by the size of the aeciospores. In *P. Smilacis* the aeciospores are 17-22x20-30μ with the walls 1-1.5μ while the aecispores of *P. macrospora* measure 32-42x37-51μ with thick walls 1.5-2.5μ, thickened above to 5-10μ.

89. PUCCINIA SORGHI Schw. Trans. Am. Phil. Soc. II. 4:295. 1832.
Puccinia Maydis Bereng. Atti Sci. Hal. 6:475. 1844.
Aecidium Oxalidis Thüm. Flora 59:425. 1876.
ON POACEAE:
Zea Mays L., Faulkland, Sept. 8, 1885, A. Commons (210); Newark, Sept. 17, 1890, F. D. Chester; Sept. 1907; Felton, Sept. 5, 1907, (1735).

The corn rust is very common in Delaware and has been repeatedly observed but apparently does little damage.

Arthur in 1904 (Bot. Gaz. 38:64. 1904; Jour. Myc. 11:65. 1905) shows that the corn rust has its aecial stage on Oxalis. These results were confirmed in 1905 by the same author (Jour. Myc. 12:17. 1906) who successfully infected corn with aeciospores from *Oxalis cymosa.*

90. PUCCINIA SUBNITENS Diet. Erythea 3:81. 1895.
ON CHENOPODIACEAE: I.
Atriplex hastata L., Lewes, April 1908, (2041), June 6, 1908, (2038).
ON CRUCIFEROUS SEEDLING: I.
Lewes, April 23, 1908, (2025).

ON POLYGONACEAE: I.

Polygonum aviculare L., Lewes, April 25, 1908, (2020).

ON POACEAE: II, III.

Distichlis spicata (L.) Greene, Lewes, Aug. 14, 1907, (1677), Nov. 16, 1907, (1854, 1855), April 25, 1908, (2021), June 6, 1908, (2039).

Arthur (Bot. Gaz. 35:19. 1903 first showed that the above species has its aecial form on Chenopodiaceae having produced aecia on *Chenopodium album* by sowings of teliospores from *Distichlis spicata*. In 1904 (Jour. Myc. **11**:54. 1905) he records successful infection results on *Chenopodium album, Cleome spinosa, Lepidium apetalum, L. virginicum, Sophia incisa, Erysimum asperum,* from sowings of teliospores from *Distichlis spicata*. This is remarkable since the above hosts represent three distinct families of flowering plants.

In 1905 (Jour. Myc. **12**:16. 1906) *Bursa Bursa pastoris* is added to the above list, since aecia were produced following sowings of teliospores from *Distichlis spicata*. Further results are recorded by the same author in 1906 (Jour. Myc. **13**:197. 1907) and in 1907 (Jour. Myc. **14**:15. 1908).

In 1908 Arthur records successful infection on *Chenopodium album* resulting from sowings of teliospores from *Distichlis spicata* collected at Lewes, Del., and sent to Dr. Arthur by the writer (Mycol. **1**:234. 1909). Cultures from Nebraska made in the same year were successful on *C. album*. Material from Nevada successfully infected *C. album, Atriplex hastata,* and *Sarcobatus vermiculatus.*

Further culture work with this species is recorded by Arthur in Mycol. 2:225. 1910; 4:18. 1912. (See also Bethel, Phytopath. **7**:92-94. 1917.)

91. PUCCINIA TARAXACI (Rebent.) Plowr. Brit. Ured. and Ust. 186. 1889.

Puccinia Phaseoli var. *Taraxaci* Rebent. Fl. Neomarch 256. 1804.

ON CICHORIACEAE:

Taraxacum Taraxacum (L.) Karst.,—Newark, July 1907, (1671).

This is doubtless a brachy-form though no pycnia have yet been demonstrated to accompany the primary uredinia. Cultures will be necessary to determine its life history with certainty. It seems probable that the uredinia are able to carry the fungus over the winter.

92. PUCCINIA TRITICINA Erikss. Ann. Sci. Nat. VIII, 9:270. 1899.

ON POACEAE:

Triticum vulgare L., Newark, July 2, 1907, (1882), June 21, 1907, (1662).

This is the common leaf rust of wheat found in all parts of the United States as well as in most sections of the world where wheat is cultivated. The life history is unknown. It is a sub-epidermal form and is morphologically very similar to leaf rusts on wild grasses commonly referred to *P. tomipara* and *P. Agropyri* (*P. clematidis* (DC.) Lagerh.), having aecia on Thalictrum, Clematis and other Ranunculaceous hosts.

93. PUCCINIA URTICATA (Lk.) Kern, Mycologia 9:214. 1917.

Aecidium Urticae Schum. Enum. Pl. Saell. 2:222. 1803.

Caeoma urticatum Link, in Willd. Sp. Pl. 6^2:62. 1825.

Puccinia Urticae Lagerh. Mitt. Bad. Ver. 2:72. 1889. (Not *P. Urticae* Barcl. 1887.)

ON CYPERACEAE: II, III.

Carex stricta Lam., Seaford, April 23, 1908, (2029).

Magnus in 1872 (Vehr. Bot. Ver. Prov. Brandbg. 14:1872.) first showed that *Aecidium Urticae* on *Urtica dioica* was the aecial stage of *P. Caricis* (Schum.) Rebent. on *Carex hirta.* Many other European investigators have repeated this work with additional hosts, including Schroeter, Cornu, Plowright, Ed. Fischer and Klebahn. A general review is given by Klebahn (Wirtsw. Rostp. 293. 1904).

In America Arthur (Bot. Gaz. 29:270. 1900) was the first to conduct successful cultures. He obtained the development of uredinia on *Carex stricta* by inoculating with spores of *Aecidium Urticae.*

Later cultures (Jour. Myc. 8:52. 1902; Bot. Gaz. 35:16. 1903) showed that aeciospores developed on Urtica gracilis following sowings of teliospores from *Carex stricta* collected in Nebraska and *C. riparia* from Iowa. In 1905 (Jour. Myc. 12:15. 1906) teliospores on *C. stipata* from Indiana and from *C. aquatilis* collected in Colorado, were used in successful cultures on *U. gracilis.* In 1907 (Jour. Myc. 14:14. 1908) Arthur again conducted successful sowings of teliospores from Indiana material on *C. stipata* and from Nebraska material on *C. riparia.* In

1909 the same author (Mycol. 2:223. 1910) used teliospores from *C. aristata* from North Dakota to successfully infect *U. gracilis* with production of aecia. In 1910 (Mycol. 4:17. 1912) the results of 1909 were repeated and successful sowings on *U. gracilis* were again made by using Indiana material to infect *U. gracilis*.

Kellerman in 1902 (Jour. Myc. 9:9. 1903) was also successful in obtaining infection on *U. gracilis* by using telial material on *C. riparia* and *C. stricta* from Ohio.

94. PUCCINIA VIOLAE (Schum.) DC. Fl. Fr. 6:62. 1815.

Aecidium Violae Schum. Enum. Pl. Saell. 2:224. 1803.

ON VIOLACEAE:

Viola affinis LeConte, Newark, May 15, 1906, I, (1622).

Viola Labradorica Schw. (?), Faulkland, Aug. 1, 1884, II, III, A. Commons, (193).

Viola lanceolata L., Selbyville, Oct. 4, 1907. (1938).

95. PUCCINIA WINDSORIAE Schw. Trans. Am. Phil. Soc. II 4:295. 1832.

Aecidium Pteleae Berk. & Curtis; Berkeley, Grevillea 3:60. 1874.

ON POACEAE: II, III.

Tricuspis seslerioides (Michx.) Torr., Lewes, Nov. 16, 1907, (1852); Newark, Oct. 16, 1907, (1834).

This species has been shown to be connected with *Aecidium Pteleae* on *Ptelea trifoliata* by Arthur in 1899 (Bot. Gaz. 29:273. 1900). He succeeded in obtaining the development of typical uredinia of this species on *Tricuspis seslerioides* by inoculating with aeciospores of *Aecidium Pteleae* from Indiana. These results were confirmed in 1902 (Bot. Gaz. 35:16. 1903) and again in 1904 (Jour. Myc. 11:56. 1905).

96. PUCCINIA XANTHII Schw. Schr. Nat. Ges. Leipzig 1:73. 1822.

ON AMBROSIACEAE:

Ambrosia trifida Mill., Newark, Sept. 15, 1905, (1556); July 26, 1906, (1616); Aug. 23, 1907, (1723).

Xanthium sp., Newark, Sept. 15, 1905, (1540); Lewes, Aug. 14, 1907, (1691).

This common species is a lepto-form possessing telia only in the life history.

Carleton (Bur. Pl. Ind. U. S. D. A. Bull. 63:26. 1904) in 1897 and 1898 conducted culture experiments showing that this species is autoecious. He repeatedly infected Xanthium seedlings by inoculating with teliospores from same host but was unable to infect *Ambrosia trifida.* He believes this species to be distinct from the form on *Ambrosia trifida.*

In 1905 and 1906 Arthur (Jour. Myc. 12:20. 1906; 13:198. 1907) confirmed Carleton's work. He also failed to infect *Ambrosia trifida* with spores from Xanthium. No pycnia have been found in herbarium specimens nor did they develop in the cultures recorded above.

It is evident from these culture experiments that we have here a rust, while morphologically indistinguishable on the two host genera, yet exists in two independent races.

97. RAVENELIA EPIPHYLLA (Schw.) Dietel, Hedwigia 33:27. 1894.

Sphaeria epiphylla Schw. Schr. Nat. Ges. Leipzig 1:40. 1822.

ON FABACEAE:

Cracca virginiana L., Townsend, June 11, 1890, A. Commons (1438).

98. TRANZSCHELIA PUNCTATA (Pers.) Arth. Result Sci. Congr. Bot. Vienna 340. 1906.

Aecidium punctatum Pers. Ann. Bot. Usteri 20:135. 1796.

Puccinia Pruni-spinosae Pers. Syn. Fung. 226. 1801.

ON RANUNCULACEAE: I.

Anemone quinquefolia L., Newark, May 8, 1897, F. D. Chester, May 10, 1907, (1656).

Hepatica Hepatica (L.) Karst, Faulkland, May 3, 1884, A. Commons, Newark, May 22, 1907, (1566), May 1908, (2254).

ON AMYGDALACEAE: II, III.

Prunus serotina Ehrh., Greenbank, Aug. 24, 1886, A. Commons (26).

Dr. Tranzschel in 1904 (Trans. Mus. Bot. Acad. St. Petersb. 11:67-69. 1905) first showed that *Aecidium punctatum* on Anemone was the aecial stage of *P. Pruni-spinosae.* He succeeded in obtaining the characteristic uredinia of this species on *Amygdalus communis, Prunus spinosa* and *P. divaricata* following sowings with aeciospores from *Anemone coronaria.* Aecia on *Anemone ranunculoides* were also used to infect *Prunus spinosa* with similar results.

In America Arthur in 1905 (Jour. Myc. 12:19. 1906) showed that this species has its aecia on *Hepatica acutiloba* (*Aecidium Hepaticum*

Schw.) having successfully infected *Prunus serotina* with aeciospores from that host. These results were confirmed in 1906 (Jour. Myc. **13**:199. 1907); a successful infection resulting in uredinia having been obtained on *P. serotina* and *P. pumila* following inoculation with aecia on Hepatica. Failure to obtain infection on *P. americana, P. cerasus* and *Amygdalus Persica,* however, indicates that in America at least there are distinct races.

It is probable that the uredinial spores are able to carry this species over the winter in some localities.

The aecial stage is perennial and the affected leaves are characteristically modified. On Hepatica the leaves stand upright and are much reduced in size and greatly thickened.

99. Uromyces appendiculatus (Pers.) Fries, Summa Veg. Scand. 514. 1849.

Uredo appendiculata Pers. Ann. Bot. Usteri **15**:16. 1795.

Uromyces Phaseoli Wint. in Rab. Krypt. Fl. **1**¹:157. 1881.

Nigredo appendiculata Arth. Result. Sci. Congr. Bot. Vienna 343. 1906.

On Fabaceae:

Phaseolus vulgaris L., Lewes, Aug. 14, 1907, (1684); Newark, September 1905, (1632); Selbyville, Oct. 4, 1907, (1981).

Strophostyles helvola (L.) Britt., Lewes, Aug. 14, 1907, (1682); Felton, Sept. 5, 1907, (1736).

Strophostyles umbellata (Muhl.) Britt., Selbyville, October 4, 1907, (1987); Wilmington, Oct. 11, 1907, (1932).

That the above is an autoecious form was shown by Arthur in 1903 (Jour. Myc. **10**:14. 1904). He cultured the form on *Strophostyles helvola.* Pycnia and aecia followed inoculation with over-wintered teliospores on the same host.

100. Uromyces Caladii (Schw.) Farl. Ellis, N. A. Fungi 232. 1879.

Aecidium Caladii Schw. Schr. Nat. Ges. Leipzig **1**:69. 1822.

Uromyces Peltandrae Howe, Bull. Torrey Club **5**:3. 1874.

Nigredo Caladii Arth. Result. Sci. Congr. Bot. Vienna 343. 1906.

On Araceae:

Arisaema dracontium Schott., Faulkland, June 4, 1885, A. Commons.

Arisaema triphyllum (L.) Schott., Newark, May 1892, I, F. D. Chester, May 15, 1906, (1619); Faulkland, July 18, 1885, III, A. Commons.

Peltandra virginica (L.) Kunth, Symrna, June 9, 1894, A. Commons; Seaford, July 9, 1907, (1672, 1864); Lewes, Aug. 14, 1907, (2261); Wilmington, Oct. 11, 1907, (1931).

101. UROMYCES CARYOPHYLLINUS (Schrank.) Wint. in Rab. Krypt. Fl. 1^1:149. 1881.

Lycoperdon caryophyllinum Schrank. Baier. Fl. 2:668. 1789.

ON CARYOPHYLLACEAE:

Dianthus caryophyllus L., Wilmington, Jan. 1909, C. O. Houghton.

102. UROMYCES ERAGROSTIDIS Tracy, Jour. Myc. 7:281. 1893.

Nigredo Eragrostidis Arth. Result. Sci. Congr. Bot. Vienna 343. 1906.

ON POACEAE:

Eragrostis pectinacea (Michx.) Steud., Selbyville, Oct. 4, 1907, (1792).

103. UROMYCES FALLENS (Des.) Kern, Phytopathology 1:6. 1911.

Uredo fallens Desmaz. Pl. Crypt. 1325. 1843.

Nigredo fallens Arth. N. Am. Flora 7^3:254. 1912.

ON FABACEAE:

Trifolium incarnatum L., Newark, spring 1905, C. O. Smith.

Trifolium pratense L., Newark, October 1888, F. D. Chester; Nov. 10, 1910, C. O. Houghton; Seaford, July 9, 1907, (1654); Clayton, July 24, 1907, (1710); Selbyville, Oct. 4, 1907 (1992).

The rust on red clover is widely distributed in the state and probably occurs wherever this host is cultivated. It is, however, rare on the crimson clover; only one other collection in America is known to the writer, and that was collected in South Dakota. This species is readily separated from the only other long cycled Uromyces on Trifolium occurring in North America by the uredinial pore characters. In the species under discussion the pores are 4-6, scattered, while in *U. Trifolii* the pores are 3-4 in an equatorial zone.

104. UROMYCES GRAMINICOLA Burrill, Bot. Gaz. 9:188. 1884.

Uromyces Panici Tracy, Jour. Myc. 7:281. 1893.

Nigredo graminicola Arth. Result Sci. Congr. Bot. Vienna 343. 1906.

ON POACEAE:

Panicum virgatum L., Collins Beach, Oct. 1, 1907, (1779); Selbyville, Oct. 4, 1907, (1790).

This species is inseparable morphologically from *Puccinia Panici* Diet. except in the number of cells in the teliospore. The Puccinia has been studied culturally by Stuart (Proc. Ind. Acad. Sci. **1901**:284. 1902) and Arthur (Jour. Myc. **11**:56. 1905; **12**:16. 1906; **14**:16. 1908) and shown to be connected genetically with *Aecidium Pammelii* Trel. on *Euphorbia corollata* in Indiana and *E. marginata* in Nebraska. Aecia on various Euphorbiaceous hosts have also been referred to that species on morphological grounds.

While no cultures of the Uromyces have been successfully carried out, it is probable that the aecial stage will be found on some member of the Euphorbiaceae. The field evidence at present available suggests that *A. Stellingiae* Tracy & Earle, which occurs on various species of Stellingia and Sebastina in the south and southwest is a very probable aecial connection. This aecidium is morphologically indistinguishable from *A. Pammelii* and it is possible that some of the forms now referred to that species will be found to belong here.

105. UROMYCES HALSTEDII DeToni in Sacc. Syll. Fung. 7:557. 1888.

Uromyces digitatus Halsted, Jour. Myc. 3:138. 1887. (Not *U. digitatus* Wint. 1886.)

Nigredo Halstedii Arth. N. Am. Flora 7^3:226. 1912.

ON POACEAE:

Homalocenchrus oryzoides (L.) Poll. (*Leersia oryzoides* (L.) Sw.), Seaford, April 23, 1908, (2034).

The aecial stage of this rather rare grass rust is at present unknown. The telial stage is known to the writer on the above host otherwise only from Wisconsin and South Dakota.

106. UROMYCES HEDYSARI-PANICULATI (Schw.) Farl. Ell. N. A. Fungi 246. 1879.

Puccinia Hedysari-paniculati Schw. Schr. Nat. Ges. Leipzig **1**:74. 1822.

Nigredo Hedysari-paniculati Arth. Result Sci. Congr. Bot. Vienna 343. 1906.

On Fabaceae:

Meibomia Dillenii (Darl.) Kuntze, Faulkland, Aug. 24, 1886, A. Commons (319); Newark, Sept. 10, 1905, (1626); Aug. 23, 1907, (1726).

Meibomia laevigata (Nutt.) Kuntze, Selbyville, July 18, 1895, A. Commons (946).

Meibomia Marylandica (L.) Kuntze, Felton, Sept. 5, 1907, (1748); Selbyville, Oct. 4, 1907, (1986).

Meibomia obtusa (Muhl.) Vail, Felton, Sept. 5, 1907, (1747).

Meibomia paniculata (L.) Kuntze, Felton, Sept. 5, 1907, (1745); Selbyville, Oct. 4, 1907, (1985); Lewes, Aug. 14, 1907, (1200); Newark, Aug. 23, 1907, (1714).

Meibomia stricta (Pursh) Kuntze, Selbyville, Oct. 4, 1907, (1984).

107. Uromyces houstoniatus (Schw.) J. Sheldon, Torreya 9:55. 1909.

Aecidium houstoniatum Schw. Tran. Am. Phil. Soc. II. 4:309. 1832.

Nigredo houstoniata Sheldon, Torreya 9:55. 1909.

On Rubiaceae:

Houstonia coerulea L., Newark, May 1908, I, (2267); Wilmington, May 31, 1914, C. O. Houghton.

Sheldon (l. c.) was the first to prove by culture experiments that *Aecidium houstoniatum* Schw. on *Houstonia coerulea* was genetically connected with a telial form occurring on *Sisyrinchium gramineum*. Arthur (Mycologia 1:237. 1908) confirms Sheldon's work using living plants of *Houstonia coerulea* bearing aecia collected by the writer at the above noted locality near Newark, and sent to Dr. Arthur at his request for that purpose. A search was made for the telial stage in the field but without success. The telia have been collected only in Maine and West Virginia.

108. Uromyces Howei Pk. Ann. Rep. N. Y. State Mus. 30:75. 1879.

On Asclepiadaceae:

Asclepias pulchra Shrk., Newark, Sept. 14, 1905, (1631).

Asclepias Syriaca L., Wilmington, August 1894, A. Commons (issued as E. & E. Fungi Columb. 648); Newark, Sept. 7, 1905, (1551); Wilmington, Oct. 11, 1907, (1930).

The life history of this common species is in doubt. It seems probable that it is autoecious though no aecia have ever been collected. Attempts to culture this species have been unsuccessful owing to a failure of the teliospores to germinate. In future study of this species it should be borne in mind that the species may be heteroecious or a brachy-form.

109. UROMYCES HYPERICI-FRONDOSI (Schw.) Arth. Bull. Minn. Acad. Nat. Sci. 2^2:15. 1883.

Aecidium Hyperici-frondosi Schw. Schr. Nat. Ges. Leipzig **1**:68. 1822.

Nigredo Hyperici-frondosi Arth. Result Sci. Congr. Bot. Vienna 344. 1906.

ON HYPERICACEAE:

Hypericum mutilum L., Felton, Sept. 5, 1907, (1751); Selbyville, Oct. 4, 1907, (1991).

Triandeum virginicum (L.) Raf., Selbyville, Oct. 4, 1907, (2247).

110. UROMYCES JUNCI-EFFUSI Sydow, Monog. Ured. 2:290. 1910.

Nigredo Junci-effusi Arth. N. Am. Flora 7^3:239. 1912.

ON JUNCACEAE:

Juncus effusus L., Newark, Oct. 14, 1905, (1537); Clayton, July 24, 1907, (1703); Collins Beach, Oct. 1, 1907, (1779).

This species is common throughout the eastern United States on this host and is separated from *U. Silphii* on Juncus by the presence of 3-4 equatorial germ pores in the uredospores. In the latter there are but 2 pores arranged slightly above the middle.

