Proceedings of the Indiana Academy of Science

1920

PROCEEDINGS

OF THE

Indiana Academy of Science

1920

FRED J. BREEZE, Editor

FORT WAYNE PRINTING COMPANY
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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 sources and riches of the State; to arrange and prepare for publication such reports of investigation and discussion as may further the aims and objects of the Academy as set forth in these articles.

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

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

ARTICLE II.

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

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

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

ARTICLE III.

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

Sec. 2. The annual meeting of the Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past President, 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. 2. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS:

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

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

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

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

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

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

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

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

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

(Approved March 11, 1895.)

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

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

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

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

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

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

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

PUBLIC OFFENSES—HUNTING WILD BIRDS—PENALTY.

(Approved March 15, 1913.)

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

AN ACT TO PROVIDE FOR THE PRINTING AND PUBLICATION OF THE PROCEEDINGS AND PAPERS OF THE INDIANA ACADEMY OF SCIENCE, AND APPROPRIATING MONEY THEREFOR.

(H. 294. Approved March 11, 1921.

Section 1. *Be it enacted by the General Assembly of the State of Indiana,* That beginning with the first day of October, 1921, and annually thereafter, there is appropriated the sum of twelve hundred ($1,200) dollars, said moneys to be used to pay for the printing of the proceedings and papers of the Indiana Academy of Science, provided that any unexpended balance of any of said sums shall be carried forward and be available for the use of said academy for future years.

INDIANA ACADEMY OF SCIENCE.

OFFICERS, 1920

President,
H. L. BRUNER.
Vice-President,
WM. A. MCBETH.
Secretary,
HOWARD E. ENDERS.
Assistant Secretary,
R. M. HOLMAN.
Press Secretary,
FRANK B. WADE.
Treasurer,
WILLIAM M. BLANCHARD.
Editor,
FRED J. BREEZE, 1920 Proceedings.

Executive Committee:

ARTHUR, J. C.,
BIGNEY, A. J.,
BLANCHARD, W. M.,
BLATCHLEY, W. S.
BRANNER, J. C.,
BREEZE, F. J.,
BRUNER, H. L.,
BURRAGE, SEVERANCE,
BUTLER, AMOS W.,
COGSHALL, W. A.,
COULTER, JOHN M.,
COULTER, STANLEY,
CULBERTSON, GLENN,
DRYER, CHAS. R.,
EIGENMANN, C. H.,
ENDERS, HOWARD E.,
EVANS, P. N.,
FOLEY, A. L.,
HAY, O. P.,
HESSLER, ROBERT,
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, 1920

Program.

Ray C. Friesner, Butler College, Indianapolis.
Stanley Coulter, Lafayette.
E. R. Cummings, Bloomington.

Nominations.

E. B. Williamson, Bluffton.
W. J. Moenkhaus, Bloomington.
J. P. Naylor, Greencastle.

State Library.

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

Biological Survey.

Herbert S. Jackson, Agr. Exper. Station, West Lafayette.
Richard Lieber, State House, Indianapolis.
Richard M. Holman, Crawfordsville.
Will Scott, Bloomington.

Advisory Board.

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

Academy Foundation Trustees.

Amos W. Butler,
Robert Hessler.

Directors of Research.

H. L. Bruner,
R. W. McBride,
John S. Wright,
Glenn Culbertson,
A. L. Foley. ....

Membership.

F. M. Andrews, Bloomington.
C. A. Behrens, West Lafayette.
A. D. Thorburn, Indianapolis.

Auditing.

E. B. Williamson, Bluffton.
Rollo Ramsey, Bloomington.

Relation of the Academy to the State.

R. W. McBride, 1239 State Life Building, Indianapolis.
Glenn Culbertson, Hanover.
Amos W. Butler, Indianapolis.
John S. Wright, 3718 Penna. St., Indianapolis.
W. W. Woollen, Indianapolis.
D. A. Rothrock, Bloomington.

Publication of Proceedings.

F. Payne, Editor, 1919.
J. A. Badertscher, Bloomington.
D. M. Mottier, Bloomington.
Geo. N. Hoffer, West Lafayette.
Fred J. Breeze, Editor, 1920.

Distribution of Proceedings.

Howard E. Enders, West Lafayette.
Wm. M. Blanchard, Greencastle.
E. R. Cummings, Bloomington.
Aute Richards, Crawfordsville.

Archaeological Survey.

Frank B. Wynn, Indianapolis.
R. W. McBride, Indianapolis.
W. N. Logan, Bloomington.
Allen D. Hole, Richmond.
Stanley Coulter, Lafayette.
Chas. Stoltz, South Bend.
H. B. Vorhees, Fort Wayne.
A. J. Bigney, Evansville.
Glen Culbertson, Hanover.
W. A. McBeth, Terre Haute.
S. F. Balcom, Indianapolis.

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. Schultz. .	Geo. W. Benton..	J. T. Scovell.
1899–1900	D. W. Dennis*...	John S. Wright...	E. A. Schultz....	Geo. W. Benton..	J. T. Scovell.
1900–1901	M. B. Thomas*	John S. Wright. .	E. A. Schultz. .	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. M. 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. M. 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. .	J. 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..	H. E. Enders.	F. B. Wade ..	W. A. Cogshall.
1914–1915	Wil. A. Cogshall.	A. J. Bigney .	H. E. Enders .	F. B. Wade ..	Wm. M. Blanchard.
1915–1916	A. J. Bigney . .	Howard E. Enders.	E. B. Williamson	F. B. Wade .	Wm. B. Blanchard.
1916–1917	W. J. Moenkhaus.	Howard E. Enders.	P. A. Tetrault. .	F. B. Wade. .	Wm. M. Blanchard
1917–1918	E. B. Williamson.	Howard E. Enders.	P. A. Tetrault.	F. B. Wade	Wm. M. Blanchard.
†1918–1919	E. B. Williamson	Howard E. Enders.	P. A. Tetrault..	F. B. Wade .	Wm. M. Blanchard
1919–1920	H. L. Bruner....	Howard E. Enders.	R. E. Holman..	F. B. Wade .	Wm. M. Blanchard
1920–1921	Howard E. Enders	Walter N. Hess....	Harry A. Dietz.	F. B. Wade.	Wm. M. Blanchard.

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

*MEMBERS.**

FELLOWS.

Andrews, F. M., 110 E. 10th St., Bloomington.......................†1911
Associate Professor of Botany, Indiana University.
Plant Physiology, Botany.

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

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

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

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

Bennett, Lee F., 309 S. 9th St., Janesville, Wis.......................1916
With the H. W. Gossard Company, manufacturers.
Geology, Zoology.

Bigney, Andrew J., Evansville..1897
Professor of Physiology, Evansville College.

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

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

Breeze, Fred J., Muncie...1910
Professor of Geography and Geology, Indiana State Normal, Eastern Division.
Geography and Geology.

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, Indianapolis..............1893
Secretary, Indiana Board of State Charities.
Vertebrate Zoology, Anthropology, Sociology.

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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 undeliverable. 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.

Cogshall, Wilbur A., 423 S. Fess Ave., Bloomington....................1906
Professor of Astronomy, Indiana University.
Astronomy.
Coulter, Stanley, 213 S. 9th St., Lafayette..............................1893
Dean of Men, Dean of School of Science, Purdue University.
Botany, Forestry.
Culbertson, Glenn, Hanover..1899
Chair of Geology, Physics and Astronomy, Hanover College.
Geology.
Cummings, Edgar Roscoe, 327 E. Second St., Bloomington............1906
Professor of Geology, Indiana University.
Geology, Palaeontology.
Deam, Charles C., Bluffton...1910
Druggist, Botanist, State Forester.
Botany.
Dryer, Charles R., Oak Knoll, Fort Wayne............................1897
Geography.
Dutcher, J. B., 1212 Atwater Street, Bloomington.....................1914
Associate Professor of Physics, Indiana University.
Physics.
Eigenmann, Carl H., 630 Atwater Street, Bloomington................1893
Professor of Zoology, Dean of Grad. School, Indiana University.
Embryology, Degeneration, Heredity, Evolution of Fishes.
Enders, Howard E., 249 Littleton St., West Lafayette.................1912
Professor of Zoology in Charge of General Biology, Purdue University.
Zoology, Parasitology.
Evans, Percy Norton, 302 Waldron St., West Lafayette................1901
Professor and Director of Chemical Laboratory, Purdue University.
Chemistry.
Fisher, Martin L., 325 Vine St., West Lafayette.......................1919
Professor of Crop Production, Purdue University.
Agriculture, Ornithology.
Foley, Arthur L., Bloomington...1897
Head of Department of Physics, Indiana University.
Physics.
Hessler, Robert, Logansport...1899
Physician.
Biology.
Hufford, Mason E., 710 Atwater St., Bloomington.....................1916
Physics, Indiana University.
Hurty, John E., 31 E. 11th St., Indianapolis..........................1910
Secretary, Indiana State Board of Health.
Hygiene and Chemistry.
Hyde, Roscoe Raymond, 4101 Penhurst Ave., Baltimore, Md............1909
Associate in Immunology, Johns Hopkins University School of Hygiene.
Zoology, Physiology, Bacteriology.
Jackson, Herbert S., West Lafayette....................................1919
Chief of Botany, Agr. Exper. Sta., Purdue University.
Plant Pathology.

Kenyon, Alfred Monroe, 515 University St., West Lafayette..........1914
Head of Mathematics, Purdue University.
Mathematics.

Koch, Edward W., Buffalo, N. Y..............................1917
Care of University of Buffalo Medical School.
Pharmacology.

Logan, Wm. N., 924 Atwater St., Bloomington.......................1917
Professor of Economic Geology, Indiana University.
State Geologist.

McBeth, Wm. A., 1905 N. 8th St., Terre Haute.......................1904
Professor of Geography, State Normal School.

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

Markle, M. S., Richmond......................................1919
Professor of Botany, Earlham College.

Middleton, Arthur R., 705 Russell St., West Lafayette................1918
Professor of Chemistry, Purdue University.

Moenkhaus, W. J., Bloomington.
Professor of Physiology, Indiana University.

Morrison, Edwin, East Lansing, Michigan........................1915
Associate Professor of Physics, Michigan Agricultural College.

Mottier, David M., 215 Forest Place, Bloomington...................1893
Professor of Botany, Indiana University.
Morphology, Cytology.

Naylor, Joseph P. Greencastle..................................1903
Professor of Physics, DePauw University.

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

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

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

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

Rothrock, David A., 1000 Atwater St., Bloomington..................1906
Professor of Mathematics, Indiana University.

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

Scott, Will, Bloomington.......................................1914
Assistant Professor of Zoology, Indiana University.
Zoology, Lake Problems.

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

Smith, Albert, 500 University St., West Lafayette....................1908
Professor of Structural Engineering, Purdue University.
Physics, Mechanics.

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

Stoltz, Charles, 530 N. Lafayette St., South Bend.....................1919
Physician.

Stone, Winthrop E., 149 N. Grant St., West Lafayette.................1893
President, Purdue University.
Chemistry, Administration.

VanHook, James M., 639 N. College Ave., Bloomington.................1911
Assistant Professor of Botany, Indiana University.

Wade, Frank Bertram, 1039 W. 27th St., Indianapolis.................1914
Head of Chemistry Department, Shortridge High School.
Chemistry, Physics, Geology and Mineralogy.

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

Woollen, William Watson, 1628 N. Penn. St., Indianapolis..............1908
Lawyer.
Birds and Nature Study.

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

NON-RESIDENT MEMBERS AND FELLOWS.

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

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

Aley, Robert J., Orono, Maine, Fellow...................................1898
President, University of Maine.
Mathematics and General Science.

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

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

Burrage, Severance, Denver, Colorado, Fellow..........................1898
Professor of Bacteriology, University of Denver.
Public Health.

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

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

Cook, Mel T., New Brunswick, New Jersey, Fellow....................1902
Plant Pathologist, New Jersey Agr. Exper. Station.
Botany, Plant Pathology, Entomology.

Coulter, John M., University of Chicago, Illinois, Fellow..............1893
Head Professor of Botany, Chicago University.

Davis, B. M., Oxford, Ohio.
Professor of Agricultural Education, Miami University.

Evermann, Barton Warren, Golden Gate Park, San Francisco, California.
Director of the Museum of California Academy of Science.
Ichthyology and Museum Administration.

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Members, Active	260
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Minutes of the Spring Meeting.
Spencer, Indiana.

The Spring Meeting of the Academy afforded its members and friends an opportunity to visit the Flatwoods of Owen and Monroe Counties—one of the most interesting regions of Indiana. The Flatwoods district, the site of a glacial lake, covers an area of about fifteen square miles southeast of Spencer. A considerable portion of the region, including the McCormack's Creek gorge, has been set aside as a State Park and placed under control of the Department of Conservation. A hotel, three miles from Spencer, is maintained on the reservation for the accommodation of visitors.

Boone's Cave, Porter's Cave, and Cataract Falls of the Eel River are other attractive points which may be reached from Spencer. Members of the Academy who know the region and are trained in the various branches of field work acted as guides.

The meeting was planned to cover three days, Thursday, Friday and Saturday, May 13th, 14th and 15th.

Good automobile roads into Spencer from all directions made it possible for members and guests to attend the meeting by automobile. Others who came by rail secured automobile service from the local garages.

Thirty-two members and fifteen guests were in attendance at the meetings and the trips.

THURSDAY, MAY 13.—Members of the Academy and their friends met on the courthouse square and at 1:30 P. M., the first party left for a half-day trip by automobile to the Eel River Cataract, about thirteen miles from Spencer. The heavy rains several days before the meetings made the cataract particularly attractive and spectacular. From the cataract the party went a-foot to the lower falls, a mile or more distant.

The second party left the courthouse about three o'clock and explored Green's Bluffs and the vicinity of Boone's Cave but the high water made a trip into the cave impossible.

Both parties returned in time for the informal luncheon served by the members of the Ladies Aid of the Christian Church. Immediately after the luncheon a short business session was held, and at its close the Academy adjourned to the auditorium of the Owen County courthouse, where Colonel Richard Lieber, Director of the State Conservation Commission, gave an address complimentary to the citizens of Spencer and vicinity, upon "Making the Most of the Resources of the State". The auditorium was well filled with an appreciative audience.

FRIDAY, MAY 14th.—Starting from Spencer at nine o'clock in the morning the entire day was spent in a study of the Flatwoods and McCormack's Creek gorge. The party was guided by members of the geological staff of Indiana University who are well acquainted with the region. The botanical and zoological interests were agreeably directed by Professors Mottier and Scott. Tours to visit the diversified interests of McCormack's Creek gorge were made before and after the sumptuous dinner served to about seventy persons by the proprietor of the hotel in this State Park.

SATURDAY, MAY 15.—The morning was devoted to a study of some of the geological formations which had not been visited in the course of the other trips, after which the last of the parties dispersed.

BUSINESS MEETING.

Spencer, Indiana,
May 13th, 1920.

After the luncheon served at six o'clock in the Christian Church by the members of the Ladies Aid Society, the meeting was called to order by the President, H. L. Bruner.

The following thirty-two members and three guests were present:

Flora Anderson
Frank M. Andrews
Mrs. Frank M. Andrews
W. S. Blatchley
Fred J. Breeze
H. L. Bruner
E. R. Cummings
Chas. C. Deam
J. C. Diggs
Fred C. Domroese
Howard E. Enders
Arthur L. Foley
Mrs. Arthur L. Foley
Ray C. Friesner
W. G. Gingery
Richard M. Holman
B. A. Howlett
Richard Lieber
Jesse G. Liston
W. N. Logan
Robert W. McBride
Clyde A. Malott
D. M. Mottier
C. H. Parrish
F. Payne
William P. Rawles
J. R. Reeves
Will Scott
James T. Thompson
Frank B. Wade
Mrs. Frank B. Wade
F. N. Wallace
M. L. Weems
K. P. Williams
Paul A. Young

The plans for the Friday and Saturday trips were announced by Chairman Friesner of the Program Committee.

F. M. Andrews, chairman of the Membership Committee proposed the names of fifteen persons who were duly elected to membership:
Everett T. Burton, 301 E. Kirkland Ave., Bloomington.
Lila C. Curtis, 533 N. Washington St., Bloomington.
Ernest Danglade, Vevay.
John C. Diggs, 54 Kealing Ave., Indianapolis.
Fred C. Domroese, 815 N. Main St., Crawfordsville.
Charles Hire, 515 E. 5th St., Bloomington.
William P. Rawles, 924 E. 3rd St., Bloomington.
John R. Reeves, 1022 E. 3rd St., Bloomington.
Robert Ridgway, 1030 S. Morgan St., Olney, Illinois.
Russell Paul Smith, 721 Richmond St., Kendallville.
E. M. Suter, 1437 Broadway, Fort Wayne.
James T. Thompson, 334 Lafayette Ave., Lebanon.
Frank M. Treat, Atwater Ave., Bloomington.

Arthur J. Wilson, 901 W. Wabash St., Crawfordsville.
Paul A. Young, 606 Walnut St., Crawfordsville.

Report was made that the 1918 Proceedings have been issued and are now in transit from the printer to the State Librarian for distribution.

The matter of affiliation with the American Association for the Advancement of Science was discussed. It was the sense of the members present that affiliation should be completed if this is feasible.

Letters from former member, Harvey Wiley, and others in distant States, and greetings from President Henry B. Ward of the Illinois Academy of Science were read.

Adjourned at 7:55 to the Owen County courthouse to hear the public lecture by Colonel Richard Lieber.

H. L. BRUNER, President.
HOWARD E. ENDERS, Secretary.

MINUTES OF THE WINTER MEETING.

Indiana Academy of Science,
Claypool Hotel, Indianapolis.
December 2, 1920.

MEETING OF THE EXECUTIVE COMMITTEE.

The Executive Committee was called to order at 7:30 P. M., in Room 200, by President H. L. Bruner. The following members were present:

F. M. Andrews
H. L. Bruner
Amos Butler
C. C. Deam
C. H. Eigenmann
Howard E. Enders
R. C. Friesner
W. A. McBeth
Robert W. McBride
D. M. Mottier
Will Scott
Chas. Stoltz
J. C. Naylor
Frank Wade
E. B. Williamson
John S. Wright

The minutes of the last meeting of the Executive Committee were read and approved.

Committee reports were considered as follows:

BIOLOGICAL SURVEY.

The Secretary reported informally for the Chairman, H. S. Jackson, that no specific steps have been made to gain the cooperation of the State Conservation Commission in a systematic survey.

In the absence of formal report from Stanley Coulter of the Special Committee on Affiliation with the A. A. A. S. the meeting was considered informally.

At present 87 members of the Academy of Science are members of the A. A. A. S. and 57 of the A. A. A. S. members residing in Indiana are not members of the Academy. Affiliation would yield an immediate net gain of approximately 57 members.

President Bruner raised the question whether the new relation would not interfere with the administration and development of our Endowment Fund. Mr. Butler advises that if, on careful consideration, the advantages outweighed the disadvantages affiliation should follow. Prof. Mottier suggested careful consideration of the fact that matters of bookkeeping would become complicated in order to recognize the designated State Members and National Members.

By consent the matter is to be referred to the General Meeting for consideration.

ON THE ACADEMY ENDOWMENT.

President Bruner reported that the efforts of the Committee during the summer were directed toward an initial movement for the foundation. Dr. Scott suggested that the small sum of $100 or $200 transferred annually from the Academy Treasury is too small to yield any marked income, or to make any funds available for the promotion of research within many years. Prof. Eigenmann suggested as a mode of procedure the Indiana Academy of Science should endorse some problem for research, and having done so to seek funds for the promotion of that particular piece of research. Robert McBride referred to the present money stringency and suggested only a very limited possibility of acquiring funds by the method named.

PROGRAM COMMITTEE.

R. C. Friesner presented the printed program of 66 titles to be read at the present meetings. He made the announcement of a slight change in location of rooms for the several sessions of the Academy, which involved change to Parlor B for the General Sessions and sectional meetings of the Physical Sciences. The Biological Section is to meet in the Assembly Room. The Banquet is to be held in the Florentine Room, the Evening Session in the Assembly Room. Programs have been sent to neighboring Academies and Scientific Societies. The Chairman reported correspondence with the Ohio Academy of Science relative to holding the Spring Meeting as a joint meeting. Their practice is to have their papers read at the Spring Meeting, therefore it is not possible to have a joint meeting this year, but the matter is to be referred to the Committee for future consideration.

NOMINATION COMMITTEE.

The report will be called tomorrow.

ON BIOLOGICAL SURVEY.

Informal report was made by the Secretary in the absence of Chairman.

STATE LIBRARY.

Amos Butler reported that the foreign papers have not been received in any numbers during the last six years but have now begun to come. Several boxes of foreign shipments have been received recently.

DISTRIBUTION OF PROCEEDINGS.

Chairman Enders reported the 1918 Proceedings were distributed June, last, but that the 1919 Proceedings have not gone to press as a result of reversion of the printing fund.

MEMBERSHIP COMMITTEE.

F. M. Andrews, Chairman, reported that he has 60 names to propose at the General Meeting tomorrow.

RELATION OF THE ACADEMY TO THE STATE.

Hon. Robert McBride reviewed the appropriation difficulties of the past two years. The Legislature at its special session in June re-appropriated an amount sufficient to cover the cost of the 1918 Proceedings and $1200.00 for the 1919 Proceedings but the latter amount reverted to the State at the close of the fiscal year, Sept. 30, 1919, and therefore no funds are available at this time for the 1919 Proceedings.

It is proposed to follow up the matter at the next session of the Legislature and to secure a somewhat larger fund for future publication.

The old, and the proposed bill to be introduced at the Legislature were read. It is recommended that the Academy print the proposed bill, together with the original bill and a brief history of the relation of the Academy to the State and circulate it to the members of the State Legislature at its next session for its information.

On motion (Butler) the Academy is to print the matter as proposed and Judge McBride is to serve as Chairman in the discharge of the provisions of this motion.

Discussion brought out the fact that the State Printer refused to accept the manuscript for the 1919 Proceedings, stating that the very short time that remained would not permit engagement in the printing to an extent to render the funds available before they would revert at the close of the fiscal year.

On motion the Secretary is to furnish each member of the Academy two copies of the proposed bill together with a list of instructions to send these copies to their representatives in the Legislature and to make a personal solicitation for his support in favor of the printing of the bill of the Academy.

On motion the Editor of the Proceedings is to send, if possible, 100 copies of separates, original paging, gratis to the authors.

TREASURER.

No report.

ADVISORY COUNCIL.

No report.

President Bruner reported that he named John M. Coulter, of Chicago University, to represent the Indiana Academy of Science at the 50th Anniversary of the Wisconsin Academy of Science, April 23, 1920, Madison, Wisconsin.

Amos Butler, under the head of new business, spoke upon the proposed archaeological survey of Indiana. Such survey is being urged by the National Research Council which advises a cooperative activity in archaeological research in the central states. The Indiana Academy of Science is asked to start the movement in this State. The matter is to be brought up tomorrow at the General Session and it is proposed to have the State History Teachers take similar action at the session next week and thus seek to stir persons to action.

On motion the Secretary is to transmit to the Editor the sense of the Academy that rules, such as are used in the publications of the Wistar Institute, be embodied in the Proceedings, as rules for the presentation and publication of manuscripts in the Proceedings.

Professor Mottier spoke on the resolution of one year ago relative to asking the Legislature to adopt the flower of the tulip tree as the State Flower.

On motion Judge McBride is asked to prepare a bill to present the matter to the Legislature.

E. B. Williamson spoke on the matter of the possibility of holding a joint field meeting with adjoining State Academies on occasional years. These might be held, now in Indiana and again in one of the adjoining states.

On motion a standing Committee on Interstate Field Meetings is to be appointed.

Adjourned 9:30 P. M.

General Session.

9:00 A. M. Parlor B, Claypool Hotel—Dec. 3, 1920.

BUSINESS SESSION.

The Membership Committee proposed the following named persons for membership, and on motion they were duly elected:

The session was called to order by President Bruner. Attendance 75. The minutes of the Executive Committee were read and approved.

Lora M. Baker, 408 S. Grant St., Bloomington.
James Harvey Bailey, Sorin Hall, Notre Dame.
Stephen Francis Balcom, 3634 Birchwood Ave., Indianapolis.
Albert Raiff Bechtel, 209 W. College St., Crawfordsville.
Katherine Belzer, 320 S. Audobon Road, Indianapolis.

Lester Bockstahler, Physics Department, I. U. Bloomington.
Blanche Brown, 5911 Beechwood Ave., Indianapolis.
Emil V. Cassady, 1841 C. D. Woodruff Place, Indianapolis.
Alexander Cavins, 1232 N. Alabama St., Indianapolis.
Lila Curtis, Indiana University, Bloomington.

John June Davis, Agricultural Exper. Station, West Lafayette.
Delzie Demaree, Benham.
Ira Harris Derby, 5460 University Ave., Indianapolis.
Charles D. Dilts, Central High School, Evansville.
Joseph Nicholas Donahue, Notre Dame University, Notre Dame.

David Hanon Dunham, 429 Main St., West Lafayette.
Austin Etter, 327 S. Henderson St., Bloomington.
Horace Wenger Feldman, 138 Chauncey Ave., West Lafayette.
Henry Bernhart Froning, 415 Pokagon St., South Bend.
Luther S. Ferguson, State Geologist's Office, Indianapolis.

Mary Fugate, 2525 Park Ave., Indianapolis.
Richard A. Gantz, Normal School, Muncie.

Dona G. Gayler, 516 S. Sluss St., Bloomington.
John Willard Giffen, 361 Garfield St., Valparaiso.
Frank V. Graham, Normal School, Muncie.

Benjamin H. Grave, 604 E. Market St., Crawfordsville.
W. A. Guthrie, Conservation Commission, 923 Lemcke Bldg., Indianapolis.
George Lee Hagey, 123 State St., West Lafayette.
Eugene H. Hardy, 1230 S. Keystone St., Indianapolis.
Frederik C. N. Hedebol, 106 E. Jefferson St., Valparaiso.

T. C. Hiestand, 514 S. Lincoln St., Bloomington.
Ralph W. Hufferd, College Ave., Greencastle.
Jacob Robert Kantor, 645 N. Walnut St., Bloomington.
Mable Clare Katterjohn, 213 S. Dunn St., Bloomington.
Alfred C. Kinsey, 7744 E. 3rd St., Bloomington.

Helen E. McDonald, 1826 E. 18th St., Anderson.
Arthur Clem McIntosh, 111 N. Dunn St., Bloomington.
Emma D. Mohr, 2210 N. Talbott St., Indianapolis.
Prentice Moore, Bloomington.
Will Morgan, University Heights, Indianapolis.

Frank W. Morgan, Science Hall, Valparaiso.
Hugh C. Muldoon, 361 Garfield St., Valparaiso.
Rev. P. Benedict Oberdoerfer, University of Notre Dame, Notre Dame.
Ralph L. Records, Edinburg.
Joseph H. Reichert, 522 E. Indiana Ave., South Bend.

G. H. Shadinger, Butler College, Indianapolis.
Frank Joseph Smigel, No. 4 Victoria Hall, Valparaiso.
Paul Smith, 122 E. Ohio St., Indianapolis.
Emory Wright Thurston, Care Eli Lilly & Co., Indianapolis.
Norman B. Tichenor, 5727 Oak Ave., Indianapolis.

Enos G. Walker, 453 College Ave., Valparaiso.
Frank N. Wallace, State Entomologist, Indianapolis.
Francis Joseph Wenninger, Notre Dame.
Pearl Dolores Wildasin, Butler College Res., Indianapolis.
Walter Winkenhofer, Bloomington.

Harold E. Wolfe, 314 N. Washington St., Bloomington.
Albert E. Woodruff, 24 S. Irvington, Indianapolis.
William L. Wright, Care Eli Lilly & Co., Indianapolis.
George Zebrowski, 521 State St., West Lafayette.
Ziegler,

The Treasurer's report was received.

Balance November 30, 1919		$486.26
Receipts, dues		305.00
Expended	$249.59	
Balance	541.67	
Total	$791.26	$791.26

Auditor E. B. Williamson reports on the accuracy of the Treasurer's Report. On motion the Treasurer is authorized, on signature of the President and Secretary, to transfer from the Treasury to the Trustees of the Research Endowment Fund the sum of $300.00.

Adjourned.

GENERAL SESSION.

Greetings were received from the representatives of the State Societies:

Dr. H. W. Rodenhamell of the Eli Lilly Co., for the Branch of the American Chemical Society.

Mrs. Rosseau McClellan, Shortridge High School, for Audubon Society.

Mr. Henry Foltz, of Indianapolis, for the Indiana Society of Architects.

Dr. Murray N. Hadley of Indianapolis, for the Indiana Medical Association.

Miss Ida M. Andrus of the Manual Training High School, for the Nature Study Club of Indiana.

Mr. Horace Shonle of the Eli Lilly Company, for the Scienteck Club of Indiana.

The representative of the Audubon Society suggested the advisability of arranging at some time or other for a joint Spring Meeting with the Indiana Academy of Science.

The papers of the General Session were then read in their order. At the close of the paper number 9, entitled "A State Archaeological Survey", the following resolution was adopted:

RESOLVED, That the Indiana Academy of Science, recognizing the value of the pre-historic remains in this state, from the scientific, historic, esthetic and economic standpoint, and knowing full well the destruction of these important objects, objects that are now gone from mankind forever, which is continually going on, expresses its interest in and its desire to record its support of an archaeological survey of Indiana.

BE IT FURTHER RESOLVED, That it is the sense of this Academy that this survey should be undertaken by a trained person under the direction of the Conservation Commission. That the officers of the Academy be directed to transmit a copy of these resolutions to the Conservation Commission and urge its acceptance of this work, and at the same time pledge the co-operation of this Academy therein. That the Chair appoint a committee of not less than seven (7) members to assist in bringing this matter to the attention of the Legislature, and act as a co-operative body with the Conservation Commission and with any similar committees that may be appointed by other organizations to further this work.

Committee on Archaeological Survey.

F. B. Wynn, Hume-Mansur Bldg., Indianapolis, Chairman.
R. W. McBride, State Life Building, Indianapolis.
W. N. Logan, Indiana University, Bloomington.
Allen D. Hole, Earlham College, Richmond.
Stanley Coulter, Purdue University, Lafayette.
Charles Stoltz, South Bend.
H. S. Vorhees, Fort Wayne.
A. J. Bigney, Evansville College, Evansville.

Glen Culbertson, Hanover College, Hanover.
W. A. McBeth, State Normal School, Terre Haute.
S. F. Balcom, 3634 Birchwood Ave., Indianapolis.

At the close of the reading of the papers of the General Session the Academy adjourned for luncheon.

1:30 P. M. Business Meeting—

The personnel of the Committee on Interstate Field Meetings was announced:

E. B. Williamson, Chairman.
R. C. Friesner.
W. Q. McBeth.

A resolution was presented by J. J. Davis requesting that the U. S. National Museum provide for additional facilities for the care of insects in conformity to the investigation and recommendation made by the American Association of Economic Entomologists. The following resolution was adopted:

RESOLVED, That the Indiana Academy of Science, realizing the value of the Division of Insects, U. S. National Museum, to the economic need and intellectual development of the people of the entire United States and the immediate need of additional facilities for maintaining this work, does hereby approve the report of the Committee of the American Association of Economic Entomologists and the Entomological Society of America at their St. Louis meeting, December 30 to January 2, 1920, and urge the National Congress to support the budget of $86,000.00 submitted to its Appropriations Committee, and that the Secretary of the Indiana Academy of Science be instructed to mail a copy of this resolution to the Chairman of the Appropriations Committee and to the Indiana Representatives and Senators in Congress.

COMMITTEE ON NOMINATIONS.

The following named persons were proposed for the offices for 1921: On motion they were duly elected as follows:

President—Howard E. Enders, West Lafayette.
Vice-President—F. M. Andrews, Bloomington.
Secretary—W. N. Hess, Greencastle.
Ass't Sec.—Harry A. Dietz, State Entomologist's Office, Indianapolis.
Treasurer—William M. Blanchard, Greencastle.
Editor—F. J. Breeze, Muncie.
Press Sec.—F. B. Wade, Shortridge High School, Indianapolis.

Adjourned for Sectional Meetings 2:00 P. M.

Biological Section of 36 titles, Assembly Room; Physical Section of 18 titles, Parlor B.

Seventy-five guests participated in the Academy dinner at 6:00 P. M. At the close of the dinner the Academy met in the Assembly Room for a general session open to the citizens of Indianapolis. The following interesting illustrated lectures were presented:

"Mountain Climbing in Glacier National Park", by F. B. Wynn.
"Glaciers and Glacial Phenomena", President W. E. Stone.

This closed the 35th Session of the Indiana Academy of Science.

H. L. BRUNER, President.
HOWARD E. ENDERS, Secretary.

Program

OF THE

THIRTY-FIFTH ANNIVERSARY

OF THE

Indiana Academy of Science

CLAYPOOL HOTEL, INDIANAPOLIS

THURSDAY AND FRIDAY
DECEMBER 2 AND 3
1920

OFFICERS

H. L. Bruner, Indianapolis........................President
W. A. McBeth, Terre Haute........................Vice-President
Howard E. Enders, West Lafayette........................Secretary
R. M. Holman, Crawfordsville........................Assistant Secretary
Frank B. Wade, Indianapolis........................Press Secretary
W. M. Blanchard, Greencastle........................Treasurer
F. Payne, Bloomington........................Editor

PROGRAM COMMITTEE

Stanley Coulter
F. B. Wynn
E. R. Cummings
R. C. Friesner

LOCAL COMMITTEE

A. W. Butler J. S. Wright
R. W. McBride

OUTLINE OF PROGRAM

Thursday, December 2

8:00 P. M. Executive Committee.

Friday, December 3

9:00- 9:30 A. M. Business Meeting, Palm Room.
9:30-12:00 A. M. General Session, Palm Room. Representatives of the various State Societies will be given an opportunity to present greetings at this session.
1:30- 2:00 P. M. Business Meeting, Palm Room.
2:00- 6:00 P. M. Sectional Meetings: Biological Sciences in the Palm Room, Physical Sciences in Parlor "B."
6:00- 8:00 P. M. Annual Academy Dinner, in the Riley Room.
8:00 P. M. General Session.

GENERAL SESSION

Friday, 9:30-12:00 A. M.

1. The Growth and Distribution of Population in Indiana. 20 minutes. Charles R. Dryer, Fort Wayne, Indiana.
2. Health Service at Purdue University. 10 minutes. O. P. Terry, Purdue University.
3. Ulysses Orange Cox (In Memoriam). 10 minutes. Barton W. Evermann, Indiana State Normal School.
4. An Appeal by an Ignoramus. 10 minutes. Robert W. McBride, Indianapolis.

5. Report of a Study of Mental Ability of Children in One Orphans' Home in Indiana. 10 minutes. Arthur A. Estabrook, Indianapolis.
6. Tests for Measuring the Emotions. 12 minutes. S. L. Pressey, Bloomington.
7. Undergraduate Research in our Colleges and Universities. 20 minutes. Horace Shonle, Eli Lilly & Co., Indianapolis.
8. Natural Resources and Education in Indiana. 15 minutes. Bernard H. Shockel, Indiana State Normal School.
9. A State Archaeological Survey. 10 minutes. Amos W. Butler, Indianapolis.
10. Our Fuel Supply. 5 minutes. A. L. Foley, Indiana University.
11. Address of Retiring President—Biological Laws and Social Progress. Henry Lane Bruner, Butler College.

SECTIONAL PROGRAM

FRIDAY, 2:00 P. M.

BIOLOGICAL SCIENCES—PALM ROOM

Zoology

12. Whistling Swans. Lantern. 15 minutes. Mrs. Etta S. Wilson, Detroit, Michigan.
13. Notes on the Termites of Indiana. Lantern. 10 minutes. Harry F. Dietz, Division Entomology, Indianapolis.
14. The Fresh Water Medusæ of Boss Lake, Elkhart, Indiana. 10 minutes. F. Payne, Indiana University.
15. Additions to the Indiana List of Dragon Flies. 5 minutes. E. B. Williamson, Bluffton.
16. Observations, II: Extension of Attack of Eriophyes upon Norway Maples. 5 minutes. Howard E. Enders, Purdue University.
17. The Anatine Genus Nyroca, and Its Nearest Allies. By title. Harry C. Oberholser, U. S. National Museum, Washington, D. C.
18. Some Observations Upon the Pythons. 20 minutes. W. Henry Sheak, Philadelphia, Pennsylvania.
19. Some Mallophaga of Our Native Birds. 30 minutes. Edwin J. Kohl, Purdue University.
20. On the Principle of the Order of Addition in Immunological Reactions. 10 minutes. Roscoe R. Hyde, Johns Hopkins University.
21. Interdependence of Agglutinin and Cytolysin in an Immune Serum. 10 minutes. Roscoe R. Hyde.
22. Some Rare Indiana Birds. 10 minutes. Amos W. Butler.

22a. Influence of Adrenin on Retina and Skin of Frog. 10 minutes. A. J. Bigney, Evansville College.

Botany

23. A New Chromogenic Bacillus Isolated from Laboratory Media. 5 minutes. P. A. Tetrault, Purdue University.
24. The Soil Flora as Affected by Cultivation and Seasonal Variations. 15 minutes. Ira L. Baldwin, Purdue University.

25. A Modification of the Romanowsky Stain. 15 minutes. Charles L. Behrens, Purdue University.
26. Effect of Centrifugal Force upon Plants. 5 minutes. F. M. Andrews, Indiana University.
27. Studies on the Aeration of Plants. 5 minutes. F. M. Andrews.
28. Phyllotaxis in *Specularia perfoliata*. 5 minutes. F. M. Andrews.
29. An Improved Method for Regulating the Thickness of Microtome Sections. 5 minutes. F. M. Andrews.
30. Studies on Pollen, III. 5 minutes. F. M. Andrews.
31. Some work with Claviceps Cultures. Lantern. 15 minutes. W. W. Bonns, Botanical Research Laboratory, Eli Lilly & Co., Indianapolis
32. The Ustilaginales of Indiana. 5 minutes. H. S. Jackson, Purdue Agricultural Experiment Station.
33. Uredinales of Indiana, III. 5 minutes. H. S. Jackson.
34. A Convenient Plant Press. 5 minutes. H. S. Jackson.
35. Indiana Plant Diseases, 1920. 15 minutes. Max W. Gardner, Purdue Agricultural Experiment Station.
36. Corn Diseases in Indiana. 10 minutes. G. N. Hoffer, Purdue Agricultural Experiment Station.
37. Indiana Fungi, V. 10 minutes. J. M. Van Hook, Indiana University.
38. The Pycnidium of Cicinnobolus. 5 minutes. J. M. Van Hook.
39. A Tricotyledonous Bean. 3 minutes. J. M. Van Hook.
40. Native Plants of White County, III. By title. Louis F. Heimlich, Purdue University.
41. Plants New to Indiana, IX. 10 minutes. Charles C. Deam, Bluffton.
42. A Species of Cuscuta Not Hitherto Reported for Indiana. 1 minute. T. G. Yuncker, DePauw University.
43. A List of Mosses Occurring in the State of ndiana. 3 minutes. T. G. Yuncker.
44. Mitotic Rhythms in *Pisum sativum L.* 10 minutes. Ray C. Friesner, Butler College.
45. A Curious Variation in the Common Milkweed, *Asclepias syriaca L.* By title. C. A. Ludwig, Clemson College.

45a. The White Pine Blister Rust Educational Campaign in New York. Burr N. Prentice, Purdue University.

45b. Growth Rate of Red Cedar. 10 minutes. Stanley Coulter, Purdue University.

Physical Sciences Parlor B

Geology and Geography

46. Some Phases of Indiana Geology. 15 minutes. W. N. Logan, Indiana University.
47. Some Evidence Indicating the Importance of Frost Action in Widening Valleys. 10 minutes. Glenn Culbertson, Hanover College.
48. Relationship of Stream Trenching to Uplift. 10 minutes. Clyde A. Malott, Indiana University.
49. Planation Stream Piracy. 15 minutes. Clyde A. Malott.
50. The Muncie Esker Belt. 10 minutes. Fred J. Breeze, Indiana State Normal, Eastern Division.
51. The Highest Point in Indiana. 10 minutes. Fred J. Breeze.

Physics and Chemistry

52. What Puts the "Pop" in Popcorn. Lantern. 10 minutes. R. H. Carr and E. F. Ripley, Purdue University.
53. Recent Progress in the Use of Ozone in Ventilation. 10 minutes. F. O. Anderegg, Purdue University.
54. Training Research Chemists in Indiana. 10 minutes. Edward G. Mahin, Purdue University.
55. Behavior of Copper, Lead, and Aluminum Under Stretching. Lantern. 20 minutes. Albert E. Woodruff, Butler College.
56. A Resistance Radio Phone. Lantern. 10 minutes. R. R. Ramsay, Indiana University.
57. Note on Antennae Resistance. Lantern. 10 minutes. R. R. Ramsay.
58. A Long-Wave Receiver. Lantern. 10 minutes. R. R. Ramsay.
59. An Experiment on the Transmutation Lantern. 10 minutes. A. L. Foley, Indiana University.
60. The Effect of the Electrodes on the Luminosity of an Electric Spark. Lantern. 5 minutes. A. L. Foley.
61. Light Intensity from Different Parts of an Electric Spark. Lantern. 5 minutes. A. L. Foley.
62. Sources of Error in Measurements of the Velocity of Sound. Lantern. 10 minutes. A. L. Foley.
63. Some Facts About Phonographs. 5 minutes. A. L. Foley.

GENERAL PROGRAM

FRIDAY, 8:00 P. M., RILEY ROOM

64. The Academy Research Fund. Stanley Coulter, Purdue University.
65. Mountain Climbing in Glacier National Park. Lantern. F. B. Wynn, Indianapolis.
66. Glaciers and Glacial Phenomena. Lantern. W. E. Stone, President, Purdue University.

ULYSSES ORANGE COX.
(IN MEMORIAM.)

BARTON WARREN EVERMANN.

Ulysses Orange Cox was born on a farm near Farmland, Randolph County, Indiana, September 29, 1864. He died at Denver, Colorado, August 25, 1920.

As a boy living in the country, in daily contact with nature, it was but natural that a real love for, and an interest in, animals and plants should soon possess him. In this respect this boy was not particularly different from other boys who have had the great good fortune to have been brought up in the country; for there, Nature is calling, ever calling, and rare indeed is the country boy who fails to hear the call and give heed to it. He can always see the sky, the clouds and the stars; he sees and feels the soil, and digs into it; he wanders through the open woods and the dark forests; he learns to know the streams, the hills, the growing and ripening crops, and the wild animals about him; daily, even hourly, he sees the birds, the insects, and the shy folk that abound for him who would be their friend; the domestic animals on the farm he learns to know intimately; and he learns the sweet sounds which wind and running water, and birds and insects make when he is hunting, fishing, or merely roaming in the woods and fields or along the streams. This is the *real productive school* in which all country boys are enrolled; the school in which more knowledge is acquired than in all the after years.

Ulysses Cox early began the serious study of animals and plants. His first published contribution to science was "A List of the Birds of Randolph County, Ind.," which appeared in the Ornithologist and Oölogist. While yet in his teens he began teaching in the country schools of his native county. He organized the high school at Farmland and was its superintendent. His experience in these schools led him to suggest a system of consolidated schools, since put into effect by Superintendent Driver with excellent results. In 1884 he graduated from Bryant's Commercial School at Indianapolis. He completed the Teacher's Training course at the Central Normal College the next year and in the same year he entered the Indiana State Normal School, from which he was graduated in 1889.

After teaching two years in the Farmland high school and assisting in the spring terms in the Indiana State Normal School, he was elected head of the department of general science in the State Normal School at Mankato, Minnesota, where he made an enviable record as an organizer and inspiring teacher. He organized and adequately equipped the chemical and physiological laboratories in that institution.

Mr. Cox took leave from his teaching duties in 1897 and entered Indiana University, from which institution he was graduated in 1900 with the degree of A. B. in zoology, his time in the University alternating with teaching during part of the year. He received the degree of A. M. in 1902.

In the fall of 1904, President Parsons had an idea that he would like to have the present writer reenter the faculty of the Indiana State Normal School as head of the department of biology. He said that I did not have to give a decision at once. The next spring he came on to Washington and renewed the invitation which was very tempting. But I had other irons in the fire which I did not wish to let get cold. My interest in the Indiana State Normal School was great, and when I began wondering where a good man could be found for the place. I had an inspiration: "U. O. Cox is the man for you." I said to Dr. Parsons, who at once replied: "You are right! Cox will make an ideal head for that department; I'll write to him at once." And thus it was that Professor Cox was called back to his alma mater in 1905, where he remained until his death.

ULYSSES ORANGE COX.

U. O. Cox's interests and abilities lay in many lines. He was a keen business man, careful and methodical in his habits and methods. He was unusually skillful in the use of tools, which was of great help to him in devising apparatus for use in his teaching. While primarily and most deeply interested in zoology and botany, he was an all-round naturalist. In 1891 he was a member of the Dr. J. T. Scovell expedition to Mount Orizaba, Mexico. He made a collection of the birds of the region and discovered and described a new species of towhee, *Pipilo orizabæ*. While at the State Normal School at Mankato he had charge of the U. S. Weather Bureau Station at that place, making observations three times daily and posting the records every morning. He was also employed at various times by the

United States Fish Commission in connection with the exploration of rivers and lakes. He built and equipped the house-boat "Megalops" with which he made a trip down the Mississippi River for the Minnesota Geological and Natural History Survey. In 1893 he was with the writer on an investigation of the streams of Nebraska, South Dakota, and Wyoming for the United States Fish Commission. In 1896 he studied Lake Pend d'Oreille and certain streams in the State of Washington, and in August of that year he and I went with the Mazamas (a club of mountain climbers, chiefly of Portland, Oregon) to Crater Lake, Oregon, where we made certain investigations for the U. S. Fish Commission. These investigations included the making of several soundings and the taking of serial temperatures at 100-foot intervals from surface to bottom of the 2,000 feet of depth of that very wonderful lake.

Another investigation he made for the U. S. Bureau of Fisheries was a study of the freshwater mussels (Unionidæ) of the lower Wabash River. In a small launch, towing a barge on which to carry their collections, he and our good mutual friend, the late Dr. J. T. Scovell, examined the Wabash critically from Terre Haute to Vincennes, with special reference to that species of mussel known as the "mucket" (*Lampsilis ligamentinus*), which is one of the best in pearl button making. Just at that time Professors George Lefevre and W. C. Curtis of the University of Missouri were carrying on their brilliant investigations on the artificial inoculation of fishes with the glochidia of Unionidæ. They desired a large number of fine muckets, and Professor Cox was able to supply them with abundant and excellent specimens from the Wabash. In a letter to Professor Cox, Dr. Lefevre wrote:

> "I want to thank you for your kind assistance in securing for our recent experiments at La Crosse such a fine lot of muckets and yellow backs. They were received in excellent condition and furnished us with an abundant supply of glochidia for the infection of the fish. Twenty-two of the muckets contained ripe glochidia and fifteen of the yellowbacks, yielding altogether a sufficient quantity for the infection of nearly the entire lot of fish which we had on hand, namely, about 25,000.
>
> "There was no indication that the muckets were not at the height of the breeding season, as the pouches were gorged with glochidia in every specimen containing them, but the yellowbacks appeared to be on the decline, as we found quite a number of completely spent females. The experiments were highly successful in every way, and we are greatly indebted to all who contributed their assistance to the work."

Soon after his election as head of the department of Biology in the Indiana State Normal School, the State Legislature provided for the teaching of agriculture in the public schools. Provision for instruction in that subject in the Normal was at once made, and Professor Cox was placed in charge. This was in addition to his other numerous duties. The rooms in the basement, then occupied by the department of Biology, were soon outgrown and, largely through the efforts of Professor Cox, a new Science Hall, adequate in its appointments and architecturally beautiful, was soon provided for his department. One of the unique features of this building, the general plans for which were made by Mr. Cox, is a roof garden for which he had longed and of which he had dreamed for many years. In that roof garden he grew a large part of the plant material used in his botanical work.

Cox was also a good photographer, so he made provision in the new building for a well-equipped dark-room where he developed thousands of negatives and made vast numbers of stereopticon slides of which he made constant use in his teaching.

In his home he had a well-equipped printing press which he had installed for the use of his son Warren, but it is more than likely he made greater use of it than did the son. On this press he printed the outlines of his lectures, laboratory directions, syllabi of subjects, and many other aids to teaching and for distribution among his students.

Mr. Cox possessed considerable musical ability. He sang tenor very well, and, while at Mankato, organized and directed an orchestra in the Normal School.

When agriculture was added to his subjects in the Normal at Terre Haute, he found the experience and training he had gained on his father's farm of great benefit to him and his students. He soon bought a small farm south of town which he largely used for experimental and instructional purposes with his classes.

As already intimated in this sketch, Mr. Cox was a man of broad interests and varied attainments; he was an all-round man in the best sense of the word. As a man of affairs, he was active in civic, scientific, and educational circles. He took a keen and active interest in matters of community and public concern. As a naturalist, he was most interested in birds and botany, but his natural history studies were not confined to those lines. He early showed an interest in mollusks as evidenced by his paper on the mollusks of Randolph County.

Mr. Cox was equally and unusually efficient, whether in the field as a collector and observer, or in the laboratory and class-room as student, teacher or investigator. During his student days and as my laboratory assistant in the Indiana State Normal School, he was (with the exception of Dr. Scovell) my most frequent companion on trips a-field. Together we explored practically all the woods, fields, ponds, and streams within a radius of ten to fifteen miles of Terre Haute. Among favorite places to which we frequently went were the Five-mile pond north of town, Coal Creek, Honey Creek, and the Goose Pond some nine miles south of the city. These were all places of unusual interest to the zoologist and to the botanist. The Goose Pond was most interesting, for there we found several species of birds not often seen elsewhere in the county—among them the least bittern, great bittern, coot, pied-billed grebe, Carolina rail, and Virginia rail. All of these species nested in that pond. Most interesting of all, we found the white water lily there in abundance. Mr. Cox suggested that we gather a considerable number of these beautiful, fragrant flowers and take a bouquet of them to certain students who were ill. The flowers were so abundant that we gathered not only enough to take a fine bouquet to each student whom we knew to be ill, but we took one to every young lady student in our classes, and to each lady member of the faculty! This incident is told to illustrate the kindly, sympathetic spirit which was so characteristic of Mr. Cox. He was ever ready to bring a little more sunshine into the life of any one who needed it.

As student and investigator, Mr. Cox was most painstaking and conscientious, quiet, industrious, level-headed and cautious. He never reached conclusions or announced results except such as were sustained by the available evidence.

As a teacher, he was one of the very best I ever knew. His success lay largely in his absolute honesty with his subject and his students, his quiet, unobtrusive manner, and his large human sympathy. His students loved him; they could not do otherwise.

As a member of the faculty, he was useful in many ways for the general good of the institution. There were so many things of general interest that he could do better than any one else; and he was always willing and ready to perform any duty assigned to him. These qualities peculiarly fitted him to service as Dean of the Faculty, which position he held during the last two years of his life, in addition to the regular duties of his department.

Personally Mr. Cox was one of the most lovable of men. I can do no better than quote from the resolutions adopted by a committee of the Faculty:

"During these years of daily association we have learned to appreciate and revere the eminent virtues of our friend and colleague. His indefatigable industry, his unselfish devotion to duty, even when physically incapacitated, his gentle, kindly and obliging disposition made him admired and loved of all, both fellow-teachers and students.

"Devoid of petty ambitions and aspirations, his attitude towards life was gracious and optimistic, free from carping criticism and querulousness. Disappointment met with equanimity; success with poise and serenity.

"His strict devotion to his chosen work did not isolate or estrange him from cordial and sympathetic human relations. Mr. Cox was always the kindly man, as well as the efficient teacher and scientific scholar."

Professor Cox was a member of numerous scientific societies, among which may be mentioned the following:

Indiana Academy of Science; American Association for the Advancement of Science, of which he became a Fellow in 1906; Washington Academy of Science; New York Academy of Sciences; The Mazamas; American Ornithologists' Union; Biological Society of Washington; American Forestry Association; American Society of Naturalists; National Geographic Society; American Nature Study Society; and The Wilson Ornithological Club.

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PRESIDENTIAL ADDRESS

BIOLOGICAL LAWS AND SOCIAL PROGRESS.

BY

H. L. Bruner.

In such a meeting as this it is entirely proper to recall the services of science to man, the discoveries which have contributed to his health and comfort and given him knowledge of the world in which he lives. By the aid of science man has acquired such control over nature as his imagination formerly attributed only to the gods. Today, he mounts into the air with Mercury, dives into the deep with Neptune, and when he speaks from the summit of some Mt. Marconi, his voice is heard in the uttermost part of the earth. These discoveries, and especially the great services of the scientist in the world war, have won for science a high place in popular esteem.

But peace has brought demands that are no less insistent than those of war. At the present time all progressive nations are facing certain social problems which were already pressing for solution in 1914. In the strain and stress of war the issues have been more sharply defined. Scientists may assist in the solution of these problems by the contribution of discoveries and inventions which make for better living, but such relief will be only temporary. A more lasting contribution, I believe, may be made by emphasizing those biological principles which must control all progressive evolution, both in society and elsewhere in the organic world. I wish, therefore, in the performance of the task assigned to me as president of the Academy, to call your attention to an old theme: namely, the importance of the general laws of biology in social progress.

That the evolution of human society follows the same laws that control evolution in other fields, is a fact often repeated since Herbert Spencer and Huxley insisted on its importance. In both cases evolution is essentially a process of differentiation and integration of parts or units originally alike and equal. The nature of these changes is shown in the embryonic development of every higher plant or animal, the multiplication of cells being followed, on the one hand, by division of labor, formation of tissues, organs and organ systems, on the other hand, by coordination and integration of associated parts to form a complete whole. Societies are formed in the same way. Beginning with a group of individuals which do all kinds of work, by division of labor and cooperation they form complex organizations which are able to accomplish vastly more than separate individuals could do. Here, also, as in animal and plant bodies, the greater the division of labor, the more dependent become the parts on the whole, the more dependent the whole upon the parts.

This tendency to differentiation in organisms is limited by other laws which produce more or less uniformity and stability. In embryonic life this conservatism leads to a repetition of ancestral history, in which the embryo follows a certain definite path and gives rise to an individual of a definite pattern. Even embryo man is not ashamed of his ancestors, although some adult men are. If this condition dominates both adult and embryonic life, the species may continue indefinitely without change, like the brachiopod Lingula, the same today as in Cambrian time. Differentiation on the other hand, creates new species and thus forms the basis of progressive evolution. Continuous repetition of the process through long periods of time has given rise to all the higher animals and plants. In the great majority of organisms, however, progress has been slow, and in many cases, has ceased altogether. Of the vast number of species that now live, or have lived, on the earth, only a few have found the path leading to high rank.

These differences in the capacity of organisms for progressive evolution may be explained in a way by saying that certain types are more plastic than others. Some are easily moulded into new shapes, while others change slowly or not at all. When such a species reaches the limit of differentiation permitted by its organization, it may continue to exist on the same plane, but it can not advance. According to Herrick, the evolution of the whole group of arthopods has been definitely limited by the lack of plasticity of the ladder type of nervous system, which apparently reached its highest development in cretaceous insects about two million years ago. At the same time also were established those rigid instincts which have continued without change down to the present. The more plastic tubular nervous system of the vertebrates, on the other hand, has shown itself capable of enormous development, and has provided the nervous equipment of those animals in which inherited instincts are largely controlled by intelligence. With a nervous system constructed on the tubular plan, the mammals have advanced farther than other animals, but among these only the primates reached the highest grade of development. From this group finally came man.

With the advent of man the old laws of evolution continue to operate, but they are more or less under the control of intelligence, which becomes a factor of increasing importance. As men were drawn together for protection or otherwise, societies were formed and division of labor occurred, but no physical differences appeared, such as are found in other animal societies, and thus each individual man retained the capacity to do all kinds of work. In such societies were laid the foundations for those collective activities, such as language, literature, science and government, which go to make up civilization. Henceforth each generation receives not only the heritage of the germ cells but also a heritage of knowledge accumulated by previous generations. By virtue of man's superior mental capacity, each generation appropriates the inherited wisdom, adds its own contribution to the general store and transmits the whole to its successor. In this manner the social heritage is enlarged.

Continuous operation of the general laws of evolution in human history is indicated by the appearance of different types and races of men, the inhabitants of different regions showing different characteristics, as in the case of lower organisms. As population and division of labor increased, more or less permanent conditions developed, but many of the early societies have doubtless disappeared without leaving a trace of their existence, while others are known only by implements or other remains. Among the surviving peoples all grades of culture are represented, many having ceased to advance long before they came in contact with the more progressive nations of western Europe.

During this long period of social evolution the human body has shown no great changes. According to Osborn, the Cro-Magnon race which inhabited Europe during paleolithic time was fully equal to modern man in physical development, perhaps also in mental capacity. A similar stability is shown by man's animal instincts. Only by adding to his social heritage has man advanced.

Henceforth human progress has been largely a series of attempts to solve certain fundamental problems. One of the first of these to receive attention was the problem of government. After experimenting with various systems, some democratic, some autocratic, many including caste and slavery, the more advanced nations of the world have adopted the democratic ideal of equal units cooperating in such a manner as to secure both the freedom of the individual and the security of the state. Under this ideal, differentiation is limited to differences in mental capacity, wealth or occupation, and each individual is free to make the most of himself. The ensuing struggle results in the development of the fittest and thus promotes the welfare of society.