111. UROMYCES LESPEDEZAE-PROCUMBENTIS (Schw.) Curt. Cat. Pl. N. Car. 123. 1867.

Puccinia Lespedezae-procumbentis Schw. Schr. Nat. Ges. Leipzig **1**:73. 1822.

Nigredo Lespedezae-procumbentis Arth. N. Am. Flora **7**:247. 1912.

ON FABACEAE:

Lespedeza frutescens (L.) Britton, Felton, Sept. 5, 1907, III, (1749); Selbyville, Oct. 4, 1907, III, (1983); Newark, Sept. 11, 1905, III, (1625).

Lespedeza hirta (L.) Hornem., Clayton, July 24, 1907, I, (1705).

Lespedeza virginica (L.) Britt., Newark, Sept. 10, 1907, III, (1730); Selbyville, Oct. 4, 1907, (1988).

This species is very common and widely distributed east of the Rocky mountains on various species of Lespedeza and has been shown to be autoecious by Arthur (Jour. Myc. **10**:14. 1904). The aecial form known as *A. leucostictum* having been produced by infecting *Lespedeza capitata* with teliospores from the same host.

112. UROMYCES MEDICAGINIS Pass. Thüm. Herb. Myc. Oecon. 156. 1874.

Nigredo Medicaginis Arth. N. Am. Flora **7**:256. 1912.

ON FABACEAE:

Medicago lupulina L., Wilmington, June 22, 1889, A. Commons (920).

The aecia of this species in Europe have been shown by Schroeter (Krypt. Fl. Schl. 3[1]:306. 1887) and by Trebaux (Ann. Myc. **10**:74. 1912) to occur on various species of Euphorbia.

No aecia in America have been found which can be referred to this species. There is, however, no evidence at present available for believing the American species different from the European.

113. UROMYCES PEDATATUS (Schw.) Sheldon, Torreya **10**:90. 1910.

Caeoma pedatatum Schw. Trans. Am. Phil. Soc. II. **4**:293. 1832.

Uromyces Andropogonis Tracy, Jour. Myc. **7**:281. 1893.

ON VIOLACEAE: I.

Viola lanceolata L., Lewes, April 25, 1908, (2036).

Viola sagittata L., Newark, June 12, 1897, F. D. Chester; Porters, June 1908; Lewes, April 14, 1908.

ON POACEAE: II, III.

Andropogon glomeratus (Walt.) B. S. P., Selbyville, Oct. 4, 1907, (1795, 1805, 1796, 1797), (Barth. Fungi Columb. 3088); Lewes, Nov. 16, 1907, (1857).

Andropogon virginicus L., Newark, Sept. 10, 1907, III, (1732); Lewes, April 23, 1908, II, (2037), June 7, 1908, III, (2088).

Dr. J. L. Sheldon (Torreya **9**:55. 1909) was the first to show that in West Virginia the aecial stage of this species on Andropogon occurred on Viola, having obtained successful infection resulting in aecia by using teliospores from *Andropogon virginicus* L. Arthur in 1909 (Mycol. 2:229. 1910) confirmed the results of Sheldon by obtaining infection resulting in abundant pycnia on *Viola cucullata* following sowings of teliospores from *Andropogon virginicus* sent by Sheldon from West Virginia.

Long (Phytopath. 2:165. 1912) reports successful infection of *Viola primulifolia* and *V. cucullata* by inoculation with teliosporic material from the same telial host used by Sheldon and Arthur. Aeciospores from *V. primulifolia* were used to inoculate the telial host resulting in typical uredinia of *U. pedatatus*.

114. UROMYCES PERIGYNIUS Halsted, Jour. Myc. 5:11. 1889.

Uromyces caricina E. & E. Bull. Torrey Club 22:58. 1895.

Uromyces Solidagini-Caricis Arth. Jour. Myc. **10**:16. 1904.

Nigredo perigynia Arth. Result Sci. Congr. Bot. Vienna 334. 1906.

ON CYPERACEAE:

Carex scoparia Schk., Newark, Sept. 10, 1907, (1731, 1734), April 5, 1908; Felton, Sept. 5, 1907, (1743); Collins Beach, Oct. 1, 1907, (1775).

Carex tribuloides Wahl., Collins Beach, Oct. 1, 1907, (1782); Felton, Sept. 5, 1907, (1739).

This species is correlated with a Puccinia occurring on Carex and Dulichium which has been referred to under various specific names. (See *P. asteratum.*) The species are morphologically indistinguishable except in the number of cells in the teliospore.

The Uromyces has been studied in culture by Arthur and Fraser. The first study leading to an understanding of the species was made by Arthur (Jour. Myc. **10**:16. 1904) who used telial material on *Carex varia* from Indiana and obtained infection resulting in aecia on *Solidago canadensis, S. serotina, S. flexicaulis* and *S. caesia.* The results were confirmed in 1910 by the same author (Mycol. 4:21. 1912) when infection resulting in aecia was obtained on *S. rugosa* using telial material on *C. deflexa* collected in Nova Scotia and Maine. This species was, at this time, also shown to have aecia on Aster by successful sowings of teliospores from *Carex intumescens* collected in Nova Scotia on *A. paniculatus* and from *C. deflexa* from Maine on *A. ericoides.*

Fraser in 1911 (Mycol. 4:181. 1912) successfully infected *S.*

rugosa (?) and *S. bicolor* by sowing teliospores from *Carex deflexa* from Nova Scotia. Similar results were obtained on *Euthamia graminifolia* when infected with teliospores from *C. scoparia* and on Solidago sp. from *C. intumescens*.

Arthur in 1912 (Mycol. 7:75. 1915) reports infection of *Aster paniculatus* and *S. canadensis* following sowings of teliospores from *C. intumescens* collected in New York and in 1914 (Mycol. 7:83. 1915) on *A. Tweedyi* from *C. tribuloides* collected in Indiana.

The aecia obtained in these cultures are indistinguishable from the aecia resulting from sowings of the correlated Puccinia. Field collections of aecia on Aster, Solidago, etc., can be properly referred only when close observations of the source of infection are made.

115. UROMYCES PLUMBARIUS Peck, Bot. Gaz. 4:127. 1879.
Uromyces Oenotherae Burrill, Bot. Gaz. 9:187. 1884.
Nigredo plumbaria Arth. N. Am. Flora 7:262. 1912.

ON ONAGRACEAE: I.

Oenothera biennis L., Newark, May 1908, I (2266).
Oenothera laciniata Hill, Seaford, June 4, 1908, I (2044).

116. UROMYCES POLEMONII (Peck) Barth. N. Am. Ured. 597. 1913.
Aecidium Polemonii Peck, Bot. Gaz. 4:230. 1878.
Uromyces acuminatus Arth. Bull. Minn. Acad. Sci. p. 35. 1883.
Nigredo Polemonii Arth. N. Am. Flora 7^3:231. 1912.

ON POACEAE: II, III.

Spartina glabra alternifolia (Loisel) Merr., Lewes, Oct. 16, 1907, (1774, 1850).

When teliosporic material from *S. cynosuroides* collected in Nebraska was used by Arthur to inoculate *Steironema ciliata* (Jour. Myc. 12:25. 1906; 14:17. 1908) aecia developed. In 1909 Arthur (Mycol. 2:229. 1910) confirmed the results with *S. ciliata* and also records successful infection of *S. lanceolata*. In 1910 (Mycol. 4:29. 1912) the development of aecia was obtained on *Polemonium reptans* following sowings of teliospores from *S. cynosuroides* collected in North Dakota and Colorado.

Fraser in 1911 (Mycol. 4:186. 1912) obtained infection resulting in aecia on *Arenaria lateriflora* following sowings with teliosporic material from *Spartina Michauxiana* and on *Spergula canadensis* from *Spartina glabra* var. *alternifolia* and on *Spergula canadensis* from *Spartina patens.*

In 1912 Arthur again conducted cultures (Mycol. 7:77. 1915) and obtained infection and development of aecia on *Collomia linearis* when telial material from Colorado was used.

From these successful results, taken together with the negative results recorded by the investigators mentioned, it would appear that well marked biological races of this species exist or that distinct species are here included.

Orton (Mycol. 4:202. 1912) pointed out that it is not possible to distinguish this species from *Puccinia Distichlidis* E. & E., the telial stage of which occurs on Spartina sp., except in the possession of one-celled teliospores. Arthur in 1915 (Mycol. 8:136. 1916) has shown that the aecial stage of the Puccinia develops on Steironema and is morphologically identical with *Aecidium Polemonii,* thus strengthening the morphological evidence of the relationship between the two forms.

117. UROMYCES POLYGONI (Pers.) Fuckl. Symb. Myc. 64. 1869.
Puccinia Polygoni Pers. Neues Mag. Bot. 1:119. 1794.
Nigredo Polygoni Arth. Result Sci. Congr. Bot. Vienna 344. 1906.
ON POLYGONACEAE:
Polygonum aviculare L., Newark, Aug. 17, 1907, III, (1712).
Polygonum erectum L., Newark, September 1888, F. D. Chester, June 21, 1907, II, (1668).

118. UROMYCES PONTEDERIAE W. Gerard, Bull. Torrey Club 6:21. 1875.
Nigredo Pontederiae Arth. N. Am. Flora 7[3]:238. 1912.
ON PONTEDERIACEAE:
Pontederia cordata L., Milford, Sept. 1, 1892, A. Commons (1986).

This species is evidently rather rare, having been recorded in North America by Arthur (l. c.) in but four states on the Atlantic coast from New York to Florida and in Missouri. Only four other collections are known to the writer. It also occurs in South America. This species is assumed to be autoecious though no aecia have been found.

119. UROMYCES PROEMINENS (DC.) Pass. Rab. Fungi Eur. 1795. 1873.

Uredo proeminens DC. Fl. Fr. 2:235. 1805.

Uromyces Euphorbiae C. & P.; Peck, Ann. Rep. N. Y. State Mus. 25:90. 1873.

Nigredo proeminens Arth. N. Am. Flora 7[3]:259. 1912.

ON EUPHORBIACEAE:

Euphorbia maculata L., Newark, September 1905, (1633), Lewes, Aug. 14, 1907, (1695), Selbyville, Oct. 4, 1907, (1980).

Euphorbia Preslii Guss., Newark, Sept. 14, 1907, III, (1630), Seaford, July 9, 1907, I, (1666); July 9, 1907, II, III, (1655), Selbyville, Oct. 4, 1907, (1994).

That this species is autoecious was first demonstrated by Arthur in 1899 (Bot. Gaz. 29:270. 1900) and later confirmed by the same author (Jour. Myc. 8:51. 1902; Bot. Gaz. 35:12. 1903). The results, however, indicate that well marked biological forms are present.

120. UROMYCES RHYNCOSPORAE Ellis, Jour. Myc. 7:274. 1893.

Nigredo Rhyncosporae Arth. Result Sci. Congr. Bot. Vienna 344. 1906.

ON CYPERACEAE: II, III.

Rynchospora axillaris (Lam.) Britton, Lewes, Aug. 14, 1907, (1687).

Rynchospora glomerata (L.) Vahl., Selbyville, Oct. 4, 1907, (1801, 1811); Seaford, Nov. 15, 1907, (1768, 1769), April 23, 1908, (2031); Lewes, Nov. 16, 1907, (1856).

All cultures so far attempted with this species have yielded negative results. It is very close morphologically to *Uromyces perigynius* which has been shown to have aecia on Aster and Solidago. In spite of the fact that attempts to infect these genera by Arthur (Mycol. 7:65. 1915) were unsuccessful, the writer is inclined to the view that it will ultimately be shown that this species has its aecia on Aster and Solidago.

121. UROMYCES SCIRPI (Cast.) Burrill, Par. Fungi Ill. 168. 1885.

Uredo Scirpi Cast. Cat. Pl. Mars. 214. 1845.

ON AMMIACEAE: I.

Hydrocotyle Canbeyi C. & R., Lewes, Aug. 14, 1907, I, (1688), June 6, 1908, (2090).

Sium cicutaefolium Gmel., Wilmington, July 11, 1890, I, A. Commons (1483).

ON CYPERACEAE: II, III.

Scirpus americanus Pers., Lewes, Aug. 14, 1907, II, (1679, 1689), June 6, 1908, (2091); Selbyville, Oct. 4, 1907, (1806).

Scirpus fluviatilis (Torr.) A. Gray, Collins Beach, Oct. 1, 1907, III, (1787).

In Europe P. Dietel (Hedwigia 29:149. 1890) was the first to successfully connect this species with its aecial form. He showed by cultures that aecia are produced on *Sium latifolium* and *Hippurus vulgaris*. Plowright (Gard. Chron. III. 7:682. 1890) added *Glaux maritima* as an aecial host of this species. Bubak in Bohemia (Cent. Bakt. 9²:926. 1902) discovered a form which only infected *Berula angustifolia*. Further cultures carried out by Klebahn (Jahr. Hamb. Wiss. Anst. **20**:33. 1903) brought out new hosts and interesting biological relations.

In America Arthur in 1906, 1907 and 1908 (Jour. Myc. **13**:199. 1907; **14**:17. 1908; Mycol. **1**:237. 1909) showed that in America *Cicuta maculata* was an aecial host. Fraser (Mycol. 4:178. 1912) confirmed Arthur's work using telia on *Scirpus campestris paludosus*.

The aecidium on *Hydrocotyle Canbeyi* is included here partly on morphological grounds and partly on field observations. As noted above the writer collected at Lewes, on Aug. 14, 1907, the aecidium on Hydrocotyle. The aecia were old and there was no evidence of uredinia or telia of *P. Hydrocotyles* (with which form the aecidium has previously been combined) on any of the affected leaves or on other plants in the vicinity. Surrounding the plants, however, were plants of *Scirpus americanus* abundantly affected with the uredinia of *U. Scirpi*. Observations and collections were again made in the same spot on June 6, 1908, when aecia were again found in abundance showing evidence of having been mature for about two weeks. A few culms of Scirpus were growing in such a position that the tips were hanging immediately above the Hydrocotyle plants bearing the aecia. On these tips fresh uredinial sori of *U. Scirpi* were present. No infection on Scirpus was found elsewhere at that date though the plants were very abundant over a wide area.

122. Uromyces seditiosus Kern, Torreya 11:212. 1911.

Aecidium Plantaginis Burrill, Bull. Ill. Lab. Nat. Hist. 2:232. 1885.

Nigredo seditiosa Arth. N. Am. Flora 7:225. 1912.

On Poaceae:

Aristida sp., Lewes, 1908.

Culture experiments reported by Arthur (Bot. Gaz. 35:17. 1903) prove the aecidial stage of *Uromyces Aristidae* to be *Aecidium Plantaginis.* He used telial material on *A. oligantha* Michx. from Texas and successful infection of *Plantago Rugelii* was obtained followed by pycnia and aecia.

Field observations made by Arthur and Fromme indicate also that *Aecidium Oldenlandianum* Ellis & Tracy, which occurs on various species of Houstonia in the southern states, also belongs here though confirming cultures have not yet been made.

123. Uromyces Silphii (Burrill) Arth. Jour. Myc. 13:202. 1907.

Aecidium Silphii Sydow, Ured. 1546. 1901.

Nigredo Silphii Arth. N. Am. Flora 7:239. 1912.

On Juncaceae:

Juncus dichotomus Ell., Sussex Co., June 18, 1875, A. Commons.

Juncus tenuis Willd., Lewes, Aug. 14, 1907, (1700); Newark, Aug. 23, 1907, (1714); Sept. 1907, (1823, 1824); Selbyville, Oct. 4, 1907, (1793, 1800).

Arthur (Jour. Myc. 13:202. 1907; 14:17. 1908) has shown that this common species has its aecia on Silphium. Using telial material on *J. tenuis* from Indiana, West Virginia and Nebraska, five successful infections of *Silphium perfoliatum* were obtained, all of which resulted in the development of pycnia and aecia. The aecia on Silphium have been collected, so far as known to the writer, only in the Mississippi Valley from Ohio to Wisconsin, Kansas and Missouri, on three species of Silphium. The range of the telial collections referred here, however, is much greater including nearly the entire United States and Canada except the south Pacific slope. It seems probable that some plants other than Silphium, at present unrecognized, also serve as aecial hosts for this species. From field observations it seems probable that certain species of Aster serve as hosts for the aecia of this species in some localities.

This species is distinguished from the only other Uromyces on Juncus occurring in the eastern United States (*U. Junci-effusi* Syd.) which occurs commonly on *J. effusus*, by the number and position of the pores in uredospores. In *U. Silphii* there are two superequatorial pores; while in *U. Junci-effusi* the pores are 3-4 and equatorial.

124. UROMYCES SPERMACOCES (Schw.) Curt. Cat. Pl. N. Car. 123. 1867.
Puccinia Spermacoces Schw. Schr. Nat. Ges. Leipzig 1:74. 1822.
Nigredo Spermacoces Arth. N. Am. Flora 7:266. 1912.

ON RUBIACEAE:

Diodia teres Walt., Newark, Sept. 18, 1905, (1627); Selbyville, Oct. 4, 1907, (1934); Cooch's Bridge, Sept. 18, 1915, C. O. Houghton.

This is doubtless an autoecious form though no cultures have been conducted. It is a very common species in the south and south central States. The above collections are near the northeastern limits of its range.

UNCONNECTED FORMS.

125. AECIDIUM APOCYNI Schw. Schr. Nat. Ges. Leipzig 1:68. 1822.

ON APOCYNACEAE:

Apocynum pubescens L., Seaford, July 9, 1907, (1649, 1653), June 4, 1907, (2053); Clayton, July 24, 1907, (2253).

This Aecidium is known otherwise only from North Carolina and New Jersey on the above host and on *A. cannabinum* L. only from the District of Columbia and North Carolina (according to Schweinitz). It is easily separated from *Aecidium obesum* Arth., which occurs on *A. Sibiricum*, by the possession of a firm peridium and much smaller aeciospores with thin walls. The latter agrees with *A. Cephalanthi* Seym. which has been shown by Arthur (Jour. Myc. 12:24. 1906; Mycol. 1:236. 1909; 4:19. 1912) to be the aecial form of *Puccinia Seymouriana* Arth. with uredinia and telia on Spartina.

126. AECIDIUM COMPOSITARUM Authors.

ON CARDUACEAE:

Rudbeckia triloba L., Naamans Creek, April 27, 1894, A. Commons.

This Aecidium like many others on Compositae is doubtless heteroecious and may belong with telia on some Cyperaceous or Juncaceous host. Since its exact affinities are at present unknown it is best for the present referred to as above.[1]

127. **Aecidium Ivae** sp. nov.

O. Pycnia amphigenous, crowded in yellowish spots, 3-15 mm. in diameter, noticeable, subepidermal, light yellow to light chestnut-brown, punctiform, 80-160 by 95-160μ, ostiolar filaments up to 80μ long.

I. Aecia usually hypophyllous, sometimes amphigenous, crowded on spots with the pycnia, cupulate, 0.2-0.4 mm. in diameter; peridium brownish yellow, recurved, erose; peridial cells rhomboidal in longitudial section, 19-27 by 35-51μ, overlapping, wall 5-7μ thick, outer wall smooth, transversely striate, inner wall closely and coarsely verrucose; aeciospores globoid or ellipsoid 21-29 by 26-23μ; wall colorless or pale yellow, 2-3μ thick, finely and closely verrucose.

On Ambrosiaceae:

Iva ovaria Bartlett (*I. frutescens* A. Gray not L.), Lewes, Aug. 14, 1907, (1676).

This species is evidently a heteroecious form and occurs otherwise, so far as is known, in salt marshes along the Atlantic coast and Gulf of Mexico in Virginia, Florida and Louisiana. It differs from *Aecidium intermixtum* Pk. (*Puccinia intermixta* Pk.) in the larger aeciospores and in the fact that the aecia develop from a limited mycelium.

128. Aecidium Uvulariae Schw. Nat. Ges. Leipzig **1**:69. 1822.

On Convallariaceae:

Uvularia sessifolia L., Seaford, June 4, 1908, (2059); Cooch's Bridge, May 25, 1915, C. O. Houghton.

The above Aecidium is scarcely distinguishable from *Aecidium Majanthae* Schum. which has been shown by European investigators to be connected with uredinia and telia on Phalaris. In America aecidia occurring on Salamonia, Unifolium and Vagnera have been similarly referred to *P. Majanthae* (Schw.) Arth. (*P. sessilis* Schw.) though no successful cultures have been made. Since slight morphological differ-

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[1] Since the above was written cultures conducted in this laboratory and reported by Arthur (Mycol. **9**:307. 1917) show that aecia on *Rudbeckia laciniata* are genetically connected with uredinia and telia on Carex referred to *Uromyces perigynius* (cf. 114). He obtained successful infection resulting in aecia on *R. laciniata* following exposure to germinating telia on *Carex sparganioides*. It is therefore probable that the collection listed here from Delaware on *R. triloba* should be similarly referred.

ences exist between the form on Uvularia and those mentioned above it seems desirable to retain it as a separate species for the present.

129. UREDO ANDROMEDAE Cooke, DeToni in Sacc. Syll. Fung. 7:853. 1888.

ON ERICACEAE:

Pieris mariana (L.) Benth. & Hook., Wilmington, Oct. 1891, A. Commons (in E. & E. N. Am. Fungi 2717).

Xolisma ligustrina (L.) Britt., Selbyville, Oct. 4, 1907, (1941).