Recently the adequacy of this ideal has been called in question by the advocates and supporters of a new experiment in class government. In Russia, the ancient stronghold of democracy, revolution has usurped the place of evolution, the government of the Czar has been overthrown, and in its place has been set up an autocracy of the proletariat, "the worst autocracy the world has even known". This system destroys the incentive to individual effort by denying the right to hold private property or to engage in private enterprise. By confiscating the property of the capitalistic classes, this system has thus far maintained itself and is spreading its poison throughout the world. In the immediate future it is a factor to be reckoned with, both in Europe and Asia. Spasmodic outbreaks may also occur elsewhere, nevertheless the influence of Bolshevism seems to be waning as its funds approach the point of exhaustion, and the final result of the experiment, apparently, will be to strengthen the cause of government by all the people.

Another problem, the solution of which lies still in the future, is the problem of international relations. The need of adjustment in this field has been recognized only in recent times. In international affairs, the rise of civilization has been marked by natural selection,—the "ape and tiger method" which figured so largely in the evolution of lower organisms. In the past, and even in recent time, attempts have been made to justify this method on various grounds. But conditions have changed. Modern nations are no longer isolated, as were the ancients. By increase of population and by improved means of communication the nations of the world have become one, and the prosperity of every state is closely linked with that of its neighbors. These common interests of nations demand a recognition of their oneness in international law,—a recognition of the principle of cooperation in place of natural selection. Unfortunately the high hopes that were conceived during the war have not yet been fully realized. But some progress has been made. The same need that led individual man to form societies is now insisting on the formation of a society of nations.

Some sort of a working league of all leading nations seems to be the next step forward.

The importance of more complete coordination in the industrial affairs of nations has become more and more apparent during recent years. A modern state is composed of many industrial groups, each one seeking special advantages for its members, and often without regard for the interests of other groups or for the good of society. Labor decides to strike in order to obtain a larger share of the profits of industry, employers endeavor to enforce their demands by means of the lockout. The result, in both cases, is an interruption of industry, while the damage too often falls chiefly on the innocent public. A few generations ago strikes and lockouts were used only as weapons of last resort, to obtain redress for grievances, either real or imagined. Today they are often used as a matter of policy, whenever the time is favorable for advancing the interests of the party concerned. The necessity of society thus becomes the golden opportunity of both capital and labor, and so dependent is society on the continuous operation of certain industries, that swift calamity would follow even a brief interruption of work. The possibility of a general strike of coal miners or railway employees has been brought uncomfortably near during recent years.

In this country, at the present time, there is no reason for alarm in regard to the final outcome of such a strike. Certain compromises would be made, work would finally be resumed and the authority of society would be vindicated. Such a settlement, however, would not prevent a repetition of the disturbances. In those industries which are essential to the public welfare, both strikes and lockouts must be prevented, and this can be done only by removing the cause. In the great industrial expansion of the past century, certain organizations of capital and labor have been formed in the social body, but the hormones which should regulate their activities are lacking. Differentiation has outrun coordination. It is necessary to adjust the relations between society and the classes so that the welfare of all shall be safeguarded. When the classes recognize the fact that they are merely organs of the social body, and when they realize that this dependence carries with it duties as well as rights, then it will be possible to enact laws which will insure a reasonable measure of industrial peace. Only by such cooperation can the classes reach their own highest good.

Some progress has been made toward this goal. Employers and employees are beginning to appreciate their obligations. Labor did its share to win the war and it has generally resisted the seductive advances of Bolshevism. It is to be hoped that the lesson of cooperation learned during the war will help to solve the problems of peace. Failure to accomplish this must mean failure in everything. Only when a species is headed for destruction are violations of the laws of coordination tolerated, even for a time.

Other social problems which are calling for attention, are due to violation of certain laws of reproduction. The growth of human population is subject to the same general laws that hold good among lower forms. The increase of every species must eventually reach a limit, and this limit has actually been reached by the great majority of living species,—a stage in which the average increase equals the average death-rate, and population fluctuates only slightly from time to time, as conditions are favorable or unfavorable for additions. Such a condition of equilibrium may be temporary or it may continue indefinitely. In the former case, under favorable conditions, it may be followed by a new increase, while unfavorable conditions may lead to actual decrease and final extermination.

In the case of man, the increase of population must be limited finally by the supply of food and other necessities. In China and India, at the present time, population varies directly with the food supply. A similar condition, which existed in Japan for more than 150 years, was brought to an end by contact with Western civilization and the adoption of Western methods and inventions. As a result, population in Japan increased 60 per cent. from 1871 to 1915, and the increase still continues. A somewhat similar change occurred in Europe after the Industrial Revolution. About 300 years ago the population of Europe had become stationary because of a high death-rate due to war, famine and plagues. When the discoveries of science made possible the control of devastating diseases and provided for a more constant food supply, population increased rapidly. At the present time, because of a declining birth-rate, population is again approaching equilibrium,—a condition already reached in France. In England, between 1871 and 1911, the rate of increase declined from 1.38 per cent. per annum to 1 per cent. per annum, and the same tendency is evident in the United States and elsewhere. According to East, the high cost of living, due to decrease of the food supply, is the chief cause of this decline, but it is not the only cause.

Under conditions now existing in international affairs, when military strength is one of the chief concerns of nations, the present tendency of the birth rate is naturally considered undesirable. If the population of France had increased as rapidly as that of Germany after 1871, the Kaiser would probably have hesitated to begin the world war in 1914. But the laws which control population are not easily changed to satisfy national ambitions or fears. It is well, therefore, to recognize the fact, that unless science comes to the rescue with improved methods of food production, the birth-rate of civilized nations must continue to decline until population becomes stationary.

The deplorable feature of the situation, from a biological standpoint, is the fact that the decline of the birth-rate is selective: it is greatest in those classes of society, which by reason of heredity and education, should be expected to contribute offspring of greatest value. Such conditions have not been confined to modern times. In the two centuries from 500 B. C. to 300 B. C., Greece produced a group of men whose achievements, judged by modern standards, indicate native ability of a high order. But the brilliant Athenian race declined, and many smaller groups,—families of statesmen, artists and scholars of later centuries, have completely disappeared. Few families of this class, according to Broman, survive a period of 250 years.

In these modern times, society takes the talented child and educates him largely at public expense, in order that he may contribute something of immediate value to the state, but the conservation of this talent for the use of future generations is a matter in which society has taken little interest. Man is wasteful of coal and of other resources of the earth, but for these he has at least the hope that he may find substitutes. The most deplorable waste is the waste of the hereditary sources from which genius springs. Professor Cattell tells us that a Harvard graduate has, on the average, three-fourths of a son, a Vassar graduate, one-half of a daughter. College graduates are regularly informed by the commencement speaker that they are the salt of the earth, the leaven of the whole lump of society, but in a biological sense the leaven is weak and the salt has lost much of its saltness. The call for highly educated men in the universities, colleges and the professions is greater today than ever before and it is certain to increase. If present tendencies continue, the future will see a great drain on the biological resources of the civilized nations.

In order to improve his stock, the breeder of domestic animals selects only perfect specimens; he knows that elimination of the superior animals will mean race deterioration. Has human mental capacity declined because the talented ones of past ages failed to perpetuate their kind? There are those who believe that such a decline has occurred since the days of Aristotle. Perhaps it is safe to say there has been no great improvement. But this much is certain. Heredity is a factor in mental evolution, and if human talent had maintained itself in the past without loss, the average mental capacity of modern civilized man would be higher than it actually is. Whether a decline of this average mental capacity has occurred, or will hereafter occur, must depend on the relation between losses and gains. To balance the loss of talent in the educated classes, there is the possibility of increase from mutations, or talent may increase in a latent condition. We know that heritable variations have occurred in the past; the existence of different races of men is sufficient evidence of this. But if this evidence seems to justify the belief that progressive mutation of the mental faculties occurs today, we are still ignorant in regard to the frequency of their occurrence. We are not certain that they replace any considerable part of the losses of talent in civilized countries. There is, however, more or less latent talent among men, in families whose members are undeveloped because of lack of education. In the United States and other progressive nations the amount of such talent may also be augmented by immigration. From all of these sources, it is possible the increase may be sufficient to fill the places made vacant by the extermination of educated families. But substitution is not restoration. The losses on the firing line can not be made good by calling up the reserves; the total strength of the army is nevertheless reduced. We must conclude that man is advancing socially at the expense of his biological heritage. Whether this heritage is increasing or decreasing is uncertain, but under the most favorable conditions, society is falling behind the high development of which it is capable. At present the only hope for improvement lies in a campaign of education. Society should see to it that the rewards of service are sufficient to enable the educated man to live a normal life as head of a family. The educated man should appreciate his obligations to society. The problem is to discover a way to utilize available talent and at the same time to conserve it for future generations.

But if civilization has been unfavorable for the reproduction of the educated classes, it has been especially favorable for the reproduction of the uneducated. In fact, it has become a veritable paradise for the unfit. In his treatment of the dependent classes, man has suspended the process of natural selection; he preserves and cares for the mentally unfortunate, permits them to multiply, and by marriage with normal individuals, to increase the number of tainted persons in the community. At the same time he is placing on society the burden of caring for an increasing number of persons who are totally unable to care for themselves. The seriousness of this problem is well known and considerable progress has been made toward a solution. Increase of the abnormal must be prevented by proper measures, and the entire group of defectives must be reduced to the lowest possible minimum. At the same time, education of the public in regard to the importance of eugenic marriage will reduce the number of tainted persons in society.

The entire situation, as I have described it, may be summarized as follows: In the development of society certain laws of progressive evolution have been violated. Man has produced an artificial environment in which the defective classes are increasing while the educated classes are not perpetuating themselves. He has permitted the formation of social groups but has not insisted on the proper coordination of these organs of the social body. In international affairs he still employs the "ape and tiger methods" of his ancestors. The scientist is interested in the solution of these problems because he is a citizen, and since the problems are largely scientific, he should assist in their solution. I will not go as far as Groves, who says that since the scientist has made our era, he is also responsible for its problems. The duty of the scientist is investigation. Our social problems have arisen because of the weakness of human nature. The supreme test is this: Can human intelligence devise plans for overcoming the defects of our social system, and having found such plans will it be able to make them effective? Looking backward at the progress already made, there is reason for encouragement. Present conditions have been reached through a long process of development. There is every reason to believe that the scientific era of society has only begun. If all of the best elements will join in enforcing the necessary obedience to the fundamental laws of evolution, the golden age of society is yet to be. Such a future can be achieved only through cooperation.

HEALTH SERVICE AT PURDUE UNIVERSITY.

O. P. Terry, M. S., M. D., Purdue University.

In University work as in Industrial work it has been recognized for a long time that health is of absolute fundamental importance.. In 1912 there was established at Purdue University what is known as a Medical and Infirmary Service. The primary object of this was the prevention of disease, especially of the contagious group. Other less important objects were the first aid and subsequent treatment of injuries received in the performance of University duties. Also the examination of any student who considered himself unfit for University duties, especially athletic or military. Still another object was to provide the student with some financial aid in case hospital care became necessary. The rules established in 1912 for governing the working of this service were simple. That they have been satisfactory is evident because they have remained practically unchanged during the past eight years. The rules governing this service are as follows:

"In order to encourage students to exercise greater care in the preservation of their health and prevention of disease, the University authorities have organized a Medical and Infirmary Service which provides for each student the opportunity for free consultation with a competent medical adviser, and, when necessary, for reception at either of the hospitals at Lafayette for a limited time, free of charge.

"The regulations governing this service are as follows:

1. Fee.—Each resident student is required to pay annually at the time of registration a medical and infirmary fee of $1.00.

2. Consultation.—The University physician will be in his office at Stanley Coulter Hall at regular hours daily for consultation on matters of health by any student, free of charge.

3. Hospital Service.—With the approval of the University Physician, any student in good standing may be received in the St. Elizabeth Hospital or the Home Hospital of Lafayette during the academic year, and the necessary hospital charges will be defrayed by the University to an extent not to exceed $1.50 per day and for a time not to exceed seven days.

4. Contagious Disease.—Following an absence from the University due to contagious disease a certificate of health must be obtained from the University Physician before re-entrance.

5. First Aid.—In accidents or emergencies occurring on the campus in connection with University duties first aid will be administered by the University physician without charge.

6. Exceptions.—Medical attendance at the homes of students or at the hospitals; drugs and medicines; treatment of injuries received in physical exercises and contests; and treatment of certain specific and chronic diseases are not included in the above privileges.

7. Nothing in the above is to be construed as interfering with the right of any student to employ the services of any physician in a private capacity, but if in so doing he wishes to avail himself of the hospital privilege as above provided, the approval of the University physician is necessary."

In addition to what the above rules specify, the Department of Pharmacy has undertaken the task of filling, free of charge, the prescriptions written for the students by the University physician. This is for the purpose of giving the students in Pharmacy some practical experience in filling prescriptions. This work is, of course, done under the careful supervision of an experienced Pharmacist.

Some points in the above rules need some explanation. It will be noted in rule 1 that all resident *students* are required to pay the fee, which means that the instructional staff and other employees of the University are not entitled to the service. In regard to rule 2, it will be seen that the University physician is not required to give treatments. This applies especially to treatments requiring the training of a specialist, for example, eye, ear, nose and throat work and genito-urinary work. However, in these cases, advice is given as to where proper treatment may be received. In regard to rules 3 and 7, it has been found by practical experience that it is better that the hospitals notify the University physician daily of the admission of students for the past twenty-four hours. The allowance of $1.50 per day covers the necessary expenses in a private ward. If any student desires more expensive surroundings he may have them at his own expense. Rules 4 and 5 are self-explanatory. It will be noted in rule 6 that the care of injuries due to athletics, whether they be caused by inter-collegiate or inter-class games, is not a part of the University physician's duties. Such injuries are taken care of by the Athletic Association which has a surgeon of its own, and whose duties bear no relationship to those of the University physician. The last part of rule 6 is in reference to such chronic conditions as tuberculosis and chronic heart and kidney troubles, and especially to venereal diseases. Of course, we know that these latter exist, but it has never been felt that the University life was endangered by them.

The medical adviser in this organiaztion is a licensed physician, who devotes an average of three hours a day to the dispensary work, in addition to which he exercises supervision over the admissions to the hospitals. The variety of the experiences given in the dispensary may be seen in the appended list of diseases, which also includes the number of times those diseases appeared for diagnosis.

It is, of course, impossible to make any more than an estimate of the value of this health service to the student body. It certainly would seem to be worth cosiderably more than its cost to the students. During 1909, 1910 and 1911 the average number of students in the hospitals during the school years averaged about 75. During 1912, 1913 and 1914 the average number dropped to below 60, even with a slightly greater attendance at the University. Since this time the hospital attendance increased to 185 during the last school year, 1919 and 1920. This increased number is due to three factors. First, that the attendance at the University was 75 per cent greater than in 1910. Second, to the fact that the students took greater advantage of the opportunity afforded for hospital treatment, and, third, to the epidemic of influenza. The second fact is attributed in part to the experiences of the students with medical and hospital work during the war.

During last year there were only three deaths among the resident students, two following mastoiditis and one appendicitis. Our experience with contagious diseases has been very satisfactory. Last year there were:

scarlet fever five cases, small pox 4 cases, diphtheria 2 cases, chicken pox 1 case, mumps 25 cases, and measles 2 cases. This list, of course, does not include the relatively enormous number of cases of bronchitis, coryza and grip which some called influenza. That the student body availed itself of the advantages of the dispensary service is indicated by the fact that of the 2,730 students, who were eligible to the service, 1,249 took advantage of it. These 1,249 presented themselves to the office of the University physician 1,980 different times with (for them) different illnesses. For some of these illnesses many calls at the office were necessary so that the total number of office consultations or treatments, given by the University physician during the school year, was probably in excess of 5,000. The number of prescriptions filled by the Pharmacy Department was 3,600. In addition to the above figures 1,100 excuses were written for the Military Department.

List of diseases, with the number of times they occurred, which were diagnosed and given a varying number of treatments in the office of the University physician, Purdue University, during the school year, 1919-1920.

BLOOD—CIRCULATION—DUCTLESS GLANDS.

Anaemia—1
Hypertrophy of Heart—1
Mitral Regurgitation—5
Myocarditis—1
Tacchycardia—4
Faint—1
Varicocele—1
Lymphadenitis—13
Lymphangitis—1
Goitre (simple)—1
Hyperthyroidism—1

CUTANEOUS.

Chilblain—2
Frost Bite—1
Tinea Circinata—6
Tinea Cruris—45
Tinea Psycosis—6
Wound (Abraded)—13
Wound (Puncture)—2
Wound (Lacerated)—19
Wound (Infected)—75
Impetigo Contagiosa—2
Paronychia—7
Burn—6
Boil—31
Stye—2
Furunculosis—13
Acne Vulgaris—16
Ingrown Toenail—2
Pediculosis—2
Scabies—2
Seborrhea—1
Dandruff—1
Impacted Cerumen—2
Otitis Externa—1
Hyperhydrosis—1
Urticaria—16
Eczema—22
Psoriasis—5
Clavus—2
Pruritis—3
Rhus Poisoning—12
Sumach Poisoning—1
Verruca—9
Vaccination—3

DIGESTION.

Stomatitis—3
Gingivitis—1
Hyperplasia of Gum over Wisdom Tooth—10
Calculus in and Infection of Wharton's Duct—1
Mumps—25
Herpes Labialis—4
Hyperchlorhydria—5
Indigestion—28
Gastritis—8
Enteritis—6
Gastro-Enteritis—1
Appendicitis—1
Colitis—13
Intestinal Toxaemia—5
Ptomaine Poisoning—2
Rectal Fistula—1
Constipation—50
Biliousness—4
Flatulency—3
Diarrhoea—21
Hemorrhoid—7
Taenia Saginata—1
Oxyuris Vermicularis—1

RESPIRATION.

La Grippe—167
Bronchitis—453
Epistaxis—3
Ulcer on Nasal Septum—1
Frontal Sinusitis—13
Coryza—142
Pharyngitis—265
Laryngitis—12
Tonsilitis—120
Broncho Pneumonia—1
Influenza—1
Asthma—2
Pleurisy—4
Incipient Tuberculosis—1
Arrested Tuberculosis—1

OSSEOUS—ARTICULAR—MUSCULAR.

Rheumatism (Articular)—6
Rheumatism (Muscular)—15
Myalgia—17
Myositis—5
Hernia—2
Sprain—15
Broken Arch—3
Sacro Iliac Joint (Movable)—1
Exostosis—2
Tendo Synovitis—1
Infection Alveolar Process—1

SYSTEMIC.

Scarlet Fever—1
Small Pox—1
Chicken Pox—1
Measles—2
Liberty Measles—1
Herpes Zoster—7
Gout—1
Lead Colic—1
Abscess—5

NERVOUS.

Concussion of Brain—2
Headache—22
Neuralgia—8
Neurasthenia—1
Epilepsy—1
Insomnia—1
Paralysis—3
Hysteria—1
Neurosis—4
Hiccoughs—1

RECEPTOR.

Eye Strain—9	Eustachitis—1
Foreign Body in Eye—13	Otitis Media—4
Conjunctivitis—40	

GENITO—URINARY.

Dysmenorrhoea—1	Phimosis—5
Endometritis—1	Acute Nephritis—2
Orchitis—2	Cystitis—1
Vesiculitis—2	Polyuria—3

SOME GUESSES BY AN IGNORAMUS.

ROBERT W. MCBRIDE.

The average man of science, when he hears this paper read, is likely to exclaim with Pope,—"Fools rush in where angels fear to tread". I frankly confess myself an ignoramous as to matters of science. I can claim only such superficial knowledge of matters that are commonly classed as scientific, as may be acquired by any busy professional man who thinks, and whose thoughts carry him beyond the boundaries of his own profession. We are surrounded by matters clothed in mystery. To the man who thinks, there is nothing more fascinating than a study of these mysteries. We want "to see the wheels go round", and to learn what makes them go. As a general thing, however, our thinking can't carry us very far. We find the problems perplexing, and we are content to leave their solution to men of science, and are prone to accept their explanations as the average orthodox churchman takes his theology,—on faith. Occasionally, however, we find heterodoxy in matters of science, as well as in matters of theology. Somehow some of the explanations do not seem to explain. For instance,—the attempts of science to explain the problems relating to life and evolution fail to satisfy me. This of course may be due to my ignorance, and to my inability to comprehend. Still an ignoramus may have ideas, and though his ideas may be wide of the mark, may there not be times when even ignorance stumbles onto a truth?

All about us are living things, but what is it that makes them live? What is life? All about us are different types of living things, but what is the cause of the difference? Were they all different from the beginning, or did they all begin alike, and have the differences resulted from causes operating since they began? Has man always been man, or did he begin as something else?

I am encouraged to make some suggestions concerning these matters, because as to life science gives no satisfactory answer, and as to evolution many things are advanced that are confessedly mere guess work. When men of science attempt to tell what life is, their answers remind one of the Lord's answer to Job in the whirlwind,—"Who is this that darkeneth counsel by words without knowledge?" As a rule, they use a multitude of words and end with a guess. Two of the latest pronouncements that have come to my knowledge are by Sir Oliver Lodge and our own Edison. Sir Oliver Lodge, in one of his latest published utterances, says:

> "To show that the living principle in a seed is not one of the forms of energy, it is sufficient to remember that that seed can give rise to innumerable descendants through countless generations without limit. It is nothing like a constant quantity of something to be shared, as there is in all examples of energy. There is no conservation about it. The end embodies a stimulating and organizing principle which appears to well from a limitless source."

In a recent issue of the Scientific American, I find an interview with Edison, who says that—

> "Life, like matter, is indestructible. There has always been a certain amount of life in this world, and there will always be the same amount. You cannot create life: you cannot destroy life: you cannot multiply life."

Again, he says:—

> "I believe our bodies are composed of myriads of infinitesimal entities, each of which is a unit of life, which band together to build a man."

Sir Oliver Lodge does not attempt to tell us what life *is*, but is quite positive that it is *not* a form of energy, and one of his reasons is that it is without limit. Life can create new life through countless generations and without limit. While Edison seems equally confident that there is only a limited amount of life in the world; that there has always been a certain amount, which can be neither increased nor diminished.

Theories of life and theories of evolution, as I understand them, are closely interrelated. While evolution is no longer a mere theory, but is an accepted and a demonstrated fact, the limits within which it is thus demonstrated and acepted are, it seems to me, far from being settled, and it is difficult to determine where fact ends and imagination begins. Thus, we are told by the evolutionist of a germ,—an atom of protoplasm that in some mysterious way and at some time in the dim and distant past appeared in primeval slime, and from which all living things have been evolved, and that this germ was the bearer of life to our globe. Of course evolution, as thus conceived, assumes the pre-existence, somewhere, of this initial germ, this life bearer. If we become inquisitive concerning the life with which this initial germ was charged, they sidestep, and we are blandly informed that evolution does not deal with origins or with beginnings,—it only deals with the way things have gone on since the germ appeared. I find that where knowledge ends, science does not hesitate to guess, surmise and imagine. So various guesses are ventured concerning the germ, with its inseparable companion or property, life; among others, that the original germ may have been wafted to us from space on the wings of an atom of cosmic dust. But as our earth is itself, relatively to the universe, only a speck of dust in illimitable space, this guess only transfers the genesis of the germ to some other speck of cosmic dust, and tells us nothing of the life it carried. Another guess is that through some mysterious process of nature's chemistry, protoplasm happened to form, with life as one of its inseparable properties, and chemists have been industriously trying to learn just how this happened and to make artificial protoplasm, and with it, of course, life. As yet I have seen no record that they have succeeded. But suppose they do? Will that tell us what life is?

And now, with much timidity, as against some of these guesses and imaginings of science, I venture my suggestions, which are, of course, only my guesses and imaginings. To me it seems a certainty that back of all the complexity of that which we call nature, is a supreme intelligence, which is made manifest by the operation of law,—law which so far as we can grasp the idea of infinity is infinite in its operation,—law which in the reach of its grasp, as well as in the certitude of its control, passes any boundary which we have been able to reach with any instrument yet devised,—

whether of things minute beyond the power of the microscope, or of things vast beyond the reach of the telescope, the spectroscope, or the camera, from the suppositious electron on one hand, to the mighty suns and the nebulous star drift of unbounded space on the other. It also seems to me that this certainty extends to all things visible or invisible, animate or inanimate, physical or non-physical, and that all are in the inescapable grasp of that law. If so, all are therefore equally within the comprehension and the design of that supreme intelligence. It also seems to me that while our world is only a comparatively insignificant atom in an apparently boundless universe, the evidence given us by the instruments devised by science shows that that universe is homogenous, and that the differences in its various members is a difference not due to differences in their composition or to laws by which they are governed, but to differences in the stages of their growth or development; that all of the things in that univer.e have always been, and always will be, including those things to which we give the names matter and force. As the scientist apparently feels justified in using his imagination by way of supplement to his knowledge, so my imagination has included under the terms "force" and "energy" other things than those which conform to the so-called law of the conservation of energy;—such as gravitation, and life, with other possible and probable undiscovered, undifferentiated, or unnamed forces or modes of energy; that nature is only a name for that which lies back of all those things,—that supreme intelligence; that the so-called laws of nature are simply attributes of that supreme governing power or entity, and the so-called forces simply the methods by which that intelligence makes itself manifest. In my ignorance I am able to find in the physical universe only three ultimate and fundamental things, viz: the action of that supreme intelligence of which I have spoken, matter or substance, and force or energy—force and energy meaning to me only different phases of the same thing. To me, matter and force are inseparable, and I cannot imagine one as existing apart from the other. Science tells us of many elements, but to me they are all resolvable into one elementary substance,—the various so-called elements being due to the manner in which the electrons composing them are combined. To me there is only one elementary force, all the various so-called forces being due to the manner in which that one elementary force manifests itself under varying conditions. My imagination carries me further, and to me life seems to be nothing more than one of those forces,—nature's organizing and con tructive force,—nature's master builder; that germs are its trestleboards on which it finds the perfect plans for the structures it is to build, whether that structure is intended to be a tree, an earthworm, or a man; that protoplasm and germs have not just happened, but that they are a part of the plan of that supreme intelligence; that each germ embodies an idea of that supreme intelligence, and that in each of these germs life, the builder, finds every detail of the future tree, plant, flower, or animal. True, I have been told that in animal life, up to a certain stage in the development of the embryo, it is not possible for us to distinguish between the human embryo and that of other animals. While this may all be true, is it not also true that life never encounters any such difficulty? On the contrary, when life begins its work with a given germ, is it not plain that it knows exactly what the finished product is to be,—

just what is enfolded within that germ? Whether it is the germ of a horse, a dog, a monkey, or a man, life makes no departure from the plan it finds traced in that germ, except in the way of development and improvement. For instance, when the germ is that of a horse ,has not the finished product been at all times unmistakably a horse? Is not the Eohippus as certainly a horse as is the thoroughbred of today. True, some of the toes of the Eohippus, with their several toenails, have disappeared under the one big toenail we call a hoof, but do not the vestiges of the submerged toes remain to tell their story?

I have watched with interest the zeal with which the search has been prosecuted for the missing link that it is said will confirm our Simian ancestry, and have wondered why, if this is true, nature neglected to preserve some vestige of our lost caudal ornament,—some hint of the missing vertebral attachment. I have wondered if it were not possible that instead of all forms of life having developed from a single germ, that nature had not exhausted itself in producing one type of germ, but instead had been capable of producing and had produced innumerable germs, so that each separate type of organic life may have had its start in its own particular germ. I know it often happens that men, in delving into their genealogy, encounter disagreeable surprises. It may be true that we are only improved monkeys (with apologies to some monkeys for some men). But if nature did not exhaust itself when it produced the initial germ, may it not be after all that the germ from which we are descended was from its beginning a germ of humanity?

Evolution must be accepted, but not necessarily the mere guesses of the evolutionist. As long as it is a mere matter of guessing, I claim the right to guess for myself. It takes more than the Neanderthal man, or the so-called Ape Man of Java, to make valid the guess of our Simian ancestry. The beginning of mankind on earth doubtless goes back to an initial germ, but it is my guess that the plan traced in that initial germ by the master architect, and which was followed by the master builder, life, was always man. Man, as man, has developed and is developing, but I decline to acknowledge kinship with either the mighty Saurian, the equivocal Simian, or the lowly earthworm.

And now I venture one other guess: Protoplasm is not life, nor is it any part of life. It is simply the conductor of life. It is the vehicle through which life acts and with which it works.

All this of course deals only with the visible, physical world, and the visible, physical universe,—the world and the universe of phantasmagoria, of visible, changing, but transient forms,—forms which are simply the effects of causes beyond our ken. It is another story that deals with that other world, where consciousness dwells, that real but invisible world of causes and of realities.

REPORT OF A STUDY OF MENTAL ABILITY OF CHILDREN IN ONE ORPHANS' HOME IN INDIANA.

ARTHUR H. ESTABROOK.

All the children in one orphans' home in Indiana have been given mental tests, with the exception of those under the age of six years. The Stanford Revision of Binet tests was used. At the same time the Pressey group tests, the primer and cross out, were given to all those attending school. A social study of each child has been made and, with this combined data, children in this orphans' home have been classified as: average, retarded, probably high grade defective, and feeble-minded. At the same time these children have been considered from the standpoint of placeability in foster homes or admission to the School for Feeble-Minded Youth at Fort Wayne. One hundred forty children, in all, have been studied. Fifty-three of these have been found to be of average mentality, 37 retarded, 12 probably mentally defective and 38 definitely feeble-minded. One hundred one of these 140 are wards of the State. Of these 101, 34 are of average mentality, 24 retarded, 10 probably high grade defectives, and 33 feeble-minded. These have been classified as to their placeability in foster homes, retention in the institution for further study and training, and those sufficiently mentally defective that they should be placed in the School for Feeble-Minded Youth because of such a degree of mental defectiveness as to be unplaceable in foster homes or retained in the Orphans' Home. Forty-eight are found placeable; 15 should be retained for further study and training, while 38 are so definitely feeble-minded as to be a detriment to the institution.

The accompanying chart shows the distribution of the mental ages showing the mental acceleration and mental retardation. It is interesting to note that 15 children are advanced in age mentally and 23 grade exactly normal for physical age; 28, or 20%, are retarded one year; 18, or 13%, are retarded two years: 56, or 40%, are retarded three or more years. This study shows the need of a mental examination and social study of all children in the orphans' homes in this state that they can be properly classified and that proper distribution of these in suitable institutions be made at the earliest possible moment, thus relieving the orphans' homes of the burden of the mental defectives who are properly not their charges, and paving the way for their proper care in a custodial institution for the feeble-minded.

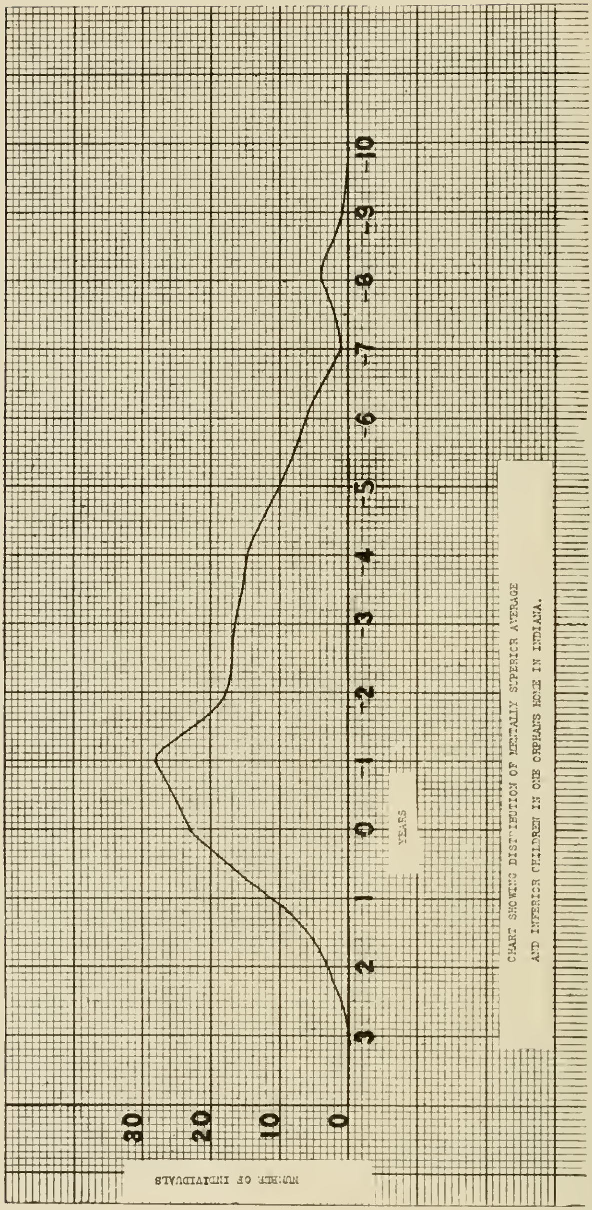
CHART SHOWING DISTRIBUTION OF MENTALLY SUPERIOR AVERAGE
AND INFERIOR CHILDREN IN ONE ORPHANS HOME IN INDIANA.
YEARS
3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10
NUMBER OF INDIVIDUALS
0 10 20 30

TESTS OF THE EMOTIONS.

Sidney L. Pressey, Indiana University.

The past three or four years have witnessed an altogether extraordinary activity in work with "mental tests". As a chief result, it is being realized that such tests are by no means as valuable as was once thought. It has frequently been stated that the most important single cause of delinquency and crime was feeble-mindedness. But a very careful investigator has recently published data (the most accurate of its kind so far) showing that the inmates of a certain state penitentiary average practically the same in intelligence as the general adult population. It was once supposed that most cases dependent upon charity showed a mental age below twelve and were to be considered feeble-minded. We now know that a "mental age" of twelve is only very slightly below average in mental development. The result is that feeble-mindedness is being used much less than formerly as an explanation of social difficulties, and that research workers are turning more and more toward emotional and environmental factors in seeking an explanation for such social and economic mal-adjustment. And there is really a great deal being done, in a quiet way, in the attempt to measure the emotions. So I want you to think of the scale, copies of which I have passed out to you, as by no means a bit of freak research, but as simply one of a number of efforts along this line.

The first test consists, as you will see, of twenty-five lists such as:

disgust fear sex suspicion aunt
roar divorce dislike sidewalk wiggle
naked snicker wonder spit fight
failure home rotting snake hug
prize gutter thunder breast insult

The subjects are told first to go through the lists and cross out everything that is unpleasant to them. Then after they have done this, they are told to go through the lists again, and to draw a circle around the one word in each list which is *most* unpleasant to them. The words are arranged according to a definite scheme; there are five sets of words, a series of jokers and words chosen as unpleasant to four different types of morbid personality. The selection of words has been made on the basis of extended experience in work with the insane and with delinquents. Back of the test is a large body of theory with regard to the neuroses; it is held by many writers that in such morbid conditions there is a marked increase in the tendency to emotionalize, and a tendency to transfer emotion from usual to unusual or associated objects. The test is scored with these two points in mind. First, the total number of words crossed out is counted. Then the scorer counts the number of times the subject has chosen an unusual word, in selecting the most unpleasant thing.

The second test consists of twenty-five lists such as:

BLOSSOM	flame	flower	paralyzed	red	sew
LAMP	poor	headache	match	dogs	light
BATH	naked	choke	tree	alone	danger
KING	father	baseball	queen	rights	razor
SLEEP	grade	ache	fright	tongue	worry

The subjects are told first to cross out all the words in small letters which are connected in their mind, or associated, with the word in capitals at the beginning of each list. They are then told to go through the lists again, and draw a circle around the *one* word in each list which is most closely connected with the capitalized word. The words are chosen very carefully with reference to pathological conditions and criminology. Thus following "DREAM" is the word "floating", since according to certain psychiatrists dreams of floating have a definite significance. Following "DEATH" are the words "water", "self", "welcome", "hopeless", as words naturally associated by many persons going through an emotional crisis. The test has back of it a large body of research going to show that in pathological conditions peculiar connections between ideas are a very important symptom. The words used are primarily words of strong emotional content, with the idea that an emotional condition would show itself also in more extensive associations. Scoring again takes into account both of these possibilities: first the number of words crossed out is counted, then the number of peculiar associates, in selecting the word most closely connected with the capitalized word.

The third test consists of twenty-five lists of which the five below will serve as examples:

begging swearing smoking flirting spitting
fear hate anger jealousy suspicion
dullness weakness ignorance innocence meekness
careless fussy reckless silly childish
poor extravagant sporty shrewd bad-mannered

The subjects are told first to cross out everything they consider wrong. Then they are told to go through again and draw a circle around the one thing in each list they consider worst. The test is an attempt to put in a convenient group test form an ethical discrimination test. The general purpose of the test is obvious, and it need hardly be said that it has a long history and an obvious relevance in the study of delinquents. Scoring again is in terms of total words crossed out (or extensiveness of the moral attitude of the individual) and unusual selection of the worst thing (or idiosyncrasy in moral judgment). In general, an effort has been made to obtain judgments as to the comparative importance of different types of wrong-doing, as in the first list, or to obtain an indication of the tendency of one's prejudices, as in the fourth.

The fourth test consists of twenty-five lists such as:

injustice noise self-consciousness discouragement germs
clothes conscience heart-failure poison sleep
sickness enemies money blushing failure
falling queerness religion dizziness boss
sin operation conspiracy lightning marriage

The subjects are told, first of all, to cross out all the things in this list about which they have ever worried, and then to go over the lists again and draw a circle around the one word in each list about which they have worried most. Again the scoring is in terms of the total number crossed out (or amount of emotional stress), and peculiar choices in words circled (or idiosyncrasy in anxiety tendencies). And again the test has back of it experience with abnormal personalities; it has obvious relations to certain kinds of anxiety states. The test, it should be added, derives most directly from a questionaire used by Woodworth in studying neurotic individuals in the army. And it is aimed to involve the content of certain types of delusion common in mental disease.

So much for the separate tests: in summarizing the total examination the total number of words crossed out is first summed, and is considered an indication of total affectivity or emotionality. The deviations are then added together, and the total used as an expression of "total idiosyncrasy".

Well—the tests doubtless seem to you very crude—and so they are; they simply represent an effort at first investigation of a subject which has until recently been all too much neglected. But as an investigatory instrument the examination has certain advantages which I would like to have you consider for a moment. I mentioned a moment ago Woodworth's questionnaire. It consisted of questions such as:

Have you worried about smoking? Yes. No.

And the person taking the examination was to underline "Yes" or "No" according as one answer or the other was correct. Putting the questions in this way it required an 11x17 sheet to ask one hundred such questions. We ask one hundred fifty questions in a space 9x6; the total examination really asks six hundred questions all on two sides of a 9x12 sheet. The great condensation is obvious.

It is thus possible in a very brief space to accumulate a large amount of data. But there are other advantages. There is no elaborate technique in giving the examination. All that is necessary is to hand the blank to the person who is to take the test and say, "Read the directions, and do what they tell you to do". It is thus possible for us to send out the blanks to other colleges and institutions and obtain results which are strictly comparable, so far as directions are concerned, to the results we obtain ourselves. Suppose for the moment you are taking the test. You do not have to write any answers. All you have to do is cross out certain words or draw lines around them. The result is that the average college student answers these six hundred questions in less than half an hour! Furthermore, in the first scoring of the blank, all that is necessary is to count up the number of words crossed out, and the number of peculiar choices made in circling words. So the examination is an extremely convenient method of obtaining information; those of you who teach will appreciate that an examination in which six hundred questions are asked and answered in thirty minutes, and in which a first valuation of the results can be obtained in three minutes, is somewhat unusual.

However, such an instrument is of little value if the information yielded by it is not worth while. The examination is intended primarily, of course, for work with delinquent and with nervously abnormal individuals. And from such groups data are not yet available, though results from a number of reform schools, a group of colored people, a theological seminary, and a colony for epileptics will be ready soon. Results from a group of college students have, however, been analyzed to show sex differences. Briefly it may be said that 64% of the girls find more things unpleasant than the average (median) man. 56% of the girls worry about more things than the median man. 69% of the girls consider more things wrong than the median man. The girls are distinctly more original than the boys in selecting the most unpleasant thing (64% above the median man), but they are distinctly less individual in selecting things to worry about (36% above the median man). They are more original in their choice of the worst thing (69% above the men's median).

The results on the individual words are even more striking. The girls find words having any sex reference, or mentioning anything disgusting, much more unpleasant than the men do. The men on the other hand find particularly unpleasant such words as "disgrace, poison, persecute, unfair, failure". So far as worries go, the girls worry much more about religious topics than the men; they tend more to be depressed. The men stand out as worrying about their own health, as being distinctly hypochondriacal.

These are simply interesting bits of fact, however. The important question is: can such an examination or questionnaire yield information which will enable one to distinguish the psychopathic or the criminalistic from the average individual, in something of the same way as scales for measuring intelligence are used to distinguish the feeble-minded? As was said before, data from pathological groups are lacking. It was thought interesting, however, to determine how definitely the two sexes could be distinguished by means of the tests. Briefly, it was found that the results in total affectivity and total idiosyncrasy were largely identical for the two sexes; there was nothing distinctive in these totals. However, the four words on each test showing *most* distinctive results (in choice of the word to be circled) were found, and results on these sixteen words alone were used. And it was found that in thirty percent of the cases an absolute distinction could be made! In fact there was only one man who scored above the median for the women. It is at once suggested that similar valuable distinctions, in separating out the pathological and the delinquent, may be possible. At least it seems worth trying.

UNDERGRADUATE RESEARCH IN OUR COLLEGES AND UNIVERSITIES.

HORACE A. SHONLE, Eli Lilly and Co., Indianapolis.

The purpose of this paper would have been better expressed if the title had been the relation of industry to undergraduate research in the schools of Indiana. The point of view is that of the scientific man in industry who would draw our educational and industrial institutions closer together.

The Scientech Club of Indianapolis has been interested in promoting Research from the time it was organized, though we are yet in early childhood, having first seen light in 1918. The membership of this organization which is drawn from the professional, scientific, and technical men of the state of Indiana, consists almost entirely of university and college trained men. In our directorate are included representatives of ten or twelve national and state scientific and technical societies. We believe that our organization composed as it is of professional men from the industries, is appreciative of the points of view of both the university faculty and the directors of industry.

Consequently, when I say that the Scientech Club is vitally interested in Research in our schools, it means that our national and state scientific organizations are alive to its value. Most of the national organizations are prevented by their constitutions from participating in local issues and consequently the sentiments of their members are being voiced through the Scientech Club.

It has been the general experience in the past that too many of our technical and scientific graduates are unable to stand on their own feet when they meet relatively simple problems. They seem to have bounded their courses on the north, south, east and west by the backs of their text books. A recent cartoon depicted a graduate groaning under a load of books marked "Knowledge" and unable to accept the volume of "Wisdom" offered him. The wisdom and judgment secured from using this knowledge acquired, is lacking. Their knowledge is too often unorganized and disconnected. They know their theories, perhaps, but they do not know how to apply them. We do not expect the universities to turn out men in four years who are capable of solving hard problems, but it is discouraging when a chemist cannot prepare a simple soap without being minutely instructed, or when an engineer is unable to apply his theories to a bridge which differed from the one in the text.

Is it the student's fault that he lacks the quality of judgment? Rather is it not the result of how he is trained? Is it not absurd to give all the details of work to the undergraduate and then expect him when a graduate, to show initiative or creative power?

When a man has thoroughly thought out and worked out his first problem in a logical manner, we find him able to apply his theories to the next with less trouble. It is not imposible to teach a man how to solve problems when in the plant, but it is unprofitable and unnecessary if our schools are fulfilling their mission. The university is far better fitted to accomplish this than is the industry, for in the latter the student, now an employee, must be a secondary consideration.

A guess that is wrong is much better than no guess at all—the positive is better than the negative. There is hope for those who have been trained to think. The usual routine of lecture, quiz, and laboratory work, too often on separate parts of the same course, is not conducive to the best training in logical thought. The questioning, inventive, creative spirit must be aroused to a greater extent than it has been in the past. To say that we haven't a place in our curriculum for such training, where the student may find himself, indicates all the greater need for a more fundamental rearrangement of our college courses. The student may have been fortunate enough to have found the profession best suited to his abilities, but very few find themselves in that profession.

How can we overcome the prevalent view that a college training is a series of disconnected facts? Wouldn't the presentation of a gas engine to a group of freshmen engineers be of value in correlating numerous subsequent pages of algebra, physics, and theories of dynamics? As most courses are now arranged, we have ample time to forget all by the time we are introduced to a concrete example of our profession. Again the realization that few chemical reactions go entirely as represented by the equation requires a rearrangement of the mental attitude of the chemist at a time when he needs to have his faculties at their best.

It may be that our point of view errs. We do not appreciate all of the complexity existing in our universities, and we therefore do not presume to dictate any policy to our schools. We do look for results, however, and industry makes its judgment on that basis—something seems to be lacking in our college trained men.

After discussing the question of undergraduate research with representatives of the schools of Indiana, the Scientech Club adopted the following resolution:

> RESOLVED: That the Scientech Club through its Research Committee exert its influence in promoting and encouraging a research atmosphere in the educational institutions of this state. As one means to this end, be it
>
> FURTHER RESOLVED: That efforts be made through the Research Committee for the inclusion, as part of the curriculum in all scientific courses of such institutions, of an approved thesis as a requirement for graduation; such thesis to embody the results of investigation carried on during the fourth undergraduate year of study under proper faculty direction, and be it
>
> FURTHER RESOLVED: That in the fulfillment of such requirement, emphasis be laid upon the training of the student. The investigation should be designed to ground the student in the fundamentals of scientific inquiry, irrespective of the application of the study to industrial or other immediate practical uses.

Before proceeding further, we wish to emphasize the fact that we realize how essential is the cordial cooperation of the heads and faculties of the educational institutions of Indiana. Without that we cannot hope for progress.

The spirit of the resolution was favorably received by the schools at our first meeting and they expressed as deep a wish to cooperate with us as we did with them. Too often in the past, research work has been considered only in the light of its immediate results and we have found that our resolution has been so misconstrued. Consequently, we have made the following explanation and introduction to our resolution.

"The Scientech Club desires to emphasize in connection with the thesis requirement for graduation its conception of the term "investigation" as distinct from the commonly accepted concept of research. It recognizes clearly that the knowledge and ability necessary for a real contribution to human knowledge cannot be expected of many men of senior standing in our universities and colleges; that the ability to do research work is possessed by few, and in varying degrees. To demand a piece of real research of the student as a thesis is not the aim of the Club. It desires that the student undertakes during the fourth undergraduate year of study the solution of a scientific problem which will afford the means of developing in him initiative, resourcefulness, power of logical deduction, and the ability to think for himself. The objective need not be research in the sense of a new contribution, but should be original to the student with respect to his previous knowledge thereof and should consist of his individual efforts in the solution of such a problem and not alone of a compilation or review of existing literature on the subject.

"The Club believes that the fulfillment of the above thesis requirement under the conditions laid down in the resolutions, will in all instances prove a great mental asset to the individual *irrespective of his future activities*, will induce in great measure the development of latent research ability in the student body, and will distinctly promote the research atmosphere of the institution.

One of the university representatives compared the chemical department of Johns Hopkins University with its few courses and stimulating creative atmosphere to that of the University of Minnesota where countless courses only, seem to abound. Education should consist of training in judgment, resourcefulness and the ability to create rather than to encourage merely the amassing of facts. It does seem useless to give courses in obsolete industrial technique at the expense of investigation and yet we are told that our curricula are too crowded to include research. Any student who has had a thorough course in quantitative chemistry need not spend a half year applying that knowledge over again in a course of water analysis. Our educational institutions must furnish the spark to kindle the tinder of creative ability wherever it exists.

It is not commonly accepted by educators that the student will most rapidly develop the right mental attitude by discovering facts for himself—even if they were known before? Are we conserving our greatest resource, the power of creative thinking? My own university experience says "No." Each man must acquire the fundamentals of scientific inquiry to succeed no matter what profession he takes up. We are not asking the universities to produce genius, nor that the undergraduate research be of practical value—but we do ask for better trained men—men who have found themselves in a slight measure at least in their vocation.

We do feel that our schools as a whole have not been doing all within their power to utilize their equipment in the past. Nor has industry done its share—closer cooperation and the establishment of industrial fellowships must be secured. The training whereby the student is taught to think logically and observe details and by which his resourcefulness and creative ability is developed can be given without requiring a large expenditure of money. Undergraduate investigation must be carried on in our schools and carried on in an atmosphere that stimulates and inspires. We do realize that increased financial aid from the state must be had in order that our schools may even exist and we pledge ourselves to assist them by every means at our disposal in securing an increased appropriation.

We believe that our organization is in a position not only to discern the weak points in the present system of training, but to cooperate with the universities and colleges in correcting any faults that may exist, and that it can bring the schools and industries into a closer and more cordial relationship.

STATE ARCHAEOLOGICAL SURVEY.*

National Research Council, Division of Anthropology and Psychology, 1701 Massachusetts Ave., Washington, D. C.

Introductory to the accompanying proposals for the establishment of archaeological surveys in the States of Illinois, Indiana, Iowa, and Missouri, it may be stated that the National Research Council is a cooperative body of scientific men associated in an organization in which the leading scientific societies of the United States are represented by voting members, elected annually. The Council operates under the charter of the National Academy of Sciences and maintains permanent offices in Washington. The function of the Council is not to engage in research on its own account but "to promote cooperation in research, at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all cooperative undertakings to give encouragement in individual initiative, as fundamentally important to the advancement of science."

One of the Divisions of the Council is charged with the problems that arise concerning the different races of men, past and present. Under this head fall such problems as the archaeology of the several States in the United States. It being the belief of anthropologists connected with the Council that the institution of State Archaeological Surveys is timely and that the results of such surveys would greatly advance archaeological knowledge, the Council offers to cooperate with the citizens of the several States and assist them, as it may, in organizing and promoting such service. It is in this spirit that the accompanying proposal is made.

*Read before the Academy of Science by Amos W. Butler.

PROPOSED ARCHAEOLOGICAL SURVEY OF THE STATES OF ILLINOIS, INDIANA, IOWA AND MISSOURI.

1. *Purpose.*

An intensive study of the prehistoric population of the Mississippi Valley.

The initial approach to this problem is an archaeological survey of the states of Illinois, Indiana, Iowa and Missouri, with a view to determining the different types of the remains of the prehistoric population, together with their distribution, so that it may be possible to publish an Archaeological Atlas for each state, comparable with that issued for the State of Ohio. On the conclusion of the Survey it would be desirable to excavate, at least partially, two or three type sites in each state, to confirm conclusions as to cultural affiliations and chronological sequence derived from the data of the Survey.

State Surveys have been instituted in the neighboring States of Ohio, Michigan, Wisconsin, and Minnesota. Those in Ohio and Wisconsin have been long sustained with the support of strong State archaeological societies. The publications and scientific achievements of these organizations are well known. It remains now for the States mentioned above to work up their territory to give us a comprehensive view of prehistoric man in the upper Mississippi Valley.

II. *Organization.*

It is proposed (1) that the Legislature of the several States be requested to appropriate the necessary funds for the Survey and for the issuing of the State Archaeological Atlas and Report; (2) that the interest and cooperation of citizens, appropriate scientific and historical organizations within the several States be enlisted; (3) that in the absence of a more suitable agency within a given State, the Survey be organized under the Direction of the State Geological Survey; (4) that in order to secure a uniformity of results and to insure a requisite scientific standard in the work of the different State Surveys, the National Research Council will, if invited to do so, appoint a committee from its personnel to cooperate with such agencies as the State may designate, to carry out its specific survey, it being understood that such a committee is to act in an advisory capacity only.

III. *Method.*

The survey for each State is to be made by counties, all sites, mounds, etc., to be located upon the standard county maps. Descriptive data for each site or mound is to be compiled, and examinations made of all available collections of specimens in the possession of local students, farmers, etc., to list the type weapons, tools, pottery, and other artifacts, these data to be compiled in the report of the Survey.

IV. *Personnel.*

A single investigator should carry out the work for each State, but should be aided by one or more assistants. The investigator should be an archaeologist with some training and field experience. Local collectors and persons interested will be invited to participate. The salaried participants of the Survey should be employes of the State's agent, presumably the State Geologist. On all of these subjects, however, the National Research Council stands ready to act in an advisory capacity, if its advice should be requested.

V. *Reasons Why State Surveys Are Desirable.*

Your State is rich in mounds, earthworks, hill forts, etc., the remains of vanished peoples. How rich your State is in this respect, no one can say, for lack of a systematic inventory. Ohio and Wisconsin, for example, have become famous for their antiquities because they made systematic surveys and published the facts. This alone should be sufficient justification for the Survey, but there are many specific reasons why the State should provide for an inventory of its antiquities. Some of these are:

(1) The Mound Builders and other prehistoric peoples are subjects of great universal interest. They appeal particularly to farmers and owners of agricultural land who are, by reason of their daily occupation, brought

into intimate contact with archaeological remains. The educational value and the intimate culture value of correct data concerning our prehistoric population has not been fully recognized. Any efforts that will serve this almost universal interest in State antiquities will therefore contribute directly to the general well being of our Citizens.

(2) Collectors of stone implements, local and State, are numerous and by their combined activities have contributed in the past to the establishment of museums and the accumulation of knowledge. Since collectors are found in every locality, their combined constituency is worthy of some public support. Such citizens of your State as are interested in minerals and fossils are served by your State Geologist, but such individuals do not greatly exceed in number those seeking reliable information as to objects of antiquity. It seems, therefore, that the State will be fully justified in rendering this service, but it cannot intelligently meet these demands until a systematic survey of the States antiquities has been made.

(3) Such a survey is the first necessary step in the conservation and preservation of the State's antiquities. Its logical end is the establishment of State Parks in which are to be found typical mounds, hill forts, etc., and also the encouragement of State and local museums. The development of automobile travel has brought the need of State Parks which shall have in themselves some worthy intrinsic interest. The State of Ohio has shown what an asset such parks can be, for example, the Serpent Mound, Fort Ancient, etc. The Survey herein proposed is essentially to take stock and to see what the State possesses in the way of antiquities so that it may take the proper steps to preserve such of these as possess great public interest.

(4) Many States are now enacting laws on the preservation and protection of antiquities. Eventually your State will be confronted with this problem. The handling of this problem will require data from such a survey as herein proposed, for without exact knowledge of what your State possesses intelligent action cannot be taken.

WHISTLING SWANS. (Olor columbiánus.)

Etta S. Wilson, 9077 Clarendon Ave., Detroit, Mich.

There has been a wonderful increase in the number of Whistling Swans of late years noticeably since the enactment of the Migratory Bird Treaty. Direct and spectacular evidence of this is given in the large numbers of the birds which fly over Detroit and vicinity, and the increasingly large numbers which remain in that neighborhood for weeks during the spring when all shooting is prohibited.

It has not been so long since the appearance of a single swan during the spring migration was a source of wonder and gratification to the observer, and in the fall the bird was unnoted. Two years ago last March one swan spent three days in the canals of Belle Isle, Detroit's beautiful playground, having taken shelter there from a violent storm which was raging. The bird was very shy and usually saw you first, departing hastily as you approached. I tramped over the island every day in the early morning and found the bird only when the swish of his big wings told me he was leaving, and as there are about 20 miles of canals and inland lakes on the island, it was quite a task. I also saw one bird flying high another morning that spring. In the fall of that year I saw no swans although hunters told me that a few had been seen at the Flats. But one morning in the spring of 1919 I saw two swans resting on the main channel of the Detroit River immediately south of Belle Isle. They discovered me almost at the same moment and rising flew swiftly toward Lake St. Clair, their great wings flapping and their feet paddling the water as they went.

Later that same morning as I was tramping through the woods at the upper end of the island I heard the plaintive notes of a number of swans, distant but coming nearer, a sound familiar enough in my childhood when I lived in Northern Michigan and swans were so common as to excite little interest. The weather was cold and foggy, with no wind or perceptible air movement; and the birds, flying low, merely skimming the tree tops, came directly over me; and I had a splendid chance to observe their formation. There were 25 birds in the long wedge-shaped flock, 10 individuals on one side and 15 on the other, each bird equally spaced from the other and each line as accurate as though spaced and limned by the hand of a master. The birds were honking sonorously; my ear catching generally about three notes, one very low and two quite high. The higher notes predominated.

I spent the day on the island. The fog lifted soon. All day swans were flying back and forth showing that they were not in migration but had stopped to rest and feed. At one time I counted 70 birds in the air, the biggest flock containing 35 birds flying in two long V-shaped lines, the others being in lesser flocks and flying singly. The largest flock that I saw that day contained about 200 birds flying in a long zigzag line quite like a huge piece of rickrack lace stretched across the sky.

From the first week in March until the middle of April swans could be seen every day, sometimes on the river, more often on the wing; and they were as abundant at the Flats as Canada Geese which are always quite common in that vicinity every spring. It certainly marked the spring migration as one of unusual interest.

But the limit of swan flocks had not been reached in the spring migration. On the first day of November I saw a most wonderful flight of swans. First there came a distant chorus of swan notes so vast in volume that it reached my ears some moments before the flock came into sight. The birds were flying very high. Words are totally inadequate to describe the grandeur and glory of that most wonderful flock. Heading it and stretching apparently almost across the width of Belle Isle where it is about half a mile wide, was a line of fully 300 birds swinging majestically along in great crescent formation followed by a similar line broken, however, near the center where there was a considerable space vacant and followed by smaller groups and birds flying singly and in twos and threes. Using my field glasses I noted that what seemed to be a mere jumble of birds in the vanguard was really a most orderly grouping of symmetrical units, all spaced and lined according to the most approved swan rules. Off to one side one great pure white bird flew along in grand style uttering his "honk, honk" in true basso profundo. He was of the flock yet not in it and I wondered if he was an outlaw who had determined to remain by the flock until he had obtained, if not the leadership, at least a respectable following. In its entirity the flock seemed to be composed about equally of old and young, birds in the grey plumage of the spring hatch and old pure white birds being intermingled.

This flock, apparently in full migration, swept on like a stupendous squadron of aeroplanes. Many of the birds were honking and in ensemble there was the same predominance of the higher notes as observed in the smaller flocks. They had come, perhaps, from the regions north of Lake Superior and would not stop until the Monroe Marshes in Lake Erie would be reached where breakfast would be served.