This species, included by Arthur in *Melampsoropsis Cassandrae* (P. & C.) Arth. (N. Am. Flora 7:119. 1907) is clearly not that species, as the urediniospores are echinulate. Its affinities are probably with Pucciniastrum. The ostiolar cells of the peridium however are not well developed and it seems best to retain it under the above name for the present.

INDEX TO SPECIES.

Host Index.

Purdue University, Lafayette, Ind.

THE TREES OF WHITE COUNTY, INDIANA

WITH SOME REFERENCE TO THOSE OF THE STATE

A Thesis

Submitted to the Faculty of Purdue University

by

LOUIS FREDERICK HEIMLICH

Candidate for the Degree of Master of Science

June, 1916

is papei was submitted for publication in the 1916 Proceedings, but the publication was deferred one ear on account of the many long papers submitted n 1916.—EDITOR

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The Trees of White County, Indiana, with Some Reference to Those of the State.

For a long time botanists have been busy describing species and working out their distribution over the surface of the earth. Dendrologists, more particularly, have been contented with the description and distribution of trees. From studies and reports made thus far, the general ranges of trees and most flowering plants are fairly well known. One might well suspect what plants grow in a certain area, but definite reports are to be preferred.

Now the significant way to study vegetation is from an ecological standpoint. Completeness is not attained by noting the species of a certain group within any political boundary. Armed with the reliable information of a geologist, the distribution and number of species and individuals, from unicellular plants in the soil and water to the most complex flowering types, should be worked out by the taxonomist-ecologist. This of course would take time, but taking each county, or stream and then working in the intervening spaces, as a unit for the working field, the completed report would show a new natural map with a far greater meaning than isolated and incomplete reports coming from various sections. This would become very far-reaching, taking into account plant diseases, and, being but a step to animal parasites on plants, an account of the complete fauna of the region as well as a complete flora as hinted at above, would be still more desirable. We should then have some really effective Life Zones.

A complete flora for the State is the aim of the committee on the Biological Survey of the Indiana Academy of Science. To my knowledge there is no similar committee or thought of a complete fauna for the State.

The Indiana State Board of Forestry is interested in determining just what species of trees grow in Indiana and just what their ranges in the State are. In the Eleventh Annual Report of the State Board of Forestry, 1911, is to be found the most authentic record of Indiana trees up to the present time. There is no pretense that the report is complete either for the total number of species in the State, or much less so for the ranges of those reported. Some counties have been very thoroughly worked, others only partly, and some not at all—at least reports are lacking. White County happens to fall into this last category.

Under these circumstances the general aim of this thesis has been a systematic report on the Native Trees of White County, their species and relative numbers. Other related features have been included as the result of a growing interest in the subject. The matter of ecology was thought of seriously, but due to the lack of time and the as yet unavailable soil report of the county*, this part has been reduced to a very brief review of the physical and geographical aspects of the county, and a consideration of the Tippecanoe River trees, with the general distribution of trees over the county. As regards the economic phases of White County trees, some isolated but interesting figures were obtained. In this connection some historical data attaches another bit of interest. Comparisons with State and national distribution by the use of maps, illustrate clearly among other things the need for further work as well as the correction of past limits or errors. Attention is also called to a new list of Hickories for the State according to Sargent's latest determinations. Besides other minor features which need not be mentioned here, I have been fortunate enough to include a new variety of willow for the State, and possibly a new species of that same genus.

Geographical and Physical Aspects of White County.

Before proceeding at once to the primary aim of this thesis, the report of species and relative numbers, I have deemed it desirable to point out certain other features, giving a general notion of the county, topography, fertility of soil, drainage, transportation facilities, etc.

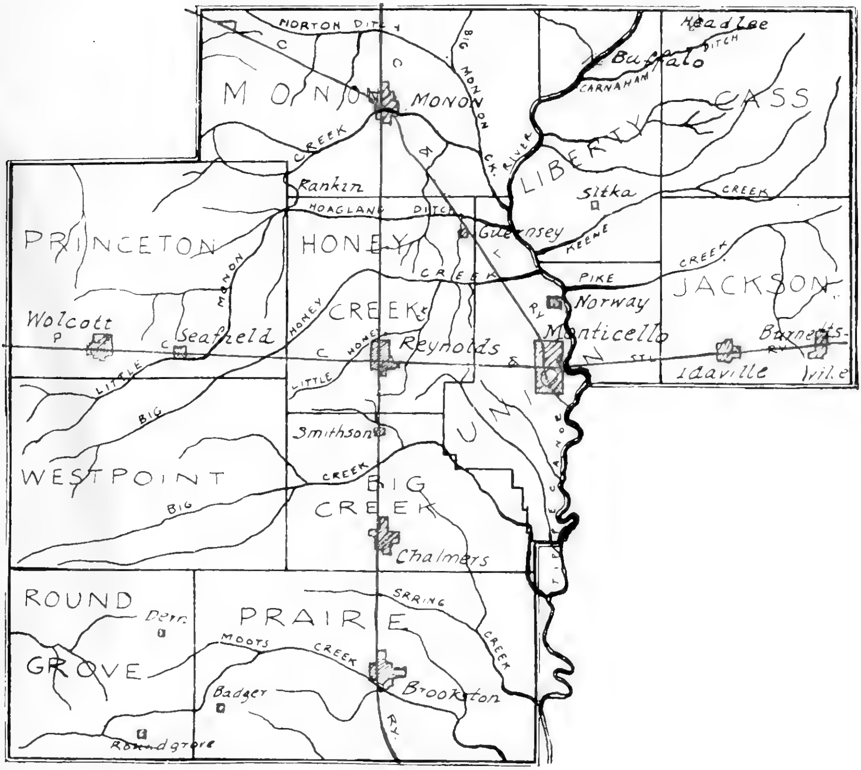
White County is located in the northwestern part of Indiana and possesses some of the best agricultural land in the world. The soil is especially fertile in the southwestern half of the county, which is prairie land. Black, rich soil in this area produces monster crops of corn and oats, with nearly all the ground surface taken up in cultivation. Comparatively less timber is to be found in this region and very likely the region has always been the less wooded part of the county—being formerly a vast sea. Boulders of the glacial age in many cases have been removed to the fence rows.

* Soil Survey made by U. S. Bureau of Soils, Summer 1915.

PLATE I.

WHITE COUNTY.

507 Square Miles—324,480 Acres.



Low sand ridges are especially characteristic of Honey Creek and Monon townships and also parts of Princeton. This area is very densely covered with forests of oak (almost exclusively Q. alba, palustris, velutina, coccinea).

In the environs of the Tippecanoe River and eastward the topography is rather more rugged. Very good farm lands are also found in this area. Formerly almost every foot of this region was heavily wooded.

The following statistics, taken from the U. S. 1910 Census, give some notion of the fertility and returns of White County soils.

(Table 1.)

Total land area in acres		324,480
Acres under cultivation:		
Cereals	165,106	
Hay	28,550	
Potatoes	750	
All other crops	893	
Small fruits	35—	195,334
Per cent of total land area cultivated		60
Number of farms		2,091
Average number of acres per farm		150.4
Value of all crops (except nuts, etc.)		$2,951,637
Expense:		
Labor	$184,833, or 88%	
Fertilizer	23,758, or 12%—	208,591.00
Net crop returns		$2,743,146.00
Net returns per acre		14.04
Land value per acre		77.69
Per cent of net per acre to value per acre		18.2

The total population in 1910 (U. S. Census) was 17,602 with only 6,511 as being included in towns.

Nearly all of the 507 square miles in White County are drained by the Tippecanoe River and its tributaries. The county as a whole is rather flat and much dredging and tile-ditching has been done in recent years. Parts of natural streams have been dredged several times and also extended. Possibly in this case more erosion would be gladly welcomed. The Tippecanoe is a geologically young and very beautiful watercourse, fed by clear lake-water at its head in Noble County and by numerous springs along its banks.

Since national and local interests are crystallizing more and more in the direction of natural beauty spots—parks and pleasure resorts—I suggest that very appealing tracts can be found along the Tippecanoe, especially north of Monticello, near Norway and up toward Buffalo.

Transportation facilities in the county are excellent. The Monon and Pennsylvania Lines cross the county. A system of good roads is in existence, about 400 miles of which are macadamized or made of gravel.

Limestone quarries are located at Monon and recently other deposits have been found several miles southwest of Reynolds. Good clay deposits and tile factories at Chalmers, Seafield and Wolcott have been in operation for a number of years.

A far more accurate and much more detailed statement covering the part here alluded to will be found in the forthcoming report of the U. S. Bureau of Soils for White County, which will be ready for distribution within a few months.

The Native Species of Trees.

Parts of the summer of 1915 and the fall of 1914 were spent in making collecting trips over various parts of the county. The regular routine work was done single-handed, and the specimens disposed of and mounted according to standard methods now form a permanent part of my private herbarium.

Realizing very thoroughly that the work of determination, especially in some genera, is not such a self-satisfying matter to any careful botanist, I endeavored to make my collection as authentic as possible. Any specimen still remaining in doubt is either entirely omitted or expressly given as doubtful.

Specimens in the Purdue Herbarium and many specimens of Oaks and Hickories, collected last summer by Mr. Deam and Prof. Hoffer and recently determined by Sargent, were available for comparison. Dr. Sargent has verified or determined all the specimens of Salix, Hicoria, Crataegus, Malus, and many Oaks. Mr. F. W. Pennell, Assistant Curator of the New York Botanical Garden, has determined specimens of Fraxinus and Cornus. Mr. W. W. Eggleston of the Bureau of Plant Industry was also consulted. I am permitted to add Salix longifolia variety argophylla (determined by Sargent) to my list, by the courtesy of Mr. C. C. Deam of Bluffton, Indiana, who was ever ready to help. Acknowledgments are also due Professor G. N. Hoffer of Purdue, not least of which are for a kindly interest in the work. Grateful appreciation to Dean Stanley Coulter, under whom this thesis was written, is here expressed, for help, encouragement and his stamp of approval.

Thanks are also tendered to Mr. Ed Newton of Monticello, Indiana, for historical accounts, and to my sister Frieda for data in connection with Part V.

As designated in the 1911 Report of the State Board of Forestry, "the number of trees included in this list is wholly arbitrary," so I have included some species—small trees, or large shrubs, not considered in that report. Further consideration of each species is deferred to another part of this paper.

The following is a complete list of all species collected:

(List 1.)

NATIVE WHITE COUNTY TREES.

Juniperus virginiana L.
Salix amygdaloides Anders.
    interior Rowlee.
    humulis Marsh.
    discolor Muhl.
    nigra Marsh.
    missouriensis Bebb.
    longifolia var. argophylla Sarg.
Populus alba L.
    grandidentata Michx.
    heterophylla L.
    tremuloides Michx.
    deltoides Marsh.
Juglans nigra L.
    cinerea L.
Hicoria cordiformis (Wang) Britton.
    ovata (Mill) Britton.
    laciniosa (Michx) Sarg.
    alba (L) Britton.
    ovata var. fraxinifolia Sarg.
Corylus americana Walt.
Carpinus caroliniana Walt.
Ostrya virginiana (Mill) Willd.
Betula lutea Michx.
Fagus grandifolia Ehrh.

Quercus alba L.
macrocarpa Michx.
bicolor Willd.
Muhlenbergii Englm.
rubra L.
palustris DuRoi.
coccinea Muench.
ellipsoidalis E. J. Hill.
velutina Lam.
imbricaria Michx.
Ulmus americana L.
fulva Michx.
Celtis occidentalis L.
Morus rubra L.
Toxylon pomiferum Raf.
Liriodendron tulipifera L.
Asimina triloba (L) Dunal.
Sassafras variifolium (L) Karst.
Hamamelis virginiana L.
Plantanus occidentalis L.
Malus malus (L) Britton.
ioensis (Wood) Britton.
Amelanchier canadensis (L) Med.
Crataegus crus-galli L.
pruinosa (Wendl) Koch.
albicans Ashe. ?
calpedendron (Ehrh) Britton.
Prunus americana Marsh.
serotina Ehrh.
Cercis canadensis L.
Gleditsia triacanthos L.
Gymnocladus dioica (L) Koch.
Robinia Pseudo-acacia L.
Zanthoxylum americanum Mill.
Ptelea trifoliata L.

Rhus glabra L.
copallina L.
hirta (L) Sudw.
Ilex verticillata (L) A. Gray.
Staphylea trifolia L.
Acer negundo L.
saccharum Marsh.
saccharinum L.
nigrum Michx.
Aesculus glabra Willd.
Tilia americana L.
Nyssa sylvatica Marsh.
Cornus alternifolia L.
stolonifera Michx.
asperifolia Michx.
femina Mill.
florida L.
Fraxinus americana L.
pennsylvanica Marsh.
Cephalanthus occidentalis L.
Viburnam Lentago L.
prunifolium L.
Sambucus canadensis L.

It may and likely will be necessary to add a few species not included in the above to make the list complete. Such probable species occurring in the county are considered in the list dealing with the details of each species. The following is merely a suspected list of those species.

(List 2.)

SPECIES LIKELY TO BE FOUND IN WHITE COUNTY.

Salix alba L.
lucida Muhl.
Hicoria microcarpa (Nutt) Britton.
glabra (Mill) Britton.
Alnus rugosa (DuRoi) Spreng.
Crataegus margarette Ashe.
succulenta Schra.

Acer rubrum L.
Fraxinus quadrangulata Michx.
  nigra Marsh.
Morus alba L.

It is stated in the 1911 Report (p. 87) that "it is believed that about one-half of our trees are found in nearly every county of the State." In that report forty-seven genera with 125 species of trees are considered. The following table compares the number of species for each genus as given in the report, with the number of the same species in the same genus for White County. Other species in the same genus not reported are added in a third column. Varieties and species of still other genera are included in other columns.

Recalling the statement referred to above, it will be seen that White County has representatives of over half the genera and about "one-half" the species, there being 33 out of 47 genera represented, with 62 species.

TABLE II.

Table Comparing Number of Genera and Number of Their Species Reported for Indiana, with Number of Same Genera and Same Species for White County.

Genus.	Species for Indiana.	Species for White Co.	Other Species in White County not Given in 1911 Report.	Species of Other General Included.
Pinus	3	0		
Larix	1	0		
Tsuga	1	0		
Taxodium	1	0		
Thuja	1	0		
Juniperus	1	1		
Salix	4	2	4 and 1 variety.	
Populus	5	5		
Juglans	2	2		
Hicoria	7	4	4 and 1 variety.	Corylus.......1
Carpinus	1	1		
Ostrya	1	1		
Betula	1	1		
Alnus	2	0		
Fagus	1	1		
Castanea	1	0		
Quercus	17	10		
Ulmus	4	2		
Celtis	3	1		
Morus	2	1		
Toxylon	1	1		
Magnolia	1	0		
Liriodendron	1	1		
Asimina	1	1		
Sassafras	1	1		Hamamelis....1
Liquidamber	1	0		
Platanus	1	1		
Malus	2	1	1	
Amelanchier	1	1		
Crataegus	18	4		
Prunus	4	2		
Cercis	1	1		
Gleditsia	2	1		
Gymnocladus	1	1		
Robinia	1	1		
				Zanthoxylum..1
				Ptelea.......1
Ailanthus	1	0		
				Rhus..........1
Ilex	1	0	1	
				Staphylea.....1
Acer	5	4		
Aesculus	2	1		
Tilia	2	1		
Nyssa	1	1		
Cornus	2	2	3	
Diospyrus	1	0		
Fraxinus	6	2		
Forestiera	1	0		
Catalpa	2	0		
				Cephalanthus..1
Viburnam	2	2		
				Sambucus.....1
Total	125	62	9 and 2 varieties.	8

Total number of Genera: Indiana, 47; White County, 34.

Below is appended a partial list of cultivated trees known to exist in White County.

(List 3.)

PARTIAL LIST OF CULTIVATED SPECIES OF TREES IN WHITE COUNTY, OMITTING THE USUAL ORCHARD TREES.

Gingko biloba	Gingko or Maidenhair Tree.
Thuja occidentalis L.	Arbor Vitae.
Chamaecyparis obtusa?	Cypress.
Picea abies (L) Karst.	Norway Spruce.
Larix larcina (DuRoi) Koch	Larch-Tamarack.
Populus nigra L.	Black Poplar.
var. italica DuRoi	Lombardy Poplar.
Castanea dentata (Marsh) Borkh.	Chestnut.
Aesculus Hippocastanum L.	Horse-chestnut.
Ailanthus glandulosa Desf.	Tree-of-Heaven.
Acer palmatum	Japanese Maple.
Acer spicatum Lam.	Mountain Maple.
Rhus cotinoides Nutt.	Smoke Tree.
Pyrus americana (Marsh) DC.	American Mountain Ash.
Viburnam opulus L. var. americanum (Mill) Ait.	Cranberry Tree.
Diospyrus virginiana L.	Persimmon.
Catalpa speciosa Warder.	Catalpa.
catalpa (L) Karst.	Catalpa.
Kaempferi.	Japanese Dwarf Catalpa.
Betula alba L.	European White Birch.

IV. DISTRIBUTION.

1. GENERAL INTIMATION.

As noted previously, White County embraces 507 square miles or 324,480 acres. I have often been over much of this area and have in a general way for a long time known most of the trees. In making a definite report, however, a definite procedure seems to be desirable.

The map on page 402 shows the territory covered during the last summer. The red lines represent the actual highways travelled, mostly by bicycle, some by automobile. Many side trips were made on foot.

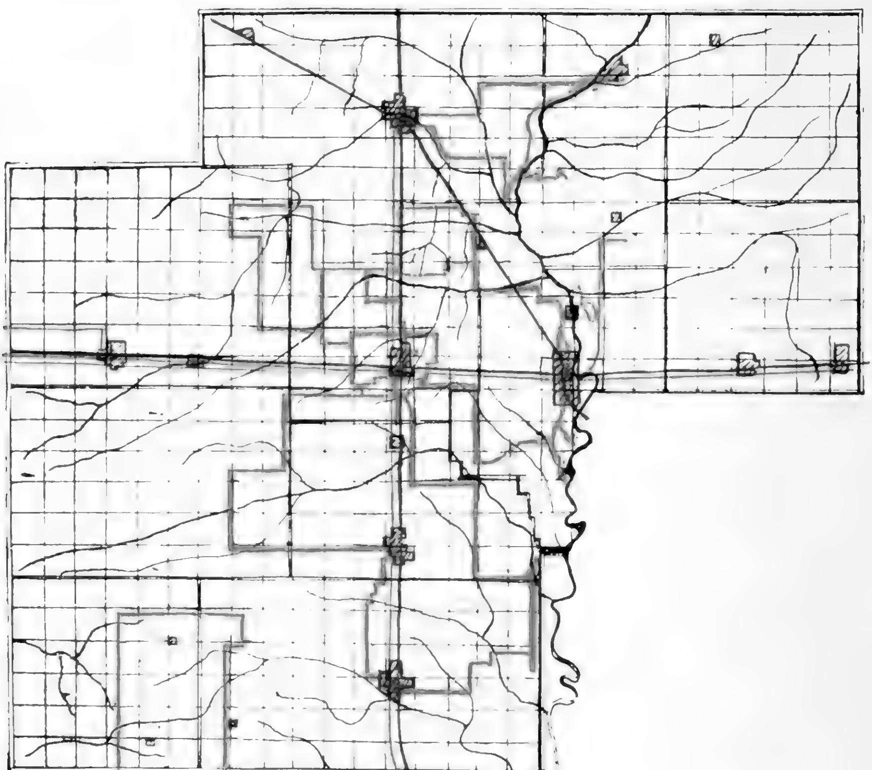
As I recall it, many days were totally unfit for the collector owing to the continuous heavy rains. As a result of this many thickets were miry or filled with water. As a further consequence, the mosquito hordes too often interfered with the pleasure of the work if nothing else. Such experiences, more or less trivial, must be evident to most collectors and serve only to hint at other difficulties besides those of determination.

In attempting to say something about the distribution of each species in the county, references are made to the general distribution and

PLATE II.

WHITE COUNTY.

Red Lines Show Actual Roads Traveled in Collecting Specimens.



the reported distribution in the State. Some maps covering these features reveal several matters of interest. First, it becomes evident that the definition of the general limits of any species is a big task, always changing, and a graphical representation of a number of species for Indiana shows quite clearly, among other things, that some counties have been quite thoroughly worked, whereas others have had little or no attention at all. Elkhart, Benton, Clinton, Jasper, Newton, Ohio, Perry, Pike, Pulaski, Rush, Switzerland, Tipton, Vanderburgh, Warrick, Whitley and White Counties are not mentioned in a single published report. As the maps show, the counties bordering on the Wabash River and extending in a continuous line from Posey to Steuben County, have been the most thoroughly worked, as have Wells County (by Deam), the group of Delaware, Jay, Randolph and Wayne (by Phinney), Jefferson (by Coulter), Clark (Baird and Taylor), area of New Albany, Floyd (Clapp), Hamilton (Wilson), and Franklin (Meyncke). (See Range maps pp. 424-429, 444, 450, 453, 456, 460, 461.)

Nearly two decades ago Dr. Cowles of the University of Chicago made an ecological study of the shores of Lake Michigan. The results of his investigations were published in the Botanical Gazette. Though none of these contain a definite list of plants for the borders of the Indiana Dune area on Lake Michigan, I have been able to pick out a number of trees mentioned in the articles as occurring in that area. And since these references seem to have had no acknowledgments in later records, I include a list of trees below, taken mostly from the Botanical Gazette, Vol. 27, No. 4, April, 1899. Most of the species occur at Dune Park in Porter County.