The most conspicuous fact in the flight of migrating swans is their unchanging lines. In the flight of Canada Geese every one has seen first one strenuous old gander and then another lead the flock, the leadership apparently going to the best man, while the remainder of the flock sway and change from long V-shape to short V-shape; or, for a time all fly in "company front". The swans seem to assemble in unchanging formation without fluctuations even among the lesser units. This statement is subject to modification but in all the flocks that I have yet seen it holds good. Even when the birds are startled when feeding and rise quickly they assume almost instantly the long slanting line or the wedge-shaped formation, each bird taking its position without confusion. It is just like a street parade in which every one knows exactly where he is to be and takes his position without ado; however, in the case of the swans it is done more expeditiously. The reason for the uniform spacing and divergent lines may be that each individual must have an unobstructed outlook and flying in this fashion it is always obtained.

The spring migration this year was about like that of last year in numbers and duration, although some few birds had remained on the Detroit River all winter and had become so tame that they came up to the yard of the residence of a man in Wyandotte Heights for the food that he threw out to them. Eventually they were both shot by a vandal who so far has escaped justice.

The great flocks passed over Detroit in the night during this fall's migration. It was most impressive to hear in the darkness of midnight their voices intermingling and blending most delightfully, as they winged their way over the vast mileage of their unmarked aerial highway. What inner knowledge is it that holds these birds and others on the correct course without sign marks, without beacons or range lights or without the aid of a more or less uncivil station agent? Does not each bird hold within the recesses of his heart a true compass? Does he not also hold in that heart of his a complete calendar which tells him when it is time to start north or south according to the time of the year? Daylight or darkness are alike to him and he keeps on his unvarying way through sunshine or the blackness of the moonless night.

The stork has certainly been kind to the ladies of the swan family, and with the protection of two paternal governments it would seem that they will again be able to raise their young and again become quite common.

It would be interesting to learn if there has been a corresponding increase in the number of Trumpeter Swans (Olor buccinator). These birds formerly were not strangers in the Lake region although they were never as common as the Whistling Swans; but during each spring and fall migration an occasional one was noted. I last heard one about 15 years ago in May, the month in which they were most apt to be seen. One still morning on Grand Traverse Bay, just as the rosy light was creeping over the water putting to flight the delicate hues of mauve, green, and amber, burnishing the silver surface of the water and changing it to pinkish gold, I was startled and awakened from slumber by the glorious call of the great Trumpeter Swan,—"Ah-ah-ah-way, ah-ah-ah-way". Far out on the lovely water swam this beautiful bird, alone save for his reflection on the silvered surface. Like a ghost he was, a ghost of all the wonderful company of his kind that had gone before.

NOTES ON THE TERMITES OF INDIANA.

BY

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Termites, or "white ants" as they are popularly known, are insects that have forced themselves on the attention of entomologists because of their economic importance. Because of their life history and habits and the fact that they live in colonies or social communities, the individuals of which belong to different castes, there is no reason why termites should not attract more attention than they do from biologists in general. The interesting work of Snyder (1, 5, 6, 7, 11)[2] and Thompson (11-14 inclusive) bear out this statement.

The present paper deals with observations on these insects with special reference to their economic aspects. Until recently there has been a tendency among entomologists to regard the termites of the United States, east of the Mississippi and north of the Ohio river, as one species, namely *Reticulitermes* (*Leucotermes*) *flavipes* Kollar. This is in spite of the fact that Snyder and Banks (1, 6, 7) have pointed out that there are two other species of the same genus *Reticulitermes* namely *R. hageni* Banks and *R. virginicus* Banks whose range in this country are at present not well defined. These two species were both found and described since 1907 from Falls Church, Virginia, a few miles from Washington, D. C. It should be pointed out that this region is one that has literally been "combed" by entomologists since the formation of the U. S. Department of Agriculture. It is therefore quite possible that intensive work will reveal not only the presence of *R. hageni* Banks and *R. virginicus* Banks over a wider area than they are now known to occur but also the presence of one or more new species.

Distribution of Termites in Indiana.

Reticulitermes flavipes Kollar is the only species that until the present time has been recorded in Indiana. Snyder (7) records it from the vicinity of South Bend, Indianapolis, and Jeffersonville. During the past season Columbus and Lafayette have been added to this known distribution.

Reticulitermes virginicus Banks was collected for the first time in Indiana at Indianapolis on July 1, 1920, by the writer. The forms collected were winged colonizing adults. The nearest point to Indiana from which this species has been recorded is Okolona, near Louisville, Kentucky (Banks, 1).

Reticulitermes hageni Banks probably occurs in Indiana, though the nearest point to our State from which it is recorded is Kane, Greene County, Illinois (Banks, 1).

Swarming.

There are two times when termites are reported to the Division of Entomology. These are as follows: First, when the annual swarming of

[1] Published with the permission of the Chief of the Division of Entomology and the Director of the Department of Conservation of Indiana.
[2] The figures in parenthesis refer to the Literature cited.

the winged colonizing adults takes place (males and females); secondly, when the characteristic damage that these insects do to buildings and their contents or to living plants is first noted. Fifteen reports of swarming or injury were obtained this year and in eight cases specimens were collected all of which proved to be *R. flavipes* Kollar.

The first swarming of termites this year was on February 29th. This was in a house in the northern part of Indianapolis. The time of swarming was 4:00 p. m. and the temperature out-of-doors was 50° F. and indoors about 70° F. No specimens of this swarm were obtained and no subsequent swarming took place.

The second swarming was in a factory building in Indianapolis on March 5th, 1920. The temperature out-of-doors was 10° F. and there was six inches of snow on the ground. The indoor temperature ranged from 50° F. at night to 70° F. and over in the day time. The swarming here took place between 8:30 and 10:00 a. m., the maximum emergence occuring about 9:00 a. m., and occurred daily at this time for four successive days.

On March 15th and April 5th *R. flavipes* swarmed in the Experiment Station Building at Purdue University at West Lafayette. Specimens of the April 5th swarm were collected and forwarded to the writer by R. W. Hosmer of the Bureau of Plant Industry of the U. S. Department of Agriculture.

The first out-of-door swarming of *R. flavipes* recorded this year took place in the southeastern part of Indianapolis simultaneously with an indoor swarming at the same locality on April 21st. From the location of the points of emergency indoors and out-of-doors there is no doubt that this swarming was from the same nest. It took place daily between 8:00 and 9:00 a. m. over a period of three days. This swarming followed a heavy rain of 2.3 inches on April 20th and a total rainfall of over 3 inches between April 17th and 20th.

The next out-of-door swarming in Indianapolis occurred on May 26th at 11:00 a. m. and in the same locality, but from a different nest, on June 3rd about an hour earlier. Only a single swarm emerged from each of these nests. The swarming on May 26th was not directly correlated with any rainfall but that of June 3rd followed a heavy shower on May 31st.

Snyder (1) following the phenological work of Hopkins (2 and 3) shows that the first swarming of *R. flavipes* is correlated with the blooming i. e. ripening of the pollen of the large flowering dogwood *Cynoxylon* (*Cornus*) *floridum* Linn. This is based on six years' observation. However, in Indianapolis the first out-of-door swarming, April 21st, occurred almost two weeks before dogwoods bloomed and the second and third, May 26th and June 3rd, out-of-door swarms occurred two weeks after all dogwoods had disappeared. At the time of the second and third out-of-door swarming dates, grapes and blackberries were blooming.

No fall swarms of *R. flavipes* were reported this year though in 1919 this occurred in the house where the spring swarming took place on April 21st.

The only swarming of *Reticulitermes virginicus* Banks observed was on July 1st. The winged adults were seen flying across a large vacant lot between 9:30 and 10:00 a. m. It was a clear bright day with a high relative humidity and temperature. This swarming occurred a month after the last swarming of *R. flavipes* Kollar and at a time when the American Linden *Tilia americana* Linn was in full bloom.

From the foregoing data it is apparent that the time when indoor swarming occurs is independent of out-of-door conditions and is determined largely by the location of the nest in or beneath the building. The location of the nest of course determines the influence that the cumulative mean indoor tempartures and average relative humidity will have on it. Out-of-doors the time of swarming depends on the cumulative mean temperatures and the mean relative humidity.

The swarming of termites in a building should in general be regarded as a danger signal. It is needless to say that it is a great annoyance to have these awkward colonizing adults aimlessly flying into one's face or into any foods that are exposed. Yet during the past season we have found two cases where swarming took place and where careful inspection failed to reveal any damage to the buildings in which it occurred. Likewise, we have found two infestations in buildings from which no swarms emerged. This naturally brings up the question as to the factors that cause a colony to swarm. These factors, though still imperfectly understood, are: (1) the kind of reproductive forms in the colony; (2) the age and size of the colony; and (3) the influence of instinct.

The role of swarming in the life economy of a colony is another point of interest. In the case of early swarming indoors the value of swarming is hard to see as practically all the adults emerging, if they are not killed, perish. This is because conditions necessary for the establishment of new colonies are seldom present. Out-of-doors the opportunities for the founding of new colonies are greater. But even out-of-doors immense numbers of colonizing adults perish. On May 26th practically all termites *R. flavipes* that emerged were eaten as soon as they issued by a large flock of sparrows that gathered for the oc asion. In the swarming of *R. virginicus* on July 1st it was observed that adults alighting on the ground were immediately snatched up and dragged off by the workers of the common corn-field ant *Lasius niger* Linn. var. *americanus* Emery.

Termite Injury.

The injury that Indiana termites do is of two kinds, namely that which is done to buildings and their contents and that which is done to living plants. The members of the genus *Reticulitermes* are subterranean insects. Under normal conditions in nature they feed on stumps, logs, and wood debris, straw, manure, and leaves. But with the advance of civilization much of the food of termites has been removed, forcing the insects either to retreat before this advance or to adapt themselves to the new order of things. They have chosen the latter course to a certain extent, at least, as is shown by the injury they do to living cultivated plants and to buildings and their contents. These insects are justly classed among our most destructive wood-borers.

There is one thing that is absolutely essential for a colony of Indiana termites to maintain itself and that is a ready access to moisture. This is obtained from the ground. Given a constant supply of moisture these insects are able to tunnel in the comparatively dry woodwork of buildings or into its contents a great distance so that the limits of a colony are hard to define. It is therefore apparent that termite injury to buildings and their contents is intimately correlated with the construction of such buildings. This is borne out by the fact that new buildings as well as old ones are subject to attack. As has been said before, the swarming of termites in a building should be regarded as a danger signal though it is not an infallible one, because a building or its contents may be infested and no swarming occur, in which case the hidden work of the insects might escape notice until irreparable injury is done. Some examples of the damage done to buildings in Indianapolis and a fuller discussion of the damage done at the Columbus Public Library well illustrates certain things that should be avoided in the construction of buildings.

The popular cement floor of porches, unless properly constructed, offers a means through which termites may gain entrance to the frame work and weatherboarding of houses. The grout of cinders and gravel are often placed flush against a wooden beam and the cement is brought flush with the weatherboarding. Usually in time there is a decided crack between the cement and the wood, allowing water to enter when the porch is scrubbed or during heavy rains. The cinders and gravel grout are no repellant to the termites as there are usually sufficient holes in the latter through which the termites can work and thus gain entrance to the wood. Three such cases of injury have been observed during the past season.

In the case of the factory building where swarming occurred on March 5th it was found that the floor of the office was laid directly on a bed of cinders and the wooden walls which separated the office from the rest of the building were flush with these cinders. Likewise, the 12x12 untreated yellow pine pillars which supported the roof were set on stones one foot beneath the surface of the ground. Three years previously the floor had been removed because of termite damage and replaced with another wooden floor. It is needless to say that the conditions for termite injury were ideal. Not only the floor but the walls and a number of the pillars were badly damaged.

In a dwelling in the northern part of Indianapolis termites had gained entrance to a "built in ice box", the wood of which was constantly moist and from this source had riddled several of the beams supporting the house. At another place where the weather boarding of the kitchen was flush with the ground this was badly damaged.

At the Columbus Public Library termites did the worst and most extensive damage that has so far been recorded for these insects in Indiana. Three hundred volumes of books were so badly riddled that they were a mere shell. The wooden racks in which they were kept were badly damaged and all baseboards, door casings and moldings on the first floor of this building were more or less infested making their removal necessary. Even pictures in contact with the molding were ruined. This building is of limestone, two stories high, and is what is commonly known as "fire proof" in its construction. It sets on an embankment about three feet high and is so built that the floor of the first story is slightly below the level of the embankment (See Diagrammatic Cross-section of Building, Figure I, A.)

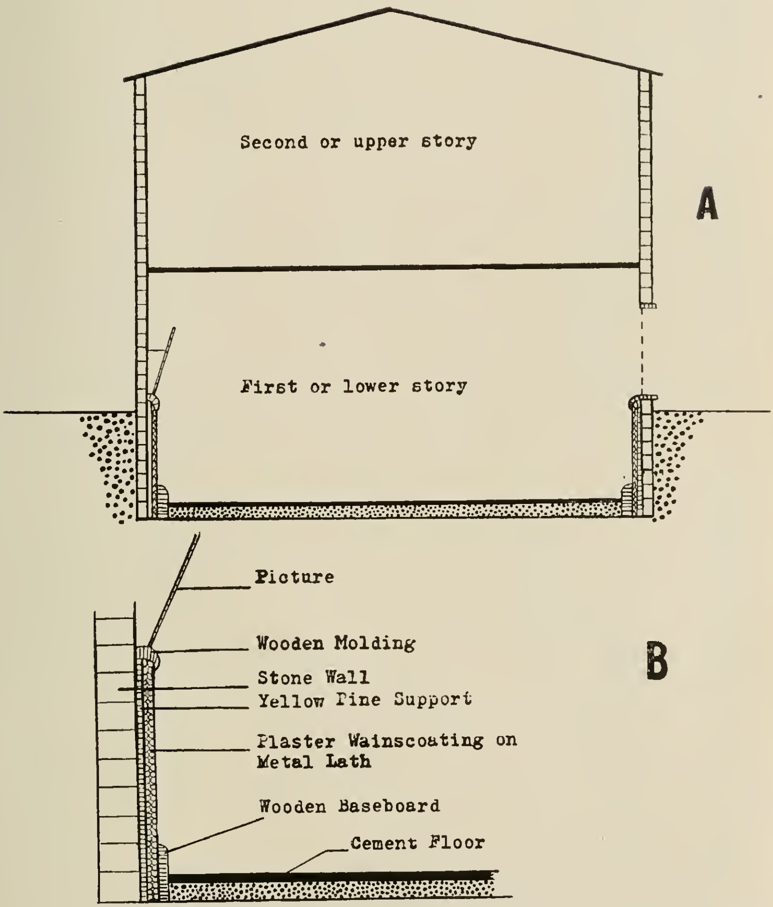

Figure I, A. Diagrammatic cross section of the Columbus Indiana Public Library building showing the relation of the first floor to the ground level.

B. Diagrammatic drawing showing relation of wood used in construction in relation to ground and termite injury. See Plates I and II.

The first, or lower floor has three large rooms which are used for book storage, as well as a boiler room, a general storage room and a book binding room. The upper floor is used for a reading and for the "stack" room.

Originally the floor in the basement was yellow pine laid on joists embedded in the ground so that the floor itself rested on the ground. Likewise, the lower edge of the baseboards and the bottoms of the door sills rested on the ground. There was a wooden wainscoating, about four feet high, around the room. The bottom of this wainscoating rested on the ground. Four years ago this floor and wainscoating were removed because they had "rotted", and there is little doubt that the "rotting" was caused by termites.

As is shown in the diagrammatic drawing, Figure I, B., the wooden floor was replaced by one of cement and a plaster wainscoating laid on patented steel wire lath was used instead of the wooden one. Had the work been done right at that time no further termite injury would have been possible. But instead of eliminating all wood in contact with the ground and bringing the cement floor flush with the plaster wainscoating, unfortunately, as is shown in the drawing, both the bottoms of the baseboards and door sills were left in contact with the ground instead of allowing them to rest on the cement floor. Further, the plaster wainscoating instead of being flush with the stone walls of the building is supported by yellow pine beams in contact with the ground. Some of these beams come in contact with the casings of the windows of the first floor and all of them are in contact with a yellow pine molding that tops the wainscoating four feet from the floor. Of course, the baseboards and door sills were badly damaged (See Plates I and II). By means of the joists supporting the wainscoating as well as the characteristic "covered runways" on the back of the wainscoating the termites had worked into the molding and from it into the pictures and their frames. The bottoms of the wooden bookracks were either in contact with the infested baseboards or their backs were in contact with the infested molding and it was an easy matter for the termites to work into them and from racks into the books.

All the foregoing examples of termite injury were the work of *R. flavipes* Kollar and are based on specimens obtained in each case. In order to identify termites it is necessary that either soldiers or winged adults be obtained.

Nothing is known of the economic importance of *R. virginicus* Banks in Indiana though in other parts of the United States where it ocurs its damage is similar to that of R. *flavipes*.

Numerous cases of termite injury to fence posts and boards have been observed and doubtless much of the "rotting" of timber is due to these insects.

Several cases of termite injury to living plants were reported during the past year. But in only one case were specimens obtained. The first case was reported by an Indianapolis florist who advised the writer that in 1919 he was forced to replant a bed of geraniums three times because termites tunnelled each planting within a few weeks after it was set out.

The second report of damage to living plants was reported by Mr. Frank N. Wallace, State Entomologist, on May 15th from Spencer, Indiana. He obtained the workers from a cavity in a living maple tree and observed that tunnels were being made into the living wood.

PLATE I.

A. Termite injury to the upper part of a yellow pine baseboard, the bottom of which rested on the ground. See also Plate II, B.

B. Piece of straight grained yellow pine molding showing how termites have eaten out the spring growths of wood.

C. Paper like strips from the bottom of a door casing in contact with the ground.

The third report of termite injury came from Indianapolis on August 27th. A backyard gardener wondering why his sweet corn did not yield as it should dug up some of the plants and found the lower parts heavily infested with termites (See Plate II, B.). Over 150 feet of row were thus damaged. Specimens submitted were *R. flavipes* Kollar.

Taken as a whole over the United States termite injury to living plants seems to be increasing due no doubt to the fact that their homes, such as logs and stumps, are rapidly disappearing because of the practice of clean cultivation. As a result the termites are forced to seek elsewhere for sufficient food and their attacks on living plants are one way that they are meeting the exigency. On the other hand it should be pointed out that keeping areas on which plants are grown free from decaying wood and other debris on which termites can exist is necessary if damage is to be prevented (See Nougareti 4) as such debris is often a source from which they start their attacks.

Acknowledgements.

The writer wishes to acknowledge the kindness of Dr. T. E. Snyder and Dr. W. M. Mann, of the U. S. Bureau of Entomology, for identifying or verifying the identification of all termites and ants mentioned in this paper.

Summary.

1. Two species of termites *Reticulitermes flavipes* Kollar and *Reticulitermes virginicus* Banks are known to occur in Indiana. A third species *Reticulitermes hageni* Banks will probably also be found in this State.
2. The interesting phenomenon of the annual swarming of the winged colonizing adults of *R. flavipes* occurs indoors as early as February 29th. Out-of-doors it occurs over a period of over a month, April 21st to June 3rd. The swarming of *R. virginicus* takes place out-of-doors a month later than that of *R. flavipes.*
3. Sparrows and ants have been observed preying on these winged colonizing males and females.
4. Termites damage buildings and their contents and their attacks on living plants are increasing. This is the way that termites are adapting themselves to the advance of civilization which has resulted in the removal of much of their food, such as logs and stumps.

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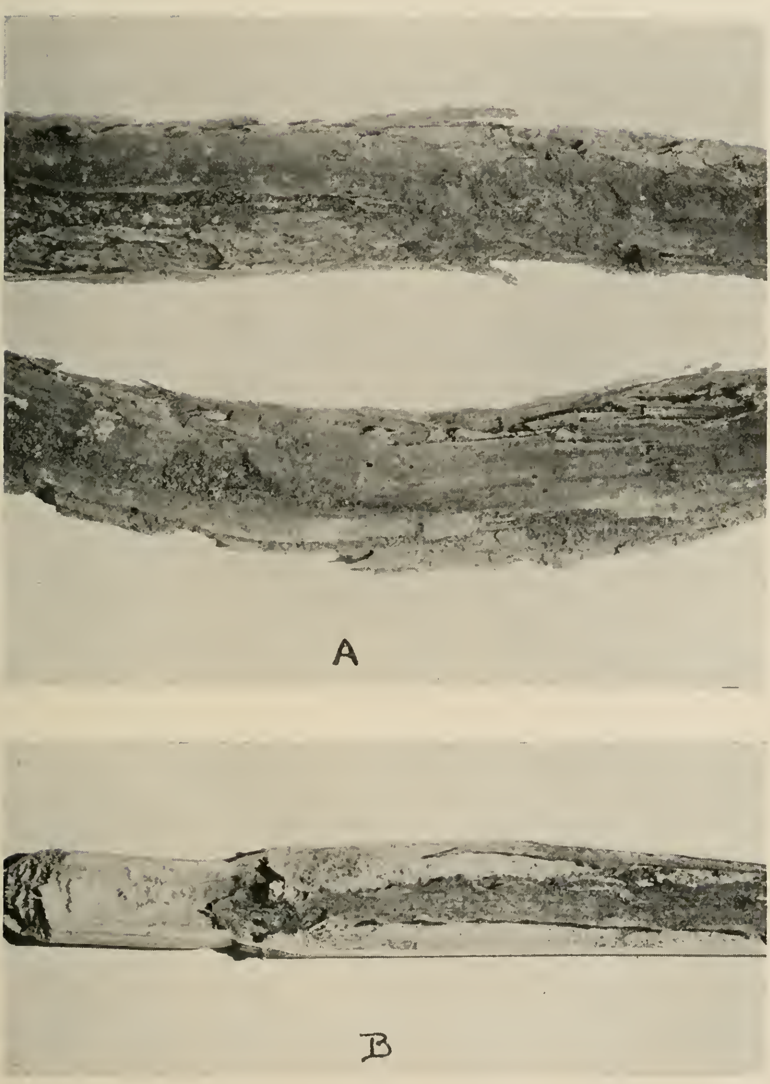

PLATE II.

A. Pieces from the bottom of the same baseboard shown in Plate I. A.

B. Termite injury to sweet corn. The fourth node and third internode are shown.

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THE FRESH-WATER MEDUSAE OF BOSS LAKE, ELKHART, INDIANA.

Abstract.

F. PAYNE.

September twenty-second, 1919, I was informed that medusae were abundant in a small artificial lake near Elkhart, Indiana. Five days later I visited the place and verified the statement. In fact they were so abundant that one could bring in a hundred with a few sweeps of the net. A second visit was made two weeks later but not a single specimen could be found. The weather had become much colder, to the point of freezing, and no doubt the change in the temperature caused their death. A few days later Mr. Boss informed me that the surface of the lake was strewn with fragments of medusae. All specimens examined were females. A few specimens were found the previous summer.

During the summer of 1920 the lake was watched carefully from June twenty-first until October second. The hydroid was found June twenty-eighth on material collected June twenty-first. These hydroids were observed to form sausage shaped buds which separated from the parent and formed new hydroids. Other buds remained attached, thus forming colonies. The largest colony found had seven hydroids. A third type of bud formed the medusa.

The first medusa in the summer of 1920 was taken July sixteenth. It was about one-half inch in diameter. The rest of the summer they were abundant, but not so numerous as they were on my first visit of the previous year. Again all the medusae were females. This, along with the fact that on previous discoveries of this medusa all the specimens were males, has puzzled me somewhat. The females became sexually mature and shed their eggs but they did not develop so far as my observations went. Plankton catches at all seasons and depths have shown no free swimming larvae. Neither has a close examination of the weeds, sticks, stones, and surfaces of boards and posts shown anything of the sort. But why is there only one sex? I do not know but the facts lead me to wonder whether the hydroids may not be male and female producing.

How the forms got into the lake is doubtful. The hydroids are very small and might occasionally become attached to fishes and thus be transferred. Neither do I see any reason why they might not be carried by wading birds.

The hydroids live over the winter in the form of contracted masses.

NOTES ON INDIANA DRAGONFLIES.

BY

E. B. WILLIAMSON.

A list of the species of dragonflies of Indiana was published June 5, 1917, as Miscellaneous Publications No. 2 of the University of Michigan, Museum of Zoology. In that paper are included all records up to the end of the year 1916.

In this paper another species is recorded, bringing the Indiana list to 126 species, and captures, during 1917-1920 inclusive, of species in new localities or at different seasons are added. The order and numbers used in the list published in 1917, referred to above, are followed here.

1. *Agrion aequabile* Say. Allen Co., July 6, 1919.

6. *Lestes congener* Hagen. Near Wolf Lake, Noble Co., Sept. 23, 1917.

12. *Lestes uncatus* Kirby. Along the Aboite River, at Devil's Hollow, Allen Co., July 6, 1919, a female of this species was taken flying in couple with a male of *Argia tibialis*.

13. *Lestes unguiculatus* Hagen. Round Lake, Whitley County, Sept. 23, 1917.

14. *Lestes vigilax* Hagen. Near Wolf Lake, Noble Co., Sept. 23, 1917.

18. *Argia tibialis* Rambur.. See note under 12. *Lestes uncatus*.

23. *Enallagma calverti* Morse. This species reappeared at the Van-Emon Swamp, near Bluffton, in 1920. On June 6 and 13 it was very abundant associated with the much rarer *E. cyathigerum*.

24. *Enallagma carunculatum* Morse. Round Lake, Whitley Co., Sept. 23, 1917.

26. *Enallagma cyathigerum* Charpentier. See note under 23. *Enallagma calverti*.

27. *Enallagma divagans* Selys. Outlet of Webster Lake, Kosciusko Co., July 4, 1917.

28. *Enallagma ebrium* Hagen. Tri Lakes, Whitley Co., June 15, 1919.

30. *Enallagma geminatum* Kellicott. Swamp and creek five miles east of Lagrange, Lagrange Co., June 20, 1920.

31. *Enallagma hageni* Walsh. Swamp and creek five miles east of Lagrange, Lagrange Co., June 20, and 27, 1920.

33. *Enallagma vesperum* Calvert. Dr. Calvert has recently shown that the widely distributed species we have been calling *Enallagma pollutum* Hagen is really not that species, and he has named it *vesperum*. Swamp and creek five miles east of Lagrange, Lagrange Co., June 20, 1920.

34. *Enallagma signatum* Hagen. Swamp and creek five miles east of Lagrange, Lagrange Co., June 20, 1920.

35. *Enallagma traviatum* Selys. Swamp and creek five miles east of Lagrange, Lagrange Co., June 20, 1920.

38. *Amphiagrion saucium* Burmeister. Swale near creek at Indian Village, Noble Co., July 4, 1917.

39. *Chromagrion conditum* Hagen. Swamp and creek five miles east of Lagrange, Lagrange Co., June 20 and 27, 1920.

40. *Ischnura kellicotti* Williamson. Round Lake, Whitley Co., Sept. 16, 1917; and June 15, 1919; lake at Indian Village, Noble Co., July 4, 1917.

43. *Ischnura verticalis* Say. Tri Lakes, Whitley Co., August 25, 1918.

45. *Tachopteryx thoreyi* Hagen. In deep sandstone ravine in sec. 1, Union Township, Perry Co., about fifteen miles northeast of Tell City, June 4, 1918, a single male, collected by Chas. C. Deam, who also collected the only other specimen taken in the state, in Montgomery Co.

48. *Cordulegaster obliquus* Say. Forest Reserve, Clark Co., June 18, 1920, a single female collected by Chas. C. Deam. We have had no record for the state except Say's statement "inhabits Indiana", published now over 80 years ago.

49. *Progomphus obscurus* Rambur. Creek at Indian Village, Noble Co., July 4, 1917: Salamonie River, Huntington Co., August 5, 1917, several caught and others seen, many had wings darkly stained with crude oil: Wabash River, Bluffton, Wells Co., August 26, 1917, only one seen, a male with oil stained wings. At this time there was no crude oil along the Wabash River near Bluffton, and I think the Wabash River specimen was undoubtedly a stray from the Salamonie about twenty miles away.

50. *Hagenius brevistylus* Selys. Bluffton, Wells Co., June 21, 1919, a single female, which alighted on John W. Carnall and was captured by him as he stood at his office door in the center of the business part of town: Aboite River, Devils Hollow, Allen Co., July 13, 1919.

51. *Ophiogomphus rupinsulensis* Walsh. Creek at Indian Village, Noble Co., July 4, 1917. On this date this rare species was flying with *Gomphus dilatatus, lividus* and *furcifer*, a remarkable Gomphine assemblage.

53. *Gomphus crassus* Hagen. In June, 1919 and 1920, this species was abundant about ripples in the Wabash River near Bluffton. During their years of abundance it is no rare thing to see *G. crassus, fraternus* and *graslinellus* hawking their way over the asphalt streets in the business part of town, and at such times they are not infrequently captured clinging to screen doors or similar supports, but they rarely if ever enter houses, in marked contrast to *Epiaeschna heros* which is more rarely seen abroad, but is often taken indoors.

54. *Gomphus dilatatus* Rambur. Creek at Indian Village, Noble Co., July 4, 1917.

55. *Gomphus exilis* Selys. On June 15, 1919, along the east end of the south side of Shriner Lake, Whitley Co., this species and *G. spicatus* were common. Both species rested on blue grass heads, and on the leaves of low maples not over two feet high: *exilis* also rested on dead weed stems and the windrow of debris along the lake, and *spicatus* often rested on the ground. One *spicatus* male had a serious old healed injury to the throax at the base of the right front wing so the wing movement was greatly restricted, but before capture nothing unusual in its actions was noticed. *Exilis* was also taken at a creek and swamp five miles east of Lagrange, Lagrange Co., June 20 and 27, 1920.

56. *Gomphus fraternus* Say. See under 53. *Gomphus crassus.*

57. *Gomphus furcifer* Hagen. Creek at Indian Village, Noble Co., July 4, 1917: Round Lake, Whitley Co., June 15, 1919.

58. *Gomphus graslinellus* Walsh. Aboite River, Devil's Hollow, Allen Co., July 13, 1919: Eel River, Allen Co., July 6, 1919. See under 53. *Gomphus crassus.*

61. *Gomphus spicatus* Hagen. See under 55. *Gomphus exilis.*

66a. *Gomphus viridifrons* Hine. A single male was taken June 17, 1917, about three miles east of Ontario and two and one-half miles west of Mongo, Lagrange Co. The day was cold and windy and the dragonfly was resting on the low, broad leaf of an aster at the edge of a woods about a quarter of a mile south of Pidgeon River. The species has been taken in Ohio and Pennsylvania; this is the first Indiana record.

69. *Dromogomphus spoliatus* Hagen. At a bayou about two miles west of Merom, Sullivan Co., July 23, 1918. This species has not been seen along the Wabash near Bluffton since 1917 when it was observed but in smaller numbers than in former years. It frequents more sluggish streams with mud bottoms, and the Wabash has apparently become a stream more suitable for it than for *D. spinosus* which prefers clear, rapid water, clean bottomed streams. *D. spinosus* formerly occurred on the Wabash but I have not seen it there now for many years. What has caused the more recent ebb in *D. spoliatus* I do not know. A few years may see it back again in undiminished numbers; *spinosus* almost certainly will never return.

70. *Boyeria vinosa* Say. Shriner Lake, Whitley Co., Sept. 16, 1917; small stream near Merriam, Noble Co., Sept. 23, 1917.

7. *Basiaeschna janata* Say. Border of tamarack swamp along Pidgeon River, one mile east of Mongo, Lagrange Co., June 17, 1917.

72. *Anax junius* Drury. On April 14, 1917, a male was dashed to the street in Bluffton by a heavy rain; on April 20, 1917, a male was taken in a store room in Bluffton, and on the same date a female *Epiaeschna heros* was taken in a nearby store. In April, 1919, a female of *Anax junius* was taken in a house in Bluffton on the third of the month, and on the fifth a male and a female were taken in two other houses; on the fifth, eighth and ninth, specimens were hawking in my home yard. On August 23, 1919, and at least a few evenings before and after that date *junius* was flying in great numbers from 6 to 7 p. m. standard time (7 to 8 p. m. fast time), along a road between woods and a corn field and over adjacent fields in low creek bottom one and a half miles east and one and a fourth miles north of Bluffton. They were feeding voraciously and the flight was very erratic, suggesting Gynacanthas but more erratic than the larger species of Gynacantha. Posey Co., April 21, 1919 (Chas. C. Deam).

75. *Aeshna constricta* Say. Near Wolf Lake, Noble Co., Sept. 23, 1917; backwater of Webster Lake, Kosciusko Co., August 31, 1919.

76. *Aeshna mutata* Hagen. VanEmon Swamp near Bluffton, June 13, 1920, a single male seen and captured. This is the first appearance of *mutata* at this swamp since 1914.

78. *Aeshna umbrosa* Walker. Creek at Shriner Lake, Whitley Co., Sept. 16, 1917; creek at Indian Village, Kosciusko Co., Sept. 1, 1919; creek and swamp five miles east of Lagrange, Lagrange Co., October 10, 1920.

79. *Aeshna verticalis* Hagen. Creek at Indian Village, Kosciusko Co., Sept. 1, 1919.

80. *Nasiaeschna pentacantha* Rambur. This rare species was taken along the Aboite River, Devil's Hollow, Allen Co., July 6 and 13, 1919.

81. *Epiaeschna heros* Fabricius. A male was taken in a downtown office

in Muncie, Delaware Co., July 25, 1916; a female was taken hawking just before sundown in my home yard in Bluffton on August 1, 1917, and a male was taken August 15 early in the morning clinging to vines in the same yard; April 12, 1919, a male was taken in the Union Savings and Trust Company, Bluffton; a number were taken in stores and houses in Bluffton in April, May and June, 1920.

83. *Macromia illinoiensis* Walsh. Salamonie River, Huntington Co., August 5, 1917; on June 4, 1918, a female was caught on a window screen at the Wells County Bank building, Bluffton.

84. *Macromia pacifica* Hagen. On August 26, 1917, two friends and myself hunted Macromias along the Wabash River above Bluffton. It was a cool windy day, altogether unfavorable for Macromias but we took an even dozen—eight of *pacifica*, two of *wabashensis* and two of *illinoiensis*. One or two identified on the wing as *taeniolata* were not captured. One *pacifica* was found crippled and unable to fly in the weeds along the river; one hind wing was broken at its base in the thorax and the body juices were exuding. Another of the same species was floating alive on the water with the front wing broken off near the base. It is probable both injuries were caused by birds. At Howe, Lagrange Co., on Sept. 3, 1916, I was asked to identify the birds which had nested in a blue bird box in the hotel yard during that year. A description of the birds by my informants left no doubt that they were great crested flycatchers. The birds were new to the parties observing them and the feeding of the young was especially interesting. They reported that they never saw the old birds carry in any other food than large dragonflies. An examination of the nest showed a quantity of bits of dragonfly wings and legs. I was able to identify a bit of wing of *Libellula pulchella* but the bulk of the material was parts of Macromias. There is no doubt that dozens of these insects had gone to supply this one nest. Martins are very numerous in boxes placed for them in Bluffton. The birds spend many hours over the river and the abandoned adjacent quarries near Bluffton. That they feed on large dragonflies is no question though I have been able to certainly identify only *Libellula pulchella*. But in many years' collecting along the Wabash I have seen only one Macromia near Bluffton. On the other hand, *Gomphus* occurs within the city limits in apparently as large numbers as elsewhere. But the Gomphi have a relatively short seasonal range, they burst their exuviae by hundreds or thousands almost simultaneously, and their eggs are laid and their aerial life ended before their predaceous enemies could gather in numbers to attack them. The longer seasonal range of Macromias, by reason of which the brooding mother bird and later her offspring, from hatching to leaving the nest, could be fed on this one species of insect, obviously invites danger. The pair of great crested flycatchers at Howe doubtless became expert Macromia catchers by the time their offspring took wing.

85. *Macromia taeniolata* Rambur. At a bayou two miles west of Merom, Sullivan Co., July 23, 1918, one male captured and one or two more seen. Later, on August 3, we found the species in numbers at the Tennessee River ferry between Jasper and Chattanooga, Tennessee.

90. *Tetragoneuria simulans* Muttkowski. Case Lake, east of Howe,

Lagrange Co., June 17, 1917; outlet of Webster Lake, Kosciusko Co., July 4, 1917.

94. *Somatochlora linearis* Hagen. This rare species was taken along Flat Creek in Wells County again in 1919, on July 9. *S. charadraea*, formerly taken on the same creek, seems to have disappeared as it has not been seen since 1913.

95. *Somatochlora tenebrosa* Say. This, like *Cordulegaster obliquus*, is another species which has not been taken in Indiana since Say's time till it was taken on July 6, 1919, at Devil's Hollow, Aboite River, Allen County. The two males seen and captured were hovering and flying about little pools in a very small creek flowing in the dense shade of small timber. This little creek, about eighteen inches wide, evidently spring fed, is a right hand tributary of the Aboite River, near the upper end of Devil's Hollow.

96. *Libellula cyanea* Fabricius. Creek and swamp five miles east of Lagrange, Lagrange Co., June 27, 1920.

99. *Libellula luctuosa* Burmeister. Shriner Lake, Whitley Co., Sept. 16, 1917.

101. *Libellula quadrimaculata* Linne. Three miles east of Ontario, Lagrange Co., June 17, 1917.

104. *Plathemis lydia* Drury. Devil's Hollow, Aboite River, Allen Co., July 13, 1919; creek and swamp five miles east of Lagrange, Lagrange Co., June 27, 1920.

105. *Perithemis tenera* Say. Round Lake, Whitley Co., August 25, 1918.

112. *Sympetrum rubicundulum* Say. Salamonie River, Huntington Co., August 5, 1917. Along the interurban railroad north of Bluffton, between the Wabash River and the Clover Leaf railroad, is a long shallow pond formed by excavations along the interurban grade. About this pond occur numbers of the yellow-winged form of *rubicundulum*, once regarded as a species under the name *assimilatum*. On Sept. 13, 1914, the following four species of *Sympetrum* were flying at this pond: *ambiguum*, *obtrusum*, *rubicundulum* and *vicinum*. *Obtrusum* and *rubicundulum* were about in equal numbers and were much more numerous than the other two. Of fifteen males and two females of *rubicundulum* taken, all but one male were of the yellow-winged form. On Sept. 2, 1917, ten males and three females were taken at this same pond. Of these males two had clear wings, five were yellow winged and three were intermediates. All the females were yellow-winged. At some deep partially shaded gravel pits about a quarter of a mile distant, four males taken the same date were all clear winged. I have noticed at other places than this interurban pond that the yellow-winged form occurred about shallow warm pools or was seen late in the season when ponds were at low water stage, and I believe there is some relation between light or warmth, or both, in producing this color form.

115. *Pachydiplax longipennis* Burmeister. Creek and swamp five miles east of Lagrange, Lagrange Co., June 27, 1920.

117. *Leucorhinia intacta* Hagen. Creek and swamp five miles east of Lagrange, Lagrange Co., June 20 and 27, 1920.

119. *Celithemis eponina* Drury. One male and one female of this species and a single female of *C. elisa*, all the specimens seen, were taken along the Wabash River in Wells County, August 26, 1917. The day was very windy

and specimens of both species were doubtless strays as neither has been seen on the Wabash at any other time. Both species were taken at Round Lake, Whitley Co., on August 25, 1918. Tenerals were flying at the same lake on June 15, 1919.

122. *Pantala hymenaea* Say. Wabash River, Wells Co., August 26, 1917, a single female, the only one seen, hawking back and forth over a smal' island. Several years ago there were heavy rains resulting in flooded fields in the creek bottoms in Wells County at the time corn in these fields was just beginning to tassel out. The high waters did not subside for several days and the corn died and the stalks fell over into the water. These flooded cornfields were visited by large numbers of ovipositing *Trameas* and *Pantalas* and by a smaller number of *Sympetrum corruptum* all of which appeared as by magic to avail themselves of this new and virgin dragonfly habitat. Of course every egg perished, but the incident afforded an example of the quick response of certain dragonfles to avail themselves of a new habitat where their enemies and competitors had not yet established themselves.

123. *Tramea carolina* Linne. Vanemon swamp, Wells Co., June 6, 1920.

THE ANATINE GENUS NYROCA AND ITS NEAREST ALLIES.

HARRY C. OBERHOLSER.

The following pages present the results of an investigation, begun many years ago, into the generic relationships of the ducks commonly included in the genera *Nyroca* Fleming (*Marila* auct. rec.) and *Fuligula* Stephens. These species are:

Nyroca ferina (Linnaeus)
Nyroca americana (Eyton)
Nyroca valisineria (Wilson)
Nyroca baeri (Radde)
Nyroca nyroca (Güldenstädt)
Nyroca innotata Salvadori
Nyroca australis Eyton
Nyroca brunnea Eyton
Nyroca nationi (Sclater and Salvin)
Nyroca erythrophthalma (Wied)
Fuligula marila (Linnaeus)
Fuligula affinis Eyton
Fuligula fuligula (Linnaeus)
Fuligula novaeseelandiae (Gmelin)
Fuligula collaris (Donovan).

Of the fifteen species thus comprised, we have examined all but two—*Nyroca innotata* and *Nyroca nationi*. Study of the structural characters of these birds has resulted in the discovery of some hitherto unnoticed characters, which indicate that to include all these species in a single genus would be manifestly improper, and that in view of important differences, some additional genera need recognition. The characters here used as generically diagnostic are constant and trenchant so far as it has been possible for us to verify them, and a number of other characters we have omitted because they fail to come up to this standard. It is becoming fairly well understood that many differences that are apparently good generic characters fail when several individuals of a species, or when species of other supposed generic groups are critically examined; and while a mere abnormality in a single individual can not be held as invalidating a generic character, it is quite evident that a character which is not practically constant in all individuals of a species can scarcely be usable in the diagnosis of a genus. It is evidently thus unsafe to base generic characters on examination of a single specimen of a species, but sufficient examples should be examined to eliminate the factor of individual variation. As in many ducks, so in the birds at present under consideration, the form, shape, and proportions of the bill are of prime importance as the indicators of generic relationships. Of other characters made use of in the present connection, those of the relative proportions of the wing and of inner toe with claw, compared with the exposed culmen, are apparently of most importance. While coloration as a primary generic character is of little or no value among these ducks, it is of interest to note that the generic classification here adopted corresponds fairly well with the general coloration of the species concerned, although *Nyroca baeri* is, of course, an exception. Furthermore, the sequence of species is virtually the same as that adopted by Mr. N. Hollister in his recent notes on the relationships of *Fuligula collaris*,[1] except that, of course, the sequence is reversed.

The measurements of which use is made in proportional comparisons in this paper have been taken as follows:

Length of wing.—The distance from the bend of the wing to the tip of the longest primary, taken with dividers without straightening the quills.

Exposed culmen (*length of bill*).—The chord of the culmen, taken from its tip to the point where the feathers of the forehead impinge on its base.

Height of bill at extreme base.—The distance in a straight line from the highest point on the base of the maxilla to the nearest point on the ramus of the mandible.

Width of bill.—Measured with dividers at the widest point near the end of the bill; at base; at point of greatest width; or at the posterior end of the nail where this coalesces with the culmen.

Length of the nail of bill.—The chord of the dertrum, measured in a straight line from its tip to the point where it coalesces with the culmen.

Inner toe with claw.—Measured with dividers along the upper side from the middle of the joint between the metatarsus and the inner toe, in a straight line to the tip of the claw.

The writer is indebted to Dr. C. W. Richmond for a number of references to generic names cited in this paper.

Fulix SUNDEVALL.

Marila OKEN, Isis (von Oken), 1817, Heft VIII, col. 1183 (nomen nudum).

Fulix Sundevall, Kongl. Vetensk.—Acad. Handl., for 1835 (1836), p. 129 (proposed for "Anates lobatae," with no species mentioned) (type by subsequent designation [Baird, Brewer, and Ridgway, Water Birds North Amer., II, 1884, p. 17], *Anas marila* Linnaeus).

Marila BONAPARTE, Compt. Rend. l'Acad. Sci., XLIII, Sept. 30, 1856, p. 651, (Reichenbach, MS.) (type by tautonymy, *Anas frenata* Sparrman [= *Anas marila* Linnaeus]) (nec *Marila* Reichenbach quae *Aithyia* Gloger).

Netturion BAIRD, Rep. Explor. and Surv. R. R. Pac., IX, 1858, p. 790 (in text) (substitute name for the group to which *Fulix* Sundevall is simultaneously restricted) (type by subsequent designation [Baird, Brewer, and Ridgway, Water Birds North Amer., II, 1884, p. 17], *Anas marila* Linnaeus).

Marila STONE, The Auk, XXIV, No. 2, April, 1907, p. 191 (Oken MS.) (type by original designation and monotypy, *Anas marila* Linnaeus) (nec *Marila* Reichenbach).

Description.—Wing 4 1/2-5 times the length of exposed culmen; bill relatively but little flattened terminally, its width near end 1 1/10-1 3/10 times its width at base, its tip squarish, its width at posterior end of nail 2 1/2-3 1/3 times the length of its nail; tip of maxilla much hooked; nail of bill broad and triangular, or narrow and strap-like; height of bill at extreme

[1]The Auk, XXXVI, No. 4, October, 1919, pp. 460-463.

base 5/6-1 1/10 times its greatest width; base of culmen not deeply concave; exposed culmen 1 4/5-2 1/5 times the height of bill at extreme base, 1 3/4-2 times the greatest width of bill, and decidedly less than the length of inner toe with claw; anterior outline of feathering at the base of culmen triangular and acutely pointed; feathering on sides of maxilla not reaching forward as far as that at the base of the culmen; no occipital crest.

Type.—*Anas marila* Linnaeus.

Remarks.—At first sight *Fulix novaeseelandiae* (Gmelin) differs somewhat from the two other species of this genus in the relatively greater height of its bill at base; in having the wing but little more than 4 1/2 times the exposed culmen; the nail of the bill narrow with its sides parallel (not triangular); the exposed culmen usually slightly less than 2 times the height of the bill at extreme base; and the width of bill at posterior end of nail usually about 3 times the length of the nail. None of the e characters, however, are trenchant or constant enough to warrant the separation of this species even subgenerically. The narrow, strap-like nail of the bill appears to be one of the best differences, but this character is present, though not constant, in *Fulix affinis*.

The generic name *Marila* Oken[1] is here regarded as a nomen nudum, in common with all the other names proposed by Oken in this now famous article giving his own equivalents for the generic groups in Cuvier's classification. Oken's proposed equivalents seem not with sufficient definiteness introduced as substitutes, and, consequently, are not removed from the category of nomina nuda. The particular name, therefore, which we have now under consideration we must reject for the group of ducks to which it has been commonly applied, at least as dating from 1817. The next name in point of time, which can be used for this group, seems to be *Fulix* Sundevall.[2] It was originally proposed for the "Anates lobatae," to include all the ducks with a lobed hind toe, but no species was mentioned, although the group was stated to contain the generic groups *Platypus* Brehm, *Hydrobates* Temminck, and *Fuligula* "a Bonaparte acceptum". Professor S. F. Baird[3] was the first author to restrict *Fulix* Sundevall to a definite modern genus of ducks, and he circumscribed the group to include the American species *Anas marila* Linnaeus, *Fuligula affinis* Eyton, and *Anas collaris* Donovan, but at the same time implying that his type was one of their European relatives. However, the type of this group was later definitely fixed by Baird, Brewer and Ridgeway[4] in the following language: "No type designated, but restricted to the group of which *Anas marila*, Linnaeus, is typical, by Professor Baird in B. N. Am. 1858, 790." There thus seems no doubt of the propriety of using the name *Fulix* for the Scaup Ducks. The term *Nettarion* Baird[5] is a name proposed for the same group in case the designation *Fulix* Sundevall could not properly be restricted as Professor Baird intended.

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[1]Isis (von Oken), 1817, Heft VIII, col. 1183.
[2]Kongl. Vetensk.—Acad. Handl., for 1835 (1836), p. 129.
[3]Rep. Explor. and Surv. R. R Pac., IX, 1858, p. 790.
[4]Water Birds North Amer., II, 1884, p. 17.
[5]Rep. Explor. and Surv. R. R. Pac., IX, 1858, p. 790.

The species now referable to this genus are:

Fulix marila marila (Linnaeus)
Fulix marila mariloides (Vigors)
Fulix marila nearctica (Stejneger)
Fulix affinis (Eyton)
Fulix novaeseelandiae (Gmelin).

Fuligula STEPHENS.

Fuligula STEPHENS. Shaw's Gen. Zool., XII. pt. ii. 1824. p. 187 (type by tautonymy. *Anas fuligula* Linnaeus).

Ania BONAPARTE. Ann. Lyc. Nat. Hist. N. Y., II. 1828. p. 386 (in synonymy of *Fuligula*; type thus by virtue of substitution. *Anas fuligula* Linnaeus).

Glaucium GRAY. List Genera Birds. 1840. p. 75 (Brisson MS., in synonymy of *Fuligula* "Ray" [= Gray]) (type by virtue of substitution. *Anas fuligula* Linnaeus).

Diagnosis.—Similar to *Fulix*. but tip of bill much rounded, its width at posterior end of nail less than 2 1/2 times the length of nail; and head with a long occipital crest.

Description.—Wing 5 times the length of exposed culmen; bill relatively little flattened terminally, its width near end 1 1/10-1 2/10 times its width at base, its tip rounded, its width at posterior end of nail 2-2 1/4 times the length of nail; tip of maxilla much hooked; nail of bill broadly triangular; height of bill at extreme base 5/6-19/20 of its greatest width; base of culmen not deeply concave; length of exposed culmen 2-2 3/8 times the height of bill at extreme base, 1 9/10-2 times the greatest width of bill, and decidedly less than the length of inner toe with claw; anterior outline of feathering at the base of culmen triangular and acutely pointed; feathering on sides of maxilla not reaching forward as far as that at the base of culmen; a long (75 mm.), slender occipital crest.

Type.—*Anas fuligula* Linnaeus.

Remarks.—This bird is much more closely allied to the genus *Nyroca* than to *Fulix*, despite its coloration, as may be seen from the diagnosis herewith given. Its long, pointed crest is unique among the species here considered, although some of the others have the feathers of the pileum lengthened into a short, bushy crest.

The name to be applied to this genus is, of course, clearly *Fuligula* Stephens,[1] as its type is, by tautonymy, *Anas fuligula* Linnaeus. The name *Platypus* Brehm,[2] by some others cited in the synonmy of *Fuligula*, is a synonym of *Somateria* Leach, as is established by the designation of its type by Lesson[3] as *Anas mollissima* Linnaeus.

The only species of this genus is *Fuligula fuligula* (Linnaeus).

Nyroca FLEMING.

Nyroca FLEMING, Philos. Zool., II. 1822. p. 260 (type by tautonymy. *Anas nyroca* Güldenstädt).

[1] In Shaw's Gen. Zool., XII. pt. ii. 1824. p. 187.
[2] Lehrb. d. Naturg. Eur. Vög., II. 1824. p. 805.
[3] Man. d'Ornith., II. June, 1828, p. 415.

Ilyonetta HEINE, Nomencl. Mus. Hein. Ornith., 1890, p. 347 (nom. emend. pro *Nyroca* Fleming, 1822; type, therefore, *Anas nyroca* Güldenstädt).

Diagnosis.—Similar to *Fuligula*, but length of wing less than 5 times the length of exposed culmen; head without a long occipital crest.

Description.—Wing 4 2/5-4 4/5 times the length of exposed culmen; bill relatively somewhat flattened terminally, its width near end 1-1 2/10 times its width at base, its tip rounded, its width at posterior end of nail 1 9/10-2 3/10 times the length of nail; tip of maxilla much hooked; nail of bill broad and triangular; height of bill at extreme base 9/10-1 2/10 times its greatest width; base of culmen not deeply concave; exposed culmen 1 4/5-2 1/5 times the height of bill at extreme base, and 1 9/10-2 1/3 times the greatest width of bill; exposed culmen decidedly less than the length of inner toe with claw; anterior outline of feathering at the base of culmen triangular and acutely pointed; feathering on sides of maxilla not reaching forward as far as that at the base of culmen; a short occipital crest or none.

Type.—*Anas nyroca* Güldenstädt.

Remarks.—The species included under this heading seem at first sight to be a heterogeneous assemblage, but, as in the case of *Fulix*, the examination and comparison of all the species involved and the proper consideration of individual variation show that no further generic division is possible without virtually making a genus of each species on characters either trivial or not wholly constant. It is quite true that *Nyroca americana* differs in structure considerably from *Nyroca nyroca*, the length of the wing in the former being more than 4 1/2 times the exposed culmen; the bill less widened at tip, its width at posterior end of nail less in proportion to the length of the nail, its height at extreme base decidedly more than its greatest width; and the length of the exposed culmen decidedly more than 2 times the greatest width of bill; but all these differences are more or less unsatisfactory, as they either by individual variation or through the characters of other species here referred to *Nyroca* grade insensibly into each other. The same situation exists in the other species. Two forms, *Nyroca nationi* and *Nyroca innotata*, have not been examined in the present connection, but the relationship, of at least the latter, in so far as determinable, seems to be doubtless with the present group.

No complication exists in the generic synonymy of this group, for the name *Nyroca* Fleming[1] has for its type by tautonymy *Anas nyroca* Güldenstädt. The *Ilyonetta* of Heine[2] is, of course, merely a substitute name for *Nyroca* Fleming, for reasons of purism.

The species belonging to this genus are as follows:

Nyroca erythrophthalma (Wied)
Nyroca brunnea Eyton
Nyroca nationi (Sclater and Salvin)
Nyroca americana (Eyton)
Nyroca nyroca (Güldenstädt)
Nyroca innotata Salvadori
Nyroca australis Eyton
Nyroca baeri (Radde).

[1]Philos. Zool., II, 1822, p. 260.
[2]Nomencl. Mus. Hein. Ornith., 1890, p. 347.

Perissonetta, gen. nov.[1]

Diagnosis.—Similar to *Nyroca*, but length of exposed culmen equal to length of inner toe with claw (instead of decidedly shorter); feathering on sides of maxilla extending forward as far as the feathering at the base of the culmen; anterior outline of feathering at the base of culmen broadly convex; and length of wing only about 4 times the length of exposed culmen.

Description.—Wing 4 times the length of exposed culmen; bill relatively little flattened terminally, its width near end about 1 1/8 times its width at base, its tip rounded, and its width at posterior end of nail about 2 times the length of the nail; tip of maxilla much hooked; nail of bill rather wide and subtriangular; height of bill at extreme base, 1 1/8 times its greatest width; base of culmen not deeply concave; exposed culmen about 2 1/4 times the height of bill at extreme base, 2 2/5 times the greatest width of bill, and equal to the length of inner toe with claw; anterior outline of feathering at base of culmen broadly convex; the feathering on sides of maxilla reaching forward as far as that at the base of culmen; a short, bushy occipital and coronal crest.

Type.—*Anas collaris* Donovan.

Remarks.—Mr. N. Hollister's excellent article on this species[2] serves but to emphasize the distinctness of this duck from its Old World relatives. As the characters that we have above given show, this species forms one of the most trenchantly distinct groups among the genera allied to *Nyroca*. Most of its distinctive characteristics are here for the first time presented, and it is quite evident that had they been appreciated before, the bird would long ago have figured as the type of a new genus, a fate that it seems to have escaped until now. In addition to the other characters by which it is readily and variously distinguishable from each of the generic groups here treated, it differs from all of these in the shape of the frontal feathering at the base of the culmen, and in the relative anterior extent of the feathering on the sides of the maxilla; and also, from all but *Aristonetta*, in having the exposed culmen equal to the length of the inner toe with claw. Notwithstanding its coloration, it is fully as well differentiated from *Fuligula* as from *Nyroca*, as the following differences from the former show: wing only 4 times the length of exposed culmen; height of bill at extreme base much more than the greatest width of bill; length of exposed culmen about 2 1/2 times the greatest width of bill; exposed culmen equal to inner toe with claw; anterior outline of feathering at the base of culmen convex, that on sides of maxilla reaching as far forward as that at the base of culmen; occipital crest short.

The only species assignable to this group must now be called *Perissonetta collaris* (Donovan).

Aithyia GLOGER.

Aythya BOIE, Isis (von Oken), 1822, Heft V, col. 561 (type by subsequent designation [Degland, Ornith. Europ., II, 1849, p. 455.], *Anas ferina* Linnaeus) (nec *Aethya* Dumont, quae *Aethia* Merrem [Alcidae]).

Aithyia GLOGER, (Froriep's) Notizen Gebiete Natur u. Heilk., XVI, No. 18, March, 1827, col. 279 (nom. emend. pro *Aythya* Boie; type, therefore, *Anas ferina* Linnaeus).

[1]perissós, mirabilis; nētta, anas.
[2]The Auk, XXXVI, No. 4, October, 1919, pp. 460-463.

Aethyja GLOGER, (Froriep's) Notizen Gebiete Natur u. Heilk., XVI, No. 18, March, 1827, col. 279 (nom. emend. pro *Aythya* Boie; type, therefore, *Anas ferina* Linnaeus).

Aethyia GLOGER, (Froriep's) Notizen Gebiete Natur u. Heilk. XVI, No. 18, March, 1827, col. 279 (nom. emend. pro *Aythya* Boie; type, therefore, *Anas ferina* Linnaeus).

Aithya BOIE, Isis (von Oken), 1828, Heft III-IV, col. 359 (nom. emend. pro *Aythya* Boie; type thus *Anas ferina* Linnaeus) (nec *Aethya* Dumont).

Fuligula SWAINSON, Nat. Hist. and Classif. Birds, II, July 1, 1837, p. 368 (Ray MS.) (type by monotypy, *Fuligula ferina* Selby [= *Anas ferina* Linnaeus]).

Athya BRANDT, in Helmersen, Lehmann's Reise Buchara und Samarkand, 1852, p. 329 (type by monotypy, "*Fuligula ferina* Linn." [= *Anas ferina* Linnaeus]).

Marila REICHENBACH, Avium Syst. Nat., 1852, p. VIII (type by original designation, *Anas ferina* Linnaeus).

Aythia SALVADORI, Cat. Birds Brit. Mus., XXVII, 1895, p. 334 (Boie MS.) (type by original designation, *Anas ferina* Linnaeus).

Diagnosis.—Similar to *Perissonetta*, but length of exposed culmen decidedly shorter than inner toe with claw, and less than twice the height of bill at extreme base; feathering on sides of maxilla not extending forward as far as the feathering at the base of the culmen; anterior outline of feathering at the base of culmen triangular and reaching anteriorly to an acute point; length of wing more than 4 times the length of exposed culmen, tip of bill squarish, its width at posterior end of nail 2 1/2 times the length of nail; height of bill at extreme base 1 1/4-1 3/8 times its greatest width; and base of culmen deeply concave.

Description.—Wing 4 1/4-4 2/5 times the length of exposed culmen; bill somewhat flattened terminally, its width near end about 1 1/20 times its width at base, its tip squarish, its width at posterior end of nail about 2 1/2 times the length of nail; tip of maxilla moderately hooked; nail of bill rather narrow and strap-shaped; height of bill at extreme base 1 1/4-1 3/8 times the greatest width of bill; base of culmen deeply concave; length of exposed culmen 1 4/5-1 6/7 times the height of bill at extreme base, about 2 2/5 times the greatest width of bill, and decidedly less than inner toe with claw; anterior outline of feathering at base of culmen triangular and acutely pointed; feathering on sides of maxilla not reaching forward as far as the feathering at the base of culmen; a short occipital crest.

Type.—*Anas ferina* Linnaeus.

Remarks.—This, the type of this monotypic genus, is very much more different from the species above included in *Nyroca* than authors have heretofore realized, largely because its distinctive characteristics have apparently been unappreciated. Its separation now as a distinct genus is based almost entirely on new characters. From *Nyroca* it may readily be separated by the deep longitudinal cavity at the base of the culmen, squarish tip of bill, and in having the width of the bill at the posterior end of nail at least 2 1/2 times the length of the nail; tip of maxilla less strongly hooked; nail of bill relatively narrow and strap-like; and the height of bill at base 1 1/4-1 3/8 times the greatest width of bill.

This genus in some respects resembles *Aristonetta*, as for instance in the much concave base of culmen, in which character it differs from all the other groups here considered. It is, however, well differentiated from *Aristonetta*, as may be seen from the diagnosis under that genus.

The generic name *Aythya* Boie[1] is the earliest name applicable to this group, but it is preoccupied by *Aethya* Dumont,[2] which is a synonym of *Aethia*, the earliest name for the genus of Alcidae formerly known as *Simorhynchus*. The *Aithya* of Boie[3] is, of course, merely an emendation of *Aythya* Boie, and is also preoccupied by *Aethya* Dumont. Likewise, *Fuligula* Swainson,[4] the type of which by monotypy is *Anas ferina* Linnaeus, is preoccupied by *Fuligula* Stephens.[5] The name *Aithyia* Gloger,[6] proposed as an emendation for *Aythya* Boie, is, however, by virtue of its additional syllable, a different word, therefore tenable under the present rules of nomenclature, and should be brought into use for this genus as its earliest valid designation.

The only species referable to *Aithyia* is *Aithyia ferina* (Linnaeus).

Aristonetta BAIRD.

Aythyia BONAPARTE, Compt. Rend. l'Acad. Sci., XXXVIII No. 14, April 10, 1854, p. 664 (type by monotypy, *Anas valisineria* Wilson) (nec *Aithyia* Gloger).

Aristonetta BAIRD, Rep. and Explor. Surv. R. R. Pac., IX, 1858, p. 793 (in text) (type by original designation and monotypy, *Anas valisineria* Wilson).

Anthya LE MOINE, Ornith. Canada, pt. 1, 1860, p. 90 (type, *Anas valisineria* Wilson).

Diagnosis.—Similar to *Aithyia*, but length of exposed culmen about equal to length of inner toe with claw, more than twice the height of bill at extreme base, and about 3 times the greatest width of bill; length of wing less than 4 times the length of exposed culmen; bill rounded at tip, and not wider near end than at base; tip of maxilla little or not at all hooked.

Description.—Wing 3 3/4-3 4/5 times the length of the exposed culmen; bill much flattened terminally, its width near end not more than its width at base, usually less; tip of bill rounded; width of bill at posterior end of nail 2 1/5 times the length of nail; tip of maxilla little or not at all hooked; nail of bill narrow and straplike; height of bill at extreme base 1 1/4 times the greatest width of bill; base of culmen deeply concave; length of exposed culmen 2 2/5 times the height of bill at extreme base, about 3 times the greatest width of bill, and equal to the length of inner toe with claw; anterior outline of feathering at base of culmen triangular and acutely pointed; feathering on sides of maxilla not reaching forward as far as the feathering at the base of culmen; no occipital crest.

Type.—*Anas valisineria* Wilson.

Remarks.—This monotypic group seems to be most nearly allied to *Aithyia*, although by no means to be included in the same genus. It forms

[1]Isis (von Oken), 1822, Heft V, col. 564.
[2]Dict. Sci. Nat., rev. ed., I, 1816, suppl., p. 71.
[3]Isis (von Oken), 1828, Heft III-IV, col. 359.
[4]Nat. Hist. and Classif. Birds, II, July 1, 1837, p. 368.
[5]Shaw's Gen. Zool., XII, pt. ii, 1824, p. 187.
[6](Froriep's) Notizen Gebiete Natur u. Heilk., XVI, No. 18, March, 1827, col. 279.

one of the most easily separated groups of those now under consideration. Some of its characters are here for the first time elucidated.

Its only species is *Aristonetta valisineria* (Wilson).

The following key to the genera here treated is added for convenience of reference and as a more graphic exposition of salient characters.

Analytical Key to Genera Allied to Nyroca.

a.[1] Length of exposed culmen about equal to length of inner toe with claw.

b[1]. Base of culmen deeply concave; anterior outline of feathering at base of culmen acutely pointed; feathering on sides of maxilla not reaching anteriorly as far as that at base of culmen; bill more flattened anteriorly, longer and slenderer, not wider near end than at base; length of exposed culmen 3 times the greatest width of bill; tip of maxilla not at all or very slightly hooked; nail of bill narrow and with parallel sides........................*Aristonetta*.

b[2]. Base of culmen not deeply concave; anterior outline of feathering at base of culmen not acutely pointed, but broadly convex; feathering on sides of maxilla reaching anteriorly as far as that at base of culmen; bill less flattened anteriorly, shorter and stouter, decidedly wider near end than at base; length of exposed culmen only 2 1/2 times the greatest width of bill; tip of maxilla strongly hooked; nail of bill rather wide and subtriangular....*Perissonetta*.

a[2]. Length of exposed culmen decidedly shorter than inner toe with claw.

b[1]. Base of culmen deeply concave............................*Aithyia*.

b[2]. Base of culmen not deeply concave.

c[1]. Tip of bill squarish, its width at posterior end of nail not less than 2 1/2 times the length of nail............................*Fulix*.

c[2]. Tip of bill much rounded, its width at posterior end of nail less than 2 1/2 times the length of nail.

d[1]. Length of wing less than 5 times the length of exposed culmen; no long pointed occipital crest........................*Nyroca*.

d[2]. Length of wing not less than 5 times the length of exposed culmen; a long (75 mm.) pointed occipital crest......*Fuligula*.

SOME OBSERVATIONS ON THE PYTHONS.

W. Henry Sheak, Philadelphia.

Most of my study has been given to birds and mammals, but I have had some exceptional opportunities to observe the great serpents, especially the pythons. I spent five years with the New York Zoölogical Company, better known as the Edwards Animal Show, as naturalist and lecturer. We always had a number of these monster reptiles in our collection, and sometimes as many as sixteen, none of them less than twelve feet in length, and some of them more than thirty. The following notes were made during those years.

The ability of snakes to perform feats of swallowing is astounding. I once knew a small boa, probably the young of *Boa constrictor* scarcely four feet in length, and with a head no larger than a man's thumb, to swallow a full-grown pigeon. We put the pigeon in the cage at night, thinking that an Indian python (*Python molurus*), seven or eight feet long, would take it, but a great swelling in the body of the little boa next morning showed what had become of the bird. As no snake chews or rends his prey, we knew that it passed his head and throat entire. The enlargement did not disappear for a week.

"Long Tom", a giant Reticulated python (*Python reticulatus*), fed on a pig weighing forty-five pounds. We wanted to get some photographs of the monster reptile taking large prey, so the pig was put in the den alive; but as his prey had been killed for him in captivity, the snake got frightened when the pig began to move about and squeal, and backed away. When the pig was killed and he smelled the warm blood, he took the animal at once and in twenty-five minutes it had disappeared. The pig is, however, an easy object to swallow, compared to a dense pelage of fur or feathers.

For two or three days the stomach was enlarged to almost the size of a beer keg, but on the third day the swelling began to diminish, and by the end of the fifth the body had returned to its normal diameter. Contrary to common belief, these big snakes will generally soon learn to take their prey after it has been killed. We usually fed them chickens or rabbits, killed, but still warm. We have, however, fed them with cold-storage rabbits that were killed in Australia. Miss Grace Clark, a young woman with much experience with big snakes in shows, tells me that she once had a snake that would take a chicken after it was dressed and cut into pieces, receiving the pieces one at a time. One evening we wanted to feed a very large pigeon to a small Indian python. In order to save him the trouble of working over the shoulders, we cut off the wings. After gorging the bird, we offered him the wings, which he took and swallowed.

The python which swallowed the pig was received from Carl Hagenbeck of Hamburg, Germany, in July, 1907. Mr. Hagenbeck had a photograph of the reptile in the act of swallowing an Indian antelope (*Antelope cervicapra*) weighing over ninety pounds. He had another Reticulated python which swallowed a ninety-seven pound ibex. A python in the Cincinnati Zoölogical Gardens swallowed a goat weighing forty-two pounds. All of the goat that passed intact were the horns, the hoofs, and a piece of sash rope four feet long that had been attached to his neck.

We had a big Reticulated python which passed the hoofs of a pig. They were shown to Dr. W. T. Hornaday, the Director of the New York Zoölogical Park, who identified them as the hoofs of the Bornean wild pig (*Sus barbatus*), of about forty pounds weight. A ship's captain in bringing over a large Reticulated python, found in the excrement the quills of a Javan porcupine, lying in the same relative position they occupied on the animal's body. The reptile must have begun at the head, extending the coils backward over the body, and pressing the quills down horizontally in their natural state of rest. Evidently, this is a species of prey a snake would not disgorge.

Our small snakes feed largely on frogs, toads, and fish; the anacondas feed extensively on fish; king snakes and king cobras eat other species of snakes; but I have never known a boa or python to take a cold-blooded animal. We often keep small snakes and iguanas with the boas and pythons, but they never take any notice of them. In a state of nature their prey consists largely of small deer and antelopes, lambs, kids, pigs, other mammals weighing less than a hundred pounds, and any bird that may be large enough to attract their attention. That their prey does not always submit without a fight is shown from the number of broken ribs that are found in the skeletons of these reptiles.

We had an artistically mounted skeleton of a twenty-two foot Reticulated python, in which there were thirty-seven ribs that showed well marked fractures, and a number of others that showed indications of fracture. Some of them had been broken two and even three times. In one, the ends had slipped past each other for about a half inch, and the two sides were knitted together. In one place there were five fractured ribs in succession. A peculiar feature about these broken ribs is the fact that they always occur toward the posterior quarters of the snake. It is probable that the animal responsible for these fractures is the Bornean wild pig. Doubtless the reptile usually seizes the pig near the head and throws his coils about the shoulders. The posterior limbs are thus left free, and with these he fights desperately till life is crushed out, frequently, as is plainly evident, doing serious damage to his assailant.

In conformity to their attenuated form, snakes have a large number of vertebræ and ribs. A peculiarity of the skeleton is that there are but two cervical vertebræ. The atlas and axis, or first and second bones of the spinal column, next to the head, bear no ribs, but they start with the third vertebra. Neither are there any lumbar or sacral vertebræ. In the Reticulated python there are 361 vertebræ. Of these, 2 are cervical, 37 caudal, and 322 dorsal. The caudal vertebræ all bear transverse processes, the proximal ones long and broad, diminishing gradually toward the tip of the tail, but they do not disappear, even in the last distal vertebra. It may be that these are but ribs ankylosed to the vertebræ. It is sometimes difficult to distinguish just where the ribs end and the transverse processes begin. This is true of the Indian python. As already intimated, there are 322 pairs of ribs. However, it is highly probable, at least possible, that this number will not hold constant. Even in man there may be thirteen, eleven, or as few as nine pairs. At least one human skeleton has been known with twelve ribs on one side and thirteen on the other.

Likewise the teeth of the python are numerous. In the upper jaw there is a row of teeth in the maxillary, and a second row, set at considerable distance inside the first and imbedded in, or rather ankylosed to, the palatine bones. In the lower jaw there is but one row of teeth, that of the inferior maxillary, but it is really double, as there is a line of tiny teeth just inside the larger ones. The teeth are all acutely conical in form, smooth, and with no cavities, depressions, or ridges, and set so that they point toward the back of the mouth. They serve merely for catching and holding the prey, not for mastication. As there are no particles of decaying food on the teeth to be carried into the wound and produce septacemia, a bite from one of these monsters usually heals quickly. None of the teeth are set in alveoli, but merely ankylosed to the outside of the bone, and as the ankylosed surface is small, it follows that the attachment is not very solid. Consequently it is not unusual for the teeth to break off when the reptile is feeding. We often found them on the floor of the cage after a feeding.

In seeking his prey, the python depends much more on his sense of smell than on that of sight. It is always dangerous to go near these big snakes with the smell of any kind of bird or mammal on the hands or clothing. When they are hungry and scent their natural food, they will strike at the first thing they see moving. They will even strike at inanimate objects which have come in touch with their natural prey. One evening we were feeding a big python. For some reason he had dropped the prey, and to get him to return to the chicken, I picked up a woolen duster which the janitor had been using to dust the glass cases, and pushed it towards his head. Instantly he struck and seized the duster in his teeth. His jaws had to be pried open to make him let go. Under similar circumstances a python in the Philadelphia Zoological Garden a few years ago, seized and swallowed a blanket. After retaining it for two days, he disgorged the article, rolled into a compact wad.

The sense of taste in the serpents is very keen. If chickens are kept in a dirty box, these reptiles will refuse to feed on them. If a python bites into the crop of a chicken containing bad-tasting matter, he will drop the chicken. To test the sensibilities of the serpents, we once put a stale egg in with a Black snake. This species (*Boscanium constrictor*) is very fond of eggs, but no sooner had the shell broken in his stomach than the little fellow commenced vomiting, and continued until the stomach was completely evacuated.

It is sometimes said that the snakes have no eyelids. In fact the eyelids are fused in a transparent skin over the eyes. When they shed they shed the skin from over the eyes as well as that from other parts of the body. Just before the old skin is removed, it dies, becomes dull in color and opaque in texture, so that for several days before shedding a snake is almost blind. There is a milky fluid between the dying epidermis and the newly forming skin beneath. It is a strange fact, but during the last few hours this fluid disappears and the skin over the eyes partially clears. As soon as the old skin is removed, the snake is able to see again as well as ever. But it sometimes happens, in captivity, at least, that the skin over the eyes is not removed when that from other parts of the body is shed, and as a consequence the snake remains blind. I have known this to happen for two successive sheddings and at the third all three skins be removed, when the reptile's vision was restored.

It is a common belief that snakes are so plentiful in India that one can scarcely walk about without stepping on them. This is erroneous. It is possible to live for considerable periods of time in that country without so much as catching a glimpse of a snake. And this is especially true when we confine our references to the big pythons. Dr. Hornaday spent two years hunting in India and Borneo, and he declares he never saw but one python, and that was a small one. The pythons are timid and shy, and lie coiled among the foliage of trees or shrubs, or in the dense grass on the ground. They never attack man or the large animals so long as they are unmolested.

MALLOPHAGA OF OUR NATIVE BIRDS.

EDWIN J. KOHL.

The Mallophaga or biting bird lice constitute a group of insects that apparently excite little curiosity in the average individual. Moreover, lice in general are looked upon with disdain. Nevertheless, they do hold an interest for some individuals, those who do not hold themselves aloof from these minute parasites, and hold no fear of infestation.

The earliest writings in which lice were mentioned and received attention were those of Francesco Redi, an Italian naturalist, in 1668. Other writings followed by such men as Otto Fabricino (1780), De Geer (1778), and Linne (1789). Not much truly scientific work was done by these men; it was rather haphazard. Christian Ludwig Nitzsch, Professor of Zoology in the University of Halle, did the first real work that is recognized today. His descriptions were excellent. He made an attempt at classifying and naming the Mallophaga. This, the beginning of our present day nomenclature, gave an impetus to real work along these lines. Such men as Denny, Giebel, Piaget, Taschenberg and others, continued the work with excellent results.

Most of this early work was along taxonomic lines, that of describing, naming and classifying, but a few men, Kramer, Melnikoff, and Grosse did some work on anatomy. The work of Grosse in itself was not of a high order. No special attention was given to accuracy of description and drawings, consequently the work was crippled somewhat until our modern entomologists revised and improved upon it.

In this country Herbert Osborn and A. S. Packard did the first work of any consequence. Osborn's "Pediculi and Mallophaga affecting man and the Lower Animals" was the first real attempt in this respect. It was by no means complete. Much remained to be done. It was at this point that Vernon Kellogg took up the investigation of Mallophaga. He made extensive collections, aimed at completeness in every respect. He made collections from most of the common birds of North America. Special attention was paid to classification, to accurate descriptions and very accurate drawings. The internal anatomy was completely worked out. Furthermore, the old Nitzschian nomenclature was revised and brought up to date. In every way the work was of a high order and set a new standard in Mallophagan lines.

The position of Mallophaga among the Insecta for a long time was a much-debated question. Each new student quite naturally shifted them from one position to another because little was known then concerning the anatomy and development of these insects. For a long time they were placed coordinate with or under the Pediculidae, for the reason that they were ectoparasites. However, it was discovered that Mallophaga have biting mouth parts, consequently they were placed in the Pseudo-Neuroptera along with various heterogeneous insects. Even the Pseudo-Neuroptera were broken up by Brauer and the Mallophaga now found themselves keeping company with Psocids and Termites under the Corrodentia. Finally, in all this rearrangement of things pertaining to classification, Kellogg gave the Mallophaga the rank of a full order. Whether or not they are ranked thus makes very little difference, relatively. They are generally placed in a position following the Corrodentia, which seem to be an intergrading group leading up to the Mallophaga. When Kellogg finally did his monumental work on the North American Mallophaga (1896-1899) he took the old Nitzschian classification and key, tore it down and rebuilt it. Subgenera were ranked as genera, and genera became families in the present-day key to the Mallophaga. This key is still intact and widely used and is the last word on keys.

The Mallophaga are purely ectoparasites. As such they live on scales and feathers of the birds. In the case of the mammal-infesting Mallophaga, they devour hair and skin or scales of the skin, and to this there are very few, if any, exceptions. Kellogg notes one instance, where a louse was found attached securely and firmly with its jaws to the skin, evidently having sucked or devoured flesh and blood. If such food as blood were found among the stomach contents when examined, it may have been blood which found its way to the feathers by injury to the host through scratching. In that manner, the louse had probably secured the blood. It is very rare to find blood among the contents of a louse's stomach and no observers record this, except the one just mentioned.

Consequently, lice would not be thought to produce any harmful effect upon the host. Such is not the case. It is noticed among poultry that the presence of lice causes tremendous uneasiness, scratching and disquiet, so much so that the effect produces a modification of habits of the host and causes a loss in weight. In case of pullets, it causes a loss in egg production, due to irritation and harmful effect upon the general habits of the bird. Among the birds the effect is not so noticeable. It is known with certainty that birds do not harbor these parasites without some distress. They dust themselves thus smothering out the lice. In extreme cases of infestation a loss of vitality is occasioned and finally death may ensue.

Some importance dare be attached to the study of lice, in that they may be carriers of certain diseases common to birds. We know that Pediculus vestimenti acts as a carrier of Bacillus typhus, and ticks carry and transmit cattle fever, fleas carry plague, etc. So it is safe to assume that in all probability lice of birds have something to do with the transmission of various bird diseases. Such investigations have as yet, not been recorded.

In collecting lice, one must secure the birds, which may be done either by capture of adults or young, or by shooting, but such a procedure may be followed only under state permit. Humanitarian methods are strongly urged, therefore live birds may be secured and released, after thorough examination and removal of its parasites.

In collecting lice, one must develop patience. Haphazard methods with a limited amount of enthusiasm and interest never produce results. At any rate, we generally examine the whole body thoroughly. Every inch of the body must be scrutinized. Feathers, if picked, must be thoroughly gone over and sometimes a hand lens is absolutely necessary. Generally the unaided vision is sufficient to enable one to find them. All birds are likely to have lice at one time or another. Acting on this assumption we must find them. In some cases the birds are so thorough in their dusting that only a single louse remains (a fertile female) to propogate and continue the species. So, hand picking, however tedious it may be, is the best and surest way. If the bird is overrun with the lice a rapid way may be employed by wrapping the bird in a white cloth, moist with kerosene. According to Dr. H. E. Enders this method is excellent. In the case of animals, if the infestation is great they may be combed out, only the loss of legs of the lice may result. So even if hand picking is tedious, nevertheless, it is the best method.

The regions on the bird in which the lice are found are definite and have some significance attached to them. For instance, a very rapid running louse like Menopon or Colpocephalum will be found in the anal regions or on the back. But such a slow one as a Docophorus will be limited to the head or neck entirely. There are reasons for this orientation. The bird can not easily scratch off a heavy-jawed and heavy-clawed Docophorus from the neck region, nor will a limited amount of dusting do much good in that region. So also will a Colpocephalum escape if the bird attempts to catch it with its bill in a dorsal, anal, or abdominal region. It escapes by running, for which it is adapted extraordinarily. It is therefore necessary that definite regions be examined and their distinct species noted.

In my observations I have found Nirmus associated with the breast region as in the American Robin: likewise in the Purple Grackle. Docophorus, no matter what species, is always restricted to the upper part of the neck and head. Colpocephalum may be found on the back of the bird, or in the anal regions. Physostomum of the kingbird, I found in the rump region and in the Eastern Vesper Sparrow in the nape region. However, in the latter case the louse may have migrated, as the louse was not found for one hour after the bird had been killed. Colpocephalum is also associated with the rump region. Lipeurus quite often is found among the wing and tail feathers. Trinoton, which is very agile and strong of foot infests the back. Whether these observations correspond with those of others, I do not know, for none are recorded.

In collecting lice in the field the usual method employed to preserve them is that of placing them in 75 or 80 per cent alcohol. There is slight shrinkage due to hardening effects of the alcohol, but insufficient to cause any serious damage or to interfere with subsequent study. Lice may also be preserved in a solution of chloral hydrate which will keep them quite soft. From much material one is enabled to make satisfactory studies. Other methods more exacting can be employed if facilities allow. Lice that are preserved by the above named methods can be put through a technique which will yield beautiful preparations.

If it is possible to collect the insects alive, they may be placed in hot water—very nearly boiling. This will have a two-fold effect. When thrown into the water they will float, consequently their legs will be extended very nicely. In this condition they will be killed by the hot water. In subsequent dehydration, from 70 per cent alcohol through 80 and 95 per cent alcohol the extended condition of the legs will be practically unchanged, for they will have become sufficiently hardened in 70 per cent alcohol. From 95 per cent alcohol we transfer them to absolute alcohol. The usual method following this is xylol and balsam, for the permanent mounts. This will give excellent preparations, which are strikingly clear, if no air or water remain in the insect.

Another method, simpler and decidedly quicker is to mount the louse directly from absolute alcohol into Euparal. Euparal as recommended very highly by Lee, is a mounting medium whose index of refraction varies to such an extent as compared to that of the cleared louse, that it allows very minute structures such as pustulated hairs to be seen very distinctly and advantageously. Another advantage in this technique lies in the fact that xylol is not needed as a final clearing agent and less shrinkage results in the insect. Moreover, the expense of xylol is entirely eliminated.

Such mounts will allow the internal anatomy to be seen in part. If the internal anatomy is not desired particularly a still clearer specimen can be obtained.

If the louse be placed into caustic potash or caustic soda previous to the final steps in dehydration, all internal structures that cause some opacity will be dissolved. It usually requires from 6 to 12 hours to completely clear the specimens after which they should be well washed in water before the final dehydration is undertaken or certain colloidal precipitates will form later. Moreover, the procedure just described will enable one to straighten out all legs, which had been drawn under the body during killing, whether directly by alcohol or hot water. They become quite soft in the potash and are somewhat easily handled.

Some precautions are necessary in the final mounting into Euparal in order that the air may not enter the legs and abdomen of the louse, and cause it to become entirely opaque. To overcome this requires care not to expose the specimen to air in removal from the absolute alcohol to the mounting medium. If, after some time, such mounts in Euparal develop peculiar polygonal crystals, they can be removed by gently heating the slide over a flame or in an oven. These crystals are camphor which has crystallized out and which was one of the solvents of the resin used in making Euparal, i. e.,—Gum Sandarac.

The species-determining characters in lice are many and varied. In the main, they constitute the greatest difficulty in the study of lice and require considerable attention.

The nomenclature of anatomical parts of lice in this paper is that followed by Kellogg in his New Mallophaga I, (1896).

The head of a louse may be said to consist of two main parts. The front which includes the clypeus, and the large swollen hindpart or occiput. The front and occipital regions are usually separated by a groove or fossa in which are situated the antennae. This is the antennal fossa. The lateral margin of this region is called the temporal margin and the posterior margin adjoining and touching the prothorax is the occipital margin. Within this swollen occipital region are found bands running from the base of the occipital margin to the inner end of the antennal fossa. These are the occipital bands. Those bands running forward, well into the front and arising at the antennal fossa are the antennal bands. The broad colored, chitinized plate between the antennal bands, is the signature. In some genera, as Docophorus and Nirmus, there arise at the lateral margin, and adjoining the antennal fosa, certain large movable spine-shaped structures.

These are called trabeculae. All these structures here named are specific characters in the determination of lice.

There is a uniform number of hairs present in the temporal and occipital margins. These hairs, as well as those of the prothorax, metathorax and abdomen are used as determining characters, as their number is uniform. Whenever these hairs seem to project through a clear space in the colored chitinized parts of the insect, they are said to be pustulated.

Differences in genera involve more than the aforementioned facts. It depends mainly on the shape of the body, the size of the trabeculae, whether movable to any marked degree; upon the size of the front as compared with the occiput; the depth of the antennal fossa or ocular emargination, and the size of the temporal margins or regions of the occiput, generally indicated as swollen temporal regions. Another genus distinguishing character is the similarity or dissimilarity of antennae in both sexes. There are other differences in genera which will be noted in the accompanying key. It is the key as revised and standardized by Kellogg from his New Mallophaga I (1896) pages 61-62.

Key to the Suborders.

A. With filiform 3- or 5-segmented antennae, and no labial palpi. Suborder Ischnocera.

AA. With clavate or capitate 4-segmented antennae, and 4-segmented labial palpi. Suborder Amblycera.

Key to the Genera of the Suborder Ischnocera.

A. With 3-segmented antennae; tarsi with 1 claw; infesting mammals (family Trichodectidae). Trichodectes N.

AA. With 5-segmented antennae; tarsi with 2 claws; infesting birds (family Philopteridae).

- B. Antennae similar in both sexes.
  - C. Front deeply angularly notched. Akidoproctus P.
  - CC. Front convex, truncate, or rarely with a curving emargination, but never angularly notched.
    - D. Species broad and short, with large movable trabeculae (at the anterior angle of antennary fossa).
      - E. Forehead with a broad transverse membranous flap projecting beyond lateral margins of the head in the male, barely projecting in female. Giebelia Kellogg.
      - EE. Without such membranous flap. Docophorus N.
    - DD. Species elongate, narrow; with very small or no trabeculae. Nirmus N.
- BB. Antennae differing in the two sexes.
  - C. Species wide, with body elongate-ovate to suborbicular.
    - D. Temporal margins rounded; last segment of abdomen roundly emarginated; antennae of male without appendage, third segment very long. Eurymetopus Tasch.

DD. Temporal margins usually angulated; last segment of abdomen convex, rarely angularly emarginated with two points.

E. First segment of antenna of male large, sometimes with an appendage; third segment always with an appendage. Goniodes N.

EE. First segment of antenna of male enlarged but always without appendage; third segment without appendage; last segment of abdomen always rounded behind. Goniocotes N.

CC. Species elongate, narrow, sides sub-parallel.

D. Third segment of antenna of male without an appendage. Ornithobius Denny.

DD. Third segment of antenna of male with an appendage.

E. Front deeply angularly notched.

EE. Front not angularly notched.

F. Antennae and legs long; a semicircular oral fossa. Lipeurus N.

FF. Antennae and legs short; oral fossa narrow, elongate, extending as a furrow to the anterior Margin of the head. Onocophorus Rudow.

Key to the Gerera of the Suborder Amblycera.

A. Tarsi with 1 claw; infesting mammals (family Gryopidae).

AA. Tarsi with 2 claws; infesting birds (except Boopia?) (family Liotheidae)

B. Ocular emargination distinct, more or less deep.

C. Forehead rounded, without lateral swelling; antennae projecting beyond border of the head. Colpocephalum N.

CC. Forehead with strong lateral swellings.

D. Antennae projecting beyond border of the head; temporal angles projecting rectangularly; eye large and simple. Boopia P.

DD. Antennae concealed in groove on under side of head; temporal angles rounded, or slightly angular; eye divided by an emargination and fleck.

E. Mesothorax separated from metathorax by a suture. Trinoton N.

EE. Meso- and metathorax fused; no suture. Laemobothrium N.

BB. Ocular emargination absent or very slight.

C. Sides of the head straight or slightly concave, with two small laterally-projecting labral lobes. Physostomum N.

CC. Sides of the head sinous; forehead without labral lobes.

D. Body very broad; metathorax shorter than prothorax. Eureum N.

D. Body very broad; metathorax shorter than prothorax. Eureum N.

DD. Body elongate; prothorax shorter than metathorax.
  E. Ocular emargination filled by a strong swelling; sternal markings forming a quadrilateral without median blotches. Nitzschia Denny.
  EE. Ocular emargination without swelling, hardly apparent or entirely lacking; median blotches on sternum.
    F. Very large; with two 2-pointed appendages on ventral aspect of hind-head; anterior coxae with very long lobe-like appendages. Ancistrona Westwood.
    FF. Small or medium; without bipartate appendages of hind-head. Menopon N.

The collections of lice discussed in this paper were made in Myerstown, Lebanon County, Pennsylvania, and vicinity. All birds as will be seen, are migratory birds except one, the English sparrow.

A list of species found on a number of birds is given herewith. There was absolutely no straggling of lice from one bird to another as might be the case if the birds were placed in one bag. These lice were collected in the field, that is, as soon as the bird was procured, they were picked and preserved in vials of alcohol. Consequently, there was no danger of migration of parasites from one bird to another.

Parasite	*Host*	
Docophorus communis (Nitz)	Quiscalus quiscalus	—Purple Grackle
	Cyanocitta cristata	—Blue Jay N.H.
	Sturnella magna	—Meadow Lark N. H.
	Toxostoma rufum	—Brown Thrasher N. H.
Docophorus icterodes (Nitz)	Anas boschas	—Mallard Duck
Docophorus fusco-ventralis (Osb.)	Nuttalornis borealis	—Olive-sided Flycatcher
	Cyanosphiza cyanea	—Indigo Bunting
Docophorus jungens (Kell)	Colaptes auratus	—Flicker
	Melanerpes erythro cephalus	—Red-headed Woodpecker.
Docophorus cordiceps (Giebel)	Actitis macularia	—Spotted Sandpiper, N. H.
Nirmus vulgatus (Kell.)	Merula migratoria	—American Robin
	Passer domesticus	—English Sparrow.
	Pipilo erythrophthalmus	Chewink, N. H.
Nirmus illustris (Kell.)	Quiscalus quiscalus	—Purple Grackle, N. H.
Lipeurus squalidus (Nitz)	Anas boschas	—Mallard duck
	Spatula clypeata	—Shoveller Duck
Colpocephalum chrysophaeum (Kell.)	Quiscalus quiscalus	—Purple Grackle
	Toxostoma rufum	—Brown Thrasher
Trinoton luridum,	Anas boschas	—Mallard Duck
	Spatula clypeata	—Shoveller Duck

Physostonum angulatum (Kell.)	Tyrannus tyrannus	—Kingbird
Physostomum diffusum (Kell.)	Poecetes grammineus	—Eeaster Vesper sparrow, N. H.
Menopon incertum	Galeoscoptes carolinesis	—Catbird

This list of species of parasites as related to the hosts upon which they were found is a new one in distribution. Many species (marked *N.H.*—New Host) here noted were not observed upon these same hosts by other observers. It will be noticed upon comparison with Kellogg's list that generally they are the same genera of birds but a different species.

Docophorus communis is a widely distributed species. Besides those hosts indicated by Kellogg and others, I have found it on Cyanocitta cristata. Nirmus vulgatus is recorded for Merula migratoria and for a number of species of western Pipilo. I have found it in addition on Passer domesticus and Pipilo erythropthalmus. Colpocephalum chrysophaeum, I found on Toxostoma rufum and Quiscalus quiscalus, whereas Kellogg observed it upon Melosphiza fascinata samuelis in California. Physostomum diffusum, I found on Poecetes gramminens and Kellogg noted it on Zonotrichia coronata, a related species. Lastly, Menopon incertum was found on Galeoscoptes carolinensis and other observers found it on the Gold Finch and the Russet-backed Thrush (Spinus tristis and Turdus ustulatus).

This distribution indicates clearly that even though a certain species of louse is observed on a host different than that of another observer, it is a host very closely related. Sometimes there are exceptions and for these Kellog has no other explanation than that of migration from one bird to another when in close quarters, in roosting on trees during migration of the birds, or huddling together of certain water birds on floating weeds and wreckage at sea. One interesting fact remains, that closely related genera of parasites infest closely related genera of hosts.

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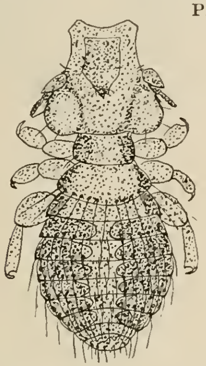
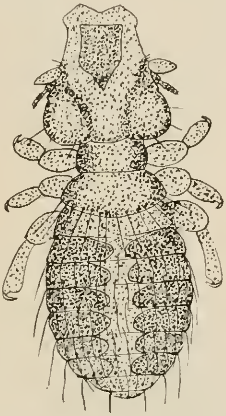
EXPLANATION OF PLATES.

Plate I.—Docophorus fusco-ventralis Osb., Male and female.
Plate II.—Docophorus icterodes Nitz., female.
Plate III.—Docophorus jungens Kell., female.
Plate IV.—Docophorus cordiceps. Giebel, male and female.
Plate V.—Docophorus communis Nitz., male and female.
Plate VI.—Nirmus illustris Kell., female.
Plate VII.—Nirmus vulgatus Kell., male and female.
Plate VIII.—Lipeurus squalidus Nitz., male and head of female.
Plate IX.—Colphocephalum chrysophaeum Kell., female.
Plate X.—Trinoton luridum Nitz., female.
Plate XI.—Physostomum angulatum Kell., female.
Plate XII.—Physostomum diffusum Kell., female.
Plate XIII.—Menopon incertum Kell., male.

PLATE I.





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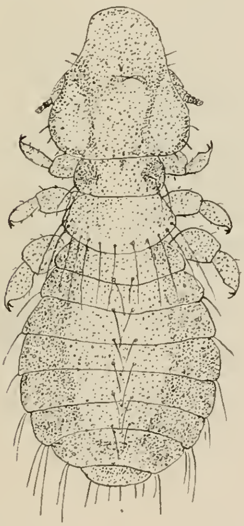

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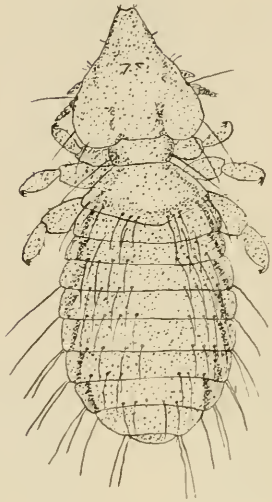

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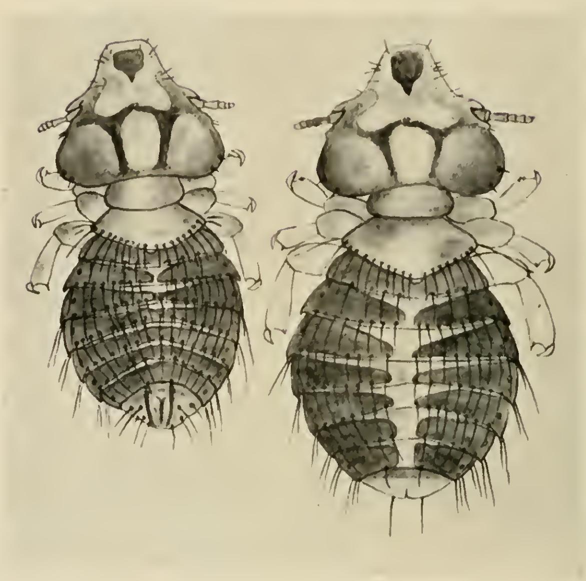

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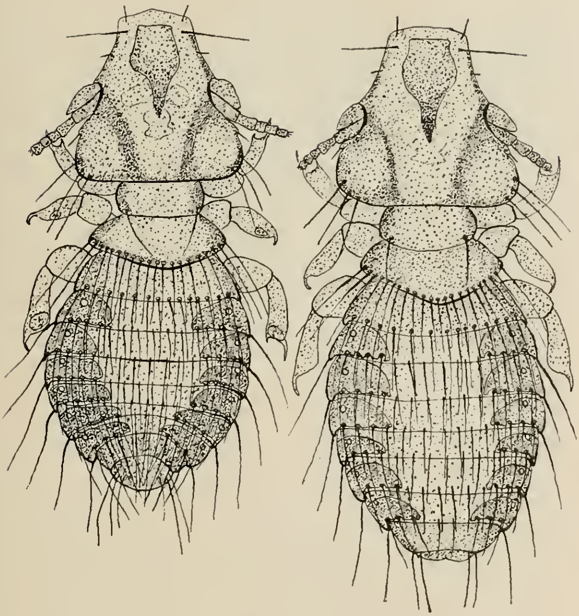

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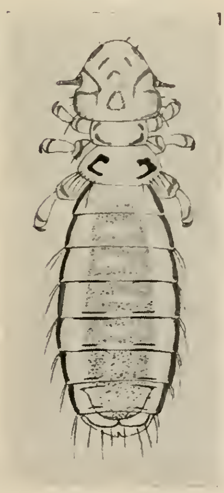

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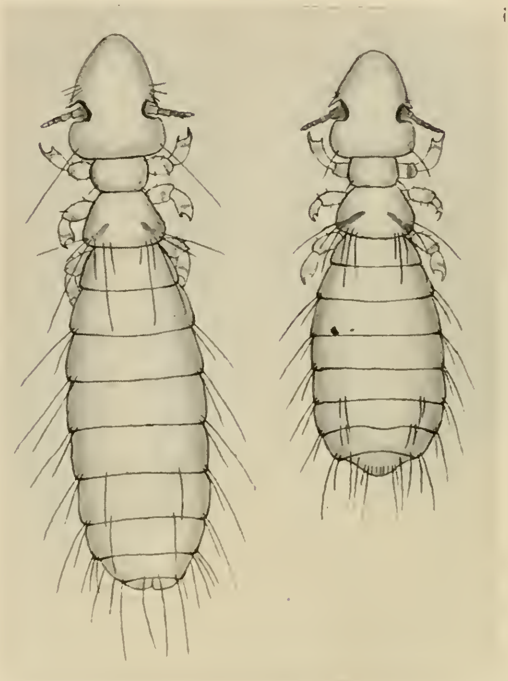

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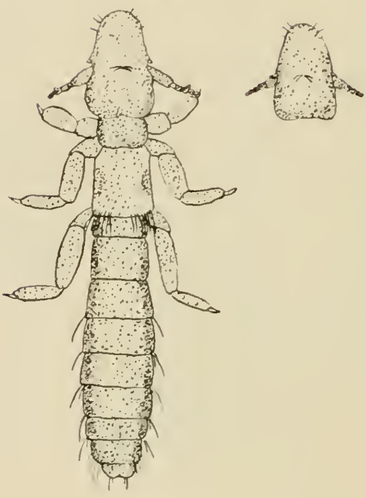

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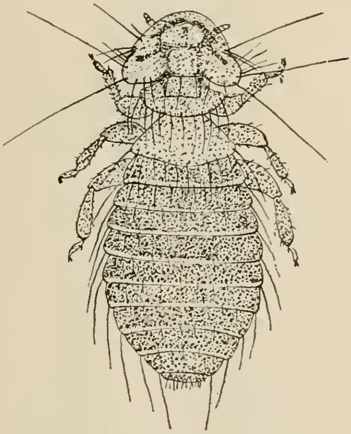

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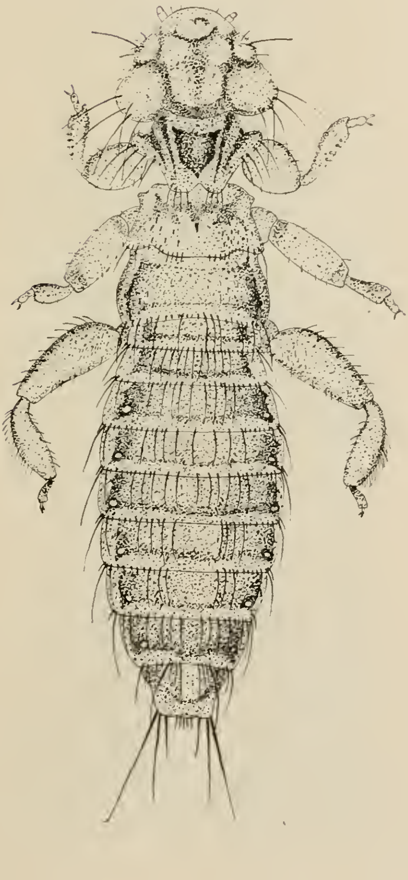
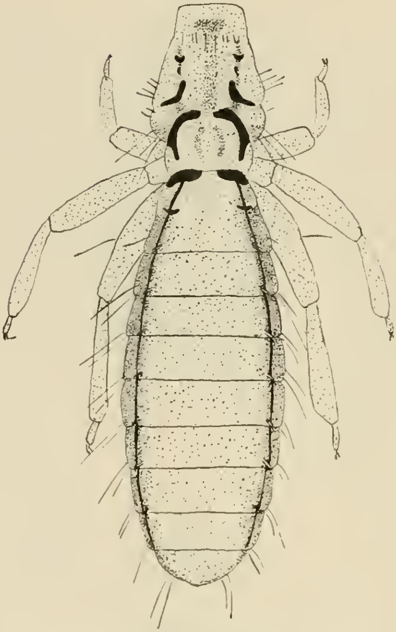


PLATE XI.



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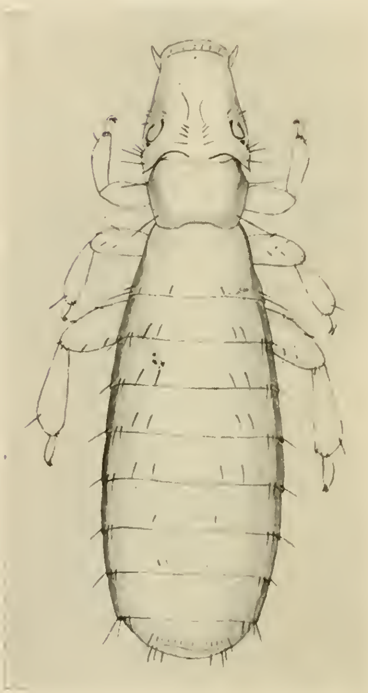
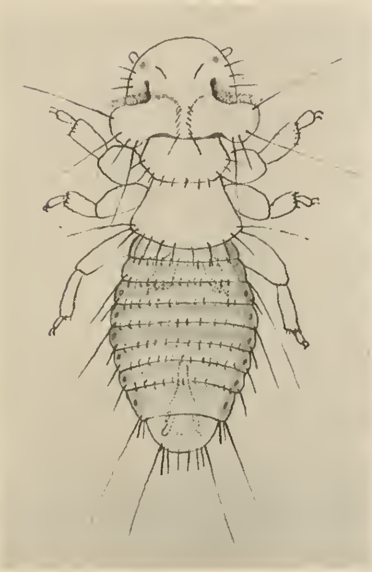


PLATE XIII.



SOME RARE INDIANA BIRDS.

AMOS W. BUTLER, Indianapolis, Indiana.

The birds of Indiana are not the same they were when we were young. They are continually changing. Of course there are certain species that remain somewhat stationary, but for the most part there are changes.

1. Those that are decreasing in numbers (water-fowl) or have entirely disappeared (Parakeet, Pigeon, Raven, Turkey).
2. Those that are increasing in numbers (Most meadow forms, sparrows, etc.).
3. Those that are extending their range (Bobolink, Bachman's Sparrow, Bewick's Wren, Mockingbird).
4. Those of (a) accidental, (b) rare, or (c) unusual occurrence:
   - (a) Brunnich's Guillemot, Man-O-War Bird, Brown Pelican.
   - (b) Snowy Owl.
   - (c) Bohemian Waxwing, Evening Grosbeak.

Added to these transpiring changes is the ever recurring one of inspiring interest, which we call migration. So to the student of birds there are countless changes and numberless surprises in his observations from year to year.

A few observations of special interest are noted here in order that they may be known and preserved.

The least known part of Indiana is that neighboring Lake Michigan. Only in recent years have experienced observers been giving attention to that area and from them we are receiving some of our most valuable records of bird distribution and behavior. With the changes that are occurring in that region many favorite bird sites are disappearing and with them are going the birds.

The proposed Dune Park, if realized, will be a factor in preserving for future generations many species of birds as well as other animals and also plants.

I am indebted to Mr. H. L. Stoddard for many interesting notes from the Dune region of Indiana. Of the Lake Michigan neighborhood in Lake and Porter counties, unless otherwise noted, the following records are from him:

HORNED GREBE. Colymbus auritus Linn. Fairly common November 2, 1919, between Millers and Dune Park, Indiana. November 9, 1919, literally hundreds of Horned (and other) Grebes fishing off shore with Loons (very numerous) between Mineral Springs and Dune Park, Indiana.

RING-BILLED GULL. Larus delawarensis Ord. Fairly common between Millers and Dune Park, Indiana, August 24, 1919. Very numerous at Dune Park, Indiana, August 31, 1919.

BONAPARTE'S GULL. Larus philadelphia (Ord). Seen by the hundred on the lake (Michigan) between Millers and Dune Park, Indiana, October 26, 1919. Noted also from same territory November 2, 1919. On November 9, 1919, between Mineral Springs and Dune Park, Indiana. More numerous than I ever saw them before. They sat on the lake in white windrows, hundreds to a row. Other hundreds fluttering over the water and still others circling high in the air like hawks.

CASPIAN TERN. Sterna caspia Pallas. One fine adult seen here this fall. Between Gary and Mineral Springs, Indiana, September 17, 1919.

FORSTER'S TERN. Sterna forsteri Nutt. A few seen at Millers, Indiana, August 16, 1919. Fairly common between Millers and Dune Park, Indiana, August 24, 1919. Between Gary and Mineral Springs, Indiana, September 10, 1919. Abundant for the season when all terns have been present in smaller numbers than usual.

DOUBLE-CRESTED CORMORANT. Phalacrocorax auritus auritus (Sw.) Dune Park, Indiana. Five seen May 6, 1919. Three seen in Lake Michigan between Mineral Springs and Dune Park, Indiana, September 24, 1919.

BAIRD'S SANDPIPER. Pisobia bairdi (Coues). One seen Dune Park, Indiana, August 31, 1919. Two, male and female, taken between Gary and Mineral Springs, Indiana, September 10, 1919.

RED-BACKED SANDPIPER. Pelidna alpina sakhalina (Vieill.). Dune Park, Indiana. May 6, 1919. One taken.

SANDERLING. Calidris leucophaea (Pall.). Millers, Lake County, Indiana. About a dozen recorded August 16, 1919. Two taken. Proved to be adult males—all adults in summer plumage. August 24, 1919, twenty-five or thirty, all adults but one, were seen along the same beach. August 28, 1919, they were common between Gary and Dune Park, Indiana. About half observed were adults changing to winter plumage and half young of the year. Over 100 seen between Gary and Mineral Springs, Indiana, September 10, 1919. On same beach only a few in immature and winter plumage were seen September 17, 1919. On September 24, 1919, at the same place larger numbers than I have ever seen here before. At least 200 on two miles of beach.

BLACK-BELLIED PLOVER. Squatarola squatarola (Linn.). One adult in summer plumage, between Millers and Dune Park, Indiana, August 24, 1919. One female plumage half changed between Gary and Dune Park, August 28, 1919. Between Gary and Mineral Springs, Indiana, on September 10, 1919, seven were seen and two collected. All adults in changing plumage. Adults precede the young of the year two or three weeks. On same beach two immature specimens were collected September 17, 1919.

TURNSTONE. Arenaria interpres interpres (Linn.). Four seen. One female taken. One adult. Three juveniles. Between Gary and Dune Park, Indiana, August 28, 1919.

PIPING PLOVER. Ægialitis meloda (Ord). Dune Park, Porter County, Indiana. Nest and two eggs found, May 6, 1919. Another nest and four eggs found in same locality May 12, 1919. These little Plover still nest in one or two places along the Indiana shore—as many as six pair being seen in one locality. The shore is being frequented more and more and the Plover will soon be gone, I am afraid. A few seen August 16, 1919, at Millers, Indiana.

ARCTIC THREE-TOED WOODPECKER. Picoides arcticus (Swains). An adult male was taken about one mile east of Dune Park, Porter County, Indiana, October 24, 1920, by H. L. Stoddard.

"This specimen did not act a bit like the other two (which were very tame) but flew nervously from tree to tree in a small scrub pine grove, uttering its loud, and to me, startling call note, a rather rapidly repeated teck, teck, teck. Finding the exact location of the note proved confusing to me. I thought there were two of the birds calling till the specimen was shot which stopped the noise. This is the third specimen from that vicinity."

The first one was taken March 11, 1917.

The second specimen was a male taken at Dune Park, Porter County, October 3, 1920. It acted much like the one taken March 11, 1917. It was found feeding on a dead scrub pine just back from the lake (Michigan) shore. It was very tame and paid no attention to me. The "tapping" is louder than that of the Sapsucker and slower than that of the Hairy or Downey and unlike the others seems to work in one tree until the food supply is exhausted. The bird had nearly completed its moult and appeared in fine fresh plumage.

November 21, 1920, the fourth specimen, a male, was taken at Mineral Springs, Porter County, Indiana, by Mr. Stoddard and sent to me, with the accompanying note: "I have heard of two others being seen four miles east of Mineral Springs and have noticed a number of well stripped trees. Removing most of the bark from one tree before going out of a neighborhood seems to be characteristic of this species. I believe there is a great flight of these woodpeckers this year."

December 8, 1920. Reports two specimens being seen and one taken in northern Illinois, and adds, "Further strengthening my statement of a big flight."

OLIVE-SIDED FLYCATCHER. Nuttalornis borealis (Swains.). Three identified at Millers, Indiana, August 16, 1919.

YELLOW-HEADED BLACKBIRD. Xanthocephalus xanthocephalus (Bonap.). Near Crawfordsville, Indiana, April 28, 1919, Mr. Frank C. Evans, Secretary Indiana Audubon Society, observed a single bird of this species. He was enabled to observe it for some time at close range and is certain of its identification. Colonies are still found breeding in lessening numbers in the swamp and lake region on both sides of the Illinois-Indiana line in Lake and the adjoining county.

EVENING GROSBEAK. Hesperiphona vespertina verpertina (W. Coop.). Dune Park, Indiana, March 30, 1919. About 50 seen. April 27, 1919, seventeen seen at same station. Last of season.

AMERICAN CROSSBILL. Loxia curvirostra minor. One, a male, seen October 28, 1919, at Upland, Grant County, Indiana, feeding upon sunflower seeds. It was very tame and permitted close approach and afforded definite identification.—Mrs. Gertrude Q. Campbell. November 1, 1919, a small flock was seen among some spruce trees near Helmsburg, Brown County, Indiana, by Philip Baker. November 20th, the same observer saw eight of these birds in the same spruces. Each time a single bird of the next species was observed. One of the last was taken and preserved for verification. Flock reported during latter part of winter and spring of 1920 by Frank Hasselman at State Game Experiment Station at Deere's Mills, in southwestern part of Montgomery County. Reported also by Joel Hadley of Indianapolis in same place as late as May 8, 1920.

WHITE-WINGED CROSSBILL. Loxia leucaptera. November 1, 1919, a single bird taken near Helmsburg, Brown County, Indiana, by Philip Baker, and sent to me for identification. It, with a small flock of American Crossbills, was feeding in a group of spruce trees. All except one flew away when the observer approached. That was the specimen of this species which I have. November 20, 1920, Mr. Baker saw a single white-winged Crossbill with eight American Crossbills in the same spruce trees. They were eating spruce seeds and were very tame. These may have been the same birds seen November 1, which remained in the neighborhood. Fall records of this species are very scarce. Two White-Winged Crossbills collected by L. L. Walters, November 9, 1919, between Mineral Springs and Dune Park, Indiana.

REDPOLL. Acanthis linaria linaria. Thirty to forty observed between Mineral Springs and Dune Park, Indiana, December 7, 1919. Ten to twenty seen between Gary and Dune Park, Indiana, December 21, 1919.

PINE SISKIN. Spinus pinus pinus (Wils.). Mineral Springs, Indiana, October 9, 1919. Many thousand Pine Siskins feeding on the weed patches near the swamp and resting on the tamaracks in the sun, out of the wind. A few goldfinches among them. By far the greatest number of Siskins I ever saw in the Dunes. October 6, 1919, still present by hundreds though not nearly so abundant as October 9. October 26, 1919, Pine Siskins still present. November 2, 1919, a few. December 7, 1919, a few.

SNOW BUNTING. Plectrophanes nivalis nivalis (Linn.). Dune Park, Porter County, Indiana, March 2, 1919. About 50. Three flocks of 40 to 50 each, between Millers and Dune Park, Indiana, November 2, 1919. About 40 seen between Mineral Springs and Dune Park, Indiana, November 9, 1919.

HARRIS SPARROW. Zonotrichia querula (Nutt.). An immature male was taken at Millers, Lake County, Indiana, October 3, 1920, by H. L. Stoddard. One was seen April 24, 1920, near Fort Wayne, Indiana, by H. C. Miller. This bird was carefully studied and the observers are confident of its identification. Miss Margaret Hanna and Mr. Sihler also observed a bird of this species, possibly the same one, a few days later.

BOHEMIAN WAXWING. Bombycilla garrula (Linn.). Over a hundred observed between Gary and Dune Park, Indiana, December 21, 1919. About forty were seen and six collected April 15, 1920, between Dune Park and Millers, Indiana.

PROTHONOTARY WARBLER. Protonotaria citrea (Bodd.). Millers, Lake County, Indiana. Fairly common along the Calumet River, August 16, 1919. H. C. Miller reports seeing one near Fort Wayne, Indiana, May 1, 1920, and another May 9, 1920. Mrs. Donaldson Bodine reports seeing four on May 7, 1920, at Crawfordsville. Rare.

PRAIRIE WARBLER. Dendroica discolor (Vieill.). Philip Baker in the spring of 1920 found four nests with eggs of the Prairie Warbler, in his orchard near Helmsburg, Indiana.

1. Found May 15, 1920. May 20th it contained four eggs. It was built ten feet up in an apple tree.
2. Found May 21st about 100 yards from No. 1. May 26th it contained four eggs. It was 8 feet from the ground.
3. June 9, 1920, located midway between Nos. 1 and 2, eleven feet from the ground. Contained four eggs.
4. July 11, 1920, 6 feet up in a Yellow Transparent Apple Tree. Contained 4 eggs.

   The first three nests were in Grimes Golden Apple trees. Both these varieties of apples are upright growers, providing good crotches, well screened with foliage.

   These four nests were found within a distance of 200 yards.

Additional interesting notes on birds of northwestern Indiana are to be found in the paper, "Notes on Birds of the Chicago Area and its immediate vicinity" by C. W. G. Eifrig, in The Auk, Volume XXXVI, 1919, pp. 513-524.

THE EFFECT OF ADRENIN ON THE PIGMENT MIGRATION IN THE MELANOPHORES OF THE SKIN AND IN THE PIGMENT CELLS OF THE RETINA OF THE FROG.

Andrew J. Bigney, Evansville College.

(Author's Abstract)

(The original printed in "The Journal of Experimental Zoology" Vol. 27, No. 3, January, 1919.)

The frogs used were mostly Rana pipiens Schreber. The adrenin employed was that prepared by Parke, Davis & Co., and sold under the name of Adrenalin Chloride, in strength 1 to 1,000.

In the melanophores of the skin, the pigment in the light expands, while in the dark it contracts. On injecting adrenin in frogs which had been in the light for six hours, it was found that the melanophores were strongly contracted. The effect being opposite to that of light. The adrenin 1:1000 and 1:10000 strength gave the best results.