(List 4.)

SOME TREES OF THE DUNE AREA OF INDIANA.

Pinus strobus L.
    Banksiana Lamb.
Abies balsamea (L) Mill.
Tsuga canadensis (L) Carr.
Thuja occidentalis L.
Juniperus virginiana L.
    communis L.

Salix glaucophylla Bebb.
adenophylla Am. auth., not Hook.
humilis Marsh.
Populus monilifera Ait. (P. deltoides Marsh).
balsamifera L.
Juglans cinerea L.
Ostrya virginiana (Mill) K. Koch.
Betula payrifera Marsh.
Fagus ferruginea Ait. (F. grandifolia).
Quercus coccinea tinctoria A. DC. (Q. velutina Lam.).
alba L.
Ulmus fulva Michx.
Celtis occidentalis pumila Muhl.
Sassafras officinale Nees and Eberm.
Hamamelis virginiana L.
Amelanchier canadensis (L) Med.
Prunus pumila L.
virginiana L.
Ptelea trifoliata L.
Rhus canadensis Marsh.
copallina L.
Acer saccharinum L.
Tilia americana L.
Cornus stolonifera Michx.
florida L.
Fraxinus americana L.
Viburnam acerifolium L.

The Range maps included for the distribution of some selected species indicate the opportunity for someone to make a careful collection, an accurate determination and a report, covering one or more counties, either to the State Board of Forestry or the chairman of the Committee on the Indiana Botanical Survey.

When reports for all counties are complete it will be interesting to note from just what counties certain species are actually absent and to seek the reason for this absence in terms of ecology or otherwise.

Besides the matter of distribution in itself, I have endeavored to add other details of more or less importance. The following, then, is a brief consideration of each species collected in White County—first the Oaks, next the Hickories, a study of the Tippecanoe flora, followed by the Willows and other species generally distributed over the county.

2. The Oaks.

The Oaks constitute the most important trees in White County in point of utility and quality as well as in number of species in any one genus represented, or as regards the number of individuals in the genus.

Seventeen species of oaks have been reported for Indiana. This is the number contained in both, Coulter's Flora and in Deam's 1911 Report. The former, however, lists Quercus texana Buckley (Texan Red Oak—Gibson, Posey, Knox—Dr. Schneck?) and Q. Phellos L. (Willow oak—Gibson, Posey, Knox)—omitting Quercus Schneckii Britton (Schneck's oak), and Q. ellipsoidalis E. J. Hill (Hill's oak).

Quercus Schneckii Britton is a species yet in doubt (Deam). It may be referable to Q. texana, but the new flora of Britton and Brown says it "has been confused with Q. texana." It closely resembles Quercus rubra L. and may supplant the latter to an unaware extent. Thus far it has been reported from Bartholomew (Elrod); Gibson, Knox, Posey and Vermillion (Schneck); Knox (Ridgway); Posey and Wells (Deam). "It is believed that it is more or less frequent along the Wabash and its tributaries," and so may occur in White County along the Tippecanoe or southeastern part of the county.

Quercus phellos L. references for Indiana have been changed to Q. imbricaria Michx. (See Deam, 1911 Report, pp. 91-92.)

Quercus ellipsoidalis E. J. Hill was described (E. J. Hill, Bot. Gaz. 27:204, 1899) after Coulter's Catalogue was published.

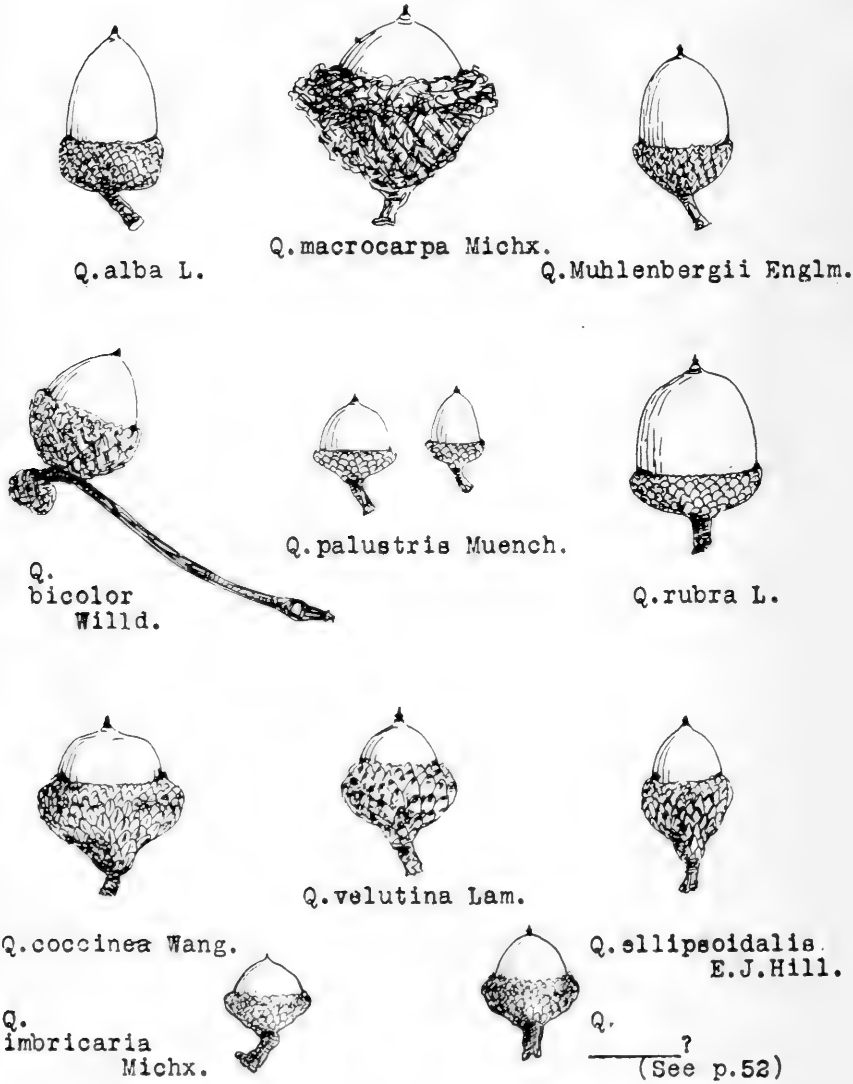
Other oaks (Q. ilicifolia Wagn. and Q. nigra L.) have been reported for our area, but for apparently sufficient reason have been referred to other species, being in most cases variant forms. (1911 Report p. 91.)

Ten out of the seventeen species reported for Indiana were found in White County. Of the seven remaining species, Q. lyrata Walt., Q. Michauxii Nutt., Q. falcata Michx., are quite restricted to the extreme southwestern counties; Q. stellata Wang., Q. Prinus L., and Q. marylandica Muench., are southern or local; the distribution of Q. Schneckii is discussed above.

PLATE III.

TYPICAL ACORNS

Of Oaks Indigenous to White County.



Just exactly how generally some of the ten species collected are distributed over the county I am unable to say. This matter will be discussed with each species separately.

The White Oaks.

Four species of the White Oak group appear in White County. These in point of number of individuals, rank as follows: (1) Q. alba L. (2) Q. macrocarpa Michx. (3) Q. bicolor Willd. (4) Q. Muhlenbergii Engelm.

Quercus alba L. White Oak. (Sp. Pl. 996-1753.)

The White Oak is one of the most numerous and perhaps the most valuable tree of the county. The largest of these trees, as well as many others of less maturity, have long ago disappeared. Some fairly large trees are, however, still to be found. The species is quite generously distributed over the entire county.

The White Oak is readily distinguished from other oaks in spite of the fact that it shows much diversity, in nearly all parts, among individuals of its own small group or species. The bark character varies on many trees. On most younger trees and on many older ones it is comparatively thin and flaky. On not infrequent large trees it is rather deeply fissured with a thickness approaching three inches or more. The outer appearance of the bark on these trees is a peculiar gray as a rule, the inner part being a rich brown.

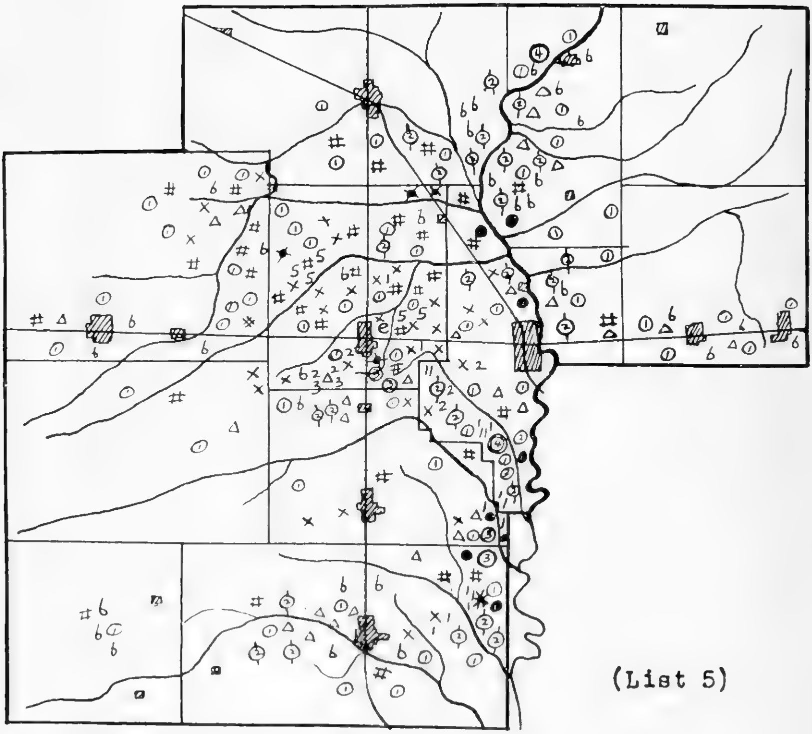
The leaves vary considerably in size and shape. Specimen No. 289 (p. 410), is the typical form. Nos. 443 and 257, also No. 446, show slight variation in size and shape. The leaves in No. 283 show a tendency toward less deep lobing and the one with the lobes more divergent are still further amplified in No. 467, giving a hint toward the leaf character of Q. stellata Wang. No. 292 is simply a large shallow lobed form. The lobes of Nos. 469 (p. 417) and 282 (p. 418) are extremely shallow and, by an amateur, the latter may be almost mistaken for the Swamp White Oak (Q. bicolor Willd.).*

A decided difference is also noted in the thickness of twigs and size of the winter buds in different individuals. In some, Nos. 469 (p. 417) and 282 (p. 418), the twigs are especially thin with correspondingly

* See Q. bicolor p. 411 for distinguishing leaf characters.

PLATE IIIi.

WHITE COUNTY.



General Distribution of the Oaks and Hickories

HICORIA

1 cordiformis(Wang)Brit.
2 ovata (Mill) Brit.
3 ovata var.fraxinifolia Sarg.
4 laciniosa (Michx.f.) Sarg.
5 alba (L) Brit.
6 unidentified.

(These ranges are incomplete).

QUERCUS

① alba L.
② macrocarpa Michx.
③ bicolor Willd.
④ Muhlenbergii Engelm.
● rubra L.
× palustris Muench.
✖ coccinea Muench.
e ellipsoidalis E.J.Hill.
velutina Lam.
△ imbricaria Michx.
* -------? (See p.52).

small buds, due perhaps mostly to general shading of the trees from which these specimens were taken. In others, of which No. 446 (p. 414) is an example, the twigs are particularly heavy and large. This specimen also shows a decidedly vigorous type of acorn with a long stalk and a broad cup.

Some of the differences are so conspicuous and constant for a number of individuals that there appears to be several races or varieties in this species.

Scarcely more than a third of the counties (33) have reported this well-known tree. It would be interesting for others while reporting this species to note if these racial characteristics, if such, are found.

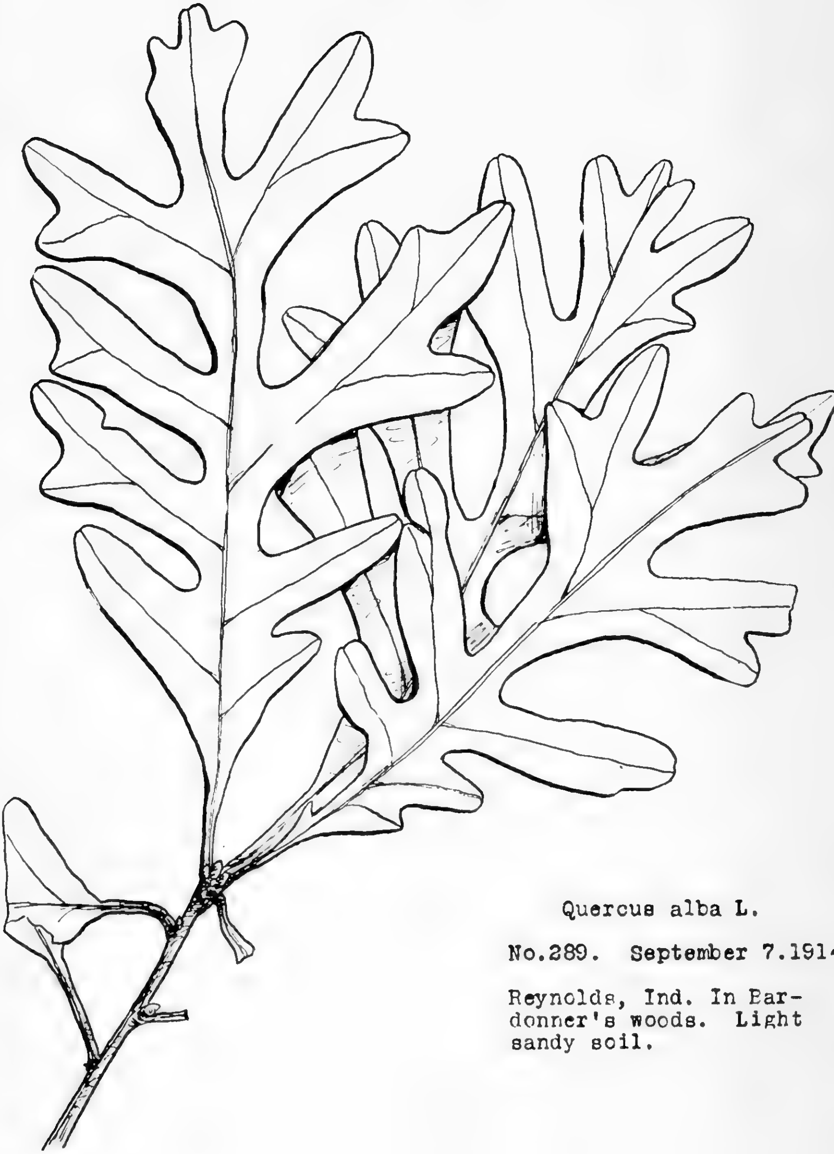
Quercus macrocarpa Michx. Mossy-cup, Blue or Bur Oak, Mossy-cup White Oak, Scrub Oak. (Hist. Chen. Am. 2 pl. 23, 1801. Q. olivaeformis Michx. f. 1812.)

The Bur Oak is more widely spread than perhaps any other oak in the United States. It has been reported from 30 counties in Indiana. In White County it occurs chiefly along the Tippecanoe and the lower stretches of the creeks emptying into that river. Not many trees were noted west of the Monon Railroad. A single tree of fair size, about three miles directly north of Reynolds, enjoys an isolation by a radius of several miles. A number of this species are to be found about two miles south of Reynolds. I very much doubt its occurrence in Princeton Township and likewise for Westpoint. It does, however, occur west of these places, for I have seen it in abundance along Carpenter Creek in Jasper County, near Remington. It is usually found in moist, rich soil, near or some small distance from streams. Specimens were taken from trees near the Ward School, three and three-fourths miles southeast of Reynolds. The Bur Oak leaves an impression of a rather coarse appearing tree throughout, easily distinguished from all other oaks.

Quercus bicolor Willd. Swamp White Oak. (Neue Schrift Geo. Nat. Fr. Berlin 3:396. 1801), (Quercus Prinus platanoides Lam. 1873. Q. platanoides Sudw. 1893).

The range of the Swamp White Oak in the United States is much more restricted than that of the two other white oaks here reported. In Indiana it is reported from 25 counties (scattering). It is very much less frequent in White County than other oaks. Several trees of

PLATE IV.



Quercus alba L.

No.289. September 7.1914.

Reynolds, Ind. In Bardonner's woods. Light sandy soil.

small size are to be found in Ward's thicket about one mile south of Reynolds. Other trees of this species were noted south of the Dyer school, five and three-fourths miles northeast of Brookston, near the Carroll County line. It is found exclusively in swampy or low, moist, rich soil.

The leaves of the Swamp White Oak are broadly obovate or oblong-ovate, rather coarsely round-toothed or pinnatifid. Unlike the White Oak the veins nearly always end in a glandular sharp tip. In the case of the White Oak there is more often a noticeable depression at the vein ending in the lobe. The bark on the younger branches peels back and curls over in a stiff and persistent papery layer, exposing the new lighter brown bark. This is quite characteristic, as is also the long-peduncled acorns.

Quercus Muhlenbergii Engelm. Chestnut or Yellow Oak, Chinquapin or Chinkapin, Oak, Tanbark Oak, etc. (Trans. St. Louis Acad. 3:391. 1887), (Q. Prinus acuminata Michx. 1801. Q. acuminata Sarg. 1895.)

This oak is reported from 35 counties in all parts of the State. It is sometimes confused with Q. Prinus L., resembling it closely, as the historical account above indicates. In White County it was noted only along the Tippecanoe River. The acorns readily distinguish it from other oaks indigenous to White County.

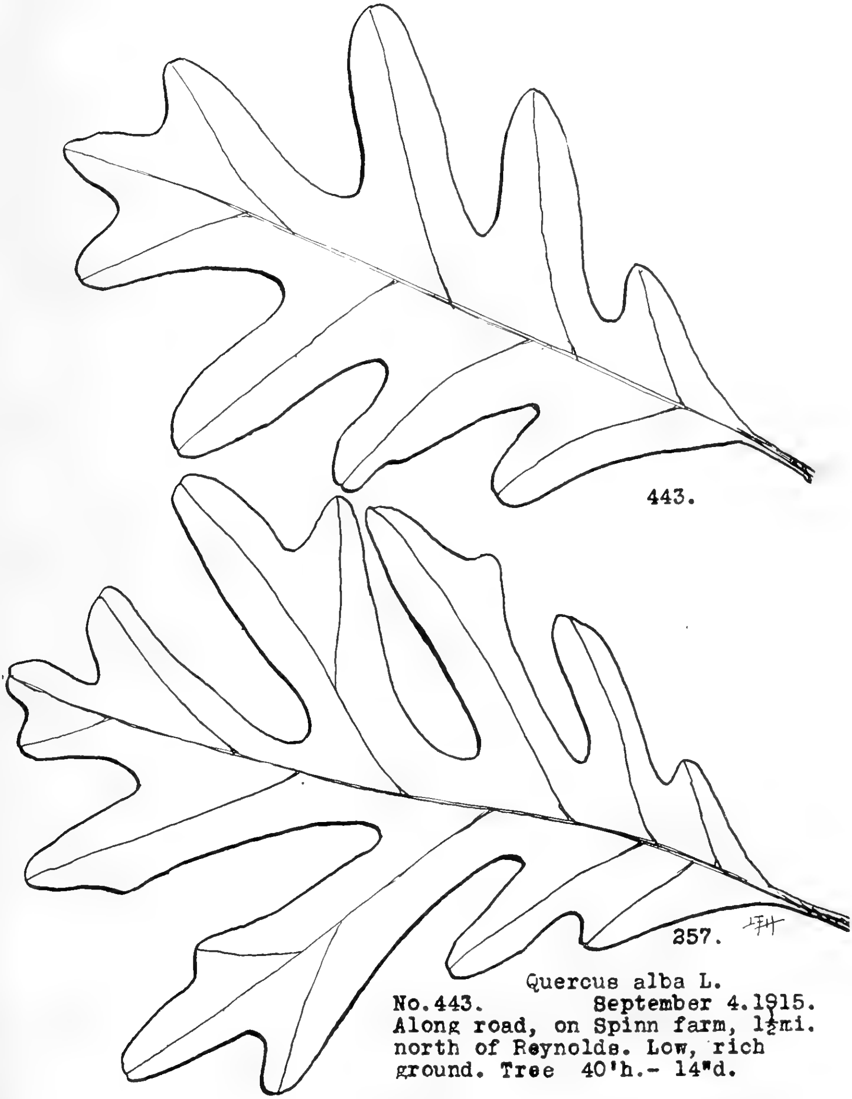
PLATE V.

Quercus alba L.

No.292. September 7.1914.

Reynolds, Ind. In Bardonner's woods. Light, sandy soil.

PLATE VI.



Quercus alba L.

No.443. September 4.1915.
Along road, on Spinn farm, 1½mi.
north of Reynolds. Low, rich
ground. Tree 40'h.- 14"d.

No.357. September 7.1914.
Scearcy farm, 1 mi. north-east
of Reynolds. Low,rich,black soil.
Tree 40'h.- 12"d.