The migration of the retinal pigment is outward in the light and into the cell in the dark. On injecting .06 cc of adrenin, 1:1000 into frogs kept six hours in the light, the pigment was found to be fully expanded after 7-15 minutes exposure. Then other frogs were kept in the dark six hours and injected with same amount of adrenin and the pigment was also expanded. Control frogs in the dark showed the pigment contracted. So the conclusion was reached that the adrenin has the same effect as light. The retinal pigment was sensitive in solutions from 1:1000 to 1:1000000 and remained for three to four hours.

The effect on the dermal melanophores is just the opposite to that on the retinal pigment. This is new to science.

In the above experiments, the frogs were decapitated, eyes removed, hardened in Perenye's fluid, imbedded, sectioned, and mounted unstained.

THE EFFECT OF CENTRIFUGAL FORCE ON PLANTS.

F. M. ANDREWS, Indiana University.

The first experiments made on plants with centrifugal force were performed by Knight[1] in the year 1806. His apparatus was simply arranged, was run by water power and the amount of centrifugal force that his machine produced was very small. His object was to observe the behavior of seedlings under a somewhat intensified gravitational force. Since the time of Knight some other investigators have investigated the action of centrifugal force on various plants and especially some of the studies have been made on seedlings. These are generally of such size or can be so selected, as to lend themselves advantageously to experimentation of this sort. Among the investigators who followed Knight in this field of study may be mentioned Müller[2] who made a study of the growth processes of roots when acted on by centrifugal force. As in the case of Knight the amount of centrifugal force which Müller employed in his experiments also was small. Ten years later the subject was again prominently investigated in a similar way by Elfing[3] who also used only a small amount of centrifugal force. The amount of such force which Elfing used varied from 29-50g, which was slightly greater, however, than that employed by the above mentioned investigators. The original paper of Elfing I have not seen. An extract of its contents has been given by F. Schwartz in the Botanische Zeitung Bd. 39, 1881, P. 176 above referred to. At the same time that the paper of Elfing appeared a similar piece of investigation had been completed independently by F. Schwartz.[4] This paper by Schwartz also appeared in 1881 from Pfeffer's laboratory in Tübingen. Schwartz worked with a specially constructed form of centrifugal machine which, however, did not use the ordinary form of revolving drum. Instead it was so constructed that it carried at right angles to the revolving main shaft, a second shaft that carried a number of boxes which contained the specimens to be investigated. These seedlings were grown in sawdust which, however, is objectionable in some respects to use in a machine of this type during experimentation. The boxes just referred to were so placed on the second shaft as to balance one another during centrifuging. Various other contrivances in connection with this machine were used and which I can not discuss here but will refer to them at a later period. Schwartz used control plants and the number of gravities employed by him was also small and did not exceed 30 gravities in any of his experiments. He as well as the other investigators did not observe a retardation of the growth of the seedlings used in their experiments. The use of the klinostat as used by Sachs or as originally constructed and used by Hunter and others in experiments performed by them does not apply in the preceding statements since

[1]Knight, T. A. Horticultural Papers P. 124.
[2]Müller, N. J. C. Die Wachsthumerscheinungen des Wurzel. Botanische Zeitung, Bd. 29, 1881, P. 716.
[3]Elfing, Fred., Beiträge zur Kenntniss des Physiologischen Einwerkung der Schwerkraft auf die Pflanzen, Botanische Zeitung, Bd. 39, 1881, P. 176.
[4]Schwartz, F., Untersuchungen aus dem Botanischen Institut zu Tübingen Bd. 1, 1881-1825

the klinostat was used to annul or make omnilateral the force of gravity on growing stems and roots.

The effect of very high centrifugal force on plants has been investigated by only a few persons and with them the length of time the experiments were carried on was very short. I first began the study of the effect of very high centrifugal force on the growth of plants in Pfeffer's[1] laboratory in Leipzig and since then have concerned myself with the subject in general. It might be supposed that very high centrifugal force varying from 3,000 to 5,000 gravities would bring about a cessation of the growth of plants and probably kill the specimens. A careful study of this subject, however. has shown that this is not the case. The following remarks will give some data to show that the plant activities of the kind mentioned did not stop but actually continued although less actively. This was shown in the following way: Seedlings of Cucurbita pepo were grown until their roots were 3 cm. long. Four of these seedlings were then placed through a strong cork so that their roots projected into a strong glass cylinder which was 5 cm. long and 28 mm. in internal diameter. The cork rested on the open end of the cylinder by a shoulder-like projection and four places in this cork were hollowed out to receive the seeds. A small quantity of water was put in the bottom of the glass cylinders to retain the moisture necessary. Gypsum was poured over the part of the seed that projected from the cork and also around the seeds to hold them in place. In all these experiments when necessary gypsum was used to hold the specimens firmly in place. This method of using gypsum in plant experimentation was first used by Pfeffer and in the year 1892. I centrifugated the above mentioned specimens two hours using 4400 g. The plants were not killed, as stated, by this severe treatment but the growth was retarded. In those experiments where 4400 g. was used and centrifuging took place in air the amount of growth was decreased from 3.5 mn under normal conditions to 2.5 mn. When so centrifuged in water the roots grew on the average 2.1 mn. In the same way decreases in the rate of growth were observed in Pisum and Helianthus when a force of 4400 g. were used. In the same way I carried out experiments on other seedlings but sometimes using less force, as low as 2000 g. for periods first of two hours and then one, two, and in many cases as long a period of time as five days. In these experiments longer glass cylinders were used than in the first case. For example Zea mays grew on the average of sixteen plants with roots ten mm. long to begin with in two hours 3.3 mn in air when so centrifuged. In water they grew 2.65 mm. in two hours while the controls in sawdust grew 3.8 mn in the same time. With a higher centrifugal force of 5000 g. they grew about one-third less in the same time. For longer periods of centrifuging of one, two and up to five days the same effect was seen. The specimen centrifuged in water was killed by the water pressure at the end of the second day in this experiment. In some other experiments of this kind this did not occur. At the end of five days of centrifuging with 2000 g the sixteen plants averaged 77.2 mm in length while the control plants averaged 103.7 mn. Arrangements for changing the moisture and air in the cylinders was provided. These experiments might be carried on for a much greater length of time if properly arranged. This is sufficient to show, however, the severe tests which

[1]Pfeffer, W, Pflanzenphysiologie, Zweite Auflage, Bd. 2, P. 567.

rather delicate plants of this kind can stand and finally recover. This they did, when planted, in about two weeks so that at the expiration of that time no difference was visible between the experimental and the control plants as seen above ground in the growth of the stem. In many cases the growth of lateral roots makes a very prolonged experiment impracticable. In each case when the roots were marked off in the usual way to show the growing region whose growth was lessened as shown by comparison the growth was not completely stopped in any zone. Other than that the growth was decreased in the growing zones the regions and relation of growth to the controls remained the same. Many more experiments have been made on other plants which confirm these points. The centrifugal force therefore used by Schwartz and Elfing and others did not cause a noticeable difference simply because it was not of sufficient intensity. In all the experiments which I performed the contents of all the cells was thrown to the centrifugal end of the cell. It returned to its normal postion in the various cells whether they were large or small after two to three days. Even after the contents had returned to its normal position, as indicated above, a much longer time was still necessary to allow the complete shock of the centrifugal force to disappear. This varied according to the plant and the intensity of the centrifugal force.

THE EFFECT OF AERATION ON PLANTS.

F. M. ANDREWS, Indiana University.

A series of experiments on aeration, of which the ones here mentioned are a beginning, are being carried out to show what effect will be produced on a considerable number of plants of different families and species and under different conditions. Some of these have shown, as would be expected, a considerable difference as regards their response when placed under these conditions. It goes without saying that carefully grown and equally vigorous and large controls to begin with should always be used and kept under precisely the same conditions except that they are not aerated.

In 1917 Beals[1] carried out under my direction some experiments on the aeration of Zea Mays. In this paper marked differences were shown between the aerated and the non-aerated specimens as is well shown by reference to his figures. In 1919 a second paper by Andrews and Beals[2] gave the results of further research on this subject. It became necessary in this paper first to ascertain the requisite amount of time for soaking the material at hand previous to its germination. The second part of the paper deals with the effect of aeration. The experiments on aeration were carried out on a more extensive scale than had been done in the above mentioned paper by Beals.[3] This paper not only substantiated the work of Beals but extended it in various ways especially as to the different quentities of air used and temperature. The photographs show the acceleration produced by aeration which was marked in every case. The literature on the subject of Aeration of plants is referred to in the paper of Andrews and Beals and further reference to it will not be made in these experiments.

The first plants used in this series of experiments were those of Avena sativa. Seedlings of equal size were fastened in the usual way in paraffined wooden lids on 1500 cc jars which contained Sachs nutrient solution. From the first the aired specimens grew fastest and more nearly normal in every respect. Both specimens, however, soon required supports since after attaining some height they were unable to stand upright. To effect this ring stands supplied with large rings were used and the upper portions of the growing plants were then passed through the rings. In the control plant only two supporting rings were needed but the specimen that had been aired had grown to such an extent that three rings, widely separated on the ring stand, were required. At the expiration of the experiment the aired specimen of Avena sativa was 70 cm. high while the unaired plant was 40 cm high. Both plants were then dried and weighed. The dry weight of the aired specimen was 3.5 grs. while the dry weight of the unaired plant was 1 gr. The transpiratory activity of the aired specimen was also much greater as would be expected than the aired plant. The root system of the aired plant was much greater and more extensive in every respect than that

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[1]Beals, Colonzo C. The effect of Aeration on the Roots of Zea Mays. Proc. Indiana Acad. Sci. 1917, PP. 177-180.

[2]Andrews, F. M. and Beals, Colonze C. The effect of Soaking in water and of aeration on the Growth of Zea Mays. Bulletin of the Torrey Bot. Club. 1919. Vol. 46, PP. 91-100.

[3]Beals, Colonzo C., l. c.

of the unaired plant. This was made necessary by the greater transpiration and growth activities of the plant which was aired in the way mentioned. The air used to aerate the specimen of Avena sativa as well as the others mentioned in this paper was propelled by the Kekulé apparatus.

In like manner air was passed through a Sachs culture solution in which were growing seedlings of Brassica alba. Here again the aired specimen showed a great advance over the unaired plant. When the plants were two weeks old the aired specimen was 12 cm. high, while the unaired specimen was 5 cm.. high. The roots of the unaired specimen were rather few and long, while those of the aired specimen were aggregated more into a mass of considerable size, were much denser and more numerous and the total length many times greater. The aerial portion of the aired plant was not only taller but more than twice as broad. The leaves of the aired plant were much larger and broader and more numerous and the transpiratory activity as in Avena sativa was much increased. The comparative difference in size of the aired and unaired specimens of Brassica alba was a little greater as the measurements will show, than the difference in size of the Avena sativa plants. The dried weight of the aired specimen of Brassica alba was 110 mg. while that of the unaired specimen was 25 mg.

Seedlings of Pisum sativum were grown in a Sachs nutrient solution as the above mentioned specimens some of which were aired and some not aired. Here again the aired specimen grew fastest and best. When twenty days old the aired seedlings were 85 cm. high and the non-aired 41 cm. high. The dry weight of the aired plant was 2.5 grs. while that of the unaired plant was 0.5 gr. In this experiment the aired specimen was nearly twice the height of the unaired plant while the dry weight exceeded that of the unaired five times.

Other experiments on Fagopyrum esculentum and on Helianthus annuus gave similar differences. The plants of Fagopyrum esculentum especially showed decided differences. Those specimens that were aired formed flowers profusely two weeks sooner than the specimens which had not been aired.

In addition to the above experiments which is only an outline of part of the work done. Miss E. G. James is at present working on an extended series of experiments on aeration of plants under my direction. She has invented several new and necessary pieces of apparatus for carrying out the work under different conditions. Experiments performed by her on Lactuca sativa confirm my experiments and also extend them in various ways.

PHYLLOTAXIS OF SPECULARIA PERFOLIATA.

F. M. Adrews, Indiana University.

Leaf arrangement in plants has always been a point of interest and has been the subject of much study. Some plants have a very open or loose arrangement of their leaves as when they are separated by considerable distances on the stem as in some alternate or opposite leaves. The number or arrangement becomes greater and denser in other plants until their leaves form rosettes or culsters as in the common Houseleek. Or again as in the cones of the genus Pinus whose scale-like leaves often form conical-like cylinders of closely set divisions. Various theories were long ago advanced to explain the arrangement of leaces on the stem and especially by Cesalpino and Bonnet that the arrangement on the stem is in keeping with definite "geometrical rules". Also many others among them A. F. Schimper had formulated a theory on the subject. An excellent summary of many of the facts on this subject has been collected by Sachs. But the effort of the plant is to arrange the leaves on its stem in such a manner that they will have the best exposure to the light. Also the question of structural physical factors in the plant itself enter into the placing of leaves on the stem. The arrangement which a given species shows is followed by all individuals of that species although, as will be seen later, this may be departed from to a certain extent. This difference I found rather markedly shown in the spiral arrangement of the leaves of Specularia perfoliata. Gray[4] describes Specularia perfoliata as follows: "Somewhat hairy, 1-9, dm, high, leaves roundish or ovate, clasping by the heart-shaped base, toothed, flowers sessile, solitary or 2-3 together in the axils, only the upper or later ones having a conspicuous and expanding corolla, capsule ellipsoid, short, straight, opening rather below the middle; seeds lenticular".

Nothing is said by Gray, Britton, or Wood about the rather marked and regular arrangement of the leaves on the stem of this plant in spirals. This arrangement together with the form of the leaves is a striking characteristic of Specularia perfoliata, and reminds one but to a much less degree of the unusually "spirally twisted raceme" of flowers of Spiranthes gracilis.

When making a trip into Brown County, Indiana, during the summer of 1920, I noticed by the roadside about one mile from Belmont, near the studio of the artist, Dr. T. C. Steele, a large number of specimens of Specularia perfoliata. Most of these plants were of normal size and appearance. Their leaves were arranged on the stem in the usual way and as to number showed four to a single turn of the stalk which is the ordinary number. Also ordinarily three circuits of the stem must be made before a leaf will be found that will stand on the stem directly above the first leaf with which the count was begun. In other words the twelfth leaf, counting the one at the starting point, will stand directly over this first one where the spiral was originally started toward the base of the stem. In this arrange-

[1]Sachs, J. History of Botany 1875 P. 163.
[2]Sacks J., History of Botany 1875 P. 162.
[3]Sachs, J. History of oBtany 1875, Chapter 4, PP. 155-181.
[4]Gray, A. New Manual of Botany, 7th edition.

ment of leaves of Specularia perfoliata the circumference of the stem was divided up equally for the leaf insertion.

Among the large number of the plants above mentioned, however, I saw five other specimens of Specularia perfoliata which looked somewhat different from the others. On examining these more closely I found them to have more leafy stems and by counting the leaves in a spiral as I did with the others I found that there were five leaves to a spiral counting the first one instead of the usual four of the other plants. Also I saw in these specimens, that it was necessary to make four circuits of the stem, instead of three as in the other plants before I found a leaf which stood directly over the first leaf with which the count was begun. The five specimens, just mentioned, of Specularia perfoliata grew about the center of a considerable number of other specimens of the same species as well as other plants. They were some larger than other specimens of the same species, but attracted my attention at close range first on account of the fact that they were some taller than the others and then on account of their denser foliage. The leaves of these specimens also divided the circumference of the stem equally as regards the insertion of the leaves. Those five plants having the greater number of leaves showed therefore a very delicate balance and arrangement with reference to the light which is extremely important for leaves of autotrophic plants.

AN IMPROVED METHOD FOR REGULATING THE THICKNESS OF MICROTOME SECTIONS.

F. M. Andrews, Indiana University.

In some of the Minot forms of microtomes several springs and other parts are arranged in such a manner as to cause the specimen in the machine to be set out the desired distance for sectioning. The above mentioned arrangement is usually very complicated, and apparently unnecessarily so, in many machines of this type. This adds greatly to the expense, liability to get out of order, and makes the apparatus unduly large and heavy. A microtome, as most other types of machines, should not be made heavy simply to remain in one position, but should only be heavy or substantial enough to prevent springing or getting out of allignment when in use. Of course this is a point that merits due consideration in a microtome when such very thin sections are to be cut, but still the present weight of most such machines of the microtome type can be greatly reduced without detriment. A simple table clamp is all that is necessary to obviate most of the difficulty of shifting of the position of the machine. The chief weight is, of course, in the framework of the machine especially in the wheel base, slide pillar and uprights of the microtome I used. This is true of most machines of this type. The weight of these parts could be reduced to one-third or even one-half of what it is without sacrificing any necessary rigidity. The weight of the wheel and frame running on the slide pillar could be much reduced especially by the proper adjustment of the balancing of the weight of the two since they are connected to the same shaft. This same balancing of weight is seen in the adjustment of the pitman rod on the crank of engines and other much more delicate machinery. The difference in weights and balancing here referred to in the case of microtomes is so considerable as often to cause considerable inconvenience and unsteadiness in operating the machine. Part of this adjustment, as the machine I used as now arranged, could be partly arranged for by a different length in the threading of the main shaft so as to throw the heavy parts of the machine, concerned in the motion, more nearly in balance when the microtome is in operation. A machine which is arranged for cutting sections in the ways here described, should be so arranged and adjusted as to turn or start with equal ease in any position. Its construction should also be such that it could be stopped instantly and at any point without having to turn a special device at the top of the slide pillar. That a microtome is not a machine that is expected to be moved about much, has no bearing on the question for whether it is moved much or little an unnecessary amount of material and weight is often present in many of its parts which could from the standpoint of cost and convenience often be eliminated. The question of setting the block for cutting thin sections is arranged in a very accurate and better way on the Jung Sliding Microtome by means of an incline plane and a spiral thread of definite value for each adjustment. Even in this machine the weight far exceeds what is necessary. The arrangements of springs on the microtome used by me were, as is generally the case sooner or later, a source of annoyance and often

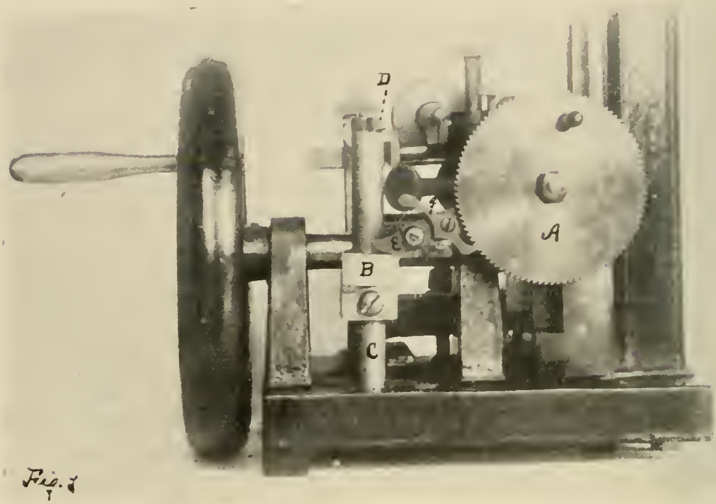

Fig. 1.

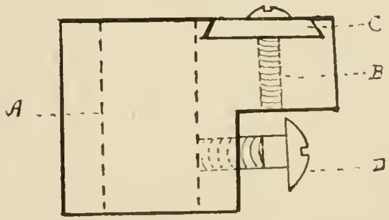

Fig. 2. Median longitudinal sectional view of the brass block. Natural size.

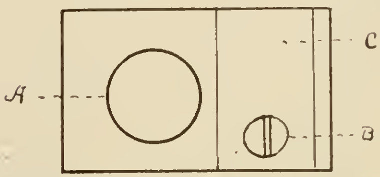

Fig. 3. Top view of brass block, natural size.

caused inaccuracies in the thickness of the sections that were cut. This latter was caused by weakness in the springs, one of which controlled the ratchet of the cogwheel, and frequently on account of this the cogwheel was not turned the specified distance. Sometimes the sections were cut too thin or the block was not set out for cutting at all. At other times a notch in the cogwheel was skipped causing the section to be cut too thick.

The above mentioned imperfections of the system of springs for adjusting the thickness of the sections was overcome by the use of a simple contrivance which at the same time insured accuracy and uniformity. The microtome I used is provided with a brass cogwheel 7.5 cm. in diameter, a circumference of 235.6200 mm. and having on its periphery 100 cogs (A Fig. 1). This cogwheel is attached to a threaded shaft which moves the paraffin block out carrying the specimen to the sectioning knife. The threaded shaft's diameter is 5 mm. and its circumference 15.7080 mm. The circumference of the wheel is therefore 15 times that of the shaft. Since there are 100 notches in the circumference of the wheel the shaft turns .15 mm. per notch or 150 u. The shaft is threaded with 20 threads to 1 cm. and therefore one thread or revolution or the 100 notches equals .5 mm. or 500 u that the section is moved out. Therefore when the large cogwheel is turned one notch the paraffin block carrying the specimen is moved out so that a section 5 u. thick will be cut. The above mentioned points make it clear that a faulty spring system for a machine cutting such thin sections would be serious for even rather thick sections and especially so for very thin ones.

My improvement is the use of a brass block (B Fig. 1) attached to post C. This post was originally in the machine and carries at the top a metal arm D so arranged as to arrest the movement upward of a lever E attached to the brass cogwheel A above referred to. The metal arm E projects 3.5 cm. beyond the circumference of the brass cogwheel A and carries a ratchet G. which turns A as the specimen is raised above the sectioning knife. The brass block B attached to C, for regulating the thickness of the microtome sections, is made of solid brass. It is 35 mm. long and 21 mm. wide on the upper side, Fig. 2. In Fig. 2 A is the path of the post C through B; B is the insert plate, B the set screw and D the set screw for the brass block B. The block B is 25 mm. high, 23 mm. long and 21 mm. wide at the shoulder where the set screw D. is placed Fig. 2. The part projecting above the set screw D which tightens the block B on the post C is 11 mm. thick, Fig. 2. This part which is just above the set screw I have cut out so as to allow an insert plate C. Figs. 2 & 3, to be used. This I made from a steel plate which covers the bobbins of a sewing machine and cut the brass block as illustrated so that its sides had the same angles as the steel plate and allowed the latter to slide true in the channel cut Fig. 2 c. This steel insert plate is in cross section 14.5 mm. at the base, 13 mm. at the top and 21 mm. long, C. Fig. 2 & 3. The illustrations C Fig. 2 & 3 represent the exact size. The block has a hole 12.5 mm. in diameter bored vertically through it at one end of the insert plate, A, Fig. 2 & 3. so that the post C, Fig. 1, can be passed through it and on which it can be moved up or down to the desired position. In case of wear on the brass lever E a new brass tip can be used. In fact it can be grooved and short new insert plates used there as at C. Fig. 2 & 3 on the lower side of E at the striking point. I made use here of the principle that hard and soft metal surfaces where wear is present should be brought together so that any wear will take place on the soft metal which can be replaced. This principle is used generally in machinery. Since the metal arm E strikes the insert plate with a sort of shearing stroke in descending it has a tendency to push the insert out of place. This I have remedied by putting a set screw B, Figs. 2 & 3, through the insert plate C and into the brass block B, Fig. 2. This is not shown in the photograph but is shown in the drawings of the brass block, Fig. 2. Figure 2 is a drawing of the brass block above mentioned which I constructed for this purpose. It carries on its upper side, where the lever strikes, the insert plate above described. Many of the later types of microtomes of the kind here illustrated are even much more complicated. In addition to a complicated and cumbersome system of expensive adjustments these parts are often housed in by a metal enclosure. All this adds, as above stated, unnecessarily to the weight and size of the machine and especially to the cost. The metal housing, just referred to, only partly protects the mechanism from dust or other injury. This would be as well or better affected by a cardboard cylinder or even by a properly made cloth hood such as is used to cover microscopes when not in use and which are left temporarily on a table in the laboratory. A light glass box can easily be made of plates of single strength glass held together at the angles and corners by strong adhesive tape. One of these I have made and used for years with entire satisfaction and whose cost of making was trivial.

I marked a graduated scale on the post C to control the number of notches on the wheel A and consequently the arc through which it would be turned and therefore the thickness of the sections that would be cut. For example when the top of the brass block B was placed 52 mm. from the base of the post C the wheel A was turned one notch and a section 5 u was cut. Raising the block B 3.5 mm. more allows a section 2 notches or 10 u thick to be cut. When the block B is raised 4.5 mm. above the second mark on C, just mentioned, a section 3 notches or 15 u is cut. Raising the block B 3 mm. above the third mark just mentioned a section 4 notches or 20 u is cut and so on. As the lever E goes up and down it moves not in a small curve, as might be expected, but in a straight line. When, however, the lever E strikes the arm D on the brass block B, Fig. 1 the lever E is turned the amount desired. This really is equivalent, in principle, to a small arc being formed when the cogwheel O is turned as a result of the small divisions for adjustment on the post C. Each one of the small arcs is very small at the periphery of the cogwheel A, especially when the brass block B is placed 52 mm. from the base of the post C which allows, as stated, a section only 5 u thick to be cut. Due to wear and especially to lost motion, the calculated positions and distances from each other that the adjustment marks on the post C should be placed for cutting the sections of different thicknesses did not quite correspond with those positions found by experiment. The variation, however, was not great and if all lost motion could be eliminated the calculated and experimental data would of course exactly coincide. The marks and figures on the post C are conveniently made with an etching tool or by covering the surface of the post C, with paraffin or better with beeswax and then applying concentrated HNO_3.

Back of the cogwheel A, Fig. 1, were originally placed two lugs or projections cast in or built in with other parts of the microtome here shown, Fig. 1. These are so placed as to limit the sections, as they could originally be cut, to a total thickness of 50 u. This is a much greater thickness than the majority of microtome sections are ordinarily cut. Occasionally, however, it is desired to cut sections thicker than this and the arrangement just referred to above of thickness limitation of the sections is a decided inconvenience. This difficulty may be solved by removing the lugs or projections above mentioned. This would then allow a sweep of the arm E through a much greater arc and would allow sections of very much greater thickness to be cut. A corresponding long graduated arc can then be attached by a shouldered center to the post C which would control by means of a movable arm the movements of the metal arm E to any desired degree or extent and therefore still cut very thin or very thick sections.

STUDIES ON POLLEN, III.

F. M. ANDREWS, Indiana University.

Since the appearance of my second contribution on the study of pollen I have continued my investigation on this subject and have added a considerable number of plants to those already studied in ways mentioned in my previous papers. As the work has progressed certain new methods have suggested themselves as expedient or in many cases as necessary for the proper advance of the work. One former method of allowing pollen to be placed for germination in the desired solution between a slide and cover-glass is, while often giving results, unfair since certain life processes can not normally be carried out under these conditions. The use of an ordinary glass ring cell cemented to a slide and having the pollen for investigation in a hanging drop also served in many cases but allowed of no regulation of temperature by an exchange of air in the ways desired. A common gas chamber served the purpose better and obviated the difficulty just mentioned and also allowed of certain other forms of experimentation, not possible with the glass ring cell, that I hope to investigate later on. In this last type of culture cell, as here used, it was necessary to use wet filter paper in the cell or a small quantity of water to prevent the specimen from drying up. All the culture cells mentioned thus far had the disadvantage of allowing only one experiment or culture to be so arranged at one time. To offset this the glass ring sell was used in large numbers but individual cultures made in this fashion require a great deal of extra work and are not conducive either to convenience or accuracy. In some cases at first when an extra large number of cultures were to be made I supplimented the glass culture ring apparatus by cells made of filter paper and kept moist in damp air under a bell jar. These latter, however, were much less satisfactory for various evident reasons.

Since my second contribution on this subject I have increased the number of plants whose pollen I have studied from 435 to 540. In the case of all of these 540 plants I have tried to grow the pollen in the following solutions: distilled water and cane sugar of 1%, 5%, 10%, 15%, 20%, 30%, 40%, 50% and 60%. A great many, of course, did not grow but many did. The pollen of all of these 540 plants were experimented with in this way and given a trial even though, as is well known, some few of them have not yielded results in this way. Of these 540 phanerogams only the pollen of five produced more than one tube on germination. This is very different from some pollen which produces many tubes on germination as in the case of Malva crispa. Of all the 540 plants I found only one whose pollen tube branched. That was the pollen of Caladium bicolor one of whose pollen tubes branched three times and two of whose pollen tubes branched twice. The record of this plant is as follows, viz: In distilled water ten pollen grains in one hundred germinated. In the cane sugar solutions 21 germinated in the 1%; 4 in 5%; 0 in 10%; 3 in 15%; 27 in 20%; 15 in 30%; 3 in 40%; 0 in 50%, and 0 in 60%. The pollen in this experiment was all of the same age and grown under exactly the same conditions. The first point of interest, therefore, is that in 10% none grew while just above and below this strength of the sugar solution the pollen grew. The second point of interest is that the branching of the pollen tube which this plant showed occurred only in the 30% of cane sugar and as above noted. It will be seen that in 40% cane sugar the germination dropped off greatly as only 3 grains of pollen grew. It has been known for a long time that the pollen tube sometimes branches as it descends through the stigma of some plants. The germination of the pollen of this plant was rather slow as it required one-half an hour to begin. Its pollen lived in the ungerminated condition for eight days and it grew best in a 20% solution of the cane sugar. Most of the pollen experimented with in the cultures used in this investigation was from plants gathered in Monroe County, Indiana. Some of the plants were obtained from widely separated localities and whereever and whenever an opportunity presented itself. Some came, for example, from Texas, some from Missouri, and others from Colorado which I gathered on Pike's Peak and vicinity. Twelve plants from Pike's Peak that I tested especially as regards their longevity, lived only ten days in the longest case. Some of these I did not expect would germinate under any conditions, whether their pollen was young or old, and this was fully verified by experiment. However, these plants were in every case also subjected to the usual investigation in order to leave no doubt on the question. Still others of the plants came from Dearborn County and from Clark County, Indiana. All of the experiments in this paper were carried out, as above stated, in pure distilled water and in the different strengths of cane sugar mentioned. The distilled water and cane sugar were as pure as possible. No experiments were performed or attention given to the question of additional substances, such as gelatine, added to these solutions. Considerable work also has been done in some phases of this field. It constitutes, however, a problem in itself and merits much more extended investigation than it has yet received.

THE USTILAGINALES OF INDIANA, II.[1]

H. S. JACKSON.

This paper is the first supplement to one bearing the same title published in the Proceedings of the Indiana Academy of Science for 1917, pp. 119-132. In the previous paper 47 species were recorded for the state on as many hosts. Each species was given a number. In the present paper additional hosts, together with some corrections or supplementary information, are given for species already listed. The same numbers are used. Ten species are also recorded for the state for the first time bringing the total to 57. Unless otherwise noted the collections were made by the writer. An index to species for the two papers is appended together with a complete host index.

Many of the species recorded should occur on other hosts and a considerable number of other species should be found within the state. The writer would appreciate it if interested persons would furnish duplicates of their collections for record in later supplements.

NOTES ON SPECIES PREVIOUSLY RECORDED.

1. CINTRACTIA CARICIS (Pers.) Magn.

ON CYPERACEAE:

Carex blanda Dewey, wooded bank of Pigeon Creek near Maxwell Bridge, Warrick Co., June 10, 1918, C. C. Deam 25286.

6. SCHIZONELLA MELANOGRAMMA (DC.) Schröt.

ON CYPERACEAE:

*Carex convoluta**Mack., Happy Hollow, north of West Lafayette, Tippecanoe Co., May 15, 1910, Miss Uhde.

7. SOROSPORIUM CONFUSUM Jackson.

This was reported in the 1917 Proceedings as on Aristida sp. The host has been determined by Mrs. Agnes Chase as *Aristida gracilis* Ell.

8. SOROSPORIUM SYNTHERISMAE (Peck) Farl.

This species was reported by Clinton (N. Am. Flora 7:39. 1906) from Indiana on *Panicum capillare* L. At the time of the previous report no specimens had been seen. The writer has, however, made a collection on this host, one-half mile southeast of Shelby in Lake Co., Oct. 14, 1920.

In the previous report collections were also recorded on *Cenchrus carolinianus* Walt. Clinton (l.c.) uses the name *C. tribuloides* to include Indiana material. All collections from Indiana on Cenchrus, however, would more properly be referred to *C. pauciflorus* Benth. (c. f. Hitchcock, Bul. U. S. Dept. Agr. 772:249. 1920).

21. USTILAGO SPERMOPHORA B. & C.

This was reported in the 1917 Proceedings as on *Eragrostis major* Host.

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[1]Contribution from the Botanical Department of the Purdue University Agricultural Experiment Station.

The host has recently been determined by Mrs. Agnes Chase as *E. cilianensis* (All.) Link.

22. USTILAGO SPHAEROGENA Burrill.

ON POACEAE:

Echinochloa Walteri (Pursh) Nash. one mile northwest of Thayer, Newton Co., Oct. 14, 1920.

This was collected in small amount on the same plants that bore *Tolyposporum bullatum* Schröt. (c. f. 49).

24. USTILAGO STRIAEFORMIS (West.) Niessl.

ON POACEAE:

Elymus virginicus L., one-half mile south of Wilders Station, Laporte Co., Oct. 5, 1920.

25. USTILAGO UTRICULOSA (Nees) Tul.

ON POLYGONACEAE:

Persicaria hydropiperoides (Michx.) Small, one-half mile south of Bolivar, Wabash Co., Sept. 15, 1919, C. C. Deam 30028; one mile northwest of Thayer, Newton Co., Oct. 19, 1920.

Persicaria lapathifolia (L.) S. F. Gray, Bluffton, Wells Co., Aug., 1905, C. C. Deam (spec. in herb. U. S. Dept. Agr.).

Persicaria Persicaria (L.) Small, four miles northwest of Patoka, Gibson Co., Oct. 6, 1917, C. C. Deam 24185.

43. UROCYSTIS AGROPYRI (Preuss.) Schröt.

ON POACEAE:

Elymus canadensis L., south of West Lafayette, Tippecanoe Co., Aug. 9, 1918.

45. UROCYSTIS CEPULAE Frost.

ON ALLIACEAE:

Allium cepa L.

In the previous report it was stated that no specimens of this smut had been seen. It has since been found to be common and to cause a serious disease of onion sets in certain sections of Lake county. An ample collection was made near Hammond, July 27, 1920. It has also been observed commonly on onion sets on the market in Lafayette. The source of these, however, is unknown. A fine specimen collected at Crawfordsville, Montgomery Co., Aug. 10, 1907, by M. B. Thomas, is in the herbarium of the Missouri Botanical Garden. No. 13283.

46. UROCYSTIS ORNITHOGALI Koern.; Fisch. de Waldh. Aperçu Syst. Ust. 41. 1877.

Specimens of Urocystis on *Quamasia hyacinthina* (Raf.) Britton were referred in the 1917 list under this number to *U. Colchici* (Schlecht.) Rab. A more careful study has led to the conclusion that they are more properly referred to *U. Ornithogali*. This species has been commonly considered identical with *U. Colchici* but is treated separately by Schellenberg in his excellent monograph of the smuts of Switzerland (Beiträge Krypt. Schweiz 3^2:139. 1911). After studying all the European material available the writer is inclined to agree with this view.

According to this treatment, the smut on Liliaceous hosts belonging to the tribe Scilleae, including besides the American *Quamasia*, species of *Muscaria, Ornithogalum* and *Scilla* in Europe, would be assigned to *U. Ornithogali*, while *U. Colchici* would include the European form on *Colchicum autumnale*. The writer is not able to express an opinion as to whether the form on Convallariaceae in Europe and America is properly assigned to either of the above species, as sufficient material has not been available for study. Clinton (Bost. Soc. Nat. Hist. Proc. **31**:452. 1904; N. Am. Flora **7**:57. 1906) has assigned specimens on *Salamonia* and *Vagnera*, collected in Iowa and Montana, somewhat doubtfully to *U. Colchici*.

U. Ornithogali differs from *U. Colchici* chiefly in the widely different character of the sorus, the size of the spores, and the character and wall color of the surrounding layer of sterile cells. In the former the sori are elliptical, commonly half as broad as long, the spore balls consist usually of one, rarely two spores, which are 18-22 u in diameter, and the sterile cells form a firmly united unbroken spore covering, the walls of which are cinnamon-brown. In the latter the sori are linear, often ten or more times as long as broad; the spore balls consist of one to two, rarely three spores, which are 14-20u in diameter; the sterile cells with light cinnamon-brown walls form a loose often interrupted layer over the spores.

SPECIES NEW TO INDIANA.

Ustilaginaceae.

48. Thecaphora Iresine (Elliott) Jackson, Mycologia **12**:154. 1920.
Tolyposporium Iresine J. A. Elliott, Mycologia **11**:88. 1919.

Sori localized in the inflorescence, involving the ovaries and parianth of one or a group of flowers, often involving the rachis and rarely occurring on the stem or leaves, forming irregular compound galls 0.3-3.5 cm. long, enclosed by a firm, grayish-green membrane, which ruptures irregularly exposing the reddish-brown spore mass; spore balls solid, subsphaeroid, 40-70u or ellipsoid, 50-70 by 60-90u, light chestnut-brown, composed of many, 15-70, spores; spores variable in shape, irregularly polyhedral, prismatic or oblong, 12-20 by 25-32u; inner wall thin, 1-1.5u, colorless or pale cinnamon-brown, smooth, exposed wall 2-4u thick, darker in color with prominent verrucose-rugose markings.

On Amaranthaceae:

Iresine paniculata (L.) Kuntze. In a dried up wooded slough, about one-half mile south of Half Moon pond, ten miles southwest of Mount Vernon, Posey Co., Sept. 21, 1918, C. C. Deam 26651 (type); Sept. 26, 1920, C. C. Deam 33041.

This remarkable smut was sent to the writer among other parasitic fungi in the fall of 1918 by Mr. Deam. It was at once recognized as a species of Thecaphora and an examination of the literature revealed that only one species of this genus was known in North America on Amaranthaceae, namely, *Thecaphora Thornberi* Griffiths (Bull. Torrey Club **31**:88. 1904). The specimen on Iresine while agreeing in general with the description of that species seemed to differ in important characters. A definite decision with reference to the relation of the two forms was therefore reserved until the type of *T. Thornberi* could be examined. Through the courtesy of Dr. Griffiths, two collections of his species, one of which was the type, were furnished for study.

The Iresine smut was found to be very closely related to *T. Thornberi* but to differ in several important respects. The sori, while involving the ovaries, are not usually confined to them, as described for *T. Thornberi*, but are indefinite, involving the ovaries and apparently the parianth of single flowers or groups of flowers and also occasionally the rachis. The spore balls are much smaller in the species under discussion, measuring 40-75u in globoid balls, reaching 90u in occasional ellipsoid balls, while in *T. Thornberi* the globoid balls are 80-115u in diameter, reaching 145u in the ellipsoid ones. The spores are also somewhat larger and the markings more prominent than in *T. Thornberi.*

In the meantime the species was described as *Tolyposporium Iresine* by Dr. J. A. Elliott (l.c.), of Fayetteville, Arkansas, from the same material, obtaining it through Prof. B. W. Wells to whom Mr. Deam had sent specimens under the impression that the galls might be caused by insects. The species obviously belongs in Thecaphora rather than in Tolyposporium and the transfer was made by the writer in a recent paper (l.c.).

The second collection made by Mr. Deam in 1920 at the type locality is ample and shows a great variation in the point at which the host is attacked and the degree of development (c. f. Fig. 1).

49. Tolyposporium bullatum Schröt. Krypt. Fl. Schles. 3[1]:276. 1887.
On Poaceae:

Echinochloa Crus-galli (L.) Beauv., one mile northwest of Thayer, near Kankakee river, Newton Co., Oct. 14, 1920; one-half mile south of Wilders Station, Laporte Co., Oct. 5, 1920.

Echinochloa Walteri (Pursh) Nash, one mile northwest of Thayer, near Kankakee river, Newton Co., Oct. 14, 1920.

The sori of this species occur in occasional ovaries of the grass and are ovate, 3-5 mm. in length, and covered by a thin, *smooth, greenish* membrane. The sori rupture irregularly disclosing the *granular* mass of black spore balls. It is not as common as *Ustilago sphaerogena* Burrill (c. f. No. 22 of 1917 list), but may occur with it in the same inflorescence. The two species are easily distinguished in the field. In *U. sphaerogena* the sori are usually larger, 3-9 mm. in length and are covered by a *tough, hispid, grayish-green* membrane, which on rupturing discloses an *agglutinated or dusty* olive-brown spore mass.

50. Ustilago Hieronymi Schröt. in P. Henn. Hedwigia 35:213. 1896.
On Poaceae:

Bouteloua curtipendula (Michx.) Torr., Bayles Mill, Wea Creek, Tippecanoe Co., Sept. 15, 1920, with E. B. Mains.

This is a common smut west of the Mississippi river, but has not before been collected, to our knowledge, so far east.

51. Ustilago residua Clinton, Jour. Myc. 8:133. 1902.
On Poaceae:

Danthonia spicata (L.) Beauv. In a woods two miles south of Corydon Junction, Harrison Co., May 26, 1919, C. C. Deam 27681.

This species usually affects the whole inflorescence. It has a wide distribution but has not often been reported. It is recorded on this host otherwise only from New Hampshire. It is especially common on the Pacific coast.

TILLETIACEAE.

52. DOASSANSIA RANUCULINA Davis, Bot. Gaz. 19:416. 1894.

ON RANUNCULACEAE:

Ranunculus delphinifolius Torr., one-half mile southeast of Shelby, Lake Co., Oct. 14, 1920.

This is a rare form known otherwise only from Wisconsin. The spores are largely germinated.

53. DOASSANSIA SAGITTARIAE (Westend) Fisch. Ber. Deuts. Bot. Ges. 2:405. 1884. *Uredo Sagittariae* Westend. Herb. Crypt. Belge 1177. 1857.

ON ALISMACEAE:

Sagittaria latifolia Willd., City water works lake, Bloomington, Monroe Co., Aug. 26, 1908. J. M. VanHook, 2383.

Sagittaria heterophylla Pursh (?), pond four miles east of Bloomington, Monroe Co., July 25, 1919. J. M. Van Hook, 3796.

This species was recorded by Prof. VanHook in the Proceedings for 1910, p. 206. It was overlooked in the previous list. I am indebted to Prof. Van Hook for the opportunity to examine specimens.

54. ENTYLOMA LINEATUM (Cooke) Davis, Trans. Wis. Acad. Sci. 9:162. 1893. *Ustilago lineata* Cooke; DeToni, in Sacc. Syll. Fung. 7:456. 1888.

ON POACEAE:

Zizania aquatica L., one mile southeast of Shelby, Lake Co., Oct. 14, 1920.

55. ENTYLOMA MENISPERMI Farl. & Trel. Bot. Gaz. 8:275. 1883.

ON MENISPERMACEAE:

Menispermum canadense L., two miles north of West Lafayette Tippecanoe Co., Aug. 9, 1918; one-half mile south of Wilders Station, Laporte Co., Oct. 5, 1920.

56. ENTYLOMA NYMPHAEAE (D. D. Cunn.) Setch. Bot. Gaz. 19:189. 1894. *Rhamphospora nymphaeae* D. D. Cunn. Sci. Mem. Med. Off. Army India 3:32. 1888.

ON NYMPHAEACEAE:

Castalia sp., one mile northwest of Thayer, Newton Co., Oct. 14, 1920.

57. ENTYLOMA RANUNCULI (Bon.) Schröt. Beitr. Biol. Pfl. 2:370. 1877. *Fusidium Ranunculi* Bon. Handb. Myc. 43. 1851.

ON RANUNCULACEAE:

Ranunculus delphinifolius Torr., one-half mile southeast of Shelby, Lake Co., Oct. 14, 1920.

This collection was made in a dried up slough on the terrestial form of the host. It consists for the most part of the conidial form which occurs equally as abundant on the upper surface of the leaf as on the lower, a condition not found on other host species. This is doubtless correlated with the fact that the stomata are abundant on the upper surface of the leaves in the terrestial form. The smut has not been reported on this host before.

Index to Species.

Synonyms are omitted. The numbers are those preceding the species name. Black-faced type indicates reference to both lists. Ordinary type to and including 47 refers to previous list, after 47 to the present list.

Host Index.

The figures refer to the species numbers of both lists. Those in black faced type are included in the present paper.

Fig. 1. *Thecaphora Iresine.* Showing variation in method of attacking host.

THE UREDINALES OF INDIANA III.[1]

H. S. Jackson, Purdue University.

The following report on the rusts of Indiana is suplementary to lists published in the Proceedings of the Indiana Academy of Science for 1915 and for 1917.[2]

The present paper is divided into two parts. In the first part an attempt has been made to list all the unrecorded hosts for species included in the 1915 and 1917 lists. Most of these host records represent new collections. Some of them, however, are corrections to previous determinations, while others represent collections which were overlooked. In a few cases the determination of the rust has been found to be incorrect and corrections of such have also been made. No attempt has been made to list the large number of collections which have been made on hosts already recorded. The number preceding the species name in this paper is the same used for that species in previous lists. The nomenclature, however, is not the same. In the 1915 list the nomenclature used was that proposed by Dr. J. C. Arthur and based largely on life histories. In the present list the more familiar generic names Puccinia and Uromyces are retained. In each case, however, the name used in the 1915 list is given as a synonym.

In the second part, twelve rust species which are new to the flora of Indiana are recorded. These are numbered consecutively with the two previous lists and bring the total number of species for the state to 167 (Nos. 36 and 70 are to be dropped so that the real total is 165).

In order that the series may be more useful to collectors a complete host index has been prepared by Miss Evelyn Allison and is appended.

Acknowledgment is gratefully made to all those who have contributed specimens. The name of the collector is given for each collection except where made by the writer. Special acknowledgment is due Mr. C. C. Deam who through his keen observations and knowledge of the state flora has made many notable additions. Mrs. Agnes Chase, Mr. K. K. Mackenzie and Mr. Paul C. Standley have determined many of the hosts.

All of the collections recorded are represented in the Arthur herbarium at the Purdue University Agricultural Experiment Station.

ADDITIONS AND CORRECTIONS TO PREVIOUS LISTS.

6. Coleosporium Solidaginis (Schw.) Thüm.

On Solidago bicolor L.

Two miles east of Corydon, Harrison Co., Oct. 6, 1920, C. C. Deam 33455.

On Solidago erecta Pursh.

North of St. Joe, Clarke Co., Oct. 25, 1916, C. C. Deam, 22468.

On Solidago juncea Ait.

One-half mile south of West Lafayette, Tippecanoe Co., Oct. 30, 1920.

[1]Contribution from the Department of Botany, Purdue University Agricultural Experiment Station.

[2]Jackson, H. S. The Uredinales of Indiana. Ind. Acad. Sci. Proc. 1917: 429-475. 1916. The Uredinales of Indiana II. Ind. Acad. Sci. Proc. 133-137 1918.

8. Coleosporium Verniae B. & C.

On Vernonia illinoensis Gleason.

Bank of Iroquois river, north of Kentland, Newton Co., Aug. 30, 1916, C. C. Deam 21529.

12. Melampsora Bigelowii Thüm.

The specimen reported on *Salix Wardi* Bebb. in the 1915 list has been examined by Dr. C. R. Ball who determines it as on *S. cordata* Muhl.

15. Pucciniastrum Agrimoniae (Schw.) Tranz.

On Agrimoniae rostellata Wallr.

One mile northwest of Tunnelton, Lawrence Co., July 16, 1919, C. C. Deam 28146.

21. Puccinia Bardanae Corda.

Bullaria Bardanae (Corda) Arth.

The host for all collections in Indiana should be *Arctium minus* Schk. not *A. Lappa* L.

25. Puccinia Hieracii (Schum.) Mart.

Bullaria Hieracii (Schum.) Arth.

On Hieracium canadense Mx.

One mile east of Kantz, Porter Co., Sept. 13, 1919, C. C. Deam 29824.

26. Puccinia Kuhniae Schw.

Bullaria Kuhniae (Schw.) Kern.

This species has been previously recorded as on *Kuhnia eupatorioides* L. All Indiana collections, according to Mr. Deam, are more properly referred to *K. glutinosa* Ell. In the 1915 list this was recorded from Harrison and Tippecanoe counties. Specimens are now at hand also from Greene Co.

29. Puccinia Asteris Duby.

Dasyspora Asteris (Duby) Arth.

On Aster lateriflorus (L.) Britton.

One-half mile southeast of Shelby, Lake Co., Oct. 14, 1920.

On Aster salicifolius Ait.

Franklin, Johnson Co., Oct. 7, 1915, F. J. Pipal.

36. The specimen on which the record for *Puccinia Ranunculi* Seym. was based (c. f. Underwood, Proc. Ind. Acad. Sci. 1893:55) has recently been examined and the rust proves to be *Polythelis fusca* (Pers.) Arth. (c. f. no. 135) and the host *Anemone quinquefolia* L.

The error in determination has been perpetuated through all the previous lists of Indiana rusts. There is some discrepancy in the records but there seems to have been but one collection involved, which was made in Montgomery County in June, 1893, by E. W. Olive and A. A. Hughart, or it was collected by Hughart and communicated to Underwood by Olive.

Puccinia Ranunculi Seym. is therefore to be stricken from the Indiana flora. It is a very rare rust known in North America only from the type collection, which is now interpreted as on *Ranunculus septentionalis* Poir. made by Dr. J. C. Arthur at Riverside, Chicago, Ill., June 2, 1883, and one from Mexico on Ranunculus sp.

The name *Puccinia Ranunculi* Seym. (1884) is untenable as Blytt used it in 1882 for another rust. Recent studies made by the writer indicate that the species is identical with *P. andina* Diet. & Neger (1899) collected in Chile, South America and that this name should replace *P. Ranunculi* Seym.

42. Puccinia Andropogonis Schw.
Dicaeoma Andropogonis (Schw.) Kuntze.
1. On Penstemon Penstemon (L.) Britton.
Wooded limestone slope, 3 miles north of Milltown, Crawford Co., May 28, 1919, C. C. Deam 27698.

43. Puccinia angustata Peck.
Dicaeoma angustatum (Peck) Kuntze.
On Koellia virginiana (L.) MacM.
Lafayette, Tippecanoe Co., June 13, 1899. J. C. Arthur.

48. Puccinia canaliculata (Schw.) Lagerh.
Dicaeoma canaliculatum (Schw.) Kuntze.
On Cyperus speciosus Vahl.
Freedom, Owen Co., Sept. 22, 1917, C. C. Deam.
The record of this rust on *C. Engelmanii* Steud. made in the 1915 list is found to have been based on an error in host identification. The host is now interpreted as *C. strigosus*. Some of the collections recorded in the previous papers are now separated as *Puccinia Cyperi* Arth. and are relisted as No. 162 of the present list.

49. Puccinia Seymouriana Arth.
Dicaeoma Cephalanthi (Seym.) Jackson.
I On Apocynum cannabinum L.
Four miles south of Corydon, Harrison Co., June 26, 1916, C. C. Deam 20497.

51. Puccinia Clematidis (DC.) Lagerh.
Dicaeoma Clematidis (DC.) Arth.
I On Anemone virginiana L.
Lafayette, Tippecanoe Co., 1894, K. E. Golden.
III On Agropyron Smithii Rydb.
Along Wabash railroad, near Wea Creek, Tippecanoe Co., Sept. 15, 1920, with E. B. Mains.

52. Puccinia Conoclini Seymour.
Dicaeoma Conoclini (Seym.) Kuntze.
On Eupatorium incarnatum Walt.
Wooded ridge, 8 miles southeast of Cannelton, Perry Co., Oct. 1, 1920, C. C. Deam 33185.
The host is a rare plant, collected for the first time in Indiana by Mr. Deam in 1919. The rust is known on this host otherwise only from Louisiana. Specimens are now at hand of this rust on *E. coelestinum* from Bartholomew, Perry, Crawford and Orange Counties.

56. Puccinia Eleocharidis Arth.
Dicaeoma Eleocharidis (Arth.) Kuntze.
On Eleocharis obtusa (Willd.) Schr.

One and one-fourth miles east of Palmyra, Harrison Co., Oct. 13, 1916, C. C. Deam 22415.

61. Puccinia Asterum (Schw.) Kern.
Accidium Asterum Schw.
Puccinia extensicola Plowr.
Dicaeoma extensicola (Plowr.) Kuntze.
I On Aster puniceus L.

Howe, Lagrange Co., May 23, 1912, J. C. Arthur.

On Brachychaeta sphacelata (Raf.) Britton.

Wooded bluff of Ohio river, six miles east of Cannelton, Perry Co., May 20, 1918, C. C. Deam 24987.

On Erigeron pulchellus Michx.

Lafayette, Tippecanoe Co., May 29, 1894, K. E. Golden (formerly reported as on *Solidago flexicaulis* L.).

III On Carex abdita Bicknell.

One-half mile southwest Chestnut Ridge, Jackson Co., May 11, 1913, C. C. Deam 12716.

On Carex muskingumensis Schw.

One-half mile south of Wilders Station, Laporte Co., Oct. 5, 1920.

On Carex normalis Mack.

West Lafayette, Tippecanoe Co., June 22, 1912, C. R. Orton.

On Carex stipata Muhl.

Lafayette, Tippecanoe Co., July 9, 1898, L. Snyder.

On Carex tribuloides Wahl.

French Lick, Orange Co., Dec. 28, 1913, Arthur & Ludwig; Winona Lake, Kosciusko Co., June 26, 1914, G. N. Hoffer.

On Carxex varia Muhl.

Everton, Fayette Co., May 1, 1915, C. A. Ludwig; North Madison, Jefferson Co., Apr. 23, 1916, J. B. Demaree.

The collections recorded under *Solidago canadensis* L. in the 1915 list should all be referred to *S. altissima* L. Collections are at hand on *S. canadensis*, however, from Lafayette, Tippecanoe Co., May 15, 1901, and April 25, 1902, collected by J. C. Arthur.

The collections recorded in the 1915 list as on *Carex conoidea* Schk. and *C. tetanica* Schk. (now referred to *C. blanda* Dewey) are now considered to be *Puccinia Grossulariae* (Schum.) Lagerh. (c. f. No. 63).

62. Puccinia fraxinata (Lk.) Arth.
Caeoma fraxinatum Lk.
Dicaeoma fraxini (Schw.) Arth.
I On Fraxinus profunda Bush.

In swamp ten miles southwest of Mt. Vernon, Posey Co., June 15, 1918, C. C. Deam 25426.

63. Puccinia Grossulariae (Schum.) Lagerh.
Dicaeoma Grossulariae (Schum.) Kern.
I On Grossularia hirtella (Michx.) Spach.

Lagrange Co., June 8, 1915, C. C. Deam.

On Ribes americana Mill.

Two miles northwest of Rochester, Fulton Co., June 7, 1920, C. C.

Deam 31023; one-half mile east of St. Joe, DeKalb Co., May 25, 1920. C. C. Deam 30392.

ON RIBES VULGARE LAM.

Royal Center, Cass Co., May, 1912, comm. C. H. Baldwin.

III ON CAREX CEPHALOPHORA MUHL.

Lafayette, Tippecanoe Co., June 24, 1898, L. Snyder.

ON CAREX CONOIDEA SCHK.

Lafayette, Tippecanoe Co., July 21, 1900, Wm. Stuart; Oct. 26, 1901, J. C. Arthur; Oct. 11, 1914, July 18, 1914, F. D. Fromme; June 24, 1914, Pipal, Orton, Fromme; Mattsville, Hamilton Co., Aug. 8, 1905, G. W. Wilson.

ON CAREX LUPULIFORMIS SARTW.

South Bend, St. Joseph Co., Sept. 24, 1917, E. Bartholomew (N. Am. Ured. 1942).

ON CAREX PUBESCENS MUHL.

Lafayette, Tippecanoe Co., April 30, 1901, J. C. Arthur.

ON CAREX SPARGANIOIDES MUHL.

Lafayette, Tippecanoe Co., Oct. 7, 1896, L. Snyder.

The collections referred in the 1915 list to *Carex digitalis* Willd., *C. laxiflora* Lam. and *C. tetanica* Schk. are now all to be considered as on *C blanda* Dewey.

The collection recorded above on *C. pubescens* was included in the 1915 list as on *C. hirtifolia*, of which *C. pubescens* was then considered a synonym. The two host species are now considered distinct and the Indiana collection is on *C. pubescens*.

64. PUCCINIA HELIANTHI Schw.

Dicaeoma Helianthi (Schw.) Kuntze.

ON HELIANTHUS DECAPETALUS L.

West Lafayette, Tippecanoe Co., Sept. 4, 1915, C. A. Ludwig (Barth. N. Am. Ured. 1550), Sept. 11, 1915 (Barth. N. Am. Ured. 1402), Oct. 3, 1915, H. C. Travelbee, Oct. 1, 1916.

ON HELIANTHUS LAETIFLORUS PRES.

Rust garden, south of West Lafayette, Tippecanoe Co., Oct. 3, 1915.

ON HELIANTHUS SCABERRIMUS ELL.

Paoli, Orange Co., Sept. 28, 1915.

66. PUCCINIA HIBISCIATA (Schw.) Kellerm.

Dicaeoma hibisciatum (Schw.) Arth.

ON MELICA MUTICA WALT.

Lafayette (Elston), Tippecanoe Co., July 28 and Oct. 22, 1899, Wm. Stuart, May 13 and 29, 1903, J. C. Arthur.

ON MUHLENBERGIA RACEMOSA (MICHX.) B. S. P.

West Lafayette, Tippecanoe Co., Dec. 3, 1901, Wm. Stuart.

ON MUHLENBERGIA SOBOLIFERA (MUHL.) TRIN.

Lafayette, Tippecanoe Co., Oct. 2, 1896, L. Snyder.

69. PUCCINIA MAJANTHAE (Schum.) Arth. & Holw.

Dicaeoma Majanthae (Schum.) Arth.

I ON IRIS VERSICOLOR L.

DeMotte, Jasper Co., June 22, 1915. J. C. Arthur.

The connection of the Aecidium on *Iris versicolor* with telia on *Phalaris* *arundinacea* L. was established in this laboratory in 1917, based on field observations made in 1916 by Prof. H. H. Whetzel and the writer in the vicinity of N. Spencer, New York.