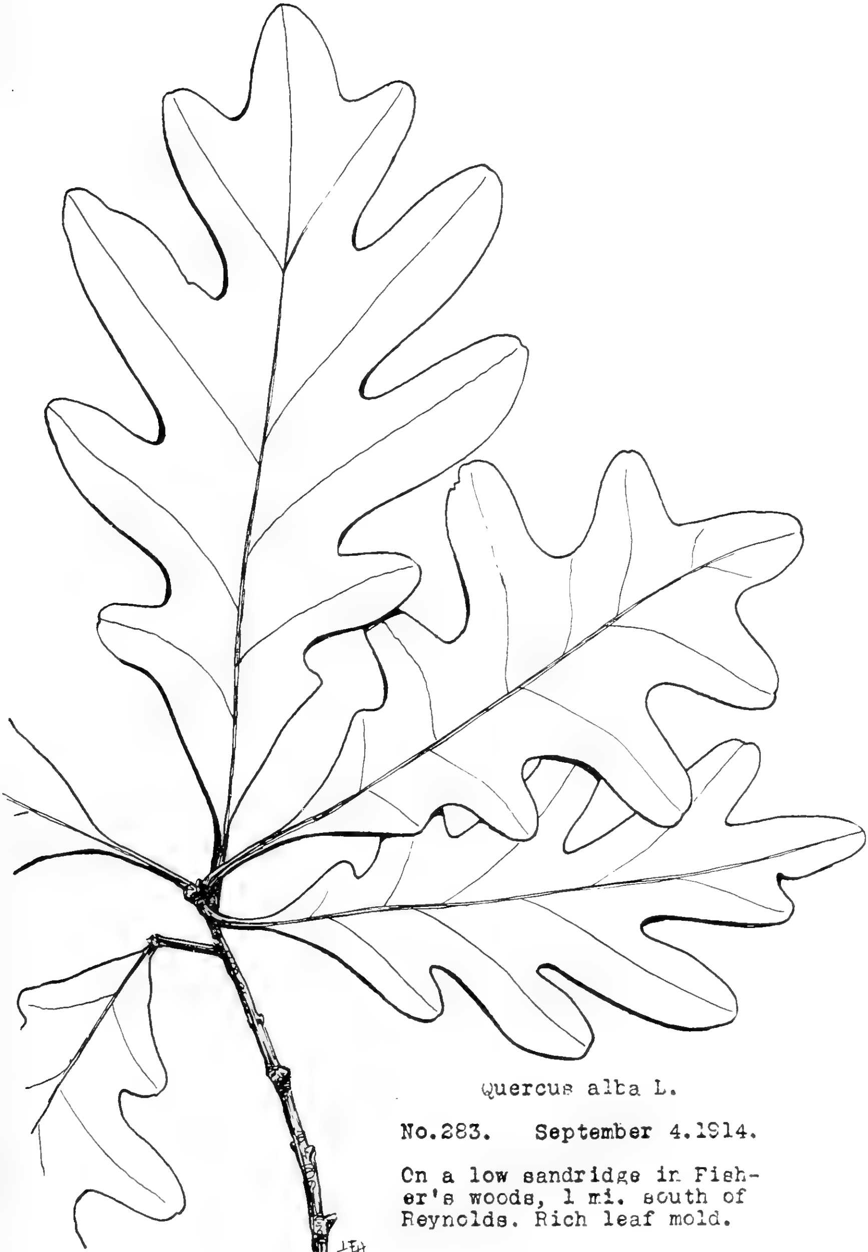
PLATE VII.

Quercus alba L.

No.446. September 4.1915.

North side of road, near Westfall farm house, 3 mi. north of Reynolds. Low elevation, a rich- sandy soil.

PLATE VIII.



Quercus alba L.

No.283. September 4.1914.

On a low sandridge in Fisher's woods, 1 mi. south of Reynolds. Rich leaf mold.

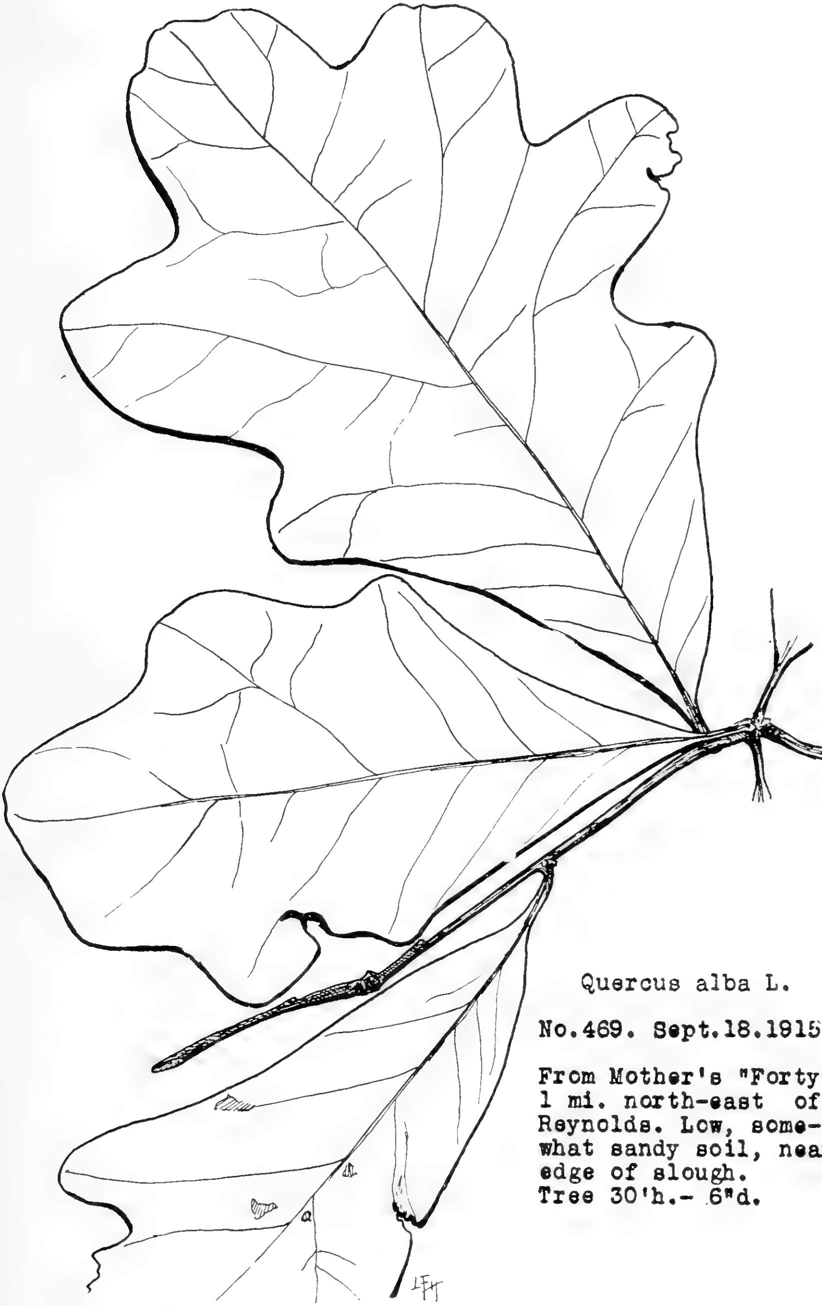
PLATE IX.

Quercus alba L.

No.467. Sept.18.1915.

Specimen from Mother's
"Forty", 1 mi. north-
east of Reynolds. Low,
somewhat sandy soil,
near edge of slough.
Tree 35'h.- 6"d.

PLATE X.



Quercus alba L.

No.469. Sept.18.1915.

From Mother's "Forty"
1 mi. north-east of
Reynolds. Low, some-
what sandy soil, near
edge of slough.
Tree 30'h.- 6"d.

PLATE XI.

Quercus alba L

No.282. September 4.1914.

Near edge of a low sand-
ridge, in Fisher's woods,
1 mi. south of Reynolds.
Tree 40'h.- 10"d.

PLATE XII.

Quercus bicolor Willd.

No.456. Sept.7.1915.

Along road,5$\frac{1}{4}$mi.north-
east of Brookston,Ind.
South of Dyer school.
Low, rich,black soil.
Tree 30'h.- 6"d.
Swamp White Oak.

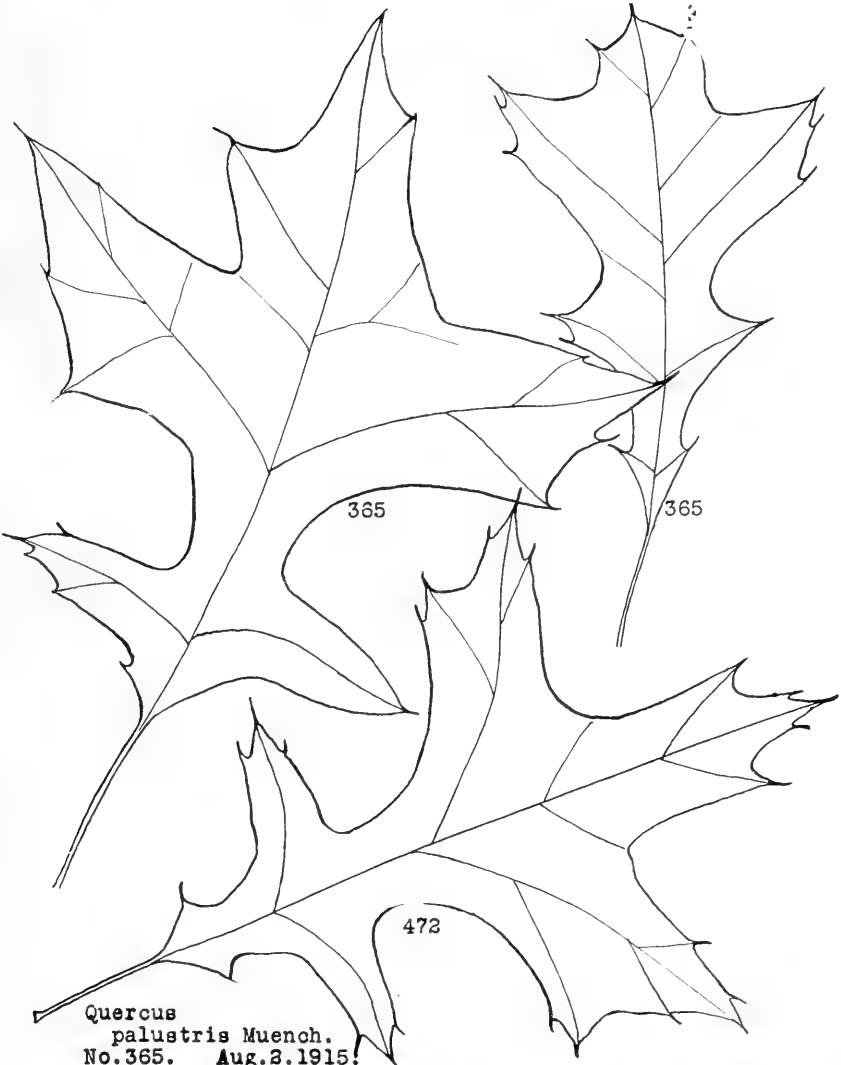
PLATE XIII.

Quercus bicolor Willd.

No. 448. Sept. 6. 1915.

In Ward's thicket, 1mi.
south of Reynolds, Ind.
Low, rich soil- swampy.
Tree 25'h.- 4"d.
Swamp White Oak.

PLATE XIV.



Quercus
palustris Muench.
No.365. Aug.3.1915!

In Ward's thicket, 1 mi. south of Reynolds. Low, moist, black soil. Swampy Tree 40'h.- 7"d.
Determined by Sargent.

No.472. Sept.18.1915.

Bordering north and east edge of an old slough, low, rich, black soil. Mother's Forty, 1 mi.e.of Reynolds.
Tree 40'h.- 8"d.
Determined by Sargent.

Quercus palustris
Muench.
No.473. Sept.18.1915.

On border of an old slough. Low, rich, black soil. Mother's Forty, 1 mi. east of Reynolds.
Tree 50'h- 10"d.

PLATE XV.

Quercus palustris Muench.

No.251. Sept. 3. 1915.
Edge of a wooded sandridge,
low, moist, rich, black soil.
Bunnell's, east of Reynolds.
Tree 30'h.-6"d.

PLATE XVI.

RANGE OF

Quercus alba L.

IN THE UNITED STATES AND INDIANA.

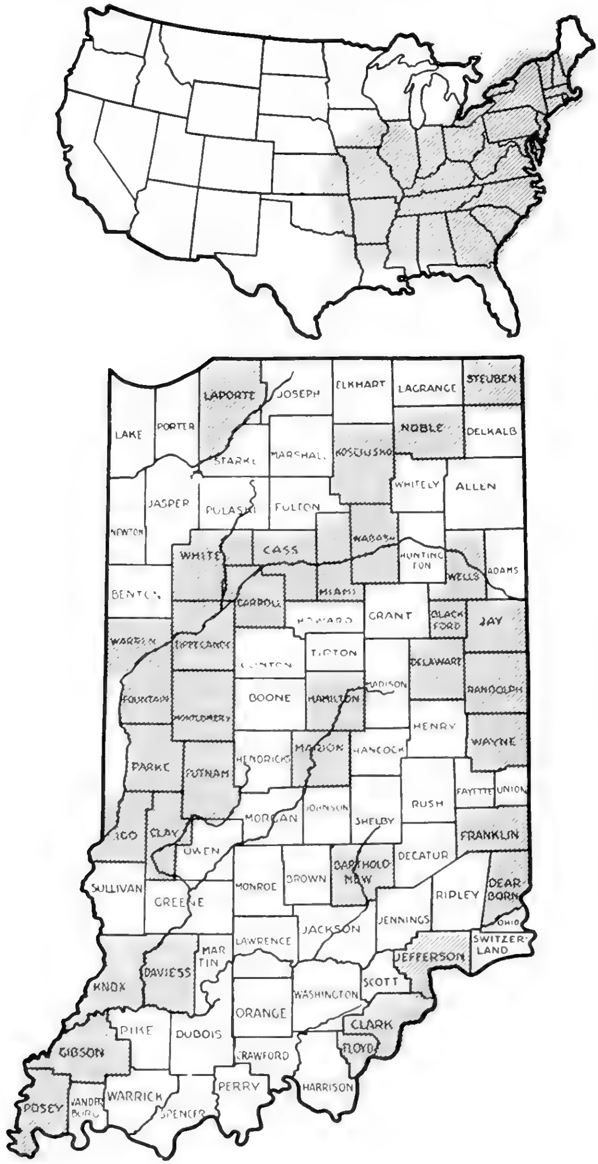


PLATE XVII.

RANGE OF
Quercus macrocarpa Michx.
IN THE UNITED STATES AND INDIANA.

PLATE XVIII.

RANGE OF
Quercus bicolor Willd.
IN THE UNITED STATES AND INDIANA.

PLATE XIX.

RANGE OF
Quercus imbricaria Michx.
IN THE UNITED STATES AND INDIANA.

PLATE XX.

RANGE OF
Quercus palustris Du Roi.
IN THE UNITED STATES AND INDIANA.

PLATE XXI.

RANGE OF

Quercus coccinea Muench.

IN THE UNITED STATES AND INDIANA.

The Black Oaks.

The Black Oaks form a difficult group in the identification of species. Numerically, the individuals in members of this group are many and well distributed over White County.

Quercus imbricaria Michx. Shingle Oak, Lea, Jack or Laurel Oak. (Hist. Chen. Am. 9 pl. 15, 16. 1801.)

This oak has been reported from 25 counties in Indiana and no doubt occurs in many others. It is the only entire-leaved oak in White County, and in our area it is a medium-sized tree. Specimens were found east of Monon, northwest of Reynolds, up in Princeton township, also southwest and east of Reynolds, at Norway, east of Chalmers near Big Creek, and east of Brookston. In a small grove just northwest of Brookston it forms an almost pure stand of fair-sized trees. It occurs in rich, moist soils or near the edges of low sand ridges.

Quercus palustris Muench. (and DuRoi?) Pin Oak, Swamp Oak, Swamp Spanish Oak. (Harbk 2:268 pl. 5-14. 1772.)

Q. palustris has been reported from 26 counties. It is said to be less frequent in the northern tier of counties. In White County it is frequent in low places, associated with other black oaks, but occupying the borders of former swamps rather than higher soil of the other nearby oaks. It is readily distinguished by its small acorns, small, thin, shallow cups, smoother bark than other indigenous oaks, wide divergent leaf lobes, and tardy pruning deflexed dead branches. (See pp. 421-423, 428.)

Quercus coccinea Wang. Scarlet Oak. (Amer. 44 pl. 4 f. 9. 1787.)

Though common throughout Indiana, the published records of this oak include but 16 counties. It is more or less common in White County. The fairly large top-shaped cup (2.5 cm. or more broad), with its glabrous, glossy, closely appressed brown scales or bracts about half enclosing the oblong-ovoid nut with its white kernel, makes this species readily recognizable.

Quercus velutina Lam. Black Oak, Quercitron, Yellow-bark Oak. (Encycl. 1:721. 1783. Q. tinctoria Bartram. Name only, 1791. Q. coccinea var. tinctoria A. Gray, 1867.)

Velutina is a very common species of oak in White County. It is also rather common in the State, being reported from 25 counties. It is said to consist of several races, differing in leaf-lobing, amount of pubescence, and size of acorns. The large, somewhat loose bracts of the acorns with the upper ones rather squarrose or tips horizontally wrinkled are characteristic. Leaves which I have taken from sucker growth measure over a foot in length and over 9 inches in breadth. They are very variable—some are deeply lobed, others almost entire. The leaves on vigorous trees are also often comparatively large. The inner bark is a deep orange. Chewed bits of the twigs are said to give the saliva a yellowish discoloration in contradistinction to the Red Oak and the Scarlet Oak, if not as well for other black oaks. (See pp. 406, 408, 429.)

Quercus ellipsoidalis E. J. Hill. Hill's Oak. (Pin Oak, Yellow or Black Oak. Bot. Gaz. 27:204. 1899.)

There is no certainty how plentiful this oak is in White County. Sargent has verified a specimen taken about a mile northeast of Reynolds on a low sand ridge. The tree was about 30 feet high and 6 inches in diameter. "In Indiana it has been reported from Lake County only." Very likely it will be found to occur at points between White County and Lake Michigan.

Quercus rubra L. Red Oak. (Sp. pl. 996. 1753.)

This is the "largest and most valuable of the biennial oaks." It is distributed throughout the State. In White County it is rather restricted to the Tippecanoe area. The leaves are usually much less deeply lobed than those of the other black oaks. The acorn when mature is usually larger than the acorns of any other White County oak, except macrocarpa. (See p. 406.)

Quercus . . . ?

A rather peculiar specimen of oak was taken about four and one-fourth miles northeast of Brookston, in an oak forest on low, rich, black soil. Two such trees were growing just beside each other. The bark is close, almost black, and shallow fissured. These trees were about 45 feet high and 10 inches in diameter. Leaf specimens with twigs, buds and acorns were collected on September 7, 1915.

From the specimens and data at hand, at least three authorities have disagreed as to the status of this oak. All say it is a variable

PLATE XXII.

Quercus -------?

No. 455. Sept. 7. 1915.

Near road, in forest on
low, rich, black soil,
$4\frac{1}{4}$ mi. N.E. of Brookston.
Trees (2) 45'h.- 10"d.
----See discussion pp.52
and 53.

form and admit the difficulty of determination. It has been said to be a variable form of Q. texana Sarg., not Buckley ?, possibly synonymous with Q. Schneckii Brit. Q. borealis Michx., or Q. falcata Michx., or a hybrid of these two have been mentioned, as has also Q. velutina Lam.

My own idea coincides exactly with none of these. Q. borealis Michx. does not occur in the State, so far as known. Not a single reference to it is made in either Coulter's Catalogue or Deam's 1911 Report. Q. falcata Michx. has been reported from but three counties in the State, viz., Gibson, Posey and Fountain, which last is somewhat exceptional. Evidently the specimen under consideration is neither of these or could possibly be a hybrid of them. Since more or less doubt shrouds the texana-Schneckii determination from more than one standpoint, and since these are the same or different species according to different authors, I hesitate in applying either name, whether of the same or different species.

Q. velutina Lam. does not seem to be very conclusive.

The supposed typical leaves, fruit, etc., used in various keys for the same species many times, vary considerably. So in this case. The leaves in this instance compare very favorably with those shown for Q. rubra L., in Hough's Handbook of the Trees of the Northern States and Canada.

I have associated it most closely with Q. rubra L., being a rather variable form of that species or a hybrid of it with velutina or coccinea. I add this note from Hough's handbook: "Gray's Oak, Q. borealis Michx. f., (also Q. ambigua Michx. f.), a large tree, occasionally found from Ontario to Quebec to the mountains of North Carolina, bearing leaves like Q. rubra L., and fruit like Q. coccinea. It is considered by some a distinct species and by others, and probably more correctly, only an aberrant form of Q. rubra L."

3. The Hickories.

With a Revised List for the State.

The Hickories are very difficult of determination and authors are by no means agreed. If I may venture upon a suggestion, it seems to me that a more careful, thorough and extensive study *in the field* is necessary before the genus can be satisfactorily divided into its species and varieties.

In the first place, the group has been favored with three genus names, viz., Juglans (L. 1753.); Hicoria (Raf.—1808.—Scoria Raf. 1808, Hicorius Raf. 1817, Hicoria Raf. 1836.); and Carya (Nutt. 1818.).

The walnuts and butternuts and our present hickories were all included under the term Juglans. The group was split up on the strength of whether the husk was dehiscent or not, and of course the so-called hickories emerged as a separate genus. Without going further into the historical side of the matter, both Hicoria and Carya as a genus name are commonly applied. I favor the term Hicoria, derived from the aboriginal or American Indian name with its apparent priority in print. Be this, however, as it may, the names and descriptions given to species are infinitely more troublesome.

The last 7th Edition, of Gray's Manual, describes eight species with all of these, possibly excepting Hicoria aquatica, within the borders of Indiana. Britton and Brown, new (2nd Ed.) Flora, contains 12 species, including but the same species as given in Gray for Indiana. Doubt shrouds several of these species as admitted in the texts.

Deam's 1911 Report lists seven species as occurring in Indiana. Except in name, this checks exactly foı those given in Coulter's Catalogue. Very brief notes on the Indiana species are noted below, old and new records are given in a list following these notes.

1. *Hicoria Pecan (Marsh) Brit.* Pecan, Illinois Nut, Soft-shell Hickory. (See p. 436.)

This tree does not occur in White County. Its range as given in the 1911 Report is the lower Wabash and lower stretches of its tributaries. (See p. —.) Without doubt this species occurs in some as yet unreported counties. In a letter from Mr. Deam, Jan. 31, 1916, he says that H. Pecan extends up the Ohio Valley at least as far as Clark County. This species and the next are not difficult of determination.

2. *Hicoria cordiformis (Wang) Brit.* Bitter-nut, Swamp Hickory, Pig-nut, etc. (See p. 436.)

This species is said to occur throughout Indiana, being, however, nowhere abundant (Deam 1911 Report). In White County it is perhaps the most abundant in the central townships.

3. *Hicoria ovata (Mill) Brit.* Shagbark, Shellbark Hickory, etc. (See p. —.)

Common in all parts of Indiana. Common in White County in rich, moist soils or the edges of sand ridges. Sargent has split the species by designating two varieties. (See p. 437.)

(a) *Hicoria ovata fraxinifolia Sargent.*

As noted in the appended list, this variety occurs in three other counties besides White. Without attempting any description here, I simply add that Sargent verified a specimen for me, taken one and one-half miles southwest of Reynolds.

(b) *Hicoria ovata var. Nuttallii Sargent.*

This variety occurs in Indiana according to two determinations by Sargent. Specimens were taken in Dekalb County, south of Auburn. Leaflets 5. (Deam's Nos. 19, 291, 19, 293.)

4. *Hicoria laciniosa (Michx. f.) Sarg.* Big Shagbark, Kingnut, etc. (See p. 437.)

This species bears a close resemblance to the preceding species. At this time I am unable to define its distribution in White County other than to say that it occurs in Honey Creek Township. Rich soil, edges of sand ridges.

5. *Hicoria microcarpa (Nutt) Brit.* Small-fruited Hickory, Little Pig-nut or Shag-bark.

The habitat and range of this species has not been well studied (Deam 1911 Report). Sargent now calls the old microcarpa, ovalis—Carya ovalis Sarg.—or Hicoria ovalis, and has singled out no less than four varieties under the species. Since hickories are more or less abundant in White County this species with one or more of its varieties may be found there. I say this in view of my limited number of specimens and its reported occurrence in Tippecanoe County. (See list p. 437.)

6. *Hicoria alba (L) Brit.* White Hickory, Bull-Nut, Mocker Nut, etc.

Said to be rather rare in the northern part of the State. Locally more or less abundant in Honey Creek Township (White County), which with its low sand ridges is more suited to its drier situations.

7. *Hicoria glabra (Mill) Brit.* Black Hickory, Pignut, etc.

Sargent now styles this species porcina. I have taken no specimens of it in White County, but owing to its wide distribution it seems reasonable to expect it there.

(a) *Hicoria glabra var. megacarpa Sargent.*

Another of Sargent's new varieties. "Franklin County, on high ground, west of Metamora. Bark tight, leaflets 5."

Without further comment I am permitted to add the following revised list for this very puzzling genus Hicoria. The determinations represent Sargent's latest efforts.

(List 6.)

Revised List of Hickories for Indiana.

The determination of all the new records were made by Sargent. Specimens of these new records were collected by C. C. Deam, Prof. G. N. Hoffer and by myself, and are deposited in the Deam Herbarium, Bluffton, Ind.; Purdue Herbarium, Purdue University; Arnold Arboretum, Harvard University, and in my own herbarium. The chief change noted in the revised list is Sargent's recognition of seven new varieties.

1. Hicoria Pecan (Marsh) Brit. Pecan, Illinois Nut, Soft-shell Hickory. Juglans Pecan Marsh. 1785; Carya olivaeformis Nutt. 1818; Carya illinoiensis (Wang) K. Koch. ?; H. Pecan Brit. 1888.

Old Records: Franklin (Meyncke—from a cultivated tree?); Gibson (Schneck); Jefferson (Young); Knox (Thomas); Posey (Schneck), (Deam) and (Wright); Vigo (Blatchley).

No new records.

2. Hicoria cordiformis (Wang) Brit. Bitter-nut, Swamp Hickory, etc. J. alba minima Marsh. 1785; J. cordiformis Wang. 1787; C. amara Nutt. 1818; H. minima Brit. 1888; H. cordiformis Brit. 1908.

Old Records: Carroll (Thompson); Delaware, Jay, Randolph and Wayne (Phinney); Fountain (Brown); Franklin (Meyncke); Gibson and Posey (Schneck); Hamilton and Marion (Wilson); Knox (Ridgway); Noble (VanGorder); Parke (Hobbs); Steuben (Bradner); Vigo and Monroe (Blatchley); Wayne (Petry and Markle); Montgomery (Thompson); Posey (MacDougal and Wright); Putnam (Grimes); Tippecanoe (Coulter); Adams, Delaware, Hamilton, Jennings, Knox, Montgomery, Owen, Vermillion, Warren and Wells (Deam).

New Records: Allen, Bartholomew, Fountain, Franklin, Johnson, Knox, Switzerland (Deam and Hoffer); White (Heimlich).

3. Hicoria ovata (Mill) Brit. Shag-bark, Shell-bark Hickory, etc. J. ovata Mill. 1768; C. alba Nutt. 1818, not J. alba L.; H. ovata Brit. 1888.

Old Records: Cass and Tippecanoe (Coulter); Clark (Baird and Taylor); Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Meyncke); Gibson (Schneck); Hamilton and Marion (Wilson); Knox (Ridgway) and (Thomas); Kosciusko (Clark) and (Scott); Posey (Schneck) and (MacDougal and Wright); Vigo (Blatchley); Wayne (Petry and Markle); Jefferson (Young); Monroe (Blatchley); Montgomery (Evans); Putnam (Grimes) and (MacDougal); Clark, Delaware, Hamilton, Jennings, Owen, Posey, Steuben and Wells (Deam).

New Records: Allen, Clark, Crawford, Franklin, Gibson, Jay, Knox, Owen, Pike, Steuben and Wells (Deam and Hoffer); White (Heimlich).

3. Hicoria ovata (Mill) Brit.

(a) var. fraxinifolia Sarg. 1916. Ash-leaved Shag-bark or Shell-bark Hickory.

No old records.

New Records: Daviess, Martin, Wells (Deam and Hoffer); White (Heimlich).

(b) var. Nuttallii Sarg. 1916.

No old records.

New Records: Dekalb (Deam).

4. Hicoria laciniosa (Michx. f.) Sarg. Big Shag-bark, King Nut, etc. C. sulcata Nutt. not J. sulcata Willd.; J. laciniosa Michx. f. 1810; H. sulcata Brit. 1888; H. laciniosa Sarg. 1894.

Old Records: Carroll (Thompson); Clark (Smith); Dearborn (Collins); Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Meyncke); Gibson and Posey (Schneck); Jefferson (Coulter) and (Young); Knox (Ridgway); Kosciusko (Clark); Miami (Gorby); Noble (VanGorder); Parke (Hobbs); Putnam (Grimes); Steuben (Bradner); Tippecanoe (Coulter); Vigo (Blatchley); Harrison, Marion, Posey, Vermillion and Wells (Deam).

New Records: Allen, Bartholomew, Floyd, Gibson, Jay, Jefferson, Martin, Washington, Wells (Deam and Hoffer); White (Heimlich).

5. Hicoria ovalis. (C. ovalis Sarg. 1916.) H. microcarpa (Nutt) Brit. J. alba odorata Marsh. 1785; C. microcarpa Nutt. 1818; H. microcarpa Brit. 1888; H. glabra var. odorata Sarg. 1895. Small-fruited Hickory, Little Pignut or Shag-bark.

Old Records: Clark (Baird and Taylor); Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Meyncke); Gibson (Ridgway) and (Schneck); Hamilton and Marion (Wilson); Jefferson (Coulter) and (Young); Knox (Ridgway); Kosciusko (Scott); Miami (Gorby); Posey (Schneck) and (MacDougal and Wright); Tippecanoe (Coulter); Laporte, Vermillion, Warren and Wells (Deam).

New Records: Allen, Bartholomew, Daviess, Floyd, Franklin, Gibson, Jay, Lagrange, Lawrence, Steuben, Sullivan, Washington, Wells (Deam and Hoffer).

5. Hicoria ovalis. (Carya ovalis Sarg.)

(a) var. odorata Sarg. 1916.

No old records.

New Records: Allen, Jefferson, Lagrange, Steuben and Wells (Deam and Hoffer).

(b) var. obovalis Sarg. 1916.

No old records.

New Records: Grant, Jackson, Lagrange, Steuben, Washington and Wells (Deam and Hoffer).

(c) var. obcordata Sarg. 1916.

No old records.

New Records: Grant, Lagrange, Porter and Wells (Deam and Hoffer).

H. ovalis. (C. ovalis Sarg.)

(d) var. ...... ??

No old records.

New Records: "These specimens seem to be a new variety," Sargent 1916. No name has been given. Specimens are from Knox and Gibson (Deam and Hoffer).

6. Hicoria alba (L) Brit. White-heart Hickory, Mocker-nut, Bull-nut, etc. J. alba L. 1753; J. tomentosa Lam. 1797; C. tomentosa Nutt. 1818; H. alba Brit. 1888.

Old Records: Cass (Benedict and Elrod); Clark (Baird and Taylor) and (Smith); Dearborn (Collins); Fountain (Meyncke); Gibson and Posey (Schneck) and (Deam); Hamilton and Marion (Wilson); Jefferson (Coulter) and (Young); Knox (Ridgway); Kosciusko (Clark) and (Scott); Miami (Gorby); Vigo (Blatchley); Wabash (Benedict and Elrod); Tippecanoe (Coulter).

New Records: Daviess, Franklin, Harrison, Jackson, Jay, Jefferson, Knox, Lawrence, Sullivan, Washington (Deam and Hoffer); White (Heimlich).

7. Hicoria porcina. (C. porcina Sarg. 1916.) Pignut Hickory, Black Hickory. *Hicoria glabra* (Mill) Brit. J. glabra Mill. 1768; C. porcina Nutt. 1818; H. glabra Brit. 1888; H. glabra hirsuta Ashe. 1896.

Old Records: Cass and Wabash (Benedict and Elrod); Carroll (Thompson); Clark (Baird and Taylor) and (Smith); Dearborn (Collins); Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Haymond) and (Meyncke); Gibson and Posey (Schneck); Hamilton and Marion (Wilson); Jay (McCaslin); Jefferson (Coulter) and (Young); Knox (Ridgway) and (Thomas); Noble (VanGorder); Parke (Hobbs); Putnam (Grimes) and (MacDougal); Steuben (Bradner); Tippecanoe (Coulter); Vigo (Blatchley); Delaware, Owen, Posey and Warren (Deam).

New Records: Crawford, Floyd, Franklin, Harrison, Lawrence, Martin, Sullivan (Deam and Hoffer).

7. Hicoria porcina. (Carya porcina Sarg.)

(a) var. megacarpa Sarg. 1916.

No old records.

New Records: Franklin (Deam).

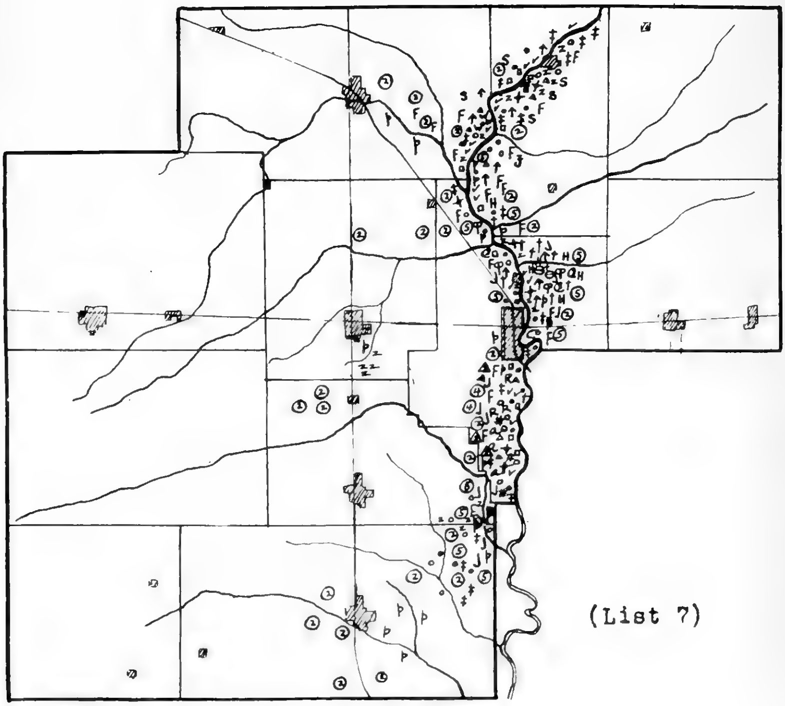
4. Trees Restricted to the Tippecanoe River Banks.

As indicated by the list and map on page 440, about half (23 out of 62) the species found in White County are totally or in some cases nearly exclusively confined to the Tippecanoe River banks. Some few of these are found at a distance from the river or the lower stretches of creeks. These include the Bur Oak, the Prickly Ash and others.

Though not restricted to the above area, the Red Cedar, the Black Walnut, Sassafras, and a few others, receive their best development in the vicinity of the Tippecanoe. The largest sassafras trees were noted near Buffalo, east bank of the river; the most abundant and largest

PLATE XXIII.

WHITE COUNTY.



(List 7)

...Trees Restricted to the Tippecanoe River Banks...

②	Quercus macrocarpa Michx.	#	Gymnocladus diocia(L)Koch.
④	Muhlenbergii Engelm.	R	Robinia Pseudo-acasia L.
⑤	rubra L.	a	Aesculus glabra Willd.
℗	Populus heterophylla L.	F	Fagus grandifolia Ehrh.
z	Zanthoxylum americanum Mill.	↑	Ptelea trifoliata L.
⚠	Acer nigrum Michx.	⍑	Staphyllea trifoliata L.
J	Juglans cinerea L.	Ⓒ	Cornus florida L.
þ	Platanus occidentalis L.	Ⓐ	alternifolia L.f.
•	Liriodendron Tulipifera L.	†	Asimina triloba (L)Dunal.
✕	Celtis occidentalis L.	‡	Carpinus caroliniana L.
∘	Ostrya virginiana (Mill)Willd.	H	Hamamelis virginiana L.
△	Cercis canadensis L.	w	Betula lutea Michx.
▫	Tilia americana L.	✱	Crataegus albicans Ashe ?
✓	Gleditsia triacanthos L.		

Cedars were seen south of Monticello, especially along the lower course of Big Creek. (See map, p. 451.)

Quercus macrocarpa Michx. See p. 409.

Quercus Muhlenbergii Engelm. See p. 411.

Quercus rubra L. See p. 431.

Populus heterophylla L. Swamp or Downy Poplar, River- or Swamp Cotton-wood., Balm-of-Gilead. In Indiana this tree is "rare and local, except in the lower Wabash bottoms." The published records of the distribution are as follows: Delaware, Jay, Randolph and Wayne (Phinney); Franklin (Meyncke); Gibson and Posey (Schneck); Hamilton (Doane); Jay (McCaslin); Knox (Ridgway); Miami (Gorby); Vigo (Blatchley); Blackford, Laporte, Posey, Wells (Deam).

I found specimens near the Carroll County line, five and three-fourths miles northeast of Brookston, in low, rich soil; trees 25 or more feet high and up to 6 inches in diameter. (See p. 454 for other species of Populus.)

Acer nigrum Michx. Black Sugar Maple, Black or Hard Maple. I cannot speak with certainty of the exact distribution of maples in the county. Species of this genus are very frequently used as shade trees and all have some escapes. Members of this genus were found in abundance near Buffalo and south along the Tippecanoe. Some trees are also to be found in oak forests of Honey Creek Township. A. nigrum was found about three miles south of Monticello. The group consisted of a number of large trees (70 feet high by 17 inches diameter) on a sandy, gravelly slope. (See other Maples p. 458.)

Juglans cinerea L. Butternut, White or Lemon Walnut, Oilnut. Reported from many counties, but said to occur in very sparing numbers in some. It is rather rare in White County and adheres to the banks of the Tippecanoe. Specimens were taken from fair-sized trees on high, rich, gravelly soil, east of Lowe's bridge, about four miles southwest of Buffalo. (See p. 454 for nigra.)

Platanus occidentalis L. Sycamore, Button-wood, Button-ball, Plane Tree. This is Indiana's distinctive tree. Found in all parts of the State, more or less frequent along streams or the borders of lakes. It has the distinction of being the largest deciduous tree in North America. (Tree at Worthington, Indiana, over 44 feet in circumference and 150 feet high.)

I have seen some comparatively large individuals along the Wabash up to the mouth of the Tippecanoe. It is found along the entire extent of the latter river through White County. It was also found in Honey Creek Township (Ward's thicket), near Spring Creek (J. P. Erickson farm) about three and one-half miles northeast of Brookston, and along Big Creek, four miles east of Chalmers.

Liriodendron tulipifera L. Tulip-tree, Yellow Poplar, Canoe-wood, Lime-tree, White-wood. The published lists for Indiana cover 41 counties. Rather rare in some localities. One of Indiana's largest and most useful trees. Not plentiful, but found along the entire length of the Tippecanoe through White County. "It is practically free from insect and fungous diseases" and is an excellent tree for re-enforcing the woodlot—a good shade tree.

The following trees are more or less common along the Tippecanoe and usually are not found far from the watercourse. Some of them have made their way along the creeks for several miles, notably Spring Creek, east of Brookston, Big Creek, Big Monon, and Pike Creek.

Celtis occidentalis L. Hackberry, etc.

Ostrya virginiana (Mill) Willd. Hop-hornbeam.

Carpinus caroliniana Walt. Am. Hornbeam, etc.

Cercis canadensis L. Red-bud, Judas-tree.

Tilia americana L. Linden, Basswood.

Gymnocladus diocia (L) K. Koch. Coffeenut-tree.

Aesculus glabra Willd. Ohio Buckeye.

Fagus grandifolia Ehrh. Beech.

Cornus florida L. Flowering Dogwood.

alternifolia L. f. Green Osier, etc.

Asimina triloba (L) Dunal. Pawpaw.

Ptelea trifoliata L. Hop-tree, Shrubby Trefoil.

Hamamelis virginiana L. Witch-hazel.

Staphylea trifoliata L. American Bladder-nut.

The last three of the above list are not included in Deam's 1911 Report. These are large shrubs or small trees. There are Ptelea at Norway, 15 feet high and 3 inches in diameter. The foliage when bruised has an unpleasant odor. The fruit is bitter and has been used as a substitute for hops. According to Coulter it is found in Jefferson, Tippecanoe, Monroe, Vigo, Putnam, Gibson, Posey, Jay, Delaware, Randolph, Wayne, Clark, Franklin, Hamilton, Cass and Fayette Counties.

The Witch-hazel is interesting because of its flowering so late in the season (October to December). The bony seeds ripen in early spring and may be "shot" several yards from their capsules. Some shrubby specimens near Norway were eight feet or more high. Distribution given in Coulter's Catalogue: Kosciusko, Laporte, Jefferson, Tippecanoe, Clark, Noble, Delaware, Jay, Randolph, Wayne, Franklin, Monroe, Vigo, Cedar Lake, Hamilton, Putnam and Steuben.

The Bladder-nut, which may be a small tree in the south, is more nearly a large shrub in our area. Specimens seen at Norway were rather tall (perhaps 15 feet high). Distribution given in Coulter's Catalogue: Jefferson, Tippecanoe, Monroe, Vigo, Putnam, Gibson, Posey, Kosciusko, Hendricks, Decatur, Knox, St. Joseph, Hamilton, Marion, Steuben and Fayette.

Gleditsia triacanthos L. Honey Locust. This is a rather characteristic and imposing tree along the Tippecanoe. It is sometimes found along the lower portions of creeks.

Robinia pseudo-acasia L. Common Black Locust. This locust was noted several miles south of Monticello and also near Lowe's bridge. It is cultivated in all parts of the county and escapes are occasionally found.

Betula lutea Michx. Yellow Birch. This species has been confused with Betula lenta, which, according to Deam, does not occur in our area. In Indiana it is rare and local. It has not been reported south of Miami County except in Crawford County, associated with the laurel (Kalmia latifolia), which is the only station of the latter in the State, except possibly another record for Floyd County.