70. The collection on *Melica mutica* Walt. recorded as *Dicaeoma Melicae* (Syd.) Arth. under this number is now referred to *Puccinia hibisciata* (Schw.) Kellerm, *Dicaeoma hibisciatum* (Schw.) Arth. See No. 66. *Puccinia Melicae* Syd. is now considered a synonym of *Dicaeoma Rhamni* (Pers.) Kuntze (*P. coronata* Corda) (See No. 86 of 1915 list) and is known in North America only on *Melica purpurascens* from Wisconsin.

71. Puccinia Menthae Pers.
 Dicaeoma Menthae (Pers.) S. F. Gray.
 On Koellia flexuosa (Walt.) MacM.
 Three miles south of Marengo, Crawford Co., Oct. 5, 1920, C. C. Deam 33403.
 On Monarda punctata L.
 Fair Oaks, Jasper Co., May 12, 1904, J. C. Arthur.

76. Puccinia obtecta Pk.
 Dicaeoma obtectum (Pk.) Kuntze.
 I On *Bidens frondosa* L.
 One-half mile northeast of Dayton, Tippecanoe Co., July 5, 1920.
 On Bidens trichosperma (Michx.) Britton.
 One-half mile northeast of Dayton, Tippecanoe Co., July 5, 1920.

79. Puccinia hieraciata (Schw.) Jackson.
 Aecidium hieraciatum Schw.
 Dicaeoma patruelis (Arth.) Jackson.
 The collection recorded in the 1915 list as on *Lactuca floridana* is now referred to *L. canadensis*.

80. Puccinia Peckii (DeToni) Kellerm.
 Aecidium Peckii DeToni.
 Dicaeoma Peckii (DeToni) Arth.
 On Carex laeviconica Dewey.
 DeMotte, Jasper Co., Nov. 6, 1913, J. C. Arthur & F. D. Kern.
 On Carex lupuliformis Sartw.
 One mile southwest of Shelby, Lake Co., Oct. 14, 1920.
 On Carex Willdenovii Schk.
 State Reservation, Clark Co., May 11, 1910, C. C. Deam 5875.

81. Puccinia poculiformis (Jacq.) Wettst.
 Puccinia graminis Pers.
 Dicaeoma poculiforme (Jacq.) Kuntze.
 III On Agropyron repens (L.) Beauv.
 Wolcottville, Lagrange Co., Aug. 1, 1919, L. S. Cheney.
 On Alopecurus aristulatus Michx.
 Lakeville, St. Joseph Co., Aug. 9, 1919, L. S. Cheney.
 On Bromus purgans L.
 North of West Lafayette, Tippecanoe Co., Oct. 1, 1916.
 On Elymus canadensis L.

Connersville, Fayette Co., Sept. 11, 1919, L. S. Cheney.

On Elymus virginicus L.

Paoli, Orange Co., Sept. 27, 1915: Wilders Laporte Co., Oct. 1920.

On Festuca elatior L.

Angola, Steuben Co., Aug. 18, 1919, L. S. Cheney.

Most of the above collections were made in connection with a national investigation of overwintering of stem rust. No overwintering of urediniospores was found to occur in Indiana during 1919.

In the 1915 report only a single collection of the aecidium of this species on *Berberis vulgaris* was recorded. In connection with the barberry eradication campaign for the control of stem rust, which is being conducted cooperatively between Purdue University and the U. S. Dept. of Agriculture, a large number of collections and observations have been made showing that this aecidium may develop in abundance on the barberry in all parts of the state. Specimens collected in 1918 and 1919 are now preserved in the Arthur herbarium from the following counties in Indiana: Allen, Franklin, Henry, Jay, Lagrange, Laporte, Noble, St. Joseph, Vanderburgh, Wabash and Wayne.

86. Puccinia Rhamni (Pers.) Wettst.

Dicaeoma Rhamni (Pers.) Kuntze.

I On Rhamnus alnifolia L'Her.

In a tamarack swamp 2 miles north of Porter, Porter Co., June 3, 1916, C. C. Deam 20027.

III On Alopecurus aristulatus Michx.

Lakeville, St. Joseph Co., Aug. 9, 1919, L. S. Cheney.

88. Puccinia Sambuci (Schw.) Arth.

Dicaeoma Sambuci (Schw.) Arth.

I On Sambucus pubens Michx.

The Shades, Montgomery Co., May 26, 1899, J. C. Arthur.

III On Carex lupuliformis Sartw.

One mile southeast of Shelby, Lake Co., Oct. 14, 1920.

89. Puccinia marylandica Lindr. Medd. Stockh. Högsk. Bot. Inst. 4[9]:2.1901.

This was previously recorded as *Dicaeoma Saniculae* (Grev.) Kuntze (*Puccinia Saniculae* Grev.) and has been commonly referred to that species by American authors. *P. Saniculae*, however, is not an American species.

Collections have been made on *Sanicula canadensis* L.? in Montgomery and Washington Counties. The Montgomery Co. specimens made by Rose and reported by Underwood (Proceedings Ind. Acad. 1893:55) have not been seen.

90. Puccinia Smilacis Schw.

Dicaeoma Smilacis (Schw.) Kuntze.

On Smilax Bona-nox L.?

Wooded bank of Ohio river, south of Leavenworth, Crawford Co., Oct. 5, 1920, C. C. Deam 33411.

94. Puccinia Urticae (Schum.) Lagerh.

Dicaeoma Urticae (Schum.) Kuntze.

On Carex trichocarpa Muhl.

Lafayette. Tippecanoe Co., April 13, 1906, G. W. Wilson & F. D. Kern; West Lafayette, Tippecanoe Co., Sept. 29, 1914, C. A. Ludwig.

The collections reported in the 1915 list on *Carex stricta* Lam. are now all to be considered as occurring on *C. Emoryi* Dewey.

95. PUCCINIA VERBENICOLA (Ell. & Kellerm.) Arth.
Dicaeoma verbenicolum (Ell. & Kellerm.) Arth.
I ON VERBENA HASTATA L.

One-half mile northwest of Dayton, Tippecanoe Co., July, 5, 1920.

97. PUCCINIA VEXANS FARL.
Dicaeoma vexans (Farl.) Kuntze.
ON ATHEROPOGON CURTIPENDULUS (MICHX.) FOURN.

It was stated in the 1915 list that the specimen on which this record was based (Lafayette, Tippecanoe Co., May 22, 1902, Wm. Stuart) was not available and the determination was doubtful. The specimen has since been located and deposited in the Arthur herbarium. It is found to be correctly determined. An earlier collection, which was overlooked, was made at Lafayette, July 11, 1900, by Wm. Stuart and distributed in Arthur & Holway's Uredineae Exsiccati et Icones, No. 58a and 58d.

Collections were also made by the writer in 1920 at two different points on Wea Creek, south of Lafayette, on Sept. 15 and Oct. 23.

98. PUCCINIA VIOLAE (Schum.) DC.
Dicaeoma Violae (Schum.) Kuntze.
ON VIOLA MISSIOURIENSIS GREENE.

Waveland (Shades), Montgomery Co., May 16, 1913, J. C. Arthur.

102. GYMNOSPORANGIUM GERMINALE (Schw.) Kern.
I ON AMELANCHIER LAEVIS X HUMILIS (according to K. M. Wiegand).

Wooded dune bordering Lake Michigan, east of Waverly beach, Porter Co., June 10, 1920, C. C. Deam 31498.

III ON JUNIPERUS VIRGINIANA L.

North Madison, Jefferson Co., May 10, 1916, J. B. Demaree.

103. GYMNOSPORANGIUM GLOBOSUM Farl.
I ON CRATAEGUS ANDUENNAE SARG.

South bank of St. Mary's river, south of Fort Wayne, Allen Co., Sept. 23, 1916, C. C. Deam 22095.

105. The rust on *Potentilla canadensis* L. so common throughout the state and recorded as *Kuehneola obtusa* (Strauss) Arth. in the 1915 list has been restudied and its affinities determined to be with Phragmidium rather than Kuehneola. It is a brachy-Phragmidium and on this account, Dr. Arthur has erected the genus Frommea (Bull. Torrey Club 44:503. 1917) to include this and one other species. The name is written *Frommea obtusa* (Strauss) Arth. (*Phragmidium Tormentillae* Fckl.). European authors in general do not consider the American species identical with the European. Those who accept this view should write the name of the American species *Phragmidium triarticulatum* (B. & C.) Farl. (*Aregma triarticulatum* B. & C.).

113. UROMYCES HEDYSARI-PANICULATI (Schw.) Farl.
Nigredo Hedysari-paniculati (Schw.) Arth.
ON MEIBOMIA MICHAUXII VAIL.

Seven miles southeast of Cannelton, Perry Co., Sept. 24, 1918, C. C. Deam 26705.

115. UROMYCES HYPERICI-FRONDOSI (Schw.) Arth.
Nigredo Hyperici-frondosi (Schw) Arth.
ON HYPERICUM PROLIFICUM L.

Northwest of Corydon, Harrison Co., Oct. 6, 1920, C. C. Deam 33465; Osgood, Ripley Co., Nov. 13, 1920, comm. C. Griffiths.

119. UROMYCES PERIGYNIUS Halsted.
Nigredo perigynia (Halst.) Arth.
I ON RUDBECKIA LACINIATA L.

Near Soldiers' Home, West Lafayette, Tippecanoe Co., June 16, and 24, 1914, C. R. Orton, et al.

III ON CAREX ASA-GRAYI BAILEY.

Clear Pond, Gibson Co., Aug. 29, 1915, G. N. Hoffer and C. C. Deam.

122. UROMYCES POLEMONII (Peck) Barth.
Nigredo Polemonii (Peck) Arth.
I ON PHLOX MACULATA L.

Norris marsh, southeast of Lake Maxinkuckee, Marshall Co., June 7, 1920, C. C. Deam 30939.

This is the first record of this rust on this host in North America.

124. UROMYCES RHYNCHOSPORAE (Ellis) Arth.
ON RYNCHOSPORA GLOMERATA (L.) VAHL.

Michigan City, Laporte Co., Sept. 13, 1916, with E. B. Mains.

125. UROMYCES SCIRPI (Cast.) Burrill.
Nigredo Scirpi (Cast.) Arth.
ON SCIRPUS FLUVIATILIS (Torr.) A. Gray.

One mile northwest of Thayer, Newton Co., Oct. 14, 1920.

139. TRANZSCHELIA PUNCTATA (Pers.) Arth.
I ON ANEMONE QUINQUEFOLIA L.

Mongo, Lagrange Co., May 27, 1920, C. C. Deam 30451; Lake Wabee, southeast of Milford, Kosciusko Co., June 3, 1920, C. C. Deam 30614.

ON THALICTRUM DIOICUM L.

Happy Hollow, north of West Lafayette, Tippecanoe Co., May 22, 1918, E. B. Mains.

III ON PRUNUS SEROTINA (EHRH.) AG.

Four miles west of West Lafayette, Tippecanoe Co., Sept. 15, 1918, with F. J. Pipal.

140. TRIPHRAGMIUM ULMARIAE (Schum.) Link.
ON FILIPENDULA RUBRA (HILL) BRITTON.

This rust has been known to occur in North America only in a small swamp located about three-fourths of a mile south of West Lafayette along the south river road known locally as the "rust garden". It was first collected May 16, 1899, and has been repeatedly collected there, especially from 1902 to 1908, by different people. About 12 different collections are deposited in the Arthur herbarium from this locality. During the past 12 years, however, no collections have been made, though it has been repeatedly searched for, and we have feared that the species was extinct in this locality. It was, therefore, with considerable interest that the writer made collections of this rust on July 5 and Sept. 2, 1920 in a small swamp about one-half mile northeast of Dayton in Tippecanoe Co.

148. Uredinopsis Atkinsonii Magn.
On Filix bulbifera (L.) Und.
Pine Creek, Warren Co., Aug. 11, 1918.

149. Uromyces seditiosus Kern.
On Aristida gracilis Ell.
Oakland City, Gibson Co., Oct. 5, 1916.
On Aristida oligantha Michx.
Paoli, Orange Co., Oct. 6, 1916.

SPECIES NEW TO INDIANA.

Uredinaceae.

156. Pucciniastrum Myrtilli (Schum.) Arth. Résult. Sci. Congr. Bot. Vienne 337. 1906.
Aecidium (?) *Myrtilli* Schum. Enum. Pl. Saell. 2:227. 1803.
Uredo minimum Schw. Schr. Nat. Ges. Leipzig 1:70. 1822.
Peridermium Peckii Thüm. Mitth. Forstl. Vers. Oest. 2:320. 1880.
Pucciniastrum minimum Arth. Résult. Sci. Congr. Bot. Vienne 337. 1906.
I On Tsuga canadensis (L.) Carr.

Wooded bluff about 5 miles southwest of Grantsburg, Crawford Co., C. C. Deam 27782.

The uredinia and telia of this species occur on Ericaceae and should be found in Indiana on Gaylussacia or Vaccinium.

The collection cited above is abundant and aecia are on both leaves and cones.

157. Uredinopsis Struthiopteridis Störmer, Bot. Notiser 1895:81. 1895.
On Anchistea virginica (L.) Presl. (Woodwardia virginica (L.) J. E. Smith).

In an *Aronia melanocarpa* swamp one and one-half miles north of Millcreek, Laporte Co., Aug. 25, 1920, C. C. Deam 32406.

This is a rare form known otherwise on this host only from Vermont and Michigan.

Pucciniaceae.

158. Gymnosporangium externum Arth. & Kern. Mycologia 1:254. 1909.
I On Gillenia stipulata Nutt.

Wooded ridge 8 miles southeast of Cannelton, Perry Co., June 3, 1918, C. C. Deam 25080.

The specimen is largely immature consisting mostly of pycnia, though a few aecia are present.

The telial stage has not yet been collected in Indiana, but develops on the branches of *Juniperus virginiana* and has been collected only in the vicinity of Mammoth Cave, Kentucky. Aecia have been collected, however, also in Missouri, Kentucky and Virginia.

The connection between the telia on Juniperus and the aecia on Gillenia was established by Arthur (Mycologia **1**:253. 1909;**2**:231. 1910).

159. Kunkelia nitens (Schw.) Arth. Bot. Gaz. **63**:504. 1917.

Aecidium nitens Schw. Schr. Nat. Ges. Leipzig **1**:69. 1822.

On Rubus allegheniensis Porter (R. nigrobaccus Bailey).

Madison and Wirt, Jefferson Co., May 6 and 7, 1910, A. G. Johnson.

On Rubus occidentalis L.

Bourbon, Marshall Co., May 22, 1889, J. H. Parks.

On Rubus procumbens Muhl.

Greencastle, Putnam Co., May, 1893, L. M. Underwood (Ind. Biol. Sur. 19); Lafayette, Tippecanoe Co., May 21, 1899, Wm. Stuart; Brookville, Franklin Co., May 8, 1915, C. A. Ludwig; Pine Creek, Warren Co., May 18, 1917, J. C. Arthur.

On Rubus sativus (Bailey) Brain.

Daleville, Delaware Co., June 8, 1914, L. Shoemaker.

The specimens listed above were in part included in the 1915 list under No. 101, *Gymnoconia intersitialis* (Schlecht.) Lagerh. Recent studies by Kunkel have shown that there are two forms of the orange rust of blackberries and raspberries, one a Caeoma with an Endophyllum-like life history and the other an opsis-Puccinia-like form. The former has been separated by Dr. Arthur (l. c.) as a new genus, Kunkelia. For the sake of emphasis this name is used above, though it should be recognized that there is considerable difference of opinion as to the relationship of the two forms, especially in view of very recent investigations by Kunkel (Jour. Agr. Res. **19**:501-512. 1920) and Clinton (Conn. Agr. Exp. Sta. Bull. **222**: 469-473. 1920). The writer is inclined to believe that we have here a rust which is in an advanced stage of an evolutionary transition from a long to a short cycled form, the transition taking place in the direction of the aecium and the long cycled form surviving in certain regions and on certain hosts.

160. Puccinia anomala Rostr.: Thümen. Flora **1877**:92. 1877.

On Hordeum vulgare L.

Lafayette, Tippecanoe Co., July 2, 1918, with E. B. Mains.

This, the leaf rust of barley, was collected for the first time in Indiana as indicated above. A number of other collections in various counties of the state have since been made, indicating that the rust was not uncommon in 1918, but was not present in severe form. Usually the infection was very slight and required careful search to find it.

Tranzschel has shown that this rust in Russia has its aecia on *Ornithogalum umbellatum* and *O. narbonense* (Myc. Cent. **4**:70. 1914). Aecia have not been collected in North America.

161. PUCCINIA CIRSII Lasch.

ON CIRSIUM UNDULATUS (NUTT.) SPRENG.

Winona Lake, Kosciusko Co., June 26, 1914, G. N. Hoffer.

162. PUCCINIA CYPERI Arth. Bot. Gaz. **16**:226. 1891.

Dicaeoma Cyperi Kuntze. Rev. Gen. 3^3:466. 1898.

ON CYPERUS FILICULMIS VAHL.

Lafayette, Tippecanoe Co., Oct. 2, 1896, L. Snyder; Michigan City, Laporte Co., Sept. 13, 1916, with E. B. Mains.

ON CYPERUS SCHWEINITZII TORR.

Crawfordsville, Montgomery Co., Oct. 7-9, 1893, L. M. Underwood; Michigan City, Laporte Co., Sept. 13, 1916, with E. B. Mains.

ON CYPERUS STRIGOSUS L.

Fern, Putnam Co., Oct. 1893, L. M. Underwood.

This species was formerly confused with *P. canaliculata* (Schw.) Lagerh., which has aecia occurring on Ambrosia and Xanthium. The Indiana specimens listed above were in part included with that species as No. 48 of the 1915 list. Kern (Mycologia **11**:134-147. 1919) has recently pointed out the distinction between the two species.

The aecidium of this species is unknown.

163. PUCCINIA PIMPINELLAE (Strauss) Link, in Willd. Sp. Pl. 6^2:77. 1825.

Uredo Pimpinellae Strauss, Ann. Wett. Ges. **2**:102. 1810.

ON OSMORRHIZA LONGISTYLIS (TORR.) DC.

Seven miles north of Zanesville, Allen Co., May 26, 1916, C. C. Deam 19820.

164. PUCCINIA POLEMONII Diet. & Holw. Bot. Gaz. **18**:255. 1893.

ON POLEMONIUM REPTANS L.

In a low flat woods on the south side of Half Moon Pond, about 10 miles southwest of Mt. Vernon, Posey Co., April 19, 1919, C. C. Deam 26992.

A second collection was made by Mr. Deam in the same spot, Sept. 26, 1920, (Deam 33050).

This species, at the time the first collection listed above was made, was otherwise known only from the type collection made on *P. caeruleum* L. (*P. occidentale* Greene?), Kootenai Co., Idaho, J. H. Sandberg, July 1892. Another collection has since been made on *P. occidentale* at Lake Tahoe, California, Aug. 23, 1920, E. Bethel. The sori in the specimens collected by Deam occur on the petioles and leaf blades, often at the margin and are cinereous from the abundant germination of the teliospores. It is a lepto-Puccinia. No pycina were observed.

165. UROMYCES GRAMINICOLA Burrill, Bot. Gaz. **9**:188. 1884.

Uromyces Panici Tracy, Jour. Myc. **7**:281. 1893.

Nigredo graminicola (Burrill) Arth. Résult. Sci. Congr. Bot. Vienne 343. 1906.

III ON PANICUM VIRGATUM L.

One mile southeast of Shelby, Lake Co., Oct. 14, 1920.

166. UROMYCES HORDEI Tracy, Jour. Myc. **7**:281. 1893.

Nigredo Hordei Arth. N. Am. Flora **7**:228. 1912.

ON HORDEUM PUSILLUM NUTT.

Mt. Vernon, Posey Co., May 11, 1916; Cynthiana, Posey Co., July 17, 1918, comm. E. P. Melhorn.

The latter collection was secured from a specimen of the grass which was sent to the Botanical Department of the Purdue University Agricultural Experiment Station for identification. The rust is a southern one and occurs also on *Festuca octoflora*, having a range from Indiana and Nebraska to Mississippi and Texas.

The aecial stage has been shown through field cultures by Long and greenhouse cultures by Arthur to be on *Nothoscordium bivalve* (Mycologia 8:139-140. 1916) and should also be found in southern Indiana.

167. Uromyces porosus (Pk.) Jackson. Brooklyn Bot. Gard. Mem. 1:281 1918.

Aecidium porosum Pk. Bot. Gaz. 3:34. 1878.

Uromyces coloradensis E. & E. Erythea 1:204. 1893.

Uromycopsis porosa Arth. Résult. Sci. Congr. Bot. Vienne 345. 1906.

I On Vicia americana Muhl.

One mile east of Christman, Porter Co., June 3, 1916, C. C. Deam 20059.

This is an autoecious rust possessing aecia and telia only. It is a western form, the present collection being the most eastern one known. The aecia are from a distributed mycelium and hence easily separated from the more common *U. Fabae*, which occurs on the same host.

Host Index.

Each species is given a number and these are consecutive for the three papers. The 1915 list includes nos. 1-141; the 1917 list nos. 142-155 and the present list nos. 156-167. In the first part of the present list the numbers refer to the same species as in the 1915 and 1917 lists. Numbers in black faced type indicate that the host is mentioned in the present paper. Numbers in ordinary type indicate that the host is mentioned only in one of the two previous papers. Synonyms are in italics.

A CONVENIENT LABORATORY PLANT PRESS.[1]

H. S. JACKSON, Purdue University.

The drying of plants is at best a laborious and uninteresting, though very necessary phase of the making of an herbarium and in the preservation of plants for illustrative or class study purposes. The old system of changing dryers has, in large part, given way in recent years to more modern and time saving methods. The introduction of the use of corrugated strawboard between the dryers and the utilization of some source of artificial heat for drying the plants[2] has taken much of the drudgery from the old methods and in general has resulted in a better quality of herbarium material.

The writer has used a simple type of plant press during the past ten years which has proven very practical and satisfactory for general laboratory purposes. On account of the simplicity of construction and the low initial cost of this apparatus it has seemed desirable to furnish a description of it with specifications and illustrations for the benefit of those who may not have solved the problem of drying plants to their satisfaction.

The first press of the sort to be described was constructed in 1911 for use in the laboratories of the Department of Botany and Plant Pathology at the Oregon Agricultural College. From one to four of them have been in constant use there since that time both for general laboratory purposes and for use in connection with classes in taxonomic botany. The writer has also used, since 1915, presses of similar construction in the Botanical Department of the Purdue Agricultural Experiment Station. A number of persons from other laboratories who have seen these presses in use at one or the other of these institutions have adopted a similar type.

The apparatus consists essentially of a box with rack on which the plant press rests, provided below with a source of heat (Fig. 1). The box is 15 by 18½ inches, inside measurement, and is open at top and bottom. It may be made square 18½ by 18½ inches if desired. The sides are made of one inch boards, ten inches wide and fastened together with screws. A rack on which the press rests (Fig. 2) is provided and placed three inches from the top of the box. This is made of material one inch square and is fastened all the way around the inside of the box. One or two cross pieces are added as illustrated, though are perhaps unnecessary. Yellow poplar lumber is found to be very satisfactory as it is not so liable to warp as some other kinds.

Heat may be conveniently supplied by two or three carbon filament electric light bulbs, the sockets for which are fastened about three inches from the bottom. Two sixteen candle power lights are sufficient for ordinary purposes, depending somewhat upon the succulence of the plants to be dried. It is well, however, to provide three sockets placed in such a way as to give the most uniform disribution of heat. The writer has also used, with entire satisfaction, special heating units of low resistance so

[1]Contribution from the Department of Botany, Purdue University Agricultural Experiment Station.

[2]Riker, P. L., Directions for collecting Plants. Bur. Pl. Ind. U. S. Dept. Agr. Circ. 126:27-35. 1913.

constructed as to fit in any standard electric light socket. Any convenient method of supplying heat by electric current may be used. It is important, however. that only a small amount of heat be supplied. It is only necessary that a draft of warm air passes through the corrugated boards of the press. Three one inch auger holes two inches from the bottom are provided on each side of the box to allow for intake of air.

The sides of the press are made of one inch boards 12½ by 18 inches. It is best to fasten a piece one and one-half inches wide crosswise at either end to prevent warping. This should be tongued and grooved and glued. Canvas straps with friction buckles are permanently fastened to the boards at either end as shown in the illustration. These should be of such length as to allow for the maximum expansion which the width of the box permits with sufficient additional length to conveniently allow for drawing the press tight. Double faced corrugated straw boards cut so

Fig. 1.—The Plant Press in Use.

Double faced corrugated card boards. cut so that the corrugations extend the short way. are used between the driers.

Heat is supplied by two or three carbon filament electric light bulbs. or by special heating units constructed to fit an ordinary electric light socket.

Any thickness of press. within the limits of the width of the box. can be used. Boards one and one-half or three inches wide are provided to fill in the space at the sides of the press on the rack when only a small amount of material is to be dried.

Ventilation is provided by six one inch auger holes placed three on each side of the box, two inches from the bottom. Photo by M. W. Gardner.

that the corrugations run the short way are used between the dryers. When succulent material is to be dried it is perhaps preferable to use one corrugated board between each pair of dryers. For the ordinary type of material two plant sheets with three dryers between each pair of corrugated boards is found entirely satisfactory. Grasses and other similar plants will be found to dry satisfactorily when three specimens and four dryers are placed between the corrugated boards. Folded sheets of newspaper are found to be entirely satisfactory for use as plant sheets, though the special sheets for sale by all dealers in herbarium supplies are preferred by many collectors. When plants are being dried for illustrative purposes a layer of sheet cotton may be used to advantage between the specimen sheets and the dryers.

When only a few plants are to be dried and the press is thin, a floor of loose but closely fitting boards should be laid on each side of the press on the rack so that all the heat will pass through the corrugated boards. For this purpose four boards 18 inches long, two or which are one and a half inches, and two three inches wide should be kept conveniently at hand.

Most material will dry in this press in less than twenty-four hours though very succulent plants will require a longer time. If the press is turned over every few hours during the early part of the drying period

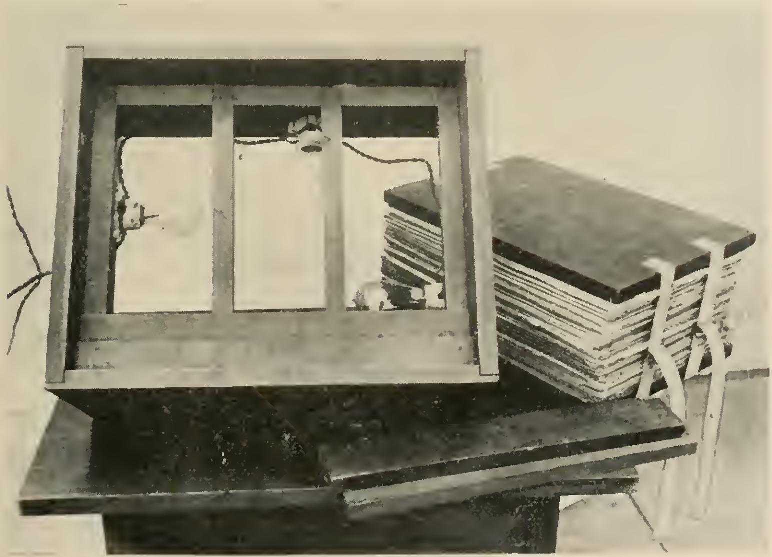

Fig. 2.—Box Raised on Edge to Show Construction.

The inside dimensions of the box are 18½ by 15 inches. The sides are ten inches high, open at the top and bottom. Sockets for electric lights are placed three inches from the bottom, and the rack on which the press rests is three inches from the top.

The press is made from one inch boards, 12½ by 18 inches. Canvas straps with friction buckles are provided at either end as illustrated.

Note the loose boards which are used for a floor at sides of press when only a small quantity of material is being dried. Photo by M. W. Gardner.

the plants will dry in a shorter time. As the plants become dry considerable shrinkage occurs and it is desirable to tighten the straps once or twice.

Where large quantities of plants are being dried at one time the apparatus described may not prove as satisfactory as some other methods in use, though a battery of four or five such presses will be found to be ample for ordinary class work. For the laboratory which has only occasional use for a plant press or for the individual collector it will, we believe, be found quite satisfactory.

INDIANA PLANT DISEASES, 1920.[1]

MAX W. GARDNER.[2]

INTRODUCTION.

In accordance with the plan outlined in last year's report,[3] the plant disease situation in Indiana for the season of 1920 is summarized herein as completely as our reports and observations permit. As in the previous report, the economic point of view is maintained.

WEATHER CONDITIONS.

The important relation of the weather to crop diseases warrants a brief report based upon the monthly summaries of Mr. J. H. Armington of the federal weather bureau at Indianapolis.

The extremely cold, wet weather of April delayed farm operations and retarded crops several weeks. The first half of May was also very cold, culminating in frosts the 14th and 15th which caused considerable injury to fruit. In some localities seed potatoes rotted in the ground because of the cold wet weather.

The latter part of May and all of June and July were in general favorable to crops. June and July were exceptionally cool and rainfall was fairly abundant. Severe hail injury occurred at Vincennes, June 1, at Madison, June 14, and at Kokomo, Berne and Decker the 23rd. At Decker the injury to corn, wheat, oats, tomatoes, melons, peaches and apples caused a loss estimated at 150,000 dollars.

August was also fairly cool and the whole summer up to the end of August was characterized by the absence of any period of heat and drouth. This type of weather greatly lessened the destructiveness of the Fusarium soil diseases such as cabbage yellows and favored the prevalence of such diseases as Septoria leaf-spot of tomato.

September was very hot especially during the latter half with less rainfall than in previous years in central and northern Indiana and dry warm weather continued well into October. This type of weather favored the ripening of fall crops and at the same time was not especially conducive to plant diseases. Light frosts occurred October 20 and heavy frosts the end of the month.

In general the 1920 season was distinctly different from its predecessor and the difference in weather is rather strikingly reflected in the plant disease conditions.

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[1]Contribution from the Botanical Department, Purdue Agricultural Experiment Station, Lafayette, Indiana.

[2]The writer wishes to acknowledge the assistance of Prof. H. S. Jackson, Mr. F. J. Pipal, Mr. G. N. Hoffer, Mr. J. B. Kendrick, Dr. C. T. Gregory and Dr. E. B. Mains of the Botanical Department and Messrs. C. L. Burkholder, F. P. Cullinan, F. C. Gaylord and H. D. Brown of the Horticultural Department of Purdue Agricultural Experiment Station. Most of the illustrations are taken from photographs made by Mr. Kendrick.

[3]*Gardner, Max W.* Indiana plant diseases, 1919. Proc. Ind. Acad. Sci. 1919, in press.

Diseases Arranged by Hosts.

APPLE.

Blotch (Fig. 1) caused by *Phyllosticta solitaria* was severe on the susceptible varieties throughout the southern half of the state and was noted at Peru by F. P. Cullinan, in DeKalb county by C. T. Gregory, and as far north as Delphi, Columbia City, Steuben county and Lake county by C. L. Burkholder. The Mann and Maiden Blush should be added to the list of

Fig. 1. Apple blotch.

susceptible varieties in the 1919 report. At Mitchell, Prof. Greene noted abundant fruit infection June 10 and petiole lesions were noted at Mooresville June 11. Unsprayed Northwestern Greenings at Knightstown showed as high as 91 per cent fruit infection and 39 per cent petiole infection and at Mooresville as high as 97 per cent fruit infection and 83 per cent petiole infection. Counts made by Burkholder in Clark county showed 97 per cent fruit infection on unsprayed Ben Davis trees. Good control was secured with Bordeaux sprays 2, 4 and 6 weeks after petal fall, while sulphur dust, Bordeaux dust and dormant sprays were ineffective.

Scab (Fig. 2) caused by *Venturia inaequalis* was especially severe in the southern part of the state but rather light in the northeast quarter of the state where its ravages are usually the worst, according to reports by Burkholder and Cullinan. Burkholder reports very little scab on unsprayed check plots in Whitley county except upon Ben Davis and Fameuse. On the other hand, the same observer reports that scab was more severe in the region between Crawfordsville and the Ohio river than in the preceding three seasons. At Mooresville, June 25, scab was noted to be abundant on

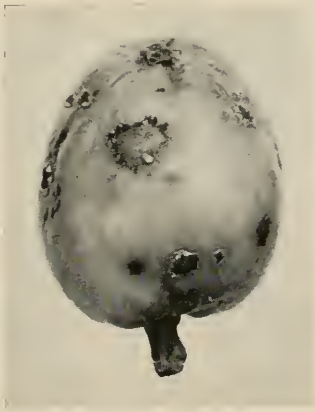


Fig. 2. Apple scab.

the leaves and fruit of Chenango, Benona, N. W. Greening, Jonathan, and Ben Davis, while there was very little on the Transparent and Duchess. Early infection of the fruit caused much cracking and malformation which was followed by secondary rots late in the season.

Observations upon varietal susceptibility by Burkholder indicate that the varieties Moyer's Pride, Salome, Ben Davis, Winesap, Rome Beauty, Delicious and Fameuse are very susceptible to scab, while resistance is shown by the varieties Yellow Transparent, Early Harvest, Stark, Flore Belle, Bellflower, Stayman Winesap, York Imperial, Black Twig and Grimes Golden.

Black rot due to *Physalospora cydoniae* occurred generally throughout the state on apple foliage. In one orchard in May the extreme prevalence of the frog-eye leaf-spot on trees badly affected with blotch was of interest because the black rot fungus is very commonly present in the old blotch cankers. In an orchard near Vincennes a local out-break of the frog-eye leaf-spot was very evidently associated with a limb which probably had been killed by fire-blight and was harboring the black rot fungus. On the other hand this leaf-spot was also present on young, well cared-for trees. June 25 the leaf-spot was noted to be especially bad on the varieties Ben Davis and Jonathan. The fruit rot of the blossom-end type as well as the type following blotch, scab and worm injury was very common late in the season.

Fire blight due to *Bacillus amylovorus* was very common on apple trees near blighted pear trees. Because of the prolonged growing season this year the attacks of fire blight continued well into the summer. July 2 this disease was found rather prevalent on certain varieties in a large orchard near Vincennes. An orchardist at Laurel found that thorough spraying for aphis control was effective against blight and that improper spraying resulted in an increased amount of blight.

Sooty blotch and fly speck (*Leptothyrium pomi*) were very common on certain varieties.

Rust (*Gymnosporangium juniperi-virginianae*) was very severe on t foliage of susceptible varieties. It was noted on Jonathan fruit a foliage in Morgan County June 25.

Powdery mildew (*Podosphaera leucotricha*) was found on the Missouri Pippin variety at Ladoga by Dr. P. J. Anderson.

The collar rot of the Grimes variety which was recorded last year (as root rot) as prevalent in southern Indiana causes the greatest fatality when the trees are 20 to 25 years old according to Burkholder. He reports one case of a 25-year-old orchard near Madison in which 25 per cent of the trees are dead or dying. Since the Grimes is otherwise a very desirable variety for southern Indiana it has been successfully top worked on other stocks.

In the case of all varieties planted on newly cleared land, Burkholder reports that a certain percentage of root rot has occurred.

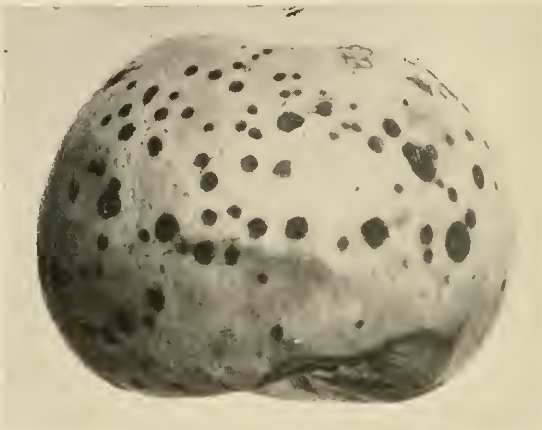


Fig. 3. Apple Jonathan spot.

Jonathan spot (Fig. 3) was noted at Mooresville. Cullinan reports this trouble as very prevalent this year and found it present on unpicked fruit at Laurel. Burkholder noted the same thing in Porter County and on King and Black Twig apples still on the trees at Aurora.

Bitter pit was rather common on Stark apples at Mooresville and is reported by Cullinan as common on Stark, Grimes, and Baldwin apples. Water core was found at Knightstown.

Frost injury occurred in many sections. At Mooresville blossom clusters and whole spurs were killed outright and the set of fruit was severely cut. Some frost banding also occurred. The first leaves were stunted, dark green and wrinkled and many turned yellow and dropped off.

Severe hail injury occurred near Decker June 23 and the quality of the crop was greatly lowered. In one orchard the entire crop was rendered unfit for market by the extreme malformation resulting from the hail bruises.

According to Burkholder spray injury to leaves and fruit occurred at itchell and in Clark county where a drenching application of 4-6-50 Bordeaux was used in blotch control work.

ASTER.

The Fusarium wilt is a very serious problem for the florists of the state and is of rather general occurrence.

BARLEY.

Bacterial blight caused by *Bacterium translucens* was noted May 26 near Lafayette. *Helminthosporium teres, H. gramineum, H. sativum* and *Rhynchosporium secalis* were noted near Lafayette by Dr. A. G. Johnson June 10.

Loose smut (*Ustilago nuda*) was reported by F. J. Pipal as severe in some fields. Stem rust was found in one field in Lake county.

BEAN.

Bacterial blight caused by *Pseudomonas phaseoli* was the most serious disease of this crop and was exceptionally severe this year both on foliage and pods. It was prevalent in the Indianapolis market gardens and was also noted near Kokomo, Wanatah, Plymouth, Hammond and Campbellsburg. Blight also was found severe on the foliage and pods of a row of Lima beans adjacent to a row of badly blighted kidney beans.

Mosaic was generally present in most gardens observed, but not as a rule on a high percentage of the plants until late in the season.

Root rot due to a Fusarium species was noted early in the season causing the death of scattered plants in market gardens. Rust (*Uromyces appendiculatus*) was found in fields near Plymouth and Wanatah. No anthracnose was noted.

Leaf-spot of Lima bean due to *Phyllosticta phaseolina* was very prevalent and destructive in gardens near Indianapolis and Lafayette.

BEET.

Leaf-spot caused by *Cercospora beticola* was not at all common this year and was noted only at Goshen late in the fall. A crown rot caused by Rhizoctonia invasion through growth cracks and broken leaf bases was found in the sugar beet crop about Hammond.

Nematode root-knot caused by *Heterodera radicicola* was found in muck soil near Goshen and badly affected plants were stunted and worthless. An area of several acres in the celery marsh near that city has been infested with nematodes and rendered unfit for truck crops for at least six years.

BLACKBERRY.

Pipal reports that orange rust (*Gymnoconia peckiana*) destroyed one planting in Posey county. Anthracnose caused by *Plectodiscella veneta* was noted in one planting near Mooresville, but was not nearly as severe as on raspberries.

CABBAGE.

Yellows caused by *Fusarium conglutinans* remains the limiting factor in this crop but was not as severe this year as in 1919 owing to the cooler temperatures. It was prevalent in small gardens as well as fields and the cabbage soils of the state are pretty generally infested. In Lake county the resistant Wisconsin Hollander is coming into rather general use as a late crop. A trial of the yellows-resistant Copenhagen developed at the Iowa station was made in Lake and Marion counties but the growers were not satisfied with the type.

Black rot caused by *Pseudomonas campestris* was noticed this year and black-leg due to *Phoma lingam* was found in Lake county and in several market gardens near Indianapolis. Clubroot occurred in a few fields in Lake county. Hail injury intumescences were noted in one field near Indianapolis.

CANTALOUPE.

Bacterial wilt caused by *Bacillus tracheiphilus* was the most important disease of this crop and its attacks continued until much later in the season than usual. Early in July, 2 to 10 per cent infection was found in fields near Decker and Princeton and the disease was later noted near Indianapolis and Lafayette. Where the hill system of culture is used, wilt often causes large blanks in the fields and in a bad wilt season like 1920 the row system is preferable.

Leaf blight caused by *Alternaria brassicae nigrescens* was generally prevalent and particularly destructive this year. In the Decker region it was just beginning to show up July 1 and by the end of the season was the most prevalent disease. Not only was it severe on the old cantaloupe fields, but it also occurred in new soil not previously in cantaloupes. In the latter case, however, the epidemic came too late to do serious damage.

Mosaic was found in several fields early in July and was rather serious even at that early date in one field near Princeton. Some plants showed such extreme effects of the disease that it seemed likely that the trouble was contracted before they were transplanted from the plant bed. Late in the season mosaic was very general in the Decker region but the attack seemed to have been of rather late inception and probably was correlated with the heavy aphis infestation. No anthracnose was found.

CARNATION.

Rust (*Uromyces caryophilinus*) was generally present in greenhouses.

CARROT.

Nematode root-knot occurred in the infested area of muck soil near Goshen.

CAULIFLOWER.

Yellows caused by *Fusarium conglutinans* occurred in several market gardens about Indianapolis. A Sclerotinia stem rot was found killing many plants in one garden.

CELERY.

The Fusarium yellows was not serious this year. The growers near Lafayette and Goshen are using the resistant Easy Bleaching variety in place of the susceptible Golden Self-blanching.

Early blight caused by *Cercospora apii* was found very severe in the Goshen crop and also near Lafayette late in the fall. The bacterial leaf-

Fig. 4. Celery bacterial leaf spot.

spot (Fig. 4) was severe in the Goshen crop and along with early blight was killing many leaves. Long petiole lesions were very common. This disease was also found near Lafayette and Indianapolis.

Late blight caused by *Septoria petroselini* was noted near Goshen and Lafayette but was not as destructive as early blight. Possibly the higher temperatures prevailing in Indiana cause early blight to be more destructive than late blight.

A mottling of the foliage of the Easy Bleaching variety suggestive of a mosaic disease was noted at Goshen and Lafayette. Nematode root-knot was found at Goshen. Affected plants were badly stunted and displayed a peculiar type of tipburn.

CHERRY.

Leaf-spot (Fig. 5) due to *Coccomyces hiemalis* was the most serious disease. Yellowing of the leaves and defoliation are caused and unaffected

Fig. 5. Cherry leaf spot.

trees are rarely found. Powdery mildew (*Podosphaera oxyacanthae*) was noted at Wanatah.

CHRYSANTHEMUM.

Leaf-spot due to *Septoria chrysanthemella* was noted in a greenhouse.

CLOVER.

Anthracnose due to *Colletotrichum trifolii* was the most important disease.

CORN.

As was the case in 1919, the Fusarium root, ear and stalk rots were the most serious diseases. Pipal reports three fields plowed up because of root rot.

Smut was generally abundant this year and was especially severe on sweet corn. Gregory reports observations which indicate that early smut infection caused barrenness. Rust was of general occurrence. One plant affected with the leaf-spot caused by *Physoderma zeae-maydis* was found at Shelbyville by J. F. Trost. Severe hail injury occurred in many sections.

COWPEA.

Leaf-spot due probably to *Phyllosticta phaseolina* was found very abundant both on leaves and pods in a field near Decker August 19. This disease was noted at Vallonia in 1919.

CUCUMBER.

By far the most serious disease was bacterial wilt due to *Bacillus tracheiphilus.* This disease was noted in greenhouses and market gardens, and in the pickle crop about Plymouth wilt was far worse than previously recorded and continued its attack well into the season. Where the single-plant-to-the-hill system of culture was used, wilt caused many unproductive blank spaces in the fields, and row planting would have been preferable to hill planting this season.

Fig. 6. Cucumber mosaic.

Mosaic (Fig. 6) was not prevalent in greenhouses but in the pickle crop was very destructive and ranked next to wilt in importance. It was found in 12 out of 15 fields examined near Plymouth, August 31, but in general the attack seemed to be of recent inception. The outstanding symptom was the yellowing rather than the mottling of the foliage.

Anthracnose due to *Colletotrichum lagenarium* was destructive in the same greenhouses where it occurred last year and was again associated with the practice of overhead watering. No fruit infection has been noted.

Angular leaf-spot caused by *Bacterium lachrymans* was found in cold-frame cucumbers and to a slight extent in the pickle crop about Plymouth. Seed disinfection for this disease is now practiced by the Heinz company and their crop is relatively free from infection.

A basal canker bearing the sclerotia of a Sclerotinia was found killing one greenhouse plant.

EGGPLANT.

Wilt (cause unknown) was present in the market garden where it was noted in 1919 but was not as destructive this year.

GOOSEBERRY.

Powdery mildew (*Sphaerotheca humuli*) occurred in Wabash county. Specimens of anthracnose caused by *Pseudopeziza ribes* were received from Marion, Indiana.

GRAPE.

Leaf-spot caused by the black-rot fungus (*Guignardia bidwellii*) was found abundant in a planting in Morgan county. Downy mildew (*Plasmopara viticola*) occurred in White and Pulaski counties and severe fruit infection was noted. The disease was also noted on the foliage of wild grape at Decker and in DeKalb county. Undoubtedly the wet season favored the appearance of this disease.

KALE.

Yellows caused by *Fusarium conglutinans* was very destructive in the Indianapolis market gardens.

LARKSPUR.

A root and crown rot apparently caused by *Sclerotium rolfsii* was found near Indianapolis by Dr. W. W. Bonns of the Eli Lilly Company.

LETTUCE.

Downy mildew and Botrytis rot were as usual prevalent in the winter greenhouse crop. A spotting of lettuce apparently of bacterial origin was found rather destructive in a market garden near Indianapolis August 17. Nematode root-knot was found in the infested muck soil near Goshen.

OATS.

Leaf-spot caused by *Helminthosporium avenae* was noted near Lafayette, May 26. Halo blight caused by *Bacterium coronafaciens* was found in Lake county. The smuts are becoming less abundant owing to the rather general practice of seed disinfection.

ONION.

Smut caused by *Urocystis cepulae* (Fig. 7) was again present in the two onion set fields in Lake county mentioned in last year's report but was

Fig. 7. Onion smut.

fairly well controlled by the formalin drip on the seed drill. The soil of these fields is heavily infested.

Smudge caused by *Colletotrichum circinans* occurred to some extent on white bulb onions in market gardens.

PARSNIP.

A leaf-spot of unknown cause and nematode root-knot were found near Goshen.

PEACH.

Taking the state as a whole, leaf curl caused by *Exoascus deformans* was by far the most destructive peach disease and according to Burkholder was much worse than it was during the three previous seasons. Burkholder reports that the disease was severe in Marion, Henry, Shelby, Bartholomew, Brown, Monroe, Putnam, Knox, Daviess, Gibson and Vanderburg counties and especially severe in Morgan and Montgomery counties. Not only was extreme defoliation caused but the young fruit was directly attacked by the fungus. As a result there was a heavy fall of the fruit at the time of the attack and the fruit continued to drop off all through the season. In an unsprayed orchard near Mooresville examined June 25, most of the fruits still remaining on the trees were affected with the large, red, "birthmark" lesions of this disease which in most cases caused marked cracking and malformation. At this time most of the affected leaves had fallen and were replaced by new foliage. In the fall Burkholder noted that in such orchards the foliage was held about two weeks longer and that only about one-half the normal twig growth was made.

In the Mooresville orchard mentioned above, the varieties Elberta and Big Red were much more severely affected than the Champion and Hale and most of the fruit on the first two varieties had fallen prematurely. The following observations on varietal susceptibility were made by Burkholder: The Crawford was damaged more than any other variety in the state and in Morgan and Montgomery counties there was a total loss of the crop on this variety. The crop on the Elberta variety was cut from three bushels to one peck and the variety Belle of Georgia was fully as susceptible as the Elberta. The Champion variety bore but half a crop because of this disease. In the same localities the varieties Admiral Dewey, Carman, Smock and Salway bore full crops. Smock and Salway were especially resistant and showed practically no foliage infection and bore so heavily that it was necessary to thin the crop one-half. Burkholder further observed that Scalecide was not effective against curl and that a thorough application of the lime sulphur dormant spray was necessary. The disease was destructive in an orchard where the spraying was done with a spray gun on a windy day and unsprayed strips were left on the branches.

Next to leaf curl, black spot caused by *Bacterium pruni* was the most serious peach disease and was much worse than in 1919. Burkholder reports that this disease was severe in Vanderburg, Daviess, Orange, Greene and Lawrence counties and worst in Knox and Gibson counties. Black spot was so destructive on the Hale variety in one orchard near Vincennes that the affected fruits were hauled out by the barrel in June. Early in July it was found prevalent on foliage and fruit and to some extent on twigs of the current year's growth. Yellowing of the affected leaves and defoliation were the result. Severe hail injury to the fruit occurred in the region about Decker and almost every hail wound was infected with this organism so that large blackened cavities occurred on a considerable percentage of the fruit. Twig invasion through hail wounds was also very general and Burkholder observed twig attack which was severe enough to cause shriveling and premature dropping of the fruit.

Burkholder further observed that in orchards containing both the Elberta and Hale varieties the Hale was much more severely affected by this disease. The same observer noted that no control of this disease was obtained in orchards thoroughly sprayed with lime sulphur but that orchards, 11 to 12 years old, which had received several heavy applications of barnyard manure during their history, showed remarkable resistance to this disease. He further noted that two to three applications of sodium nitrate to orchards of the Hale variety during the current season had no apparent effect upon the disease.

Burkholder reports brown rot, caused by *Sclerotinia cinerea*, from Knox, Gibson, Vanderburg, Daviess, Greene, Morgan, Henry, Montgomery, Floyd, Clark and Jefferson counties. He found brown rot worse in the orchards affected with the black spot disease and according to his observations the varieties Champion and Carman were most severely affected. Hale was less severely attacked, while the Elberta variety was affected the least. Except in Vanderburg county where brown rot was the worst, Burkholder found that spraying controlled the disease fairly well. Very little brown rot was found in the crop in the Decker region probably because of the care given to the orchards.

Scab due to *Cladosporium carpophilum* was unusually prevalent in the Decker region and was generally present on fruit in local markets.

Die-back attributed to *Valsa leucostoma* was found by Burkholder in neglected sod orchards in Brown, Bartholomew, Greene, Orange and Daviess counties.

In the Decker region the hail storm of June 23 caused severe damage to fruit and limbs. Splitting and breaking down of the heavily loaded trees in one orchard at Decker were attributed to 1918-19 winter injury and Burkholder reports 1919-20 winter injury in Spencer County.

PEAR.

Fire blight continued its attack rather late into the season and was generally present throughout the state. Leaf infection was noticed at Knightstown July 6.

Sooty blotch was noted at Knightstown September 21. Black rot caused by *Physalospora cydoniae* was rather prevalent in the crop about Mooresville.

PLUM.

Brown rot was unusually destructive this year. Plum pockets was reported from Delaware county.

POTATO.

Tipburn or hopperburn was not as severe as in 1919 although it caused a heavy loss in the late crop. It seemed to be worse in the central part of the state. Bordeaux sprays seemed to control this trouble at Lafayette.

Fusarium wilt was the most serious disease in the northern half of the state and caused considerable loss. F. C. Gaylord reports the disease from Porter, LaPorte, St. Joseph, Elkhart, Kosciusko, DeKalb, Tippecanoe, Hancock, Marion, Owen and Decatur counties. Gregory found wilt also in Lagrange and Floyd counties. Undoubtedly much of this trouble was due to the use of infected seed. A field test near Valparaiso showed a marked reduction in yield due to the use of infected seed stock. That soil infestation is responsible for much of the wilt is indicated by the occurrence of the disease in about equal percentages in test plots planted with seed from widely separated sources and by the abundance of the disease in a field planted with seed carefully selected for freedom from wilt.

Early blight caused by *Alternaria solani* was found epidemic in a field of early potatoes near Indianapolis July 17, and the disease was also noted at Lafayette in the late crop. In October Gregory and Gaylord found early blight prevalent in Floyd and Clark counties in the extreme southern end of the state.

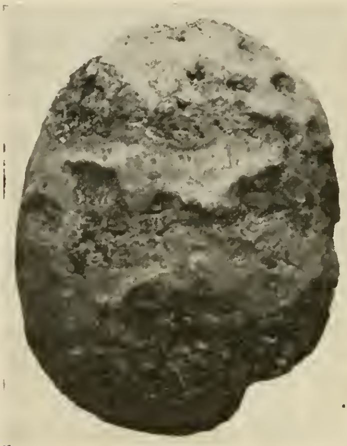


Fig. 8. Potato scab.

Common scab (Fig. 8) was of general occurrence where untreated seed was used and soil infestation is not uncommon since scab occurred in some fields planted with treated seed. As a result of the observations of Gaylord and Gregory scab is known to have been present in Lake, Porter, Laporte, St. Joseph, Lagrange, Dekalb, Fulton, Cass, Whitley, Carroll, Tippecanoe, Clinton, Madison, Hancock, Marion, Clark and Floyd counties.

Black scurf caused by *Rhizoctonia solani* was of widespread occurrence as a blemish of the tubers. The disease also caused the stunting and death of young plants. Gaylord and Gregory report black scurf from Lake, Porter, St. Joseph, Elkhart, Lagrange, Fulton, Tippecanoe, Madison and Clark counties. In seed disinfection tests in Lake county as high as 67 per cent of the tubers in the check rows showed black scurf. The occurrence of a small percentage of black scurf on the tubers from disease-free and treated seed indicated that the soil of this field which had not been in potatoes for five years was infested to some extent.

Gregory reports cases of black-leg caused by *Bacillus phytophthorus* in Laporte, Tippecanoe and Hancock counties.

Gregory found the non-parasitic leaf roll disease in St. Joseph, Noble, Fulton, Hancock, Clark, Floyd and Dekalb counties and reports it rather serious in fields noted in the latter three counties. In one field in Dekalb county he reports a 50 per cent incidence of the disease and a 25 per cent reduction in yield. When potatoes grown in the Wanatah region were planted in the greenhouse a low percentage of typical leaf roll plants resulted.

Three typical and extreme cases of the mosaic disease occurrd in an experimental field at Lafayette planted with Indiana-grown Rural New Yorker seed. Gregory reports a 37 per cent loss in yield in a field of Early Ohio potatoes in Dekalb county due to mosaic and a 100 per cent infestation of mosaic in a field of the Bliss Triumph variety in Floyd county.

The potato situation in the vicinity of Hammond presents a serious problem. In past years high yields were obtained but now 40 to 60 bushels per acre is representative. The plants are distinctly stunted, the leaves curled and wrinkled and the yield reduced to one or two small tubers. Imported seed, especially from the Wanatah region, is considered far more desirable than home grown seed. Typical mosaic symptoms are not present but it is suspected that the trouble is due to this disease.

Considerable difficulty was experienced this year as a result of rotting of the seed pieces in the soil before the sprouts were up. This caused the occurrence of many blank spaces in the fields.

QUINCE.

Fire blight caused by *Bacillus amylovorus* was reported from several localities.

RADISH.

Black-root was noted in cold frames near Indianapolis June 4. Downy mildew (*Peronospora parasitica*) and white rust (*Cystopus candidus*) were found on plants going to seed July 17. Marked hypertrophy of the floral parts was caused and lesions caused by both fungi were present on the seed pods.

RASPBERRY.

Anthracnose caused by *Plectodiscella veneta* is undoubtedly the limiting factor in raspberry culture in many sections of the state and was especially severe this year. Burkholder reports the disease present in the following counties: Lake, Laporte, Lagrange, Steuben, Cass, Miami, Wabash, Fountain, Bartholomew, Greene, Knox, Vanderburg, Warrick, Lawrence, Orange, Washington, Floyd and Jefferson. Specimens were received from Whitley and Madison counties and it was also found in Morgan and Marshall counties. The coalescence of old lesions of the previous year about the bases of the bearing canes produces a girdling effect which causes the leaves to be stunted and yellowish and the fruit to ripen prematurely. Affected canes often die before any fruit is matured. Anthracnose lesions were noted on newly planted scions and the disease is undoubtedly introduced into new plantings with diseased cuttings.

Leaf-spot due to *Septoria rubi* was found in Lake county.

RHUBARB.

Leaf-spot due to *Ascochyta rhei* was present in practically all plantings examined.

ROSE.

Powdery mildew (*Sphaerotheca pannosa*) was prevalent this year. Black spot caused by *Diplocarpon rosae* (Fig. 9) occurred in greenhouses.

Fig. 9. Rose black spot.

RYE.

Ergot was noted on volunteer rye. Stem rust was found in one field in Lagrange county by R. J. Hosmer. Six specimens of a head smut (Ustilago sp.) were found by Jackson in one field in Porter county.

SOYBEAN.

Bacterial blight caused by *Bacterium glycineum* was prevalent in fields near Lafayette. Leaf infection was very heavy but pod infection was not as abundant.

An unmistakable mosaic disease occurred on a small percentage of the plants in one field. The leaves showed typical mosaic symptoms, the pods were fewer and smaller, and very few seeds were produced. In fact mosaic plants were practically a total loss so far as seed production was concerned. There were several rows of garden beans along one side of this field which were severely affected with mosaic and it is possible, of course, that the disease may have crossed over to the soybeans from the garden beans.

SPINACH.

The non-parasitic yellows or blight which is so severe in the truck region near Norfolk, Va., was found near Goshen in October. Typical stunting of the plants and yellowing of the leaves were produced.

SQUASH.

Bacterial wilt was noted near Lafayette.

STRAWBERRY.

Leaf-spot caused by *Mycosphaerella fragariae* was of general occurrence.

SWEET POTATO.

Black rot caused by *Sphaeronema fimbriatum* (Fig. 10) and scurf caused by *Monilochaetes infuscans* were present in the seed being planted on one farm near Vincennes.

Fusarium stem rot was of rather widespread occurrence and was noted at Vincennes, Indianapolis and Lafayette, in some cases, in fields not previously in sweet potatoes. This disease caused stunting, yellowing or wilting, and premature death of the vines and a conspicuous blackening of the interior portions of the stems.

Fig. 10. Sweet potato black rot.

TIMOTHY.