Specimens were taken from two trees about two miles south of Buffalo near the water's edge of the river. These were thought to be different species at first, but they are likely both lutea. It is certain that one is lutea and the other will likely be found to be so when fresh material is available. A mere guess at the height of these trees would place them about 40 feet high. They were associated with maples, ashes, sycamores and honey-locusts.

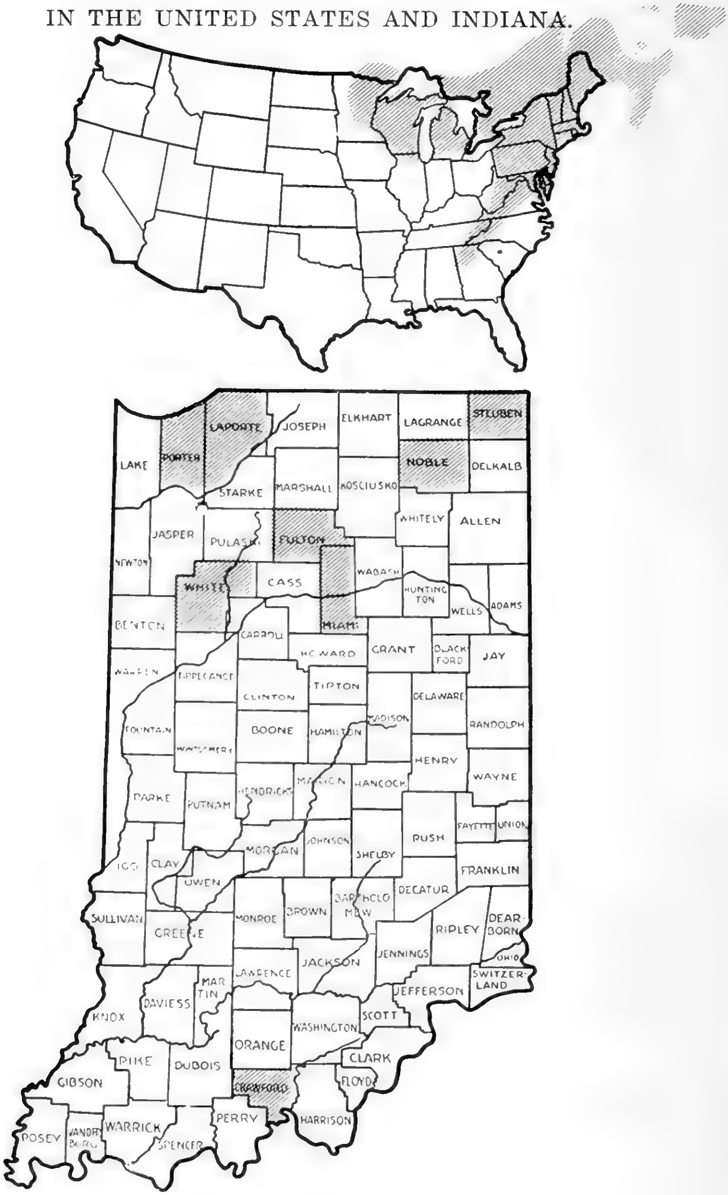
Zanthoxylum americanum Mill. Prickly Ash, Toothache Tree, An-

PLATE XXIV.

RANGE OF

Betula lutea Michx.

IN THE UNITED STATES AND INDIANA.



gelica Tree, etc. This species is conspicuous along some parts of the Tippecanoe (Norway and Buffalo). Several trees were found in Ward's thicket, about a mile south of Reynolds, and also along Big Creek, four miles east of Chalmers. It is variously called a small tree or a large shrub and is not included in the 1911 Report. Some of the specimens found were about 10 feet high and 3 inches in diameter.

In Coulter's Catalogue it is reported from Posey, Vigo, Cass, Kosciusko, Steuben, Jefferson, Randolph, Franklin, Shelby and a dozen other counties.

The Thorns constitute one of the most puzzling genera in the plant kingdom. More field work is necessary before statements of ranges and abundance of each species in White County is possible. It is likely that more species occur in the county than is given here. (See p. 457.)

Crataegus pruinosa (Wendl) K. Koch. Waxy-fruited Thorn. (C. populifolia Ell. 1821; not Walt.; Mespilus pruinosa Wendl. 1823; C. pruinosa K. Koch. 1853; C. Porteri Brit. 1900. Specimens of this thorn were obtained east of Norway across the river in the vicinity of the mouth of Pike Creek. A number of thorn trees are present in this locality, this species being perhaps locally abundant. On gravelly soil, low river bank. Trees 12 feet high, 4 inches in diameter. Determined by Sargent.

Deam says this thorn is well distributed in Indiana. Specimens have been seen from the following counties: Decatur, Delaware, Gibson, Hamilton, Madison, Steuben, Warren, Wells (Deam); Putnam (Grimes).

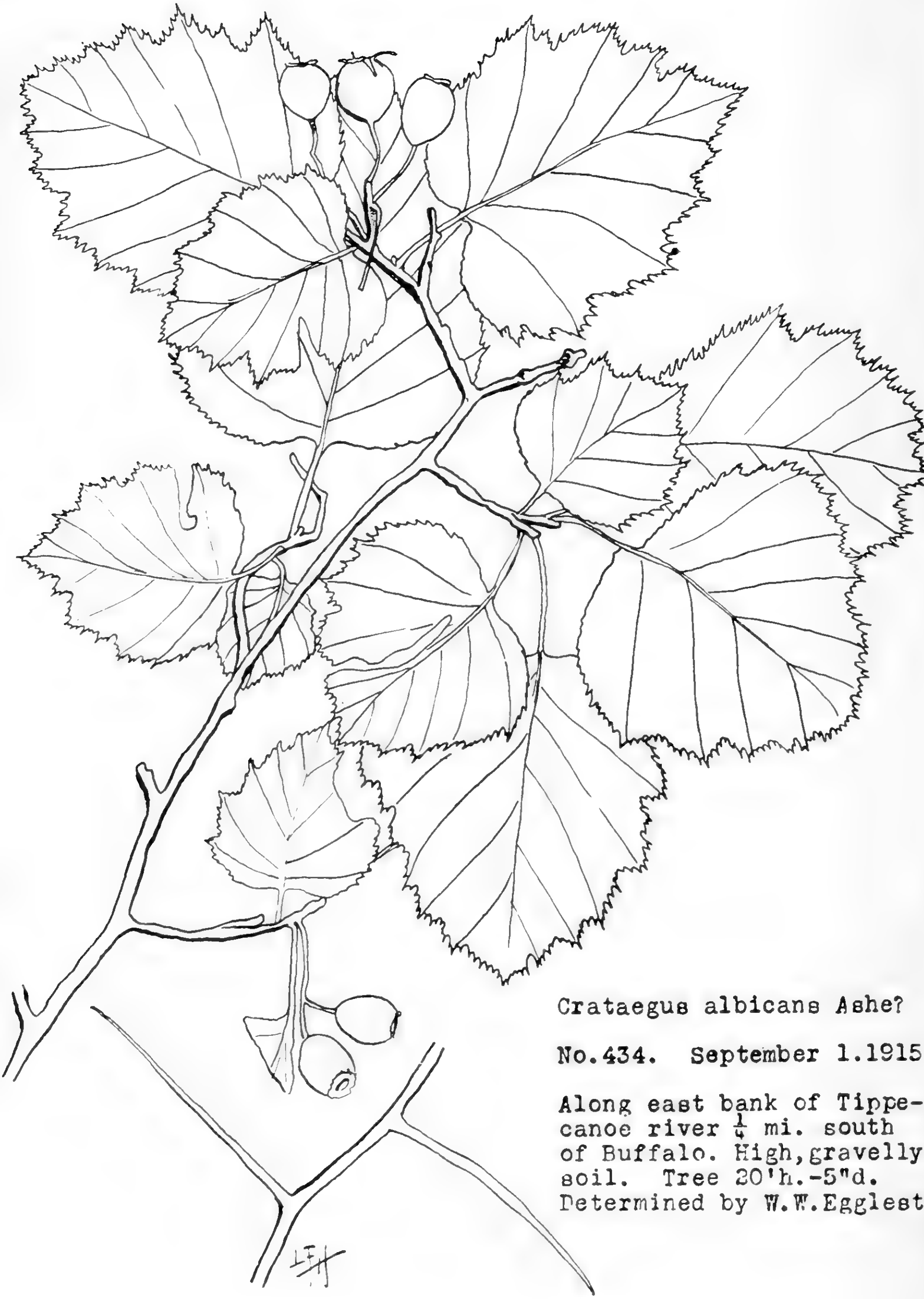
Crataegus albicans Ashe? Tatnall's Thorn. C. albicans Ashe 1901; C. Tatnalliana Sarg. Feb. 1903; C. polita Sarg. Apr. 1903. I quote the following from a letter from W. W. Eggleston: "Your specimen of Crataegus sent me . . . . is received. It belongs in the Coccineae and seems to be C. albicans Ashe? More complete material showing the leaves on the vegetative shoots is desirable to be sure of the identification, for with this material I could not be quite sure that it is not C. coccinea L." Britton and Brown, 2nd Ed., makes the following distinction between the two species:

Leaves on vegetative shoots cuneate, C. coccinea.

Leaves on vegetative shoots cordate, C. albicans.

It will be noted that C. albicans has not been reported as occurring in the State. Its general range is given as "Western New England to

PLATE XXV.



Crataegus albicans Ashe?

No. 434. September 1.1915.

Along east bank of Tippecanoe river ¼ mi. south of Buffalo. High, gravelly soil. Tree 20'h.-5"d. Determined by W. W. Eggleston.

southern Michigan, south to Delaware and in the mountains to northeastern Tennessee."

C. coccinea has the following record for the State: Floyd (Deam); Noble (VanGorder); Steuben (Deam).

The specimen taken was from a lone tree, one-fourth mile south of Buffalo on a high, gravelly river-bank. Tree 20 feet high, 5 inches in diameter. No. 343. September 1, 1915. Additional material is not to be had before the completion of this thesis and so the exact determination must be deferred till some later date. (See p. 457 for other Haws, also p. 449.)

Thus the Tippecanoe River has some 28 species clinging closely to its banks, besides claiming specimens of all other species in White County, except possibly one or two species of willows, Quercus ellipsoidalis and Malus ioensis.

5. Report of a New Species and a New Variety for the State.

Salix missouriensis Bebb. Missouri or Diamond Willow, Heart-leaved Willow. 1895.

S. cordata Muhl. 1803; S. angustata Pursh. 1814; S. cordata angustata (Pursh) Anders. 1867; S. acutidens Rydb. 1901.

The above are the synonyms given in Britton and Brown, 2nd Ed., with S. cordata Muhl. preferred.

Sargent, who determined my specimen, called it S. missouriensis.

In Gray's Manual, 7th Ed., cordata and missouriensis are treated as separate species, the last, however, with this note: "A poorly understood tree, said to flower earlier than S. cordata; perhaps a variety (var. vestita Anders.) of that species."

In Hough's Handbook of the Trees of the Northern States and Canada, the Missouri Willow is given as Salix missouriensis *Muehl.*, with the synonym of S. cordata var. vestita Sarg.

In the face of all the above, hybridization is mentioned by each of the contending authors. (See ranges given on map, p. 450.)

This willow has hitherto been unreported for the State except that S. cordata Muhl. and S. cordata angustata (Pursh) Anders. are reported in Coulter's Catalogue, the former with the record: "In a few counties in rather sparing numbers, growing in low, moist soils. More abundant southward. Flowers in April and May. Putnam (MacDougal); Vigo

PLATE XXVI.

Salix missouriensis Bebb.

No.374. August 4. 1915.

Along road ditch, near
Pennsylvania railroad,
$1\frac{3}{4}$ mi. east of Reynolds.
Low, wet, rich soil.
Bushes about 10 ft. high.
Determined by Sargent.

(Blatchley); Tippecanoe (Coulter)." The last mentioned has this record: "In wet soil in the northern part of the State. Flowers from April to May. Steuben (Bradner)."

I have seen no specimens of the above for comparison. The report of missouriensis may or may not be new to the State. Owing to the hybridizing character of the willows and the difficulty of separation, much additional work is necessary before the status of this genus is settled satisfactorily.

The specimens I found in White County consisted of a small group of shrubby growth not more than 10 feet high, one and three-fourths miles east of Reynolds, near the Pennsylvania Railroad, growing along a road ditch in low, wet, rich, black soil. Specimens with fruiting parts were taken on August 4, 1915. Stems with catkins were also collected on April 16, 1916.

Salix longifolia var. *argophylla Sarg.* 1916. By the courtesy of Mr. Deam, I am allowed to report this new variety of willow for the State. A specimen was taken by Mr. Deam "on the bank of the big dredge ditch (Little Monon Creek), meeting the railway from the south, about a mile east of Seafield, White County. Determined by Sargent."

I took specimens of S. longifolia Muhl., determined by Sargent as S. fluviatilis, about three and one-half miles north of the above place, along the same creek, and also about three miles northeast of this place on the banks of the Hoagland ditch.

The latest floras do not include the above variety. (See S. interior Rowlee, p. 452.) (S. sessifolia Nutt., S. argophylla Nutt., S. fluviatilis argophylla Sarg.)

Crataegus albicans Ashe? Tatnall's Thorn. If the above determination can be verified, it will increase the already long list of thorns for the State. As has been indicated on p. 445, Eggleston favors this determination with the material at hand. If Salix missouriensis does not prove to be new to the State this species may be. (See p. 446.)

PLATE XXVII.

RANGE OF
Salix Missouriensis Bebb.
IN THE UNITED STATES AND INDIANA.

BRITTON AND BROWN – 2nd Edi.

Salix cordata Muhl.
S. angustata Pursh.
S. cordata angustata Anders.
S. missouriensis Bebb.
S. acutidens Rydb.

HOUGH.

U.S. Salix Missouriensis Muehl.
S. cordata var. vestita Anders.

GRAY – 7th Edi.

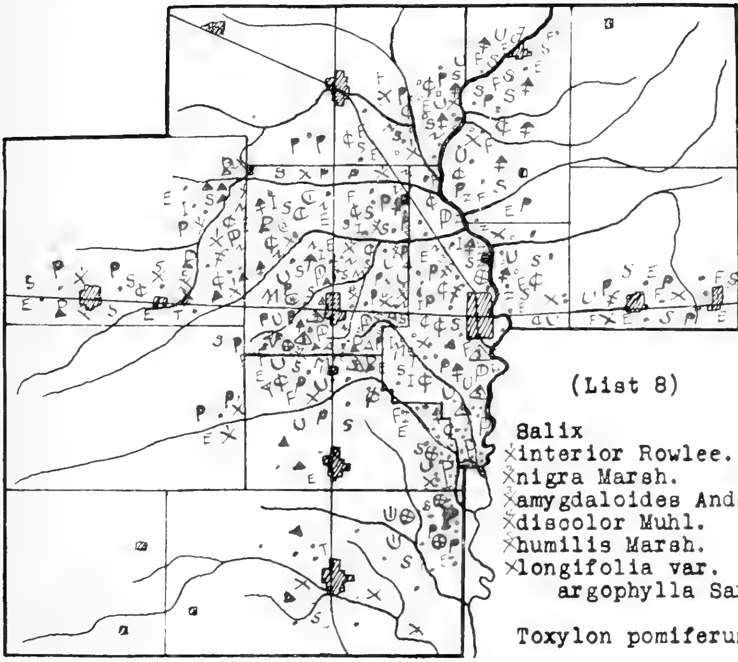
Ind. Salix missouriensis Bebb.
S. cordata – var. vestita Anders.?
Salix cordata Muhl.
var. myricoides (Muhl) Carey.

COULTER.

Salix cordata Muhl.
Salix cordata angustata (Pursh) Anders.

PLATE XXVIII.

WHITE COUNTY.



(List 8)

Salix
- interior Rowlee.
- nigra Marsh.
- amygdaloides Anders.
- discolor Muhl.
- humilis Marsh.
- longifolia var. argophylla Sarg.

Toxylon pomiferum Raf.

General Distribution of Trees over the County -- Omitting the OAKS and HICKORIES, and also those Species more Typically Restricted to the Tippecanoe.

Amelanchier canadensis(L)Med.
Populus alba L.
grandidentata Michx.
tremuloides Michx.
deltoides Marsh.
Sassafras sassafras (L)Karst.
Malus malus (L) Britton.
ioensis(Wood)Britton.
Nyssa sylvatica Marsh.
Crataegus Crus-galli L.
Calpodendron(Ehrh)Medic.
Ilex verticillata(L)A.Gray.
Acer saccharinum L.
saccharum Marsh.
negundo L.
Fraxinus americana L.
pennsylvanicaMarsh.

Corylus americana Walt.
Morus rubra L.
Ulmus americana L.
fulva Michx.
Prunus americana Marsh.
serotina Ehrh.
Cephalanthus occidentalis L.
Cornus femina Mill.
stolonifera Michx.
Zanthoxylum americanum Marsh.
Sambucus canadensis L.
Rhus copallina L.
hirta Sudw.
glabra L.
Juniperus virginiana L.
Viburnam prunifolium L.
Lentago L.

6. Species Generally Distributed Over the County.

Salix interior Rowlee. Sandbar Willow. The willow referred to as the Sandbar willow of various authors suffers various scientific names without much apparent agreement. The record in Britton and Brown is as follows: S. longifolia Muhl. 1803; not Lam. 1778; S. interior Rowlee 1900; S. linearifolia Rydb. 1901. Has been confused with S. fluviatilis Nutt. (S. Wheeleri (Rowlee) Rydb. . . . . from N. B. to Ill., differs in having the leaves permanently silky.). Gray's 7th Ed. says that S. longifolia Muhl. is the Sandbar willow. Synonym, S. interior Rowlee; S. fluviatilis auth., not Nutt. Hough gives S. fluviatilis Nutt. as the Sandbar willow with the synonym of S. longifolia Muhl.

Thus the trials and patience of the amateur, and I should also include the expert, are once more exemplified, if not sorely pressed. One wonders in so many cases if no agreement ever will result. At any rate, the species which answers the description of S. interior Rowlee is abundant along the streams of White County.

This species is not given in the 1911 Report. In Coulter's Catalogue the record is as follows: Salix fluviatilis Nutt., Syn. S. longifolia Muhl. Tippecanoe (Cunningham); Putnam (MacDougal); Vigo (Blatchley); Jefferson (J. M. Coulter); Clark (Baird and Taylor).

Due perhaps chiefly to their tendency to hybridize, the willows are admittedly difiicult of determination. The remaining forms considered as occurring in White County seem to be less confusing.

Salix nigra Marsh. Black Willow. This willow is more or less abundant in White County. Specimens were taken from Honey Creek Township. Its range is more than the total eastern half of the United States.

Salix amygdaloides Anders. Peach-leaved Willow. Although having a large range in North America, from Quebec through Saskatchewan to British Columbia, and through northern Kentucky to the Rio Grande in New Mexico, along the mountains to Oregon and Washington, this species is not mentioned in Coulter's Catalogue, and in the 1911 Report the published record is but from one county, Kosciusko (Scott), with the then new record of a specimen each taken in Lake County by Umbach and Deam. Distribution in White County uncertain, specimen taken from Honey Creek Township.

PLATE XXIX.

RANGE OF

Salix amygdaloides Anders.

IN THE UNITED STATES AND INDIANA.

Salix discolor Muhl. Glaucous Willow. This form has been omitted from the 1911 Report. In Coulter's Catalogue it is reported from Tippecanoe (Cunnington); Jefferson (Barnes); Vigo (Blatchley); Kosciusko (Coulter); Clark (Baird and Taylor); Gibson and Posey (Schneck); Knox (Spillman); Hamilton (Wilson); Steuben (Bradner). It is more or less abundant in White County. Specimens were taken in Monon and Honey Creek Townships.

Salix humilis Marsh. Prairie Willow. This willow is not included in the 1911 Report, nor is it mentioned in Hough's Handbook of the Trees of the Northern States and Canada. The range for Indiana as given in Coulter's Catalogue is as follows: Laporte (Barnes); Putnam (MacDougal); Vigo (Blatchley); Tippecanoe (Coulter); Hamilton (Wilson); Steuben (Bradner).

In this, as in many other instances, the attention is drawn to the number of well-worked counties. It occurs in Honey Creek Township and is very likely in other townships.

Populus tremuloides Michx. American Aspen, Quaking Asp or Aspen, 1803. The Quaking Aspen is a very familiar tree in White County. Very abundant in low, wet places. Sometimes found growing with the Cottonwood.

Populus deltoides Marsh. Cottonwood, Necklace Poplar. (P. carolinensis Moench. 1785; P. monilifera Ait. 1789; P. angulata Ait. 1789.) This is a much larger tree than the Quaking Aspen. Common throughout the county. Said to consist of several races.

Populus grandidentata Michx. Large-toothed Aspen. Scattered throughout the county in low, rich soils, or near the edges of sand ridges.

Populus alba L. White or Silver-leaf Poplar. Introduced from Europe. Escapes in all parts of the State, although the published records are meagre. Escapes in several places in White County. Specimens were taken from trees along Big Creek about four and one-fourth miles east of Chalmers.

For Populus heterophylla see p. 441. The above species of this genus are arranged in the order of their frequency in White County.

Juglans nigra L. Black Walnut. Common throughout the State. Found along the Tippecanoe River and also some distance from its banks in locally abundant numbers. Cultivated throughout the county. (See p. 464.) (J. cinerea, see p. 441.)

Corylus americana Walt. Hazelnut, Filbert. The hazel sometimes becomes a rather large shrub. It is very abundant in White County, as well as throughout the State.

Ulmus americana L. American or White Elm. Reported from 29 counties in the State. Of general distribution in White County along with—

Ulmus fulva Michx. Slippery, Red, or Moose Elm. Said to be in more sparing numbers in the State than the preceding, but nevertheless reported from an extra county. Not abundant, merely local in White County.

Morus rubra L. Red Mulberry. Isolated trees or very small groups in various parts of the county. Along the lower stretches of Spring Creek it is associated with elms, hop-hornbeams, etc.

Toxylon pomiferum Raf. Hedge, Osage Orange. The natural range of this species covers only the adjacent borders of Texas, Oklahoma, Indian Territory, Arkansas and Louisiana, or from Missouri and Kansas south to Texas. It has been cultivated over a considerable part of the country and escapes are more or less frequent. Escapes in Indiana are given for Decatur (Ballard); Franklin (Meyncke); Hamilton (Wilson); Jefferson (J. M. Coulter); Tippecanoe (Thompson); Vigo (Blatchley); Montgomery (Evans); Putnam (Grimes); Knox (Deam).

In various parts of White County it has a tendency to spread away from the fence rows. Reports of isolated trees occurring along the Tippecanoe are likely, but at this time must be given as uncertain.

Sassafras variifolium (L) Karst. Sassafras. Although but one species of Sassafras is recognized, two forms are known and attention to the difference is here noted. "One is known as White Sassafras, which is nearly all sap wood, and the bark of the roots is white. In contact with the soil the wood soon rots. The other is known as the Red Sassafras. The bark of the roots and the greater part of the wood is red, and is durable in contact with the soil."* Both forms are common in White County. The larger trees are found along the Tippecanoe near Buffalo.

Malus malus (L) Brit. Apple. The apple tree has escaped in various parts of White County and large trees are sometimes found.

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* Deam 1911 Report, page 238.

PLATE XXX.

RANGE OF

Malus ioensis (Wood) Britton.

IN THE UNITED STATES AND INDIANA.

It is not included in the 1911 Report nor in Coulter's Catalogue. Why should it not receive the same treatment as other escapes? (Toxylon, Populus alba, Ailanthus, etc.)

Malus ioensis (Wood) Brit. Western Crab Apple. This is a western form, as the range map shows (p. 456). A broad-leaf and a narrow-leaf form are described in the 1911 Report. Both forms occur in White County. Specimens were taken from trees on a low sand ridge about one mile northeast of Reynolds. (See Deam 1911 Report, pp. 248 and 250.)

Amelanchier canadensis (L) Medic. Service-berry, June-berry, May or Sand-cherry. The June-berry remains a small tree in White County and is met with in very sparing numbers in different parts of the county. The specimens taken were somewhat variable, but it is thought all belong to the same species.

Crataegus crus-galli L. Cockspur Thorn, Newcastle Thorn. A small tree, said to be well distributed in Indiana, but with reports only from the following counties: Decatur (Mrs. C. C. Deam); Knox and Gibson (Schneck); Owen (Grimes); Vigo (Blatchley); Crawford, Jackson, Lawrence, Posey and Wells (Deam). More or less abundant along the Tippecanoe and in sparing numbers over the county.

Crataegus calpodendron (Ehrh) Med. Pear Thorn, Pear or Red Haw. (C. Crus-galli Mill. not L.; C. tomentosa DuRoi, not L.; C. Chapmani Ashe; etc.). Specimens of this thorn were found in Honey Creek, Monon and Union Townships. It is likely to be found in others. Specimens have been examined from the following counties: Putnam (Grimes); Marion, Posey and Wells (Deam).

The national as well as the State distribution of the thorns must be as yet rather uncertain. For notes on other White County thorns see pp. 445, 446.

Prunus americana Marsh. Wild Red Plum. Found throughout Indiana and reported from thirty-four counties. Single trees and small clumps in various parts of White County.

Prunus serotina Ehr. Wild (Black) Cherry. Common in all parts of the State. Very common in White County. The wood, bark and fruit are each of some economic importance.

Zanthoxylum americanum Mill. Prickly Ash. Toothache Tree. According to Coulter's Catalogue, "A small tree, sometimes reduced to a shrub, which is generally distributed over the State." In White County it is most commonly found along the Tippecanoe. It was also noted in Ward's thicket in Honey Creek Township and along the lower part of Big Creek.

Rhus hirta (L) Sudw. Staghorn Sumac. (Rhus typhina L.) Said to be frequent but not especially abundant in any of its stations in various parts of the State. Rather abundant in some places of White County. Perhaps the most common sumac in the county.

Rhus glabra L. Smooth Upland or Scarlet Sumac. This sumac is similar to the preceding, but is glabrous throughout. Reported as being more common in the State than the above species. Well distributed but not so abundant in White County.

Rhus copallina L. Dwarf Black or Mountain Sumac. Upland Sumac. This form becomes a distinct small tree in White County. Noted mostly in Honey Creek Township.

The above three species are rich in tanin and are extensively used for tanning. None of them are poisonous, but the last two should be handled with care by persons with thin, sensitive skins. Another species of rhus, *R. Toxicodendron L.* (or R. radicans L.), the Poison Ivy, which grows both as a climbing vine or as a low shrub, is very poisonous. The berries are not poisonous and are largely eaten by birds. The poison ivy is commonly met with in different parts of the county.

Ilex verticillata (L) A. Gray. Virginia Winter-berry, Black Alder, Fever-bush. This is a shrub, attaining a height of 6 feet or more. Abundant in White County as well as in the State.

Acer saccharinum L. Soft, Silver, or White Maple. Reported from many counties. In White County most abundant near the Tippecanoe. A few large trees (60 to 70 feet high) are to be found in Fisher's Woods one mile south of Reynolds. Extensively used as a shade tree.

Acer saccharum Marsh. Sugar, Rock, or Hard Maple. Reported as frequent to common in all parts of Indiana. Of uncertain distribution in White County. Specimen from a small tree about four and one-fourth miles southeast of Chalmers along a small stream near the banks of Big Creek.

Acer negundo L. Box Elder, Ash-leaved or Cut-leaved Maple. Rare east of the Appalachians, rare to infrequent in northern Indiana. Used to some extent as a shade tree in White County. Rather inferior tree, escapes easily. Specimens were found along the Tippecanoe, near Tioga, and also near Buffalo. Its natural migration into White County seems doubtful. Escapes were also noted in Honey Creek Township. (For notes on A. nigrum see p. 441.)

Nyssa sylvatica Marsh. Gum, Black or Sour Gum, Pepperidge. Well distributed in Indiana. Frequent to common in White County. A tall tree attaining a greater diameter than most trees in the county. The leaves are variable and are not to be mistaken for those of N. aquatica L., which has been off the list of Indiana trees. (See Deam 1911 Report p. 93, also pp. 321-323.)

Cornus stolonifera Michx. Red Osier, Kinnikinnik. Absent from the extreme southern counties, but abundant in the northern counties (Coulter's Catalogue). Found in all parts of White County. Readily distinguished by its bright purple twigs at some distance. Sometimes a rather tall, thick-stemmed shrub.

Cornus femina Mill. Panicled Cornel or Dogwood. White-fruited Dogwood. (C. paniculata L'Her. 1788; C. caudissima Marsh. 1785; not Mill. 1768.) Reported in Coulter's Catalogue from various parts of the State. Taller in White County than is noted in the preceding reference (3 to 6 feet high). Britton and Brown give it a height of 6 to 15 feet. Many specimens in White County are between these figures. Often found in great clumps in low, wet places in woods or in the open. The fruit is white and usually abundant. (For other Cornels see p. 442.)

Fraxinus americana L. White Ash, Gray Ash. This ash is very common along the Tippecanoe and is distributed over the county generally. Marked differences in the twigs of older and younger trees and other minor differences were noted. Frequent to common in all parts of the State.

Fraxinus pennsylvanica Marsh. Curiously enough this ash is variously known as the White, Gray, Black, Green, Red, Blue, Water, Swamp, or River Ash. It also bears at least three other scientific names, (F. pubescens Lam.; F. lanceolata Borck.; F. viridis Michx. f.) Its leaves, and especially its fruit, are very variable. (See Deam 1911 Report, illustrations p. 334.) More or less frequent in all parts of Indiana, but reported from only twenty-two counties. Its distribution for White County is not determined; specimens were taken from Honey Creek Township, southwest of Reynolds.

PLATE XXXI.

RANGE OF

Viburnam Lentago L.

IN THE UNITED STATES AND INDIANA.

PLATE XXXII.

RANGE OF

Viburnam prunifolium L.

IN THE UNITED STATES AND INDIANA.

The above two species were the only ones of this genus found in the county. This was a disappointment, since F. quadrangulata Michx., and F. nigra Marsh., are reported from Cass, Tippecanoe and a number of other counties. Both of these may occur in the county.

Cephalanthus occidentalis L. Button-bush, Honey-balls, Pond-Dogwood, etc. An abundant shrub or small tree (20 feet high) in all parts of the State (Coulter). Found in all parts of White County, though not so abundant as a medium-sized shrub. Easily recognized by its flowers.

Viburnam lentago L. Sheep-berry, Nanny-berry, Black Haw, etc.

Viburnam prunifolium L. Black Haw, Stag-bush, etc. It is somewhat surprising to find that the latter, having a much smaller range in the United States, should be reported from so many more counties in Indiana than the former with its very great range. (See range maps pp. 460 and 461.) In so far as I have been able to discover, the former is far more plentiful in White County, sometimes forming great patches on cut-over areas. The fruit of both is sweet and edible.

Sambucus canadensis L. Elder-berry. Abundant throughout the State in various situations (Coulter). Common in White County. The flowers and fruit have strong medicinal properties. (Brit. & Br.)

Juniperus virginiana L. Red Cedar, Juniper, etc. This is the only native evergreen of the county. Reported from various counties with different degrees of abundance. Well distributed in White County, reaching its best development along the Tippecanoe. Many trees, some of fair size, were found about two miles up from the mouth of Big Creek.

(For other species distributed more or less generally over the county see The Oaks, pp. 405-433, and the Hickories, pp. 433-436.)

V. ECONOMIC USES.

The original forest of White County must have been extensive and must have exhibited a high-grade quality of timber quite generally. For several decades after 1830 there were numerous sawmills operating in various parts of the county. Some of the pits, wells or other vestiges of these mills are still to be seen, though perhaps the location of most of them is a matter of speculation.

The results of individual inquiry concerning the specific activities of these early sawmills were very meagre, but through the efforts of Mr. Ed Newton of Monticello, Ind., I am able to cite a few definite historical accounts.

Historical Sketch of the Sawmills of White County.

In 1830 Joseph Rothrock built a brush dam across the Tippecanoe River at Tioga, south of Monticello, and installed a sawmill, which was probably the first mill built in White County. It never amounted to much and its location is now only a memory.

A Norwegian, Hans Erasmus Hiorth, bought a thousand-acre tract of land in 1832 and laid out the town of Norway, north of Monticello. He built a timber dam across the Tippecanoe, set up two sawmills and operated them by power obtained from the dam. They were run very successfully for many years, but have now been dismantled for over a third of a century.

In 1848 a dam was built across the Tippecanoe at Monticello and in the following year Zebulin Sheetz built the first sawmill in Monticello, operating it with power obtained from the dam. A second mill was built later by Hoagland & Conklin. Both of these mills have been dismantled for some forty years and their very location is forgotten.

In 1882 W. E. Meyers built a steam sawmill at Idaville, capable of cutting from 6,000 to 8,000 feet of lumber per day. This mill was run for several years very successfully, but has gone the way of all the preceding.

Definite history for a mill operated by the Wrights along the Tippecanoe between Monticello and Buffalo was not available.

At present there are a number of portable sawmills distributed over the county. These are operated by thrashing-machine engines and their owners will locate wherever there is 10,000 feet or more of timber to cut.

The only active stationary mills coming to my knowledge are those of Pierce & Son at Burnettsville and that of John H. Knickerbocker at Monticello. The Pierce mill has been running for several years, but the latter, which uses electric power, was started only last summer. But very little of the material cut at either mill is shipped, most of the lumber being used in the immediate vicinity.

The lumber concerns of Monticello report no sales of native timber for a number of years. This is also true for concerns in Idaville and Brookston. The Colborn-Dye Company of Wolcott, however, in looking over their files for the past five years, find the following statistics:

TABLE III.

White County Oak Bought and Sold by the Colborn-Dye Company of Wolcott.

1911	25,100 feet.
1912	8,878 feet.
1913	7,858 feet.
1914	22,622 feet.
1915	11,813 feet.
Total	76,271 feet.

"We have probably had 3,000 to 4,000 feet from our local people, which is not included in the above. The figures given above are all for oak timber shipped from Burnetts Creek."

Several carloads of walnut were shipped from Monticello in the spring of 1915.

Messrs. Reed, Spencer & Wright of Wolcott have bought and are cutting for shipment a quantity of white oak east of Monticello.

The figures for a mill near Reynolds, covering four active years, are as follows. (Thomas Lemon.)

TABLE IV.

	1907.	1908.	1912.	1914.	Total.
Feet of lumber	51,704	63,490	76,819	6,345	198,358
Cords of wood	719	1,158	....	211	2,086
Railroad ties	....	3,159	4,906	583	8,648
Fence posts	....	....	3,501	....	3,501

A reply from Brookston (M. B. Yount) enumerates various cuts of lumber aggregating 51,000 feet, as follows:

TABLE V.

7,000	feet 1-inch board finishing lumber @ $30-$50 per 100 feet.
15 000	feet 2½-inch bridge plank @ $30 per 100 feet.
7,000	feet 1-inch boards @ $25 per 100 feet.
22,000	feet of 2 x 4 and 2 x 6, 8, 10, 12, 14, 16 feet long, @ $25.

All oak—some white oak, little black oak, remainder red oak. (1915.)

TABLE VI.

Jacob Dieter of Reynolds reports:

5,000	railroad cross-ties.
245,000	feet of lumber.
5,000	fence posts.

All black and white oak.

Mr. Wm. F. Prall has done much cutting on the Bunnell estate near Reynolds and reports the following figures for the period of September, 1915, to March, 1916:

TABLE VII.

10,000	railroad cross-ties.
25,000	feet of lumber.

In nearly this same time he has cut 200,000 feet of lumber in Carroll County just across the White County line.

The reports from the above five sources make a grand total of 574,129 feet of lumber, 43,648 railroad cross-ties, 8,501 fence posts and 2,086 cords of wood. Other mills in the county will show as high and possibly higher figures. Besides the output of these portable mills using up native timber there is, speaking comparatively, a considerable amount of timber cut up as cord wood and fence posts. The supply is becoming less and less each year, and were the county at once deprived of all the timber now left, the lack of this valuable resource still remaining, I am sure, would be keenly felt.

Much timber land has been cleared for agricultural purposes and this work is still in progress. Very often parties have been so anxious to clear a section that timber was given away for the work of its removal. Practices in clearing have often been very wasteful. I mention this with the very contrasting idea in mind of how governments and foresters are taking every precaution to conserve the rapidly diminishing forests by preventing and controlling fires, insect and fungous pests. Man seems to enter as the most destructive agent of all, not alone by being merely uneconomical but by lacking judgment in making cause for erosion, or perhaps denuding, a place entirely unfit for any other purpose. Forest management and care of trees generally is almost entirely unknown in White County, as it doubtless is in many other counties of the State. Further than that, any admonition to take care of the forests would seem absurd to most citizens. And yet some have seen fit to set out little groves of the much heralded but rather overrated catalpa. White County is an integral part of the hardwood area of the country and as such merits its share of attention.

Below is given a summary covering some interesting features taken from a report of the Department of Labor and Commerce, Bureau of Corporations (The Lumber Industry, Part I, Standing Timber, Jan. 20, 1913). Figures for White County in comparison with the following data are not available. Those acquainted with the area or any other part of the State may draw their own conclusions.

The total amount of standing timber in the continental United States, suitable for the manufacture of lumber under present standards in the industry, is about 2,800 billion board feet, of which 2,200 billion, or 78%, is privately owned. (Unit is the board foot, which is 1 foot square and 1 inch thick.)

The present (1913) commercial value of the privately owned standing timber is about $6,000,000,000, and is becoming more and more valuable. The yearly drain on saw timber is about fifty billion board feet. Only fifty-six years' supply remains.

TABLE VIII. COMPARISONS OF CUT OF LUMBER BY SPECIES.*

SOFTWOODS.

	United States.	Indiana.	Illinois.	Ohio.	Michigan.
Active mills reporting	48,112	1,604	827	1,632	1,323
Total lumber cut	44,509,761	556,418	170,181	512,904	1,889,724
Yellow pine	16,277,185				
Douglas fir	4,856,378				
White pine	3,900,034	64	153	203	258,080
Hemlock	3,051,399	432		8,415	614,622
Spruce	1,748,547			78	21,797
Western pine	1,499,485				
Cypress	955,635		4,186		
Redwood	521,630				
Balsam fir	108,702				9,645
Cedar	346,008	595	30	16	17,647
Larch	204,022				
Tamarack	157,192		152	48	44,956
White fir	89,318				
Total softwood	33,896,959	1,216	4,521	10,389	996,747

TABLE IX.

HARDWOODS.

	United States.	Indiana.	Illinois.	Ohio.	Michigan.
Oak	4,414,457	228,343	101,279	259,410	40,023
Maple	1,106,604	43,644	7,163	43,852	543,214
Yellow poplar	858,500	29,174	3,628	42,317	
Red gum	706,945	23,649	9,748	2,194	
Chestnut	663,891	2,789		16,424	
Beech	511,244	98,729	1,472	49,421	111,340
Birch	452,370	1,216	475	856	64,341
Basswood	399,151	13,917	587	16,007	69,453
Elm	347,456	40,364	12,102	33,182	58,321
Cottonwood	265,600	4,143	3,939	2,944	6,384
Ash	291,209	23,488	2,894	25,753	24,865
Hickory	333,929	23,513	11,095	21,774	1,850
Tupelo	96,676	262	764		
Walnut	46,108	7,669	5,051	8,580	184
Sycamore	56,511	11,003	5,073	5,243	749
Cherry	24,594	1,969	163	2,105	1,587
All others	37,557	1,330	227	2,453	666
Total hardwood	10,612,802	555,202	165,660	532,515	922,977

*Table 18, pp. 88, 89, 90, 91, 92. Department of Commerce and Labor, Bureau of Corporations. The Lumber Industry, Part I, January, 1913.

TABLE X.

Indiana ranks 26th in total lumber cut in the United States.

Indiana ranks 9th in hardwoods cut.

Indiana is a poor last in softwoods cut. (Illinois next.)

The greatest softwood States in the Union in order are: Washington, Louisiana, Mississippi, Texas, Oregon, North Carolina, Alabama, Minnesota, Virginia, Wisconsin, Arkansas, Georgia, California, etc.

The greatest hard wood States in the Union in order are: Tennessee, Michigan, West Virginia, Kentucky, Arkansas, Pennsylvania, Virginia, Wisconsin, Indiana, Ohio, Missouri, Mississippi, North Carolina, etc.

TABLE XI.

Indiana ranks	9	in Oak.
	7	in Maple.
	7	in Yellow Poplar.
	7	in Red Gum.
	15	in Chestnut.
	2	in Beech. (Mich. first.)
	14	in Birch.
	7	in Basswood.
	3	in Elm. (Wis., Mich.)
	12	in Cottonwood.
	5	in Ash. (Ark., Wis., O., Mich.)
	5	in Hickory. (Tenn., Ark., Ky., Mo.)
	14	in Tupelo. (La., Va.)
	2	in Walnut. (O., Ind., Ky., Tenn. Supply very short.)
	1	in Sycamore. (Ind., Mo. close second. Ark. poor third.)
	5	in Cherry. (W. Va., Pa., N. Y., O., Ind.)
	9	in all others. (Ky. big first.)

TABLE XII.

Number of Indiana Sawmills, Grouped According to Output.

Total sawmills	1,599	1,000- 2,500 M	80
Less than 50 M	195	2,500- 5,000 M	26
50- 500 M	1,121	5,000-10,000 M	3
500-1,000 M	173	10,000-15,000 M	1

The pioneers in White County used much timber for log houses, fuel, and rail fences. Much is still used for house and barn sills, bridge stringers and planks. Fence posts and corner braces, with wire, have long ago taken the place of rail fences, although one can still find some rail fences in existence. Old settlers tell of much wood being formerly used as fuel by the railroads at their inception. For domestic use wood is still the chief fuel in the county. Formerly most fuel wood was cut in "full cord wood" length, now it is nearly all cut in "block wood" length. Not much pole wood is sold. So far as I know, very little White County timber gets to manufacturing establishments.

VI. SUMMARY.

With the completion of this thesis it is not meant that the final word on Trees of White County has been said. More observation is necessary to complete ranges within the county, and more material is necessary to determine some species definitely. Very likely a few species have escaped observation.

Sixty-two out of 125 trees reported for the State have been found in White County; 17 small trees or large shrubs are noted, in addition to two new varieties for the State.

The likelihood of a new willow and a new thorn for the State are mentioned. A new variety of willow is also reported.

The peculiar oak found northeast of Brookston needs further investigation, as do all of the above, and other species as well.

Lack of time has precluded further data being included.

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