Stripe smut caused by *Ustilago striaeformis* was collected near Lafayette by Dr. A. G. Johnson.

TOMATO.

Septoria leaf-spot was worse than last year and was by far the most serious and widespread parasitic disease of tomatoes. It was generally present in gardens and the canning crop and the wet weather greatly favored its development. In many cases extreme defoliation was caused and the fruit was exposed to sunscald. In an experimental field near

Lafayette the disease was so severe that late in September only tufts of the youngest leaves remained on the plants.

As usual Fusarium wilt was severe in the Indianapolis greenhouses. The wilt-resistant Marvel variety has proved acceptable to one greenhouse grower as a substitute for the Bonny Best. Out of numerous single plant selections made last year with the purpose of isolating a wilt-resistant strain of Bonny Best, two showed good resistance but both came into bearing too late to suit the desires of the growers.

In the field crop wilt was noted as a rule only on scattered plants. From two to six per cent of wilt was found in 12 out of 14 fields visited near Kokomo July 13. In certain of these fields set with southern-grown plants it was practically certain, judging from the distribution and severity of the disease, that it was introduced with these plants. This illustrates a danger in the use of southern-grown tomato plants by Indiana canners. Wilt has not yet become a serious factor in the Indiana canning crop owing to the fact that so much new soil has been available and crop rotation has been practiced. In gardens and old tomato fields the disease persists and there are indications that it is also harbored in plant beds. The disease is very destructive under Indiana conditions and infestation of the soil should be guarded against.

Mosaic was not as severe as in 1919, although it was very general late in the season. In a late epidemic of this kind the yield is not noticeably reduced but plants infected early in the season are likely to be valueless. In one field near Indianapolis there was practically 100 per cent infection of mosaic, much of it of the dwarfed, fern-leaf type which results in a very marked reduction in yield. In certain fields there was some indication that mosaic was carried with the seed but carefully controlled and rather extensive tests with seed from mosaic plants have so far yielded only negative results.

Fig. 11. Tomato anthracnose.

Evidence of the spread of mosaic by cultural practices in greenhouses was afforded in a canning crop near Hammond, the plants for which were grown in a greenhouse and trimmed back with a shears. One mosaic plant was found among the plants in the greenhouse and in the field crop grown from these plants mosaic was epidemic. In a greenhouse crop at Lafayette the spread of mosaic was very evidently associated with the use of the pruning knife.

Early blight caused by *Alternaria solani* was rather conspicuous in one greenhouse near Indianapolis, causing large target-board lesions on the leaves. The disease occurred in the Paoli region but was not very prevalent in central Indiana.

Leaf mold (*Cladosporium fulvum*) was severe in many greenhouses.

Anthracnose caused by *Colletotrichum phomoides* (Fig. 11) was especially prevalent this year late in September. In fields at Lafayette, a considerable percentage of the ripe tomatoes showed anthracnose lesions.

Bacterial spot caused by *Bacterium exitiosum* (Fig. 12) was rather general in the canning crop and was noted on seedlings in Georgia being grown for shipment to Indiana growers. It was also noted in plant beds in Indiana by H. D. Brown. Its attack on the foliage of plants in the field is not noticeably destructive but serves as a source of fruit infection which probably takes place through wounds made by insects. The black, scabby fruit lesions are very objectionable from the canner's point of view. The disease is carried over winter with the seed and seed disinfection in corrosive sublimate 1 to 3,000 for 5 minutes has been recommended as a control measure.

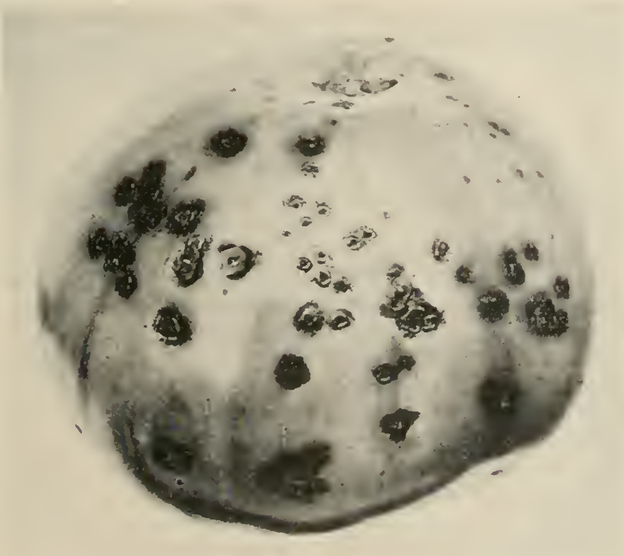


Fig. 12. Tomato bacterial spot.

Buckeye rot due to *Phytophthora terrestria* was noted in three greenhouses near Indianapolis. Only the lower fruits were infected and it is evident that infection was the result of splashing from the soil underneath. In one case the rotting fruits were picked off and thrown on the ground thus affording the fungus every opportunity to develop and spread to other fruits. Strict sanitation should of course be practiced in attempting to control this disease.

Blossom-end rot was very destructive in both the greenhouse and field crops on the early set of fruit and in the Lafayette region where the soil dries out very quickly the disease continued to be prevalent well into the season. In fields near Lafayette. H. D. Brown reports a loss of three tons per acre of green fruit actually removed because of this disease. This loss is appalling when one considers that the final yield was but eight tons per acre.

In the canning crop growth cracks probably occasion more loss in the aggregate than all the parasitic diseases combined and this trouble is about equal to blossom-end rot as a source of loss. Not only are growth cracks an objectionable blemish in themselves but most of the fruit rot late in the season in the canning crop both in the field and in the crates is due to the infection of these growth cracks by rot-producing organisms. Growth cracks cause heavier losses to the canner than to the grower since much of the fruit rot occurs after picking, whereas the loss due to blossom-end rot falls largely upon the grower.

Sunscald was very common owing to the foliage destruction by Septoria leaf-spot and consequent exposure of the fruit. Catface was very prevalent in the canning crop and is an objectionable blemish from the canner's standpoint. According to Dr. B. J. Howard of the Federal Bureau of Chemistry, the catface scars are prone to crack and permit rot infection.

A peculiar type of non-parasitic wilting of the plants occurred in the Paoli region and at Lafayette. Affected plants showed the hollow stem condition, the pith having dried out and collapsed even in the very young shoots. At Lafayette the affected plants were near a row of trees along the edge of the field and a similar relation was reported from Paoli so it is possible that this hollow stem wilt was due to soil drouth produced by the tree roots.

A small, circular, conspicuously white, raised spot with a darker center occurred rather commonly on tomatoes about Lafayette and Indianapolis. This has been called "white spot" or "bird's-eye spot" and is often associated with bacterial spot. Probably it is due to an insect injury.

A Sclerotinia stem rot was found on a few greenhouse plants following wounds and wilt infection. Wind scalding of the leaves was noted at Hammond July 27. Hail injury was conspicuous on fruits and stems in the Indianapolis region July 17.

From the standpoint of disease introduction the importation of tomato plants grown in the south for the Indiana canning crop is distinctly dangerous. Evidence of the introduction of Fusarium wilt into fields with southern plants was secured. Wholesale nematode infestation of the roots of the seedlings was found in shipments from several points in the south. Infested plants lived throughout the season when set out in Indiana fields but were stunted and below normal in yield. The galls on the old roots became very large and additional galls were formed on the new secondary roots sent out above the original infestation. Whether or not the soil of Indiana fields will remain permanently infested with nematodes is not known and tests are now under way to determine this point. In view of the persistence of the nematode infestation in muck soils near Goshen and Akron,—and the Goshen infestation is of at least six years standing,—it would appear to be a questionable practice to flood Indiana each spring with nematode-infested plants. Furthermore, H. D. Brown found nematode galls on tomato seedlings in a cold frame at Hardinsburg, a fact which would indicate that these nematodes already may be indigenous in certain localities in southern Indiana.

TURNIP.

An unquestionable mosaic disease of turnips was found near South Bend, Oct. 12, associated with a rather heavy infestation of tarnished plant bugs. The diseased plants were stunted and the leaves showed characteristic mosaic etiolation, mottling and dark green puffy areas.

Turnips and cabbage growing in the nematode-infested muck soil near Goshen were not affected with root-knot.

WATERMELON.

Fusarium wilt seemed to be generally present in fields previously used for watermelons. In one field near Princeton not in watermelons in six years about 2 per cent of the plants were killed by wilt. This indicated that the fungus persisted at least six years in the soil. In an 80-acre field on new soil near Vincennes no wilt was found.

Leaf-spot or blight caused by *Alternaria brassicae nigrescens* was found prevalent in one field near Decker August 19.

WHEAT.

The foot-rot widely announced as "take-all" in 1919 was found only in an experimental field near Wanatah where the disease occurred in 1919. The other infested fields were not replanted with wheat this year, however. This disease seems to be rather closely associated with the varieties Red Cross and Salzer's Prizetaker.

Scab caused by *Gibberella saubinettii*, which was very abundant in 1919, was not at all common this year. Pipal reports that it was serious locally in Davis and Posey counties.

Stem rust was not at all abundant on winter wheat except locally. Hosmer reports that some stem rust was noted in practically all localities where barberries were found and one rather extensive infestation occurred in Knox county. On spring wheat stem rust was more common. Leaf rust was common on spring wheat but was present to only a slight degree on winter wheat. In general this was not an epidemic year for either stem or leaf rust.

Bunt or stinking smut is in general becoming less prevalent in Indiana because of the wide use of the formaldehyde seed treatment. It was worse in the northern third of the state and its occurrence locally seemed to be associated with certain threshing rings.

Loose smut of wheat was not as prevalent as in 1919. While the average loss was about 2 per cent, in certain fields as high as 25 per cent of loose smut was found. Pipal reports that in 400 demonstration fields a practically perfect control was obtained by the hot water treatment while an average of 5.1 per cent of smut occurred in the check fields. The central treating plant control method is meeting with marked success.

SUMMARY.

The plant diseases of outstanding economic importance as observed during the 1920 season are as follows:

Apple..............blotch: scab: black rot: (hail injury).
Aster..............Fusarium wilt.
Bean...............bacterial blight: mosaic.
Cabbage............yellows.
Cantaloupe.........bacterial wilt: leaf-blight: mosaic.
Celery.............early blight; bacterial spot.
Cherry.............Coccomyces leaf-spot.
Corn...............Fusarium root, stalk and ear infection; smut.
Cucumber...........bacterial wilt: mosaic.
Kale...............yellows.
Onion (sets).......smut.
Peach..............leaf curl; black spot.
Pear...............fire blight.
Plum...............brown rot.
Potato.............Fusarium wilt; hopperburn or tipburn.
Raspberry..........anthracnose.
Soybean............bacterial blight . .
Tomato.............Septoria leaf-spot: Fusarium wilt: mosaic; blossom-end rot; infected growth cracks.
Watermelon.........Fusarium wilt.
Wheat..............loose smut: stinking smut.

Plant diseases found in 1920 which have not been previously recorded for Indiana:

Apple..............water core.
Barley.............bacterial blight caused by *Bacterium translucens;* leaf-spot caused by *Rhynchosporium secalis.*
Bean...............root rot due to Fusarium species.
Beet...............nematode root-knot.
Carrot.............nematode root-knot.
Cauliflower........yellows caused by *Fusarium conglutinans.*
Chrysanthemum......leaf-spot due to *Septoria chrysanthemella.*
Corn...............*Physoderma zeae-maydis.*
Cucumber...........nematode root-knot.
Larkspur...........*Sclerotium rolfsii.*
Lettuce............nematode root-knot.
Oats...............Halo blight caused by *Bacterium coronafaciens.*
Parsnip............nematode root-knot.
Peach..............die-back (*Valsa leucostoma*).
Pear...............sooty blotch
Soybean............bacterial blight caused by *Bacterium glycineum* (previously noted, Plymouth, 1918): mosaic.
Spinach............blight or mosaic.
Squash.............bacterial wilt.
Sweet potato.......scurf caused by *Monilochaetes infuscans;* Fusarium stem rot.
Tomato.............white spot or bird's-eye spot (cause unknown).
Turnip.............mosaic.

INDIANA FUNGI—V.

J. M. Van Hook.

In the present paper, sixty-eight species are listed. For the most part, these have been collected since 1915. While they are not all new to Indiana they are new to the species in the herbarium of Indiana University. The object here is not merely to make a list of those fungi new to the state, but to study independently all those brought to our notice or collected for the purpose of study, in Indiana. In these studies, special attention will be given to the so-called Imperfect Fungi and to extend the number of hosts of a single species.

The author has appended corrections and additions to the descriptions already given, since many of the earlier descriptions are so meager that many specimens which should have been referred to them, have doubtless been published as new species. These merely needed redescriptions. It is the belief of the author that a more critical study of material gathered in quantity and in various conditions of development, will go far to discourage new species making, as well as to bring about the reduction of the number of those already listed. The discovery of new hosts is especially to be desired as the form of the fungus may vary considerably with the host. The neglect of this careful study in the past has been conducive to the making of new species. While many new species exist, and while we have a number for future publication, we have come to believe that we can render a greater service to botanical science by extending descriptions already published.

Under those listed, no attempt has been made to give complete descriptions, but to note the variation from the original descriptions and to extend those descriptions.

When the place of collecting is omitted, it is understood to be Monroe County; likewise, when the collector is not mentioned, the specimen was collected by the author.

PHYCOMYCETES.

Albugo Portulacae (D.C.) O. Kuntze. On living leaves of Portulaca oleracea. Greene County, September 20, 1914. Weatherwax. 3686.

Empusa Muscae (Fr.) Cohn. On body of common housefly. Fly fastened to leaf of ash. July 28, 1916. 3697.

USTILAGINALES.

Schizonella melanogramma (D.C.) Schroet. Abundant on Carex picta, Huckleberry Hill, May 25, 1917. 3746.

Sphacelotheca Sorghi (Link) Clinton. On broom-corn, causing grain smut. October 25, 1918. Weatherwax. 3758.

THELEPHORACEAE.

Corticium cinereum Fr. On dead hickory, Bollman's Woods, March 6, 1902. F. Mutchler. 3724.

Stereum spadiceum Fr. On dead red oak bark, Huckleberry Ravine, October 22, 1917. 3749.

CLAVARIACEAE.

Clavaria amethystina Bull. Ground under oak tree, Griffey Creek, July 15, 1920. C. E. O'Neal. 3784. A beautiful plant easily recognized by its amethyst color.

AGARICACEAE.

Amanita bisporigera Atk. Ellis Creek, July 10, 1919. O'Neal. 3760. Several specimens were found in the border of a woods associated with A. phalloides and A. rubescens. It resembles A. phalloides but is much smaller. It can be really told from A. verna by its two-spored basidia.

Amanita flavorubescens Atk. On ground. Campus, June 21, 1920. 3771a. Griffey Creek, July 15, 1920. O'Neal. 3771b.

Amanitopsis farinosa Schw. Two specimens found S. E. of Bloomington, growing on ground. July 26, 1919. O'Neal. 3764. Resembles A. vaginata, but is smaller and has a mealy appearance.

Amanitopsis vaginata Fr. var. fulva Sacc. On alluvial soil four miles east of Bloomington. O'Neal. July 3, 1919. 3763. Colored as Amanita caesarea but is readily distinguished by its generic character. Also collected on Campus, July 12, 1920. 3779.

Clitocybe dealbata Fr. In open woods associated with Russula virescens. O'Neal. June 26, 1919. 3761. Resembles C. candida, but may be distinguished by its apiculate spores.

Clitocybe monodelpha Morg. On ground (Buried roots?) Campus, July 12, 1920. Flora Anderson. 3780. (This specimen is very scaly and has the general appearance of an Armillaria. Scales reddish brown.)

Cortinarius cinnabarinus Fr. On ground among moss, Griffey Creek, July 13, 1920. O'Neal. 3782. Resembles C. sanguineus Fr., but has pale red flesh.

Lepiota caerulescens Pk. on edge of brook, June 26, 1919. O'Neal. 3762. This plant changes to a bright blue color on drying.

Paxillus involutus Fr. On ground, four miles east of campus, July 7 1919. Dense woods. O'Neal. 3765.

Pleurotus applicatus Batsch. On dead maple, Jordan Field, February 3 1902. Mutchler. 3725.

Russula squalida Pk. On Huckleberry Hill, April 27, 1916. Hemmer, 3695.

POLYPORACEAE.

Boletus gracilis Pk. On ground in open woods, with B. felleus, Ellis Creek, June 26, 1919. O'Neal. 3759. Distinguished by its long and usually slender stipe.

Daedalia extensa Pk. On white oak and yellow poplar, near Borden, Clark County, November 2, 1908. A very fine and interesting fungus. This was sent to Professor W. A. Murrill for identification with the following note: "This fungus grew away from the light, spreading over the surfaces of the two kinds of wood where they lay on each other. It may be a Poria but it looked like a Daedalia when fresh."

Under the title of Daedalia extensa rediscovered, Professor Murrill (in

Mycologia p. 110. 1920) says in part: "This species was first described by Peck in his annual report in 1891 as follows: (Then follows Peck's report). The type collection is gone and there is nothing left but the description; but this,like most of Peck's descriptions, is exceedingly good. I have a specimen collected a few years ago at Bloomington, Indiana, by Van Hook (2398) on oak and tulip-tree wood. This specimen corresponds to Peck's description, except that the hymenium is avellaneous instead of whitish. I have compared it with a number of resupinate specimens of Trametes mollis and find that it differs from them just as Peck said—especially in the character of the pores, the thicker context, and the absence of any free margin. The young margin is tomentose and whitish, becoming fulvous or brown in dried specimens. To clear up a doubtful species is much better than to describe a new one; and mycologists are indebted to Professor Van Hook for his timely aid in this addition to our knowledge of a very rare and interesting species, which is now known from two localities instead of one." (Note: Through error this material was labelled as being collected at Bloomington. It should read as being collected at Borden, Clark County, Indiana.)

Fomes fulvus Gill. On Prunus americana, Sheet's Hill, April, 1916. 3693.

Fomes graveolens Schw. On limb blown from large standing yellow poplar, Clark County, May, 1920. 3767.

Polyporus delectans Pk. On dead maple twenty feet from the ground, Orange County, October 10, 1920. A. C. McIntosh. 3792.

Polyporus hispidus Bull. On living sugar maple, Kinser Pike, October 9, 1920. Mabel Katterjohn. 3791.

Poria incerta (Pers.) Murr. On beech, Brown County, October 22, 1908. A. G. Wood. 2033. This species is common on other deciduous woods. Murrill says it prefers conifers, where it produces brown rot. Also it attacks a large number of deciduous woods.

Poria medullapanis (Jacq.) Fr. This is Polyporus dryinus of B. & C. On red-oak, City Water Works, October 27, 1908. 2194. On maple, Clark County, November 22, 1908. 2436. On partially burned elm log, North Pike, March 3, 1908. 2587.

Poria semitincta (Pk.) Cke. On old yellow poplar fence rails, University Farm, July, 1920. 3795.

Ceratostomella barbirostris (Duf.) Sacc. Extremely common on dead maple throughout the southern part of the state. It is usually found on decorticated wood, but may occur also upon the bark. Fruiting specimen number 3673 grew over the bark. Specimens with spores were sought for eight years and spores not found until April, 1916, when it was determined. The spores are 5 to 7½ by 2½. The asci are 33-38 by 3½ to 5 microns. Olive-brown pubescence is abundant in number 3672.

Ceratostomella echinella E. & E. Jolietville, Hamilton County, January 17, 1914, G. B. Ramsey. The spores in this specimen (3681) measure 3½ to 4½ by 1½ to 1¾. Asci, 26 to 30 by 3½ to 4½.

Diatrype platystoma (Schw.) Berk. On Acer Saccharinum, 1911. Owens, 3676.

Erysiphe cichoracearum D. C. On leaves of Aster, Eel River, Greene County, September 7, 1914. Weatherwax. 3688. On leaves of Taraxacum officinale, July, 1920. 3781.

Eutypella scoparia (Schw.) E. & E. On bark of Ulmus fulva, Hamilton County, December 31, 1913. G. B. Ramsey. 3678.

Gyromitra esculenta (Pers) Fr. Campus, May 8, 1910. Owens. 2783.

Hypoxylon perforatum (Schw.) Fr. On decorticated elm, Mason's Woods, November 1, 1920. 3797. The perithecia were just arriving at maturity, and had not yet become perforate to any extent. This specimen resembles certain forms of H. rubiginosum and H. fuscopurpureum very closely. The stroma is ½ to 1 mm thick, effused in oval or elongated areas 1 to 4 cm long. Color, ferruginous to chestnut-brown. Perithecia slightly elongated (½ mm long). Asci long tapering, 150 to 190 by 6 to 9; p. sp. 75 to 85 by 6 to 9. Spores mostly 13 by 6½.

Hypoxylon serpens (Pers.) Fr. On dead wood of red-oak, Boone County, December 20, 1913. Ramsey. 3566.

Microsphaera alni (D. C.) Winter. On oak leaves, 1916. 3734.

Nectria episphaeria (Tode) Fr. Parasitic on Valsa on beech bark, May 5, 1916. W. P. James. 3679. Makes the bark a beautiful red over large areas.

Nectria Ipomoeae Hals. On young sweet-potato plant, spring of 1916 (Sphaeronema fimbriatum on this same plant). 3706.

Nummularia Bulliardi Tul. On Cornus florida 1916. 3708.

Ophiobolus fulgidus (C. & P.) Sacc. On dead stems of Ambrosia trifida, Scott County, April 7, 1917. Bertha Hanger. 3735.

Rosellinia pulveracea (Ehr.) Fckl. On hard decorticated oak, Hamilton County, January 17, 1914. Ramsey. 3675.

Teichospora vialis (Fr.) Berl. & Vogl. On decorticated Juglans cinerea, November 20, 1913. Ramsey. 3674.

Valsa Linderae Pk. On Lindera benzoin, April 21, 1917. Hanger. 3736.

Valsaria exasperans (Gerard) Sacc. On oak (Red or scarlet), near Cascades, April 18, 1920. Mills. 3768.

FUNGI IMPERFECTI.

Sphaeropsidales.

Actinonema Tiliae Allesch. On leaves of Tilia americana. Both on and under tree late in autumn. 3691.

Dothiopsis eunomia Karst. May 19, 1917. 3740. This species was first described by Karsten in Hedwigia 1884 under the name of Dothiora eunomia.

Phyllosticta Liriodendri Thuem. On living leaves of Liriodendron tulipifera, Campus, July 24, 1916. Hemmer. 3696.

Phyllosticta Smilacis E. & E. On leaves of Smilax rotundifolia, Brown County, October 10, 1914. Weatherwax. 3687. Spores vary slightly from the description as follows: 15 to 25 by 5 to 8 microns. One of the most striking things about this fungus is that one rarely finds spores in the pycnidia. We had systematically collected it for years but found the pyncidia empty. In Torr. Bull., 1900, p. 572, Ellis and Everhart say: "This has been observed on various smooth-leaved species of Smilax for twenty years or more, but it does not appear to have been described." The probable reason for this is its habit of ridding itself of spores so quickly.

Septoria albaniensis Thuem. On leaves of Salix nigra, autumn. 3692. Our measurements of spores are: 25 to 42 by 2½ to 3 microns.

Sphaeronema fimbriatum (Ell. & Hals.) Sacc. On young sweet-potato plant, spring of 1916. (This and Nectria Ipomoeae were both in fruit on one plant.) 3707.

Sphaeropsis malorum Pk. On pear, May 15, 1917. Wade. 3739. On quince, October 24, 1916. 3709.

Vermicularia Dematium (Pers.) Fr. *var.* microspora *n. var.* On Acer saccharinum, Campus, March 17, 1916. For the most part, on decorticated wood. Also on inside and outside of loosened bark in the same region. 3673. Many varieties of this species have been described, based for the most part upon spore size and shape. The form as it appears here, has a remarkably small spore as compared with other forms heretofore noted. So noticeable is this difference that a varietal distinction becomes necessary. The following description as differing from the species type is here recorded:

Pycnidia 150 to 500 microns (Usually 235 to 325.), varying greatly in size and shape; spines 125 to 300 by 5 to 7½, opaque, especially dark near the base, pointing outward; spores 5 to 8 by 1 to 2, hyaline.

Melanconiales.

Cylindrosporium Scrophulariae Sacc. & Ell. On living leaves of Scutellaria canescens, Griffey Creek, July 7, 1920. O'Neal. 3790. Differs somewhat from the description as follows: the broad margin around the spots, is dark purple. Spores are septate and one end often broader. The three guttulae not noticeable. Acervuli about 50 microns in diameter. Habit on the leaves is much like Septoria Scrophulariae.

Cylindrosporium Toxicodendri E. & E. On Rhus Toxicodendron, 1911. C. E. Sutton. 3528.

Cylindrosporium Ulmicolum E. & E. On living leaves of Morus rubra, Campus, October 15, 1915. This fungus was associated with a species of Alternaria which, however, seems to follow as a saprophyte. 3659. Spores 45 to 65 by 2 to 6, and mostly 4-septate.

Gloeosporium Betularum Ell. & Mart. On Betula nigra, Campus, June 31, 1920. These leaves were taken from young trees which had been shipped from Tennessee. Though differing much from the orginal description, there seems to bo no doubt of the species being the same as described from Pennsylvania. (See Am. Nat. 1882, p. 1,002.) In our specimens, the acervuli are almost wholly hypophyllous and are variable in size, sometimes quite large and rupturing irregularly. The most striking thing about this species is the abundance of pointed spores. They are described as being obovate; however, they also have the lower end tapering to a point. 3774.

Gloeosporium nervisequum (Fckl.) Sacc. Belongs to Gnomonia veneta (Sacc. & Speg.) Kleb. On sycamore, University Farm, August 3, 1920. Spores are for the most part, 4 to 5 by 10 to 12. The acervuli are here usually on the upper side of the leaf and along the outer edges of the vein—that is, in two rows. 3793.

Marsonia Martini Sacc. & Ell. On living leaves of Quercus robur, Campus, June 25, 1920. 3775.

Hyphomycetes.

Alternaria Amaranti (Pk.) On leaves of Amarantus retroflexus, city of Bloomington. October 5, 1915. 3637.

Cercospora Mississippiensis Tracy & Earle. On leaves of Smilax rotundifolia. 1916. 3732.

Cladosporium Paeoniae Pass. On leaves of cultivated Paeony, 1916. 3730.

Epicoccum purpurascens Ehrbg. On Sorghum following a Septoria leaf spot. Lawrence County. October 19. 1916. 3711.

Fusicladium Alopecuri E. & E. On a grass. University Waterworks area. September 30. 1914. 3682.

Ramularia arvensis Sacc. On Potentilla monspeliensis, Getty's Creek. June 13. 1920. In our specimens. the spots have reddish-brown margins; conidiophores slightly wavy and hyphophyllous as well as epiphyllous; conidia 10 to 37 by 3 to 4. the two-celled ones 16 to 37 by 3 to 4. On living leaves killing them. The similarity of these affected leaves to those of strawberry attacked by Mycosphaerella is very striking. 3769.

Ramularia Celastri Ell. & Mart. On Celastrus scandens. Lawrence County, October 19, 1916. 3702.

MYXOMYCETES.

Ceratiomyxa fruticulosa (Muell.) Macbr. On rotten log. Ellis Creek. July 25. 1919. O'Neal. The so-called "pillars" resemble coarse white threads of a Hyphomycete. 3778.

Lindbladia effusa (Ehr.) Rost. Single specimen found on a decaying log north of City Waterworks. July 18. 1919. O'Neal. Specimen much blackened by premature drying. 3766.

Tilmadoche polycephala (Schw.) Macbr. On living leaves of Polygonum aviculare. Bloomington, July 7. 1920. W. H. Adams. 3777.

Indiana University,
December, 1920.

THE PYCNIDIUM OF CICINNOBOLUS.

J. M. Van Hook.

The occurrence of Cicinnobolus as a parasite, for the most part on the powdery mildews, has been well known since the genus was established in 1853; however, there seems to have been more interest in forming new species rather than noting the various forms, many of which are doubtless caused by the specific parts of the host attacked, their shape determining the shape of the pycnidium of the parasite. For example, when a conidiophore of a host is converted into a pycnidium it is entirely different in shape and size from one formed from a perithecium of a host.

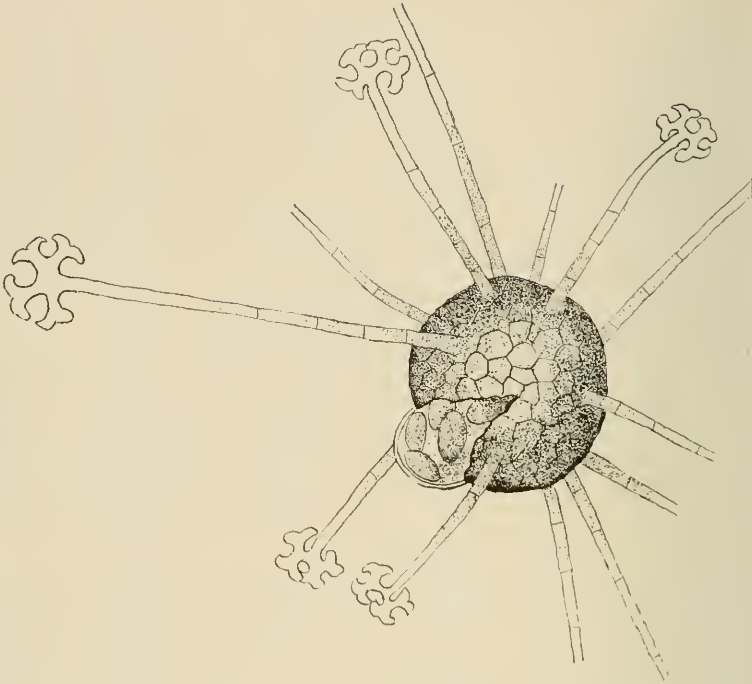
Many species of this genus are now described, most of these being named from the host of the powdery mildew rather than from the host of the Cicinnobolus. From what is already known of the wide variation of the fruiting forms of these parasites, together with the similarity of description of many of their essential parts, much confusion of species has doubtless been made. It is hoped that critical study of seasonal variation of the parasite upon a single powdery mildew host will be made in the future along the lines of Griffiths (The Common Parasite of the Powdery Mildews. Bull. Torr. Bot. Club, 26, 1899.).

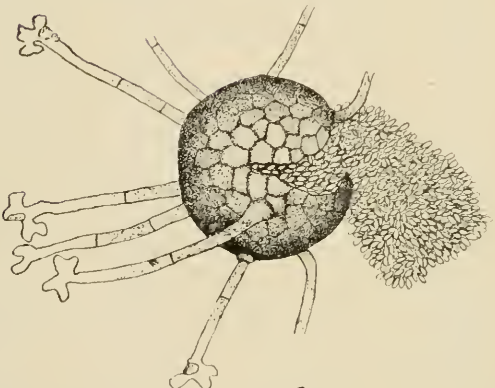
Most species have been described as parasitizing the mycelium or conidiophores of their hosts; however, in at least three cases they are reported on perithecia. These are by Griffiths on Erysiphe cichoracearum DC., by Saccardo and Sydow on Uncinula salicis (DC.) Winter and by Cocconi on Phyllactinia corylea (Pers.) Karst. It is not strange that the last two should have been originally called respectively a Phoma and a Phyllosticta. So far as the writer can learn, the Cicinnobolus herein mentioned has not previously been reported on the mycelium, conidiophore or perithecium of Podosphaera oxycanthe (DC.) de Bary.

The present brief paper is to show a form exceedingly common on the powdery mildew of cherry, here in Monroe County, Indiana. This seems to form fruit only in the perithecia of the host and usually at about the same stage of its maturity. In figures 1 and 2 of the accompanying plate, the comparative forms of the attacked and unattacked perithecia are shown. These figures represent a fair average of a large number examined and measured. It will be observed that parasitized fruit bodies are slightly smaller and have only slightly less developed appendages. Attention is always attracted by the presence of conidia instead of asci when the perithecia are crushed, though a more critical examination of the exterior will enable one to judge when pycnidia are present.

These parasites are an extremely interesting and attractive group from an economic view as well as from a morphological one. There has always appeared to be a possibility of their employment to hold certain of the most dangerous powdery mildews in check.

It would also be an interesting problem to determine the exact relation of the pycnidium of the Cicinnobolus to the perithecium of the host by means of a critical study of stained sections made from material such as was used in making the accompanying figures.





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3

Fig. 1.—Normal perithecium. Fig. 2.—Parasitized perithecium highly magnified. Fig. 3.—Conidia

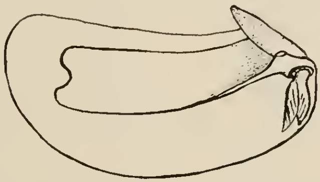
(The writer wishes here to thank Professor Weatherwax for making the three camera lucida drawings which accompany this paper.)

Indiana University,
Septemer, 1920.

A TRICOTYLEDONOUS BEAN.

J. M. Van Hook.

While examining a number of Lima bean seed in the summer of 1920. the writer was surprised to find between the ordinary cotyledons a third body, apparently a third cotyledon. Its shape and location is well shown in the accompanying figure. While a greater portion of the extra cotyledon lies parallel with the others and pressed between them, the part at the end where it is attached is twisted so that it is vertical to its flat surface and lies beween the plumule and radicle. The two regular cotyledons are also attached at this end.



Enlarged tricotyledonous bean with one of the outer cotyledons removed.

Polycotyledonous beans may not be of rare occurrence, though the writer knows of none reported on Lima beans. Harris (Mem. N. Y. Bot. Gard. 1916.) reports a race of the common bean which has the cotyledons varying from two to seven in number, but which tends to be tetracotyledonous.

Indiana University,
October, 1920.

NATIVE PLANTS OF WHITE COUNTY—III.

Louis F. Heimlich, Purdue University.

The author's first report of native plants of White County was that of a single species, which at the time of publication was the first record of that plant for the state. The title of the paper is "The Primrose-leaved Violet in White County" and it appears in the Proceedings of the Indiana Academy of Science, 1914, pages 213-217.

The second report of native plants of White County is included in a thesis, written for the M.S., degree, Purdue University, 1916, and published in the Proceedings of the Indiana Academy of Science, 1917, pages 387-471, subject: The Trees of White County, Indiana, with some Reference to Those of the State. Included in the list of trees are also a number of native shrubs. The total number of species reported in the thesis is seventy-nine species and two varieties.

The list below includes one hundred and twenty species classified as one hundred fifteen species of herbs and five species of shrubs or woody vines. The author has made no attempt to collect plants below the Araceae. He also realizes that the list is very far from complete. Nearly all of the species here reported are represented by herbarium specimens. Most of the species were collected in Honey Creek Township about the vicinity of Reynolds. The nomenclature is that of Gray's New Manual of Botany, seventh Edition. The plants are listed in their natural order, followed by brief notes relating to distribution, abundance, etc. When no data is attached, it is understood that the species is more or less common in Honey Creek Township. The list contains many species which are not native but are more or less well established. Their origin, according to Gray, is mentioned in each case. The list follows.

HERBS.

Araceae (Arum Family).

1. Arisaema triphyllum (L) Schott. Jack-in-the-pulpit.
2. Arisaema dracontium (L) Schott. Green Dragon.
   Tippecanoe river, three miles south of Buffalo.

Lemnaceae (Duckweed Family).

3. Wolffia columbiana Karst. Columbia Duckweed.
   Backwater Tippecanoe river near mouth of Pike Creek.

Commelinaceae (Spiderwort Family).

4. Tradescantia reflexa Raf. Reflexed Spiderwort.

Liliaceae (Lily Family).

5. Uvularia perfoliata L. Perfoliate Bellwort.
6. Uvularia grandiflora Sm. Large-flowered Bellwort. Both species found along banks of Tippecanoe river.
7. Lilium canadense L. Wild Yellow Lily. Along railroads.

8. Asparagus officinalis L. Common Asparagus. Frequent escape, but not native.
9. Smilacina racemosa (L) Desf. False Spikenard or Solomon Seal.
10. Polygonatum biflorum (Walt) Ell. Small Solomon Seal.
11. Medeola virginiana L. Indian Cucumber-root. Not common.
12. Trillium recurvatum Beck. Prairie Wakerobin.

Amaryllidaceae (Amaryllis Family).

13. Hypoxis hirsuta (L) Coville. Star Grass.

Orchidaceae (Orchid Family).

14. Calopogen pulchellus (Sw) R. Br. Calopogon or Grass Pink. Very rare.
15. Spiranthes cernua (L) Richard. Wild Tube-rose, Nodding or drooping Ladies' Tresses. Very rare.

Polygonaceae (Buckwheat Family).

16. Rumex crispus L. Yellow Dock.
17. Rumex acetosella L. Field or Sheep Sorrel.
18. Polymonum aviculare L. Knot-grass or Door-weed. Not native, but very common, Eurasia.

Chenopodiaceae (Goosefoot Family).

19. Chenopodium album L. Lamb's Quarters, Pigweed. Not native but very common.

Phytolaccaceae (Pokeweed Family).

20. Phytolacca decandra L. Common Pokeweed, Pigeon Berry. Poisonous.

Aizoaceae (Carpet-weed Family).

21. Mollugo verticillata L. Carpet Weed. Not native ? From farther south.

Caryophyllaceae (Pink Family).

22. Stellaria media (L) Cyrill. Common Chickweed. Not native, from Europe. Common.
23. Silene antirrhina L. Sleepy Catchfly.
24. Silene stellata (L) Ait. f. Starry Campion.
25. Saponaria officinalis L. Soapwort, Bouncing Bet. Not native, from Europe.

Portulacaceae (Purslane Family).

26. Claytonia virginica L. Spring Beauty.

Ranunculaceae (Crowfoot Family).

27. Ranunculus abortivus L. Small-flowered Crowfoot.
28. Thalictrum dioicum L. Early Meadow Rue.
29. Hepatica acutiloba DC. Hepatica. Tippecanoe river.
30. Anemone quinquefolia L. Wood Anemone.
31. Caltha palustris L. Marsh Marigold. Tippecanoe river.
32. Aquilegia canadensis L. Columbine. Tippecanoe river.

Berberidaceae (Barberry Family).

33. Podophyllum peltatum L. May apple, Mandrake.

Papaveraceae (Poppy Family).

34. Sanquinaria canadensis L. Bloodroot. Tippecanoe river.

Fumariaceae (Fumitory Family).

35. Dicentra canadensis (Goldie) Walp. Squirrel Corn.
36. Corydalis sempervirens (L) Pers. Pale Corydalis.

Cruciferae (Mustard Family).

37. Lepidium virginicum L. Wild Peppergrass.
38. Capsella Bursa-pastoris (L) Medic. Shepherd's Purse. Not native, very common. From Europe.
39. Sisymbrium altissimum L. Tumble Mustard. Not native. From Europe.

Capparidaceae (Caper Family).

40. Polanisia graveolens Raf. Clammy-weed.

Saxifragaceae (Saxifrage Family).

41. Saxifraga pennsylvanica L. Swamp Saxifrage.

Rosaceae (Rose Family).

42. Fragara virginiana Duchesne. Wild Strawberry.
43. Potentilla monspeliensis L. Rough Cinquefoil, Barren Strawberry.
44. Potentilla canadensis L. Common Cinquefoil, Five-finger.

Leguminosae (Pea Family).

45. Cassia chamaecrista L. Partridge Pea.
46. Lupinus perennis L. Wild Lupine.
47. Trifolium pratense L. Red Clover.
48. Trifolium repens L. White Clover.
49. Melilotus alba Desr. White Melilot, Sweet Clover.
50. Psoralea onobrychis Nutt. Sainfoin Psoralea, French-grass.
51. Petalostemum candidum Michx. White Prairie Clover.

Linaceae (Flax Family).

52. Linum medium (Planch) Britton. Stiff Yellow Flax.

Oxalidaceae (Wood Sorrel Family).

53. Oxalis violacea L. Violet Wood Sorrel.

Geraniaceae (Geranium Family).

54. Geranium maculatum L. Wild Cranesbill.

Polygalaceae (Milkwort Family).

55. Polygala sanguinea L. Field or Purple Milkwort.

Euphorbiaceae (Spurge Family).

56. Euphorbia corollata L. Flowering Spurge.

Malvaceae (Mallow Family).

57. Abutilon theophrasti Medic. Velvet Leaf, Indian Mallow.
58. Malva rotundifolia L. Common Mallow, Cheeses.

Violaceae (Violet Family).

59. Viola pedata L. Bird-foot Violet.
60. Viola papilonacea Pursh. Meadow or Hooded Blue Violet.
61. Viola sagittata Ait. Arrow-leaved Violet.
62. Viola lanceolata L. Lance-leaved Violet.

Melastomaceae (Melastoma Family).

63. Rhexia virginica L. Meadow Beauty, Deer-grass.

Onagraceae (Evening Primrose Family).

64. Ludvigia alternifolia L. Seedbox, Rattlebox.
65. Ludvigia hirtella Raf. Hairy Ludwigia.
66. Oenothera biennis L. Common Evening Primrose.

Umbelliferae (Umbel Family).

67. Eryngium aquaticum L. Button Snakeroot, Rattlesnake weed.

Ericaceae (Heath Family).

68. Monotropa uniflora L. Indian Pipe, Corpse Plant. Rare, saprophytic or parasitic.
69. Monotropa hypopitys L. Pinesap, False Beech Drops. Rare, saprophytic or parasitic.

Primulaceae (Primrose Family).

70. Steironema lanceolatum (Walt) Gray. Lance-leaved Loosesstrife.
71. Steironema quadrifolium (Sims) Hitche. Prairie Moneywort.
72. Dodecatheon meadia L. Shooting Star.

Asclepiadaceae (Milkweed Family).

73. Asclepias tuberosa L. Butterfly-weed, Pleurisy-root.
74. Acerates floridana (Lam) Hitche. Florida Milkweed.

Polemoniaceae (Polemonium Family).

75. Polemonium reptans L. Jacob's Ladder, Bluebell, Greek Valerian.

Boraginaceae (Borage Family).

76. Myosotis virginica (L) BSP. Spring or Early Scorpion-grass, Forget-me-not.
77. Lithospermum gmelini (Michx) Hitche. Hairy Puccoon.

Verbenaceae (Vervain Family).

78. Lippia lanceolata Michx. Fog-fruit.

Labiatae (Mint Family).

79. Nepeta cataria L. Catnip.
80. Prunella vulgaris L. Heal-all, Carpenter-weed.
81. Physostegia virginiana (L) Benth. Dragon-head, Obedient Plant.

82. Stachys palustris L. Woundwort.
83. Monarda fistulosa L. Wild Bergamot.
84. Hedeoma pulegioides (L) Pers. American Pennyroyal.
85. Pycnanthemum virginianum (L) Dur. & Jackson. Virginia Mountain Mint.
86. Lycopus americanus Muhl. Cut-leaved Water Hoarhound.
87. Mentha piperita L. Peppermint.
88. Mentha gentilis L. Spearmint.

Solanaceae (Nightshade Family).

89. Solanum carolinense L. Horse Nettle.
90. Datura stramonium L. Jimson Weed.

Scrophulariaceae (Figwort Family).

91. Verbascum thapsus L. Common Mullen. Naturalized from Europe.
92. Scrophularia leporella Bicknell. Hare Figwort.
93. Veronica virginica L. Culver's-root, Culver's-Physic.
94. Veronica serpyllifolia L. Thyme-leaved Speedwell.

Plantaginaceae (Plantain Family).

95. Plantago major L. Common Plantain. From Eurasia.
96. Plantago lanceolata L. Rib Grass, Buckthorn Plantain. From Europe.

Rubiaceae (Madder Family).

97. Galium boreale L. Northern Bedstraw.
98. Galium tinctorium L. Wild Madder.
99. Houstonia caerulea L. Bluets, Innocence.

Lobeliaceae (Lobelia Family).

100. Lobelia cardinalis L. Cardinal-flower. Scattered over county.

Compositae (Composite Family).

101. Liatris spicata (L) Willd. Dense Button-snakeroot, Devil's-bit.
102. Antennaria plantaginifolia (L) Richards. Plantain-leaved Everlasting.
103. Ambrosia trifida L. Great Ragweed.
104. Ambrosia artemisiifolia L. Ragweed, Roman wormwood.
105. Lepachys pinnata (Vent) T. & G. Gray-headed Cone-flower.
106. Achillea millefolium L. Common Yarrow, Milfoil. Eurasia.
107. Anthemis cotula L. May-weed, Dog Fennel. From Europe.
108. Chrysanthemum leucanthemum L. Ox-eye or White Daisy. From Europe.
109. Tanacetum vulgare L. Common Tansy. From Europe. One record of the escape of this plant. No plants at this locality at present.
110. Taraxicum officinale Weber. Common Dandelion. From Europe.
111. Pyrrhopappus carolinianus (Walt) DC. False Dandelion.
112. Prenanthes alba L. Rattlesnake-root.
113. Prenanthes trifoliata (Cass) Fernald. Gall-of-the-earth.
114. Prenanthes altissima L. Tall White Lettuce.
115. Hieracium venosum L. Rattlesnake-weed.

SHRUBS OR WOODY VINES.

Liliaceae (Lily Family).

116. Smilax rotundifolia L. Common Green Brier.

Rosaceae (Rose Family).

117. Spirea latifolia Borkh. Meadow-sweet.
Answers description of S. alba DuRoi of Britton and Brown better than the above name from Gray.
118. Rosa humilis Marsh. Pasture rose.

Leguminosae (Pea Family).

119. Wisteria frutescens (L) Poir. American Wisteria. Tippecanoe river.

Vitaceae (Grape Family).

120. Vitis labrusca L. Northern Fox Grape.

PLANTS NEW TO INDIANA—IX.

CHAS. C. DEAM, Bluffton, Indiana.

Specimens of the plants reported are deposited in my herbarium under the numbers given. The Gramineae were determined at the U. S. Dept. of Agriculture; the Carices by K. K. Mackenzie; and the determination of the remainder, unless otherwise mentioned, were verified at the Gray Herbarium.

Elodea Planchonii Caspary.

Knox County, August 18, 1919. No. 29,224. About six miles northwest of Decker, floating in rather swift running water in the upper course of the Deshee River which at this point is a dredged ditch. Determination made by Harold St. John of the Gray Herbarium.

Paspalum laeviglume Scribner.

Knox County, Sept. 21, 1920. No. 32,940. Right of way of the railroad at Vollmer Siding, two miles north of Decker.

Muhlenbergia cuspidata (Torr.) Rydb.

Tippecanoe County, Oct. 20, 1920. Collected by H. S. Jackson along Big Wea Creek, about three miles southwest of Lafayette.

Leptochloa filiformis (Lam.) Beauv.

Perry County, August 13, 1919. No. 28,949. Abundant in a small corn field just south of Tell City, and near the U. S. Hame Works.

Poa paludigena Fernald.

Lagrange County, June 21, 1920. No. 31,117. Noted in one place growing in sphagnum in an old tamarack swamp five miles east of Lagrange. Associated with Geum rivale, Rhamnus alnifolia, etc.

Panicularia acutiflora (Torr.) Kuntze.

Harrison County, June 10, 1919. No. 27,855. In a small pool on the north side of the Corydon and Milltown pike, on the crest of a ridge about four miles northwest of Corydon.

Bromus purgans variety latiglumis (Scribn.) Shear.

Allen County, Sept. 16, 1906. No. 1,707. Alluvial bank of the St. Mary's River on the south side of Ft. Wayne. Huntington County, Sept. 30, 1920. No. 32,606. Bank of the Salamonie River three miles northwest of Warren. Parke County, Sept. 17, 1920. No. 32,832. Wooded bank of Sugar Creek just east of Turkey Run State Park. Steuben County, Aug. 18, 1916. No. 20,878. Moist sandy shore of the east side of Clear Lake.

Elymus virginicus variety hirsutiglumis (Scribn.) Hitchc.

Cass County, Aug. 21, 1920. No. 32,098. Low bank of the Wabash River opposite Georgetown. Huntington County, Sept. 13, 1920. No. 32,608. Bank of the Salamonie River three miles northwest of Warren. Marion County, Aug. 24, 1913. No. 14,073. Bank of White River, eight miles above Indianapolis. Warren County, Sept. 15, 1920. No. 32,734. Low bank of Pine Creek one and a half miles south of Rainsville.

Cyperus acuminatus Torr. & Hook.

Greene County, October 2, 1917. No. 24,088. In the bottom of a dredged ditch about two miles northwest of Lyons.

Crawford County, May 28, 1919. No. 27,710. Low wet place in a flat woods about three miles northwest of Leavenworth.

Carex Sprengelii Dewey.

Miami County, June 8, 1920. No. 31,060. A large colony in blue grass sod along the road bordering Eel River, about one-half mile southwest of Chili. Noble County, May 28, 1920. No. 30,501. Several large clumps in blue grass sod along the roadside about one mile south of Rome City.

Carex substricta (Küken.) Mackenzie.

Laporte County, June 4, 1920. No. 30,764. In a marsh enclosed by tamarack, one-half mile north of Mill Creek.

Zygadenus chloranthus Richards.

Lagrange County, Aug. 28, 1920. No. 32,489. Low sedge opening in a tamarack swamp five miles east of Lagrange. Also found in a sedge opening in the tamarack marsh on the south side of Pigeon River one mile east of Mongo.

Iris foliosa Mackenzie & Bush.

Gibson County, June 10, 1913. No. 19,303. Low wooded border of Foote's Pond about nine miles southwest of Owensville. Posey County, May 23, 1911. No. 8,287. Moist woodland about 12 miles southwest of Mt. Vernon. My specimens were determined by E. B. Williamson who for many years has cultivated many species of Iris, and who has made a special study of the genus. Live specimens from the localities mentioned were sent to him and have been cultivated by him in his garden ever since. Among the many species of Iris he has under cultivation are Iris foliosa, Iris versicolor and Iris hexagona. When the three species are grown side by side it is easy to see that all are quite distinct. It is believed that all references to Iris hexagona in Indiana should be referred to Iris foliosa.

Berteroa incana (L.) DC.

Elkhart County, July 7, 1920. No. 31,322. Common along the sandy roadside two miles northeast of Bristol. Noted also in two other places in sandy soil along the roadside and adjacent fallow fields in the same county.

Erysimum repandum L.

Jay County, May 18, 1919. No. 27,488. Spread over an area almost a rod square along the roadside on the Portland and Winchester road about six miles south of Portland.

Heuchera macrorhiza Small.

Clark County, July 11, 1919. No. 27,998. Common on the wooded limestone cliffs with a north exposure, just east of the mouth of Fourteen-mile Creek. Closely associated with Sullivantia ohionis which is common on the wet shaded cliffs.

Heuchera parviflora Bartl.

Perry County, July 24, 1920. No. 28,566. In the shade of large trees on a dry sand stone cliff on the farm of John Gleason about two miles southwest of Leopold. Only a few plants found.

Amelanchier humilis Wiegand.

Lagrange County, May 27, 1920. No. 30,433. On a cleared sand hill about one and an eighth mile southeast of Mongo. Here it averaged 20-30 inches in height. In an adjoining black oak woods, it sometimes reached a height of five feet.

Rubus idaeus variety canadensis Richardson.

Lagrange County, June 21, 1920. No. 31,116. In a tamarack swamp five miles east of Lagrange. Lake County, July 28, 1907. No. 2,379. In a thicket on the dunes near Pine. Steuben County, July 4, 1904. Among the tamarack on the low border of the west side of Graveyard Lake.

Prunus cuneata Raf.

This is an erect shrub which usually is about three to six feet tall. However, it is occasionally somewhat higher, and I found one specimen twelve feet high and about one and a half inches in diameter breast high. It sends up suckers and is usually found in clusters. It prefers a moist habitat, although it is often found in quite dry sandy places among the dunes. Along the beach of Lake Michigan like all other woody plants it is often somewhat scrubby but never decumbent and rooting at the nodes. Its favorite habitat is low places between the dunes, and at a distance from the dune area it is found in low flat Quercus palustris woods, usually associated with Aronia melanocarpa, species of Salix, etc. I have taken it so many times in so many counties that I will give the names of the counties only in which I have taken specimens: Cass, Elkhart, Fulton, Lake, Newton, Porter, Pulaski, St. Joseph and Starke. By other writers this form in our area has been called Prunus pumila. There is but one form in our area and I believe it is properly referred to this species.

Trifolium reflexum variety glabrum Loja.

Posey County, June 15, 1918. No. 25,431. Common in a flat woods ten miles southwest of Mt. Vernon. Associated with Quercus stellata, Quercus falcata, Agave, Baptisia leucantha, etc. For a description of the form see Muhlenbergia Vol. 5:38:1909.

Geranium Bicknellii Britton.

Lake County, July 12, 1920. No. 31,631. In a burned over area in a Quercus palustris-Quercus velutina woods one mile south of Griffith. Associated with Corydalis sempervirens, etc., vigorous specimens had a spread of three feet in diameter. Starke County, July 14, 1920. No. 31,855. In a burned over area in a clearing in a Quercus palustris-Quercus velutina woods three miles north of Ora. Here it was very closely associated with Epilobium angustifolium; and vigorous plants had a spread of three feet.

Callitriche autumnalis L.

Lake County, July 12, 1920. No. 31,640. In a dried up marsh one mile south of Griffith, especially frequent among a lot of cat-tails.

Cornus stricta Lam.

Knox County, Aug. 19, 1919. No. 29,252. Low place in Little Cypress Swamp about twelve miles southwest of Decker. Also noted in the same county in a very low place in a woods bordering Swan Pond about six miles northwest of Decker. Posey County, April 20, 1919, and Aug. 15, 1919. No. 29,086. A shrub about 6-7 feet tall in a low place in a low woods about ten miles southwest of Mt. Vernon. In this low woods within a radius of 250 feet have been found for the first time in Indiana the following southwestern plants: Styrax americana, Trachelospermum difforme and Trifolium reflexum var. glabrum.

Vaccinium angustifolium Ait.

This blueberry is frequent in sandy black oak woods of the northwestern counties, and no doubt has been reported by authors under some other name. I have found it in Elkhart, Lake, Laporte, Newton, Porter and Starke Counties.

Vaccinium vacillans variety crinitum Fernald.

This form appears to be more robust than the species, and in its distribution seems to follow the distribution of the species. I have specimens from the following counties: Clark, Floyd, Jackson, Pulaski and St. Joseph Counties.

Gentiana villosa L.

Harrison County, Oct. 6, 1920. No. 33,443. Found by Mrs. Chas. C. Deam in a black oak woods about two miles southeast of Corydon.

Vincetoxicum gonocarpos Walt.

Knox County, Sept. 21, 1920. No. 32,969. On the bank of a small slough near White River and about one mile east of where it empties into the Wabash. This species was reported by Clapp as a very rare plant in the vicinity of New Albany. It was also reported as occurring in Gibson and Posey Counties in Coulter's Catalogue on the authority of Dr. Schneck, but Schneck's herbarium contained no specimen.

Salvia silvestris L.

Marshall County, July 15, 1920. No. 31,898. Several large colonies in a closely grazed pasture field on the west side of the road about one-half mile north of Culver. This is a European weed, and judging from the vigor of the colonies, and the fact that it was not touched by horses or cattle, it might become a troublesome weed. In the same pasture were several colonies of Galium Mollugo, another European weed.

Veronica peregrina var. xalapensis (H.B.K.) Pennell.

This is the pubescent form of this species and comes into our area from the northwest. It is the common form in the northwestern counties, especially in sandy fallow fields, etc. I have specimens from Knox, Kosciusko, Lagrange, Laporte, Perry and Steuben Counties.

Agalinis Gattingeri (Small) Small.

Noble County, Aug. 25, 1914. No. 14,608. A single specimen found at the base of a white-black oak ridge on the south side of Deep Lake which about one mile south of Wolf Lake. Perry County, Sept. 24, 1918. No. 26,707. Open woods on top of the Van Buren Ridge near the Harmony school house, about seven miles southeast of Cannelton. This species was determined by Francis W. Pennell, Jan. 17, 1921.

Galium Mollugo L.

Marshall County, July 15, 1920. No. 31,899. Several colonies in a closely grazed pasture on the west side of the road about one-half mile north of Culver.

Galium verum L.

Noble County, June 21, 1920. No. 31,110. Abundant in dry soil along the roadside about one mile west of Kendallville. Here it grows in large pure stands in blue grass sod.

A SPECIES OF CUSCUTA NOT HITHERTO REPORTED FROM INDIANA.

T. G. Yuncker, DePauw University.

At the meeting of this Academy last year I presented a paper on the species of Cuscuta occurring in Indiana. Included in that report were seven native species (*C. glomerata; C. compacta; C. Cephalanthi; C. Coryli; C. polygonorum; C. pentagona* and *C. Gronovii*) that were known to occur in the state and two foreign species (*C. Epithymum* and *C. Epilinum*) which are probably in the state although not seen by the writer.

Since that time I have received two collections from different counties of another species, *C. cuspidata* Englm., which has, so far as the writer knows, never been collected before in Indiana. One of the specimens was collected by Mr. W. A. Hunter, president of the Vigo County Bee Keepers' Association, who writes as follows regarding it:

"I only observed a small patch near my apiary, about two miles southwest of Prairieton (Vigo Co.), Indiana; less than one-half mile from the Wabash river, which is the state line between Indiana and Illinois. This patch was in the river bottoms, along the fence row between two corn fields. It was quite plentiful for a few rods along the fence row......The honey bees were working on the flowers, as well as the wild bees and other insects. They seemed to be very active when the flowers were in full bloom."

The other specimen was recently sent to me by Mr. C. C. Deam who collected it in a "low field along the Wabash River about 40 rods south of where the wagon road comes to the river from the east and just below the old dam, or about two miles south of New Harmony, Posey Co."

Cuscuta cuspidata is typically found in the prairie region from the Mississippi river westward to the mountains and southward to Louisiana and Texas. Until the finding of these specimens in Indiana the farthest east that this species had been found of which we have any authentic record was in St. Clair County, Illinois where it has been collected several times. This species belongs to the group of dodders characterized by the possession of sepal-like bracts closely subtending the individual flowers. Only four species belonging to this group are found in the United States three of which (*C. glomerata; C. compacta* and *C. cuspidata*) are now known to occur in Indiana. *C. cuspidata* is differentiated from *C. glomerata* and *C. compacta* by its looser inflorescence and more or less cuspidate or mucronate, infrequently obtuse, sepals and bracts. Also, there are ordinarily but one to three bracts about each flower whereas in the other two species the number of bracts is usually greater.

C. cuspidata seems to prefer species of Compositae for hosts, the two specimens sent in being on Ambrosia. It has been found infrequently parasitizing leguminous plants, usually alfalfa, but it is not believed that it will ever become a pest in Indiana.

A LIST OF INDIANA MOSSES.

T. G. YUNCKER, DePauw University.

Reports of mosses occurring in Indiana have been, in the main, meager and local, with only one report, by Professor L. M. Underwood, including species from more than one county. The writer has had the privilege of examining three collections of mosses that have not been hitherto reported upon. These collections include a large number of specimens collected from all parts of the state and it was thought that a list including all these collections together with all those previously reported upon would be of value indicating the presence and distribution of our moss flora.

Probably one of the largest collections of mosses in the state that has not previously been reported is that belonging to Mr. C. C. Deam. Mr. Deam's collection includes specimens from nearly every part of the state. The writer has had the privilege of examining and identifying this collection during the past year.* Another large and excellently prepared and preserved collection is that owned by Professor J. P. Naylor of DePauw University. Although a physicist, Professor Naylor has been an enthusiastic collector and student of mosses for many years and has built up a large collection mainly from Putnam County. Miss Lucy Allen, a former student at DePauw, made a small collection from Putnam County which is deposited in the DePauw University herbarium. In addition to these three unreported collections all the species reported in publications on Indiana mosses known to the writer have been included in the list which includes one hundred and seventy-four species, thirty-two of which are being reported from Indiana for the first time, it is believed. Under each species is given a list of the counties where it has been found together with the collector's name in parenthesis. The arrangement and nomenclature is essentially that of Grout's "Mosses With Hand Lens and Microscope".

The following bibliographical list indicates the publications from which lists of mosses have been taken and incorporated in the present report. Professor Underwood included in his report a few specimens collected by Barnes, Blatchley, Mottier and Röll. None of the collections included in the following bibliographical list have been seen by the writer with the exception of the one made by Professor Underwood which is deposited in the DePauw University herbarium.

Haines, Mrs. Mary P., A list of ferns, mosses, Hepaticae and lichens in Wayne County, Indiana. 9th & 10th Ann. Rept., Geol. Survey of Indiana. pp. 235-239. 1879.

Pickett, F. L., and Nothnagel, Mildred. The mosses of Monroe County. Proc. Indiana Acad. Sci. pp. 69-75. 1913.

Pickett, F. L., and Nothnagel, Mildred, The mosses of Monroe County, II. Proc. Indiana Acad. Sci. pp 103-105. 1914.

Underwood, L. M., List of cryptogams at present known to inhabit the state of Indiana. Proc. Indiana Acad. Sci. pp. 65-67. 1894.

*Doubtful specimens were referred to Dr. A. J. Grout and Mr. G. B. Kaiser of Philadelphia for verification.

Wilson, Guy, Flora of Hamilton and Marion Counties, Indiana. Proc. Indiana Acad. Sci. p. 157. 1895.

Young, A. H., Bryological Notes. Bot. Gaz. 2:61-62. 1876.

SPHAGNACEAE.

Sphagnum cuspidatum Ehrh.
Jefferson (Young).

Sphagnum cymbifolium Ehrh.
Fulton (Underwood); Kosciusko (Deam); Steuben (Deam).

Sphagnum papillosum laeve Warnst.
Fulton (Underwood).

Sphagnum papillosum intermedium (Russ.) Warnst.
Wells (Deam).

Sphagnum recurvum mucronatum.
Fulton (Underwood).

Sphagnum rufescens.
Fulton (Underwood).

Sphagnum squarrosum Pers.
Jefferson (Young).

GEORGIACEAE.

Georgia pellucida (L.) Rabenh.
Hamilton (Wilson as *Tetraphis pellucida*); Putnam (Underwood, Naylor).

POLYTRICHACEAE.

Catherinea angustata Brid.
Crawford (Deam); Jackson (Deam); Jefferson (Young as *Atrichum angustatum*); Knox (Deam); Martin (Deam); Owen (Deam); Putnam (Naylor, Underwood); Scott (Deam); Vigo (Underwood as *Atrichum angustatum*); Wayne (Mrs. Haines as *Atrichum angustatum*).

Catharinea undulata (L.) W. & M.
Allen (Deam); Brown (Deam); Jefferson (Deam); Lagrange (Deam); Monroe (Deam); Noble (Deam); Posey (Deam); Pulaski (Deam); Putnam (Deam, Naylor, Underwood as *Atrichum undulatum*); Steuben (Deam); Wayne (Mrs. Haines as *Atrichum undulatum*); Wells (Deam).

Polytrichum commune L.
Jefferson (Young); Monroe (Pickett & Nothnagel); Putnam (Naylor); Starke (Deam).

Polytrichum formosum Hedw.
Jefferson (Young); Montgomery (Barnes); Wayne (Mrs. Haines).

Polytrichum Ohioense R. & C.
Clark (Deam); Hamilton (Wilson); Hancock (Deam); Jackson (Deam); Jefferson (Deam); Marshall (Deam, Underwood); Martin (Deam); Monroe (Pickett & Nothnagel); Orange (Deam); Owen (Miss Deam); Putnam (Allen, Naylor); Ripley (Deam); Wells (Deam).

Polytrichum Piliferum Schreb.

Monroe (Pickett & Nothnagel).

Pogonatum brevicaule (Brid.) Beauv.

Monroe (Pickett & Nothnagel); Putnam (Naylor, Underwood).

BUXBAUMIACEAE.

Buxbaumia aphylla L.

No specimens of this plant have been seen by the writer. However, Professor Mottier reports finding it in Monroe County and Professor Naylor reports having seen it in Putnam County.

FISSIDENTACEAE.

Bryoziphium Norvegicum (Brid.) Mitt.

Parke (Allen): Putnam (Underwood).

Fissidens adiantoides (L.) Hedw.

Jefferson (Young); Wayne (Mrs. Haines).

Fissidens bryoides (L.) Hedw.

Monroe (Pickett & Nothnagel).

Fissidens cristatus Wils.

Jefferson (Young as *Fissidens decipens*); Monroe (Pickett & Nothnagel).

Fissidens incurvus Schwaegr.

Putnam (Naylor, Underwood).

Fissidens incurvus minutulus Austin.

Monroe (Pickett & Nothnagel).

Fissidens Julianus (Savi.) Schimp.

Monroe (Mottier in Underwood as *Conomitrium Julianum*); Putnam (Allen).

Fissidens obtusifolius Wils.

Putnam (Naylor).

Fissidens subbasilaris Hedw.

Jefferson (Young); Putnam (Naylor); Wayne (Mrs. Haines).

Fissidens taxifolius (L.) Hedw.

Monroe (Pickett & Nothnagel); Putnam (Allen. Naylor, Underwood); Wayne (Mrs. Haines).

DICRANACEAE.

Pleuridium subulatum (L.) Rabenh.

Putnam (Naylor).

Ditrichum pallidum (Schreb.) Hampe.

Jefferson (Young as *Trichostomum pallidum*): Monroe (Pickett & Nothnagel); Montgomery (Deam): Putnam (Allen); Ripley (Deam); Spencer (Deam); Vigo (Underwood as *Leptotrichium pallidum*); Wayne (Mrs. Haines as *Trichostomum pallidum*).

Ditrichum tortile (Schrad.) Hampe.

Lake (Röll in Underwood as *Leptotrichum tortile*): Putnam (Naylor); Spencer (Deam).

Ceratodon purpureus (L.) Brid.
Dearborn (Deam); Jefferson (Young); Lagrange (Deam); Montgomery (Deam); Owen (Underwood); Putnam (Naylor, Underwood); Steuben (Deam); Tippecanoe (Underwood); Wayne (Mrs. Haines); Wells (Deam).

Dicranella heteromalla (L.) Schimp.
Jefferson (Young as *Dicranum heteromallum*); Lake (Röll in Underwood); Monroe (Pickett & Nothnagel); Putnam (Naylor, Underwood).

Dicranella rufescens (Dicks.) Schimp.
Putnam (Underwood).

Dicranella varia (Hedw.) Schimp.
Jefferson (Young as *Dicranum varium*); Monroe (Pickett & Nothnagel); Putnam (Naylor, Underwood).

Dicranum flagellare Hedw.
Lake (Röll in Underwood); Putnam (Naylor); Ripley (Deam); Wayne (Mrs. Haines); Wells (Deam).

Dicranum fulvum Hook.
Putnam (Naylor).

Dicranum fuscescens Turn.
Putnam (Naylor).

Dicranum montanum Hedw.
Jefferson (Young).

Dicranum scoparium (L.) Hedw.
Crawford (Deam); Jefferson (Young); Martin (Deam); Monroe (Pickett & Nothnagel); Montgomery (Deam); Putnam (Naylor, Underwood); Washington (Deam); Wayne (Mrs. Haines); Wells (Deam).

Dicranum viride (S. & L.) Lindb.
Wayne (Mrs. Haines).

Leucobryum glaucum (L.) Schimp.
Crawford (Deam); Floyd (Deam); Jefferson (Young); Lagrange (Deam); Martin (Deam); Monroe (Miss Nothnagel); Montgomery (Deam); Noble (Deam); Putnam (Naylor, Underwood as *Leucobryum vulgare*); Steuben (Deam); Wayne (Mrs. Haines as *Leucobryum vulgare*).

GRIMMIACEAE.

Hedwigia albicans (Web.) Lindb.
Jefferson (Young as *Hedwigia ciliata*); Putnam (Allen, Naylor); Wayne (Mrs. Haines as *Hedwigia ciliata*).

Grimmia apocarpa (L.) Hedw
Jefferson (Young as *Schistidium apocarum*); Monroe (Pickett & Nothnagel); Putnam (Allen, Naylor, Underwood).

Grimma conferta Funck.
Wayne (Mrs. Haines as *Schistidium confertum*).

Grimmia Pennsylvanica Schwaegr.
Wayne (Mrs. Haines).

EPHEMERACEAE.

Ephemerum crassinervium Hampe.
Putnam (Naylor).

TORTULACEAE.

Weisia viridula (L.) Hedw.
Jefferson (Young); Monroe (Pickett & Nothnagel); Putnam (Allen, Naylor, Underwood); Wayne (Mrs. Haines).

Gymnostomum curvirostre (Ehrh.) Hedw.
Jefferson (Young); Owen (Underwood); Putnam (Naylor, Underwood); Wayne (Mrs. Haines).

Gymnostomum rupestre Schleich.
Jefferson (Young).

Didymodon rubellus (Hoffm.) B. & S.
Monroe (Pickett & Nothnagel).

Barbula fallax Hedw.
Wayne (Mrs. Haines).

Barbula unguiculata (Huds.) Hedw.
Jefferson (Young); Monroe (Pickett & Nothnagel); Putnam (Naylor); Wayne (Mrs. Haines).

Barbula unguiculata obtusifolia (Schultz) B. & S.
Monroe (Pickett & Nothnagel).

Tortella caespitosa (Schwaegr.) Limpr.
Crawford (Deam); Harrison (Deam); Jefferson (Deam, Young as *Barbula caespitosa*); Montgomery (Deam); Putnam (Naylor); Scott (Deam); Wayne (Mrs. Haines as *Barbula caespitosa*).

Pottia truncatula (L.) Lindb.
Tippecanoe (Underwood as *Pottia truncata*).

Desmatodon Porteri James.
Perry (Deam).

ORTHOTRICHACEAE.

Drummondia clavellata Hook.
Hamilton (Wilson); Jefferson (Deam, Young); Monroe (Blatchley in Underwood); Putnam (Naylor); Tippecanoe (Underwood); Wayne Mrs. Haines).

Orthotrichum Porteri Aust.
Monroe (Pickett & Nothnagel).

Orthotrichum strangulatum Sulliv.
Jefferson (Young); Wayne (Mrs. Haines).

FUNARIACEAE.

Physcomitrium immersum Sulliv.
Monroe (Pickett & Nothnagel).

Physcomitrium turbinatum (Mx.) Brid.
Hamilton (Wilson); Jefferson (Young as *Physcomitrium pyriforme*); Monroe (Pickett & Nothnagel); Owen (Underwood); Putnam (Allen, Naylor, Underwood); Switzerland (Deam); Tippecanoe (Underwood); Wayne (Mrs. Haines as *Physcomitrium pyriforme*).

Aphanorhegma serratum Sulliv.
Putnam (Naylor).

Funaria flavicans Mx.
Monroe (Pickett & Nothnagel).

Funaria hygrometrica (L.) Sibth.
Crawford (Deam); Hamilton (Wilson); Jefferson (Young); Monroe (Pickett & Nothnagel); Putnam (Naylor, Underwood); Shelby (Miss Deam); Steuben (Miss Deam); Wayne (Mrs. Haines); Wells (Deam).

TIMMIACEAE.

Timmia megapolitana Hedw.
Montgomery (Barnes in Underwood).

AULACOMNIACEAE.

Aulacomnium heterostichum (Hedw.) B. & S.
Allen (Mrs. Deam); Crawford (Deam); Harrison (Deam); Jefferson (Young); Lagrange (Deam); Monroe (Pickett & Nothnagel); Montgomery (Barnes in Underwood); Putnam (Naylor, Underwood); Steuben (Deam); Wayne (Mrs. Haines).

Aulacomnium palustre Schwaegr.
Jefferson (Deam, Young); Lagrange (Deam); Marshall (Deam); Noble (Deam).

BARTRAMIACEAE.

Philonotis fontana (L.) Brid.
Jefferson (Young as *Bartramia fontana*).

Philonotis Muhlenbergii (Schwaegr.) Brid.
Jefferson (Young as *Bartramia Marchica*); Wayne (Mrs. Haines as *Bartramia Marchica*).

Bartramia pomiformis (L.) Hedw.
Crawford (Deam); Jefferson (Young); Lagrange (Deam); Monroe (Pickett & Nothnagel); Putnam (Naylor, Underwood); Steuben (Deam); Wayne (Mrs. Haines).

BRYACEAE.

Leptobryum pyriforme (L.) Wils.
Putnam (Naylor); Wayne (Mrs. Haines as *Bryum pyriforme*).

Pohlia nutans (Schreb.) Lindb.
Lagrange (Deam); Marshall (Deam); Martin (Deam); Monroe (Pickett & Nothnagel); Steuben (Deam); Wayne (Mrs. Haines as *Bryum nutans*).

Mniobryum albicans (Wahlenb.) Limpr.
Kosciusko (Deam); Putnam (Allen, Naylor); Tippecanoe (Deam).

Bryum argenteum L.
Jefferson (Young); Monroe (Pickett & Nothnagel); Pulaski (Deam); Putnam (Underwood); Warrick (Deam); Wayne (Mrs. Haines).

Bryum bimum Schreb.
Wells (Deam).

Bryum caespiticium L.
Putnam (Allen, Naylor, Underwood); Wayne (Mrs. Haines); Wells (Deam).

Bryum capillare L.
Monroe (Pickett & Nothnagel).

Bryum intermedium Brid.
Monroe (Pickett & Nothnagel); Owen (Underwood); Putnam (Naylor); Wells (Deam).

Bryum pseudotriquetrum (Hedw.) Schwaegr.
Putnam (Naylor); Wayne (Mrs. Haines).

Bryum Wahlenbergii Schwaegr.
Jefferson (Young).

Rhodobryum roseum (Weis.) Limpr.
Jefferson (Young as *Bryum roseum*); Monroe (Pickett & Nothnagel); Putnam (Naylor, Underwood); Wayne (Mrs. Haines as *Bryum roseum*).

Mnium affine Bland.
Gibson (Deam); Jefferson (Deam); Montgomery (Barnes in Underwood); Wayne (Mrs. Haines).

Mnium affine ciliare (Grev.) C. M.
Harrison (Deam); Monroe (Pickett & Nothnagel); Putnam (Naylor); Ripley (Deam).

Mnium cuspidatum (L.) Leyss.
Allen (Deam); Brown (Deam); Decatur (Miss Deam); Dubois (Deam); Floyd (Deam); Hamilton (Wilson); Huntington (Deam); Jefferson (Young); Kosciusko (Deam); Lagrange (Deam); Lawrence (Deam); Monroe (Pickett & Nothnagel); Orange (Deam); Putnam (Allen, Naylor, Underwood); Randolph (Deam); Steuben (Deam); Wayne (Mrs. Haines); Wells (Deam).

Mnium marginatum (Dicks.) Beauv.
Putnam (Naylor).

Mnium medium B. & S.
Gibson (Deam); Parke (Deam).

Mnium punctatum L.
Putnam (Naylor).

Mnium rostratum Schrad.
Jefferson (Young); Monroe (Pickett & Nothnagel); Putnam (Naylor); Wayne (Mrs. Haines).

LESKEACEAE.

Thuidium delicatulum (L.) Mitt.
Crawford (Deam); Harrison (Deam); Lagrange (Deam); Lawrence (Deam); Martin (Deam); Monroe (Pickett & Nothnagel); Montgomery (Deam); Perry (Deam); Porter (Deam); Putnam (Allen, Naylor, Underwood as *Hypnum delicatulum*); Steuben (Deam); Wayne (Mrs. Haines as *Hypnum delicatulum*).

Thuidium microphyllum (Sw.) Best.
Gibson (Deam); Jefferson (Young as *Hypnum gracile*); Knox (Deam); Lagrange (Deam); Martin (Deam); Putnam (Naylor); Rip-

ley (Deam); Steuben (Deam); Warrick (Deam); Wayne (Mrs. Haines as *Hypnum gracile*).

Thuidium minutulum (Hedw.) B. & S.

Jefferson (Young as *Hypnum minutulum*).

Thuidium paludosum (Sulliv.) R. & H.

Allen (Deam); Lagrange (Deam).

Thuidium pygmaeum B. & S.

Monroe (Pickett & Nothnagel).

**Thuidium tamariscinum* B. & S.

Jefferson (Young as *Hypnum tamariscinum*); Wayne (Mrs. Haines as *Hypnum tamariscinum*).

Thuidium Virginianum (Brid.) Lindb.

Martin (Deam); Putnam (Naylor); Wayne (Mrs. Haines as *Hypnum gracile Lancastriense*).

Leskea denticulata Sulliv.

Wayne (Mrs. Haines).

Leskea gracilescens Hedw.

Dearborn (Deam); Jefferson (Deam); Knox (Deam); Putnam (Naylor); Ripley (Deam); Tippecanoe (Deam); Warrick (Deam); Wells (Deam).

Leskea obscura Hedw.

Gibson (Deam); Jefferson (Young).

Leskea nervosa nigrescens (Kindb.) Best.

Perry (Deam).

Leskea polycarpa Ehrh.

Putnam (Naylor); Wayne (Mrs. Haines).

Anomodon apiculatus B. & S.

Putnam (Naylor).

Anomodon attenuatus (Schreb.) Hueben.

Harrison (Deam); Jefferson (Young); Monroe (Pickett & Nothnagel); Owen (Deam); Perry (Deam); Putnam (Allen, Naylor); Wayne, Mrs. Haines).

Anomodon fragilis (?)

Wayne (Mrs. Haines).

Anomodon minor (Beauv.) Fuern.

Jefferson (Young as *Anomodon obtusifolius*); Owen (Deam); Putnam (Naylor); Wayne (Mrs. Haines as *Anomodon obtusifolius*); Knox (Deam).

Anomodon rostratus (Hedw.) Schimp.

Crawford (Deam); Dearborn (Deam); Jefferson (Young as *Leskea rostrata*); Hamilton (Wilson); Monroe (Pickett & Nothnagel); Montgomery (Barnes in Underwood); Owen (Deam, Underwood); Putnam (Naylor, Underwood); Ripley (Deam); Warrick (Deam); Wayne (Mrs. Haines); Wells (Deam).

Anomodon tristis (Cesat.) Sulliv.

Noble (Deam); Putnam (Naylor); Wayne (Mrs. Haines).

Thelia asprella (Schimp.) Sulliv.

Jefferson (Young); Putnam (Naylor); Wayne (Mrs. Haines).

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*Dr. Grout states in his "Mosses" that this species is not known from North America.

Thelia hirtella (Schimp.) Sulliv.
Jefferson (Young); Monroe (Pickett & Nothnagel); Putnam (Naylor); Wayne (Mrs. Haines).

HYPNACEAE.

Brachythecium acuminatum (Hedw.) Kindb.
Dearborn (Deam); Jefferson (Young as *Hypnum acuminatum*); Putnam (Naylor); Wayne (Mrs. Haines as *Hypnum acuminatum*).

Brachythecium acutum (Mitt.) Sulliv.
Knox (Deam); Gibson (Deam).

Brachythecium campestre B. & S.
Wayne (Mrs. Haines as *Hypnum campestre*).

Brachythecium cyrtophyllum Kindb.
Wells (Deam).

Brachythecium oxycladon (Brid.) J. & S.
Jefferson (Deam, Young as *Hypnum laetum*); Monroe (Pickett & Nothnagel); Montgomery (Barnes in Underwood as *Hypnum laetum*); Putnam (Naylor, Underwood as *Hypnum laetum*); Steuben (Deam); Wayne (Mrs. Haines as *Hypnum laetum*); Wells (Deam).

Brachythecium plumosum (Sw.) B. & S.
Monroe (Pickett & Nothnagel); Putnam (Naylor).

Brachythecium rivulare B. & S.
Jefferson (Young as *Hypnum rivulare*).

Brachythecium rutabulum (L.) B. & S.
Monroe (Pickett & Nothnagel); Putnam (Underwood as *Hypnum rutabulum*); Wayne (Mrs. Haines as *Hypnum rutabulum*).

Brachythecium salebrosum (Hoffm.) B. & S.
Crawford (Deam); Monroe (Pickett & Nothnagel); Putnam (Allen, Naylor); Steuben (Deam); Wayne (Mrs. Haines as *Hypnum salebrosum*).

Brachythecium Starkei (Brid.) B. & S.
Monroe (Pickett & Nothnagel).

Bryhnia graminicolor (Brid.) Grout.
Putnam (Naylor).

Eurynchium hians (Hedw.) J. & S.
Jefferson (Young as Hypnum hians); Putnam (Naylor); Wayne (Mrs. Haines as *Hypnum hians*).

Eurynchium serrulatum (Hedw.) Kindb.
Crawford (Deam); Dearborn (Deam); Grant (Deam); Harrison (Deam); Jefferson (Young as *Hypnum serrulatum*); Lagrange (Deam); Monroe (Pickett & Nothnagel); Posey (Deam); Putnam (Allen, Naylor, Underwood as *Hypnum serrulatum*); Ripley (Deam); Wayne (Mrs. Haines as *Hynum serrulatum*).

Eurynchium strigosum (Hoffm.) B. & S.
Jefferson (Young as *Hypnum strigosum*); Putnam (Naylor); Wayne (Mrs. Haines as *Hypnum strigosum*).

Eurynchium strigosum robustum Roell.
Jefferson (Deam); Putnam (Naylor).

Cirriphyllum Boscii (Schwaegr.) Grout.
Crawford (Deam); Jefferson (Young as *Hypnum Boscii*); Monroe (Blatchley in Underwood as *Hypnum Boscii*); Putnam (Naylor, Underwood as *Hypnum Boscii*); Scott (Deam); Switzerland (Deam); Wayne (Mrs. Haines as *Hypnum Boscii*).

Homalotheciella subcapillata (Hedw.) Card.
Wayne (Mrs. Haines as *Homalothecium subcapillatum*).

Climacium Americanum Brid.
Hamilton (Wilson); Jefferson (Young); Monroe (Pickett & Nothnagel); Montgomery (Deam); Owen (Deam); Putnam (Allen, Naylor, Underwood); Wayne (Mrs. Haines); Wells (Deam).

Porotrichum Alleghaniense (C.M.) Grout.
Jefferson (Young as *Hypnum Alleghaniense*); Putnam (Underwood as *Hypnum Alleghaniense*).

Drepanocladus fluitans (Dill.) Warnst.
Wayne (Mrs. Haines as *Hypnum fluitans*).

Drepanocladus vernicosus (Lindb.) Warnst.
Noble (Deam).

Cratoneuron filicinum (L.) Roth.
Lagrange (Deam); Tippecanoe (Deam).

Calliergon cordifolium (Hedw.) Kindb.
Lagrange (Deam); Owen (Deam); Wayne (Mrs. Haines as *Hypnum cordifolium*).

Campylium chrysophyllum (Brid.) Bryhn.
Monroe (Pickett & Nothnagel); Putnam (Naylor); Switzerland (Deam).

Campylium hispidulum (Brid.) Mitt.
Crawford (Deam); Jefferson (Deam, Young as *Hypnum hispidulum*); Montgomery (Deam); Owen (Deam); Posey (Deam); Putnam (Naylor); Scott (Deam); Steuben (Deam); Wayne (Mrs. Haines as *Hypnum hispidulum*); Wells (Deam).

Campylium radicale Beauv.
Montgomery (Barnes in Underwood as *Hypnum radicale*).

Amblystegium fluviatile (Sw.) B. & S.
Monroe (Pickett & Nothnagel); Montgomery (Barnes in Underwood); Putnam (Naylor, Underwood); Randolph (Deam); Shelby (Deam).

Amblystegium irriguum (Wils.) B. & S.
Putnam (Naylor).

Amblystegium irriguum spinifolium Sch.
Lagrange (Deam); Steuben (Deam).

Amblystegium Juratzkanum Schimp.
Crawford (Deam); Harrison (Deam); Randolph (Deam); Steuben (Deam).

Amblystegium Kochii B. & S.
Decatur (Deam); Monroe (Pickett & Nothnagel).

Amblystegium orthocladon (P.B.) Kindb.
Monroe (Pickett & Nothnagel); Wayne (Mrs. Haines as *Hypnum serpens orthocladon*).

Amblystegium riparium B. & S.
Decatur (Deam); Jefferson (Young as *Hypnum riparium*); Monroe (Pickett and Nothnagel); Putnam (Naylor).

Amblystegium serpens (L.) B. & S.
Crawford (Deam); Dearborn (Deam); Grant (Deam); Hamilton (Wilson as *Hypnum serpens*); Jefferson (Young as *Hypnum serpens*); Lagrange (Deam); Putnam (Naylor, Underwood); Wayne (Mrs. Haines as *Hypnum serpens*).

Amblystegium varium (Hedw.) Lindb.
Lagrange (Deam); Monroe (Pickett & Nothnagel); Jefferson (Deam); Putnam (Naylor); Wayne (Mrs. Haines as *Hypnum varium*); Wells (Deam); Allen (Deam); Whitley (Deam).

Hypnum cupressiforme L.
Hamilton (Wilson); Putnam (Underwood).

Hypnum curvifolium Hedw.
Harrison (Deam); Jefferson (Young); Monroe (Pickett & Nothnagel); Putnam (Allen, Naylor).

Hypnum Haldanianum Grev.
Jefferson (Young); Putnam (Naylor).

Hypnum imponens Hedw.
Jefferson (Young); Martin (Deam); Monroe (Pickett and Nothnagel); Putnam (Naylor); Wayne (Mrs. Haines).

Hypnum Patientiae Lindb.
Putnam (Underwood as *Hypnum arcuatum*).

Hypnum recurvens (Mx.) Schwaegr.
Jefferson (Young).

Hypnum riparium cariosum (?).
Wayne (Mrs. Haines).

Hypnum serpens radicle (?).
Wayne (Mrs. Haines).

Hypnum tenuirostris B. & S.
Jefferson (Young as *Hypnum cylindrocarpum*); Wayne (Mrs. Haines as *Hypnum cylindrocarpum*).

Raphidostegium adnatum (Mx.) B. & S.
Jefferson (Young as *Hypnum adnatum*).

Raphidostegium Carolinianum (C.M.) J. & S.
Crawford (Deam); Monroe (Pickett & Nothnagel); Putnam (Naylor).

Raphidostegium Carolinianum admixtum Sulliv.
Martin (Deam); Monroe (Pickett & Nothnagel); Crawford (Deam).

Plagiothecium denticulatum (L.) B. & S.
Allen (Deam); Putnam (Naylor).

Plagiothecium deplanatum (Sch.) Grout.
Floyd (Deam); Jefferson (Young as *Hypnum deplanatum*); Monroe (Pickett & Nothnagel); Putnam (Naylor); Wayne (Mrs. Haines as *Hypnum deplanatum*).

Plagiothecium elegans (Hook.) Sulliv.
Putnam (Naylor).

Plagiothecium geophilum Aust.
Monroe (Pickett & Nothnagel); Putnam (Naylor).

Plagiothecium Roseanum (Hampe) B. & S.
Putnam (Naylor); Switzerland (Deam).

Plagiothecium sylvaticum (Huds.) B. & S.
Putnam (Naylor).

Amblystegiella adnata (Hedw.) Nichols.
Jefferson (Deam); Montgomery (Deam); Perry (Deam).

Amblystegiella confervoides (Brid.) Loeske.
Perry (Deam).

Entodon brevisetus (H. & W.) J. & S.
Wayne (Mrs. Haines as *Cylindrothecium brevisetum*).

Entodon cladorrhizans (Hedw.) C. M.
Jefferson (Young as *Cylindrothecium cladorrhizans*); Monroe (Pickett & Nothnagel); Putnam (Allen, Naylor, Underwood); Wayne (Mrs. Haines as *Cylindrothecium cladorrhizans*).

Entodon seductrix (Hedw.) C. M.
Clark (Deam); Dearborn (Deam); Jay (Deam); Jefferson (Young as *cylindrothecium seductrix*); Lagrange (Deam); Monroe (Pickett & Nothnagel); Noble (Deam); Perry (Deam); Putnam (Allen, Naylor, Underwood); Warrick Deam); Wayne (Mrs. Haines as *Cylindrothecium seductrix*).

Platygyrium repens (Brid.) B. & S.
Harrison (Deam); Monroe (Pickett & Nothnagel); Perry (Deam); Putnam (Allen, Naylor); Wayne (Mrs. Haines); Wells (Deam).

Pylaisia intricata (Hedw.) R. & C.
Jefferson (Young); Putnam (Naylor); Wayne (Mrs. Haines as *Pylaisia velutina*).

Pylaisia Schimperi R. & C.
Monroe (Pickett & Nothnagel); Wayne (Mrs. Haines as *Pylaisia intricata*).

Pylaisia subdenticulata Schimp.
Wayne (Mrs. Haines as *Pylaisia denticulata*).

LEUCODONTACEAE.

Leucodon brachypus Brid.
Wayne (Mrs. Haines).

Leucodon julaceus (Hedw.) Sulliv.
Jefferson (Young); Monroe (Blatchley in Underwood, Pickett & Nothnagel); Putnam (Naylor, Underwood); Wayne (Mrs. Haines).

Forsstroemia Ohioensis (Sulliv.) Lindb.
Wayne (Mrs. Haines as *Leptodon Ohioense*).

Forsstroemia trichomitria (Hedw.) Lindb.
Jefferson (Young as *Leptodon trichomitrion*); Monroe (Pickett & Nothnagel); Wayne (Mrs. Haines as *Leptodon trichomitrion*).

NECKERACEAE.

Neckera pennata (L.) Hedw.
Wayne (Mrs. Haines).

FONTINALACEAE.

Fontinalis dalecarlica B. & S.
Putnam (Allen).

Fontinalis Lescurii Sulliv.
Putnam (Naylor).

A CURIOUS VARIATION IN THE COMMON MILKWEED.

C. A. Ludwig, Clemson College.

During the first half of August, 1917, while spending a few weeks at home. I found a variant milkweed, *Asclepias syriaca* L., which was so unusual that it was removed to the back yard of my parents' home for further observation. During the next summer, 1918, two other similar plants were discovered by my mother and transferred to the yard by my father. These three plants and some seedlings from the first of the three are now growing there. I have not seen them during the growing season since 1917[1]; but as there seems to be no prospect of my being in a position to investigate their behavior soon, it appears to be worth while at this time to note their occurrence, with such notes as the very imperfect observations warrant.

The first plant was discovered along the village street about a hundred yards north of the Methodist church in the village of Blooming Grove, Franklin County, Indiana. The distinguishing feature of the plant was the peculiar irregularity of most of the leaf margins, with an accompanying narrowing of the leaves. Many leaves consisted of but little more than the midrib. They had much the appearance of having been partially eaten by chickens, and it was only a careful examination that showed another cause to be responsible.

The plant contained a few fruits and it seemed desirable to save seed and determine whether or not the progeny would show the same character, but before the seed were ripe the plant was cut off by some workman engaged in mowing weeds. However, one stem with the fruits was recovered and placed in water. By this means a number of viable seeds was secured. The other stems were recovered for a herbarium specimen, and the plant itself was transplanted to the back yard.

In 1918 the peculiar leaf characteristic was largely absent. At best it was represented by no more than a slight narrowing, since my mother wrote me that I must have obtained the wrong plant the summer before, as the leaves were normal. Furthermore, as noted above, she found two more abnormal plants. These were transplanted the same season near the first one. All three of these plants have had the abnormal leaves during the seasons of 1919 and 1920. The first one also produced seed in 1920. Figs. 1 and 2 show the first plant as it appeared in the summer of 1919. Fig. 3 shows Nos. 2 and 3 as they appeared at the same time. Figs. 4-6 show tracings of some of the leaves of No. 1, made from the herbarium specimen already mentioned. These show clearly the extreme narrowing of many of the leaves and the irregularities of the margins.

On April 18, 1918, one hundred four of the immature seeds secured the autumn before were planted in a shallow box. A number of seedlings were secured from them and set out a short distance from the mother plant. Of these seedlings about a dozen are still living. None of them shows the leaf character so evident in the parent. The leaves may possibly show a

[1]I am indebted to my mother, Mrs. A. C. Ludwig, for the observations made since 1917, and for the photographs reproduced with this paper.

slight narrowing; but they are not noticeably irregular, for they were reported as appearing normal.

As was mentioned above there seems to be little chance of my being able at any time soon to investigate adequately the behavior of these aberrant plants. For that reason I am willing to turn over my material and notes to anyone who is willing and in a position to do the work.

Fig. 1.—Upper part of plant No. 1, summer of 1919.

Fig. 2.—Same plant, showing a larger portion of the plant. Note that the bottom and apical leaves approach the normal in shape.

Fig. 3.—Upper part of plants 2 and 3, summer of 1919.

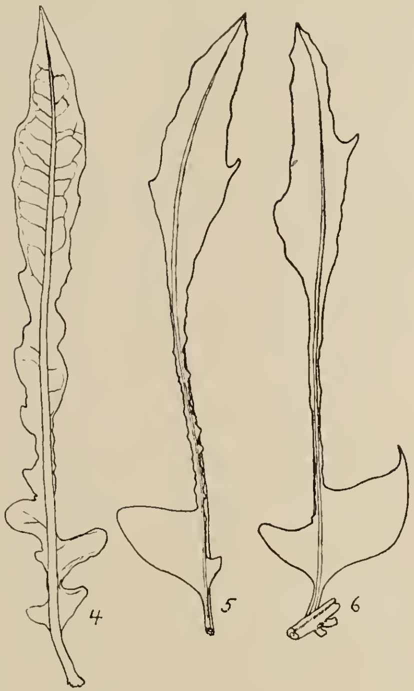


Fig. 4.—Lower side of leaf of plant No. 1 (summer, 1917) from herbarium specimen.

Figs. 5 and 6.—Upper side of leaves from same specimen.

Figs. 4, 5, and 6 are one-half natural size.

SOME EVIDENCE INDICATING THE IMPORTANCE OF FROST ACTION IN WIDENING VALLEYS.

Glenn Culbertson.

At several points along the lower reaches of Clifty gorge in Jefferson county, Clifty Creek in its first attempts at valley widening has eroded the sides of the valley to such an extent as to cause more or less extensive landslide areas. In the case of several of these, the naked soil and rock are exposed for a horizontal distance of several hundred feet, and vertically several scores of feet. About one-half mile from the Madison and Hanover road across the mouth of the valley, there is such an erosion area on the slope facing west. Near the south end of this exposure a large mass of the original rock extends out into the valley, as may be seen by referring to the figure.

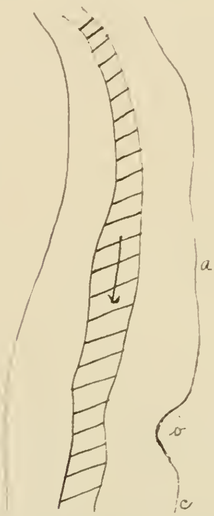
The formation into which the stream is cutting at this point is that of the Lorraine shales of the Ordovician. At this horizon the Lorraine is composed of alternating layers of limestone from one to three inches in thickness and comparatively soft blue shale comprising at least 75 per cent of the whole. At the point "A" in the figure, the stream at every flood stage undercuts the steep slope and removes all debris consisting of broken lime stone and shale resulting from the weathering of the exposure. The projection at "B" is composed of the same material as that at "A", and is from its position especially exposed to the action of the stream at flood stage and thruout its course in the two mile gorge the stream gradient is high.

Why has this projection "B" been able to endure while a similar material both upstream and down has been carried away? In the judgment of the writer, it is due to the fact that a spring emerges from the hillside above, the waters of which flow over the projecting rocks at "B", and not only prevents freezing, but keeps them uniformly at the same temperature and moisture. The part "B" which stands out some twelve or fourteen feet beyond the part "A" and at least six feet beyond the part "C" which is completely protected from the force of the flood waters by the projection, is kept well covered by the spring waters at all times. The difference in the rate of valley widening here which is quite marked, is probably due to two, if not three processes. First and foremost is frost action. The alternate freezing and thawing which occurs many times during the winter, loosens annually large quantities of material from the steep slope at "A" which is entirely unprotected by vegetation. The Spring floods periodically remove this. Some material of this sort, however, is loosened and accumulated during the summer and autumn. Hence another cause of weathering must be sought, that does not take place at "B". Alternate expansion and contraction due to change in temperature is responsible for part of this work, but in the writers judgment, alternate wetting and drying, which takes place many times during the summer, may be equally as efficacious.

At two other points in Jefferson County, a similar protective influence of the waters of springs has been noticed. In these cases the formations protected were resistant Devonian limestones, and the mass of the projecting area was not nearly so great as in the case of the less resistant

Lorraine shales described above. These were sufficiently striking, however, to indicate that all such weathering agencies as the above, probably have much more to do with the widening of valleys in native rock formatior than has been generally conceded.

Photo showing character of materials at a and b.



Rough Sketch of Bed of Clifty Creek Showing Special Feature of b.

PLANATION STREAM PIRACY.

BY

CLYDE A. MALOTT.

Introduction.

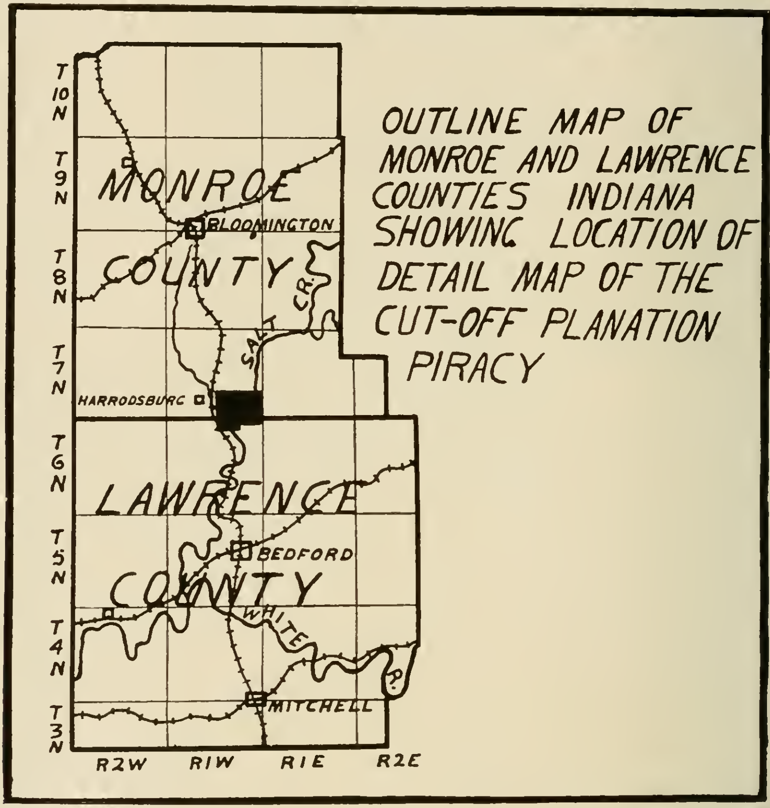
Definition of Stream Piracy.—Stream piracy is not an uncommon phase of stream adjustment during the development of the erosion cycle. Stream piracy consists of the diversion of a portion of a stream system usually by the encroachment of a portion of a more vigorous stream system. Thus the drainage area of the more vigorous stream is enlarged at the expense of the weaker stream. This encroahcment and diversion take place slowly by stream adjustment during the development of the erosion cycle. Stream piracy has nothing in common with stream derangement. Streams are frequently thrown out of their normal courses by such processes as glaciation vulcanism, deposition of sand by the wind, etc., but such stream derangement is not considered as a phase of stream adjustment and does not come under the term stream piracy. Stream piracy and stream derangement are very different physiographic processes.

Types of Stream Piracy.—Broadly speaking there are three types of stream piracy which may accompany stream adjustment. The most common, perhaps, is the headward erosion type. A condition favoring the development of this type is the cuesta where vigorous streams flow down the steep scarp. Such streams are frequently able to etch their way by headward erosion through the frontal scarp of the cuesta and divert the head-waters of more sluggish streams upon the back-slope. Examples of the headward erosion type have been described by Gilbert, Davis, Darton, and others. Probably the most famous examples of the headward erosion type are Kaaterskill and Plaaterskill creeks on the frontal scarp of the Catskill Mountains. Here these streams have undercut the headwaters of Schoharie Creek on the back-slope of the cuesta. A notable case of this kind in southern Indiana has recently been described by the writer.[1] Muddy Fork of Silver Creek of Clark and Washington counties has taken some 35 square miles of the drainage basin of one of the forks of Blue River. In this case the pirate stream had its beginning on the steep slope of the Knobstone escarpment. This form of headward erosion piracy usually gives rise to a barbed drainage pattern. Another form of headward erosion piracy is common in such mountains as the Appalachians, where not doubt the trellis drainage patterns so prevalent have been brought about by stream adjustment in which headward erosion piracy has played the chief role. The case of the Shenandoah River and Beaverdam Creek near Snickers Gap in the Harpers Ferry locality as described by Willis is a classical example of this form of headward erosion stream piracy.

A second type of stream piracy may be called the subterranean type. This type is fairly common in limestone regions where subterranean drainage exists. A favorable condition is considerable relief of the limestone

[1] "Some special Physiographic Features of the Knobstone Cuesta region of southern Indiana—An Example of Explanatory Physiography," Proceedings of the Indiana Academy of Science, 1919.

area. Subterranean piracy is dependent upon differential work of the surface streams in their downward cutting. Those stream basins or portions of stream basins which are relatively high above neighboring stream basins in limestone regions are subject to diversion by subterranean piracy. The most notable case yet described is that described by Beede in his paper on the "Cycle of Subterranean Drainage, as Illustrated in the Bloomington, Indiana, Quadrangle," published in the Proceedings of the Indiana Academy of Science, 1910. In this case several square miles of the upper por-



tion of Indian Creek drainage basin have been diverted by subterranean piracy into the more deeply intrenched streams on either side of the headwaters of Indian Creek.

The third type of stream piracy is the type with which the present paper deals. It is commonly found where a larger stream has reached the stage of maturity in an area of considerable relief. By the lateral planation of the mature main stream a nearly parallel minor stream may be literally cut into two streams, each entering the master stream independently. The upper part of the once continuous stream will enter the main stream at the place where the master stream invaded the valley of the minor stream. The lower part of the minor stream will be left in a valley far too large for it. This form of stream piracy is less frequently seen in streams which are approximately equal in size. Where such cases occur it is probable that one stream does not cause the piracy by lateral planation more than the other, but they may be mutually responsible. In any case the stream which is deeper acquires the drainage of the other. Since this type of piracy takes place on account of lateral planation, usually by the major more mature stream, it is here proposed that this type of stream piracy be called planation piracy.

A Typical Case of Planation Stream Piracy.

Location and Geography.—The area which affords a typical example of planation stream piracy lies mainly in southern Monroe County, Indiana. A topographic map of the locality accompanies this paper. The area as mapped laps somewhat over into Lawrence County. Some seven square miles are included in the mapped area, the larger part of which lies in T. 7 N., R. 1 W. The portion of the area in Lawrence County lies in the next township to the south. A small portion of the mapped area is included in the extreme southeastern part of the Bloomington Quadrangle area. The case of piracy is about two and one-half miles east of Harrodsburg station and just south of the little village of Fairfax. The area is some twelve to fourteen miles south of Bloomington.

The area is cut by the intrenched valley of Salt Creek. The valley on approaching the area from the north makes an abrupt turn to the west and northwest, and then again turns to the south when within three-fourths of a mile of Harrodsburg station. It leaves the area trending in a southeasterly direction. These abrupt turns in the valley of Salt Creek have given rise to an upland mass of land partly surrounded by Salt Creek valley. The individual drainage of the upland is by rather minor streams, chief among which are Upper and Lower Cut-off creeks. These streams are not more than two miles in length. Clear Creek which heads near Bloomington enters Salt Creek near the southwest corner of the mapped area.

The area is rather sparsely settled and most of the steeper slopes are wooded. The gently rolling upland area and the broad valley of Salt Creek are under cultivation, but no part of the area is attractive from the standpoint of agriculture.

Topography and Relief.—The topography is shown specifically upon the accompanying topographic map which has been prepared to show the outstanding topographic features and their relationships. The area has a maximum relief of slightly over 250 feet, extending from the valley of Salt Creek which has an elevation of about 500 feet to the higher parts of the upland which reach an elevation of 750 feet or slightly more above sea level. Towards the east side this maximum relief of 250 feet is attained immediately between the valley and the upland. The chief topographic feature is the deeply cut, but flat-bottomed valley of Salt Creek. This valley ranges in width from about one-fourth of a mile to a mile. In places this valley is flanked by terraces which are from 10 to 40 feet in height above the present flood-plain. For the most part the upland rises abruptly from the valley floor with an ascent varying from 125 to 250 feet. The upland is sharply trenched by minor stream development. The upland spaces between the minor stream valleys are rather gently rolling or flat, with some development of shallow sinkhole topography.

Geologic Conditions and Physiographic Development of the Locality.—Since an understanding of the geology of a locality is frequently quite essential in the interpretation of the topographic forms present a brief sketch of the geology will be given here. The upland mass is composed chiefly of solidified Mississippian rocks of Keokuk and Warsaw age, covered over with a thin soil mantle except where the slopes are quite steep. Small deposits of late Tertiary gravel are present on the upland adjacent to Salt Creek valley. Salt Creek valley is partly filled with Pleistocene and recent alluvial material.

The rocks of Keokuk age are massive to thin bedded impure sandstones and sandy shales, all usually of a bluish color, consisting of the upper part of the so-called Knobstone group of rocks. These sandy shales and argillaceous, fine-grained sandstones are mainly exposed on the steep slopes of the area. More than 200 feet of the Knobstone rocks are exposed on the steep slopes on the eastern side of the area. Everywhere on top of the upland the clastic Knobstone rocks are covered with the thin to massive bedded Harrodsburg limestone of Warsaw age. The contact of this limestone with the underlying Knobstone is about 740 above sea level at the east side of the area, about 650 feet in the middle of the area, and about 580 feet in the hill east of the mouth of Clear Creek near the southwest corner of the area. With these figures in mind, reference to the topographic map will show that practically all of the tillable upland is on the Harrodsburg limestone. This limestone has a total thickness of about 90 feet, but only in one or two localities in the mapped area is the total thickness to be found. This limestone area is covered by a red soil in and on which are quantities of chert which has weathered from the limestone.

The dip of the Mississippian rocks may be computed from the figures given above on the contact of the Harrodsburg limestone and the Knobstone rocks. The dip is mainly west, or slightly south of west. The rate of dip is variable, being abnormally great in the eastern half of the area. There, the dip amounts to something like 80 feet to the mile, while in the western half of the area the dip has subsided to approximately the normal amount of 35 feet to the mile. The extraordinary dip at the eastern side of the area is probably because of proximity to a considerable structural disturbance a short distance east of the mapped area.

The region is a dissected plain. The topographic map shows distinctly the general level of the plain in the gently rolling to flat upland interstream spaces. This upland plain is about 760 feet above sea level at the eastern side of the area. It inclines to the west where it has an elevation of about 675 feet. This plain as preserved in the area is a portion of a more extensive one developed on the rather resistant Harrodsburg limestone which caps the upland area. The Harrodsburg limestone capping has protected the underlying easily eroded and weathered Knobstone rocks. Since this partly preserved plain inclines practically with the dip of the Harrodsburg limestone upon which it is developed, it may be regarded as a structural plain. It may also be called a structural peneplain, since it is a plain developed on the structural level of the Harrodsburg limestone by fluvial agencies. It owes its preservation as a plain to the rather superior resistance of the limestone to mechanical denudation, and to the fact that its subterranean drainage in the limestone has temporarily greatly retarded its fluvial destruction. Where the streams have cut through the Harrodsburg limestone into the mechanically non-resistant Knobstone rocks they are flanked by very steep slopes, having angles of 20 to 50 degrees from the horizontal. This sharp stream trenching is quite characteristic of Knobstone topography.

The structural plain developed on the Harrodsburg limestone extends miles eastward from the area, and rises directly with the strata in that direction. But less and less of the interstream surface is level to the eastward; and finally the Harrodsburg limestone ceases to be present, though the plain itself has risen to an elevation of 900 to 1,000 feet above sea level. The divides in this high-level area are rather sharp, but have even crests of approximately the same elevation. This area furnishes a most excellent example of mature topography. This maturely dissected area which reaches elevations of 900 to 1,000 feet above sea level is probably representative of the earlier Tertiary fluvial peneplain, and may be correlated with the Highland Rim peneplain of Kentucky and Tennessee. The Highland Rim peneplain remnants represent the highest level attained in Indiana. In the region in question no part of the area reaches up to the Highland Rim level. Portions of the structural plain, however, probably represent a later more local peneplain of fluvial origin. This level has an elevation of 650 to 700 feet. The presence of old stream gravels at these elevations on the upland adjacent to the valley of Salt Creek is evidence of local peneplanation. These gravels were noticed near the higher places on the ridge in section 34, between Salt Creek and Lower Cut-off Creek. They are probably of latest Tertiary age, having been deposited as alluvial gravels previous to the uplift which is ordinarily believed to have ushered in the Pleistocene.

The Pleistocene uplift was responsible for the stream trenching of the area. This uplift allowed Salt Creek to intrench itself into the uplifted land mass 150 feet or more below the stream gravels of late Tertiary age Stream trenching was considerably greater than the difference in the elevation of the present graded valley and the old gravels, since the present valley is partially filled with Pleistocene gravels, sands, and silts. It is filled some 50 to 80 feet below the present stream level. The upper part of the Pleistocene valley filling has been partly removed and reworked by the meandering stream over the over-broadened valley-flat. Terraces ranging in height from a few feet to over 40 feet above the present flood plain indicate that the Pleistocene filling of the intrenchesd valley has been partly removed. This Pleistocene valley material is composed largely of material derived from the rocks in which the valley is cut, but a portion of it is distinctly outwash material from the Illinois glacial lobe which came as far south as the headwaters of Salt Creek at the northern and northeastern limits of the triangular-shaped unglacial area in southern Indiana.

The Name of Cut-Off Piracy.—Upper and Lower Cut-off creeks are two small streams shown on the map accompanying this paper, and the names are applied to the streams for the first time, in this paper. These names were suggested from the name. "The Cut-off", applied to a sag-like opening or col in the south half of section 35, which appears on Siebenthal's map of Monroe County published in 1895. In this paper the liberty is taken of making the term apply specifically to the sag, the expression "The Cut-off Col" being used. Since the col has resulted from a physiographic action in which a formerly continuous stream was divided into two sections, the term "Cut-off" has been applied to each section, the upper section or stream being named Upper Cut-off Creek and the lower section or stream being named Lower Cut-off Creek. The physiographic action which divided the parent stream into Upper and Lower Cut-off creeks was lateral planation or the side-wise swinging of Salt Creek in the process of widening its valley. This process took place in such a degree that Salt Creek actually invaded the territory of the parent Cut-off Creek and the upper part was diverted. Thus this case of planation piracy may well be called "Cut-off Piracy".

Evidence of Diversion of Upper Cut-off Creek.—That the valleys of Upper and Lower Cut-off creeks were once one continuous valley and the drainage of the present two stream systems was once a unit, is seen in the present courses of the streams and the existence of the low sag which separates them. Upper Cut-off Creek, arising in the southeastern quarter of section 36, flows west bearing slightly to the northward. In the southeast quarter of section 35 near Phillips School, it turns abruptly through a flat-bottomed opening and passes northward over the flat flood plain of Salt Creek to Salt Creek channel near Fairfax. (Figures 1 and 2.) Lower Cut-off Creek heads in a great sag, here called the Cut-off Col, one-fourth mile west of where Upper Cut-off Creek debouches upon the flood plain of Salt Creek. (Figures 3 and 4.) After extending west for three-fourths of a mile the valley of Lower Cut-off Creek turns southward and opens into Salt Creek valley. The upper part of Lower Cut-off Creek valley is directly in line with the valley of Upper Cut-off Creek. It may be said that Upper Cut-off Creek has no valley after making the abrupt turn northward through the opening at Phillips School, as it there debouches upon the

Fig. I. View showing Upper Cut-off Creek where it turns abruptly northward through the narrow, flat-bottomed opening at Phillips School.

Fig. 2. View of the flat-bottomed opening through which Upper Cut-off Creek enters onto the wide flood plain of Salt Creek at Phillips School. Salt Creek flood plain is confluent with this flat-bottomed opening, and is beyond the projecting spurs of upland shown at either side of the view.

valley-flat of Salt Creek. The alignment of the valleys of the two streams, the presence of Cut-off Col between the valleys, the ending of the valley of Upper Cut-off Creek where the stream turns northward at Phillips School, the more sharply trenched condition of the upper valley, the undersized stream in the broad gently-sloping lower valley, and the great semicircular bend of the steep south bluff of the entrenched valley of Salt Creek show clearly that a once continuous stream has been divided and the upper portion caused to empty into Salt Creek valley several miles farther upstream than where the drainage formerly entered. This condition undoubtedly resulted from the rather extraordinary widening of Salt Creek valley in the Phillips School locality by lateral planation.

Conditions Which Favored the Cut-off Piracy.—A number of conditions favored the Cut-off planation piracy. The parent Cut-off Creek flowed almost parallel with Salt Creek in its westward direction near Fairfax. This parallelism was not an extraordinary thing in this small stream, as the southward turn of Salt Creek valley allowed it to come into Salt Creek in a normal manner. (The southward turn of Lower Cut-off Creek is rather exceptional, as it causes the parallelism of the two streams to continue a greater distance than it otherwise would; but a discussion of this condition is not essential to the present problem.) Lateral planation is a normal action taking place in valleys which have reached the mature stage. But the conditions in the vicinity of Fairfax are rather favorable for an unusual amount of lateral planation. The valley here makes an abrupt bend somewhat greater than a right angle. Such a turn should normally cause the waters of the valley to impinge against the outside valley-wall, or in this case on the south bluff. It may be noticed that the valley is much wider in the vicinity of Fairfax than it is for several miles either above or below this locality. No terraces flank the south side of the valley here, but on the inside of the great valley-bend more than the usual amount of terrace material is present. This abrupt turn of the valley certainly favored lateral planation on the outside of the great bend. The extraordinary concave bluff-line, with its farthest south extension near Phillips School, is a rather striking indication of the concentration of waters against the south side of the valley.

Another feature which enters into the problem is the fact that there has been much more water flowing in Salt Creek valley at times during the past than there is at present. Salt Creek is a small sluggish stream meandering in a valley rather too large for it. The Pleistocene valley-fill material and the flanking terraces are proof that the valley once was a sluice-way for the exit of glacial waters. No doubt during the melting seasons of the glacial ice near the headwaters of this valley, the valley was in a highly flooded condition, and the stream that occupied it was much larger than the present one. Lateral planation must have taken place on a much greater scale during this time than at present. The much larger Pleistocene stream must have brushed all outside turns of the meandering valley with considerable vigor. The great curve cut out in the south bluff south of Fairfax must have been made during this time, as the curve seems unusually large to have been made by the present rather feeble stream. The present position of the stream channel has no relation to this great curve. In one or two meanders in the flood-plain the present stream does come against the south bluff in the northern part of section 36, but this touching of the bluff in these two places has not yet destroyed the symmetry of the great curve in the wall-like bluff.

There is a strong probability that the parent Cut-off Creek received a small tributary from the northeast in the vicinity of the present site of Phillips School. The territory of this stream was invaded by the over-widened valley of Salt Creek. The sags, one near the center of section 35 and one in the N. W. quarter section 35, are indications that the upper portions of two small tributaries of Cut-off Creek became engulfed in the widened valley of Salt Creek. In the case, however, of the tributary which came in near the present site of Phillips School, the whole of the area of the tributary became a part of Salt Creek valley. When the great curve had advanced far enough to come into the valley of Cut-off Creek or approach it through the valley of the tributary, piracy of the upper part of the parent Cut-off was effected. It is believed that the piracy was effected during the Pleistocene period.

Static Rejuvenation of Upper Cut-Off Creek Basin.—The virtual division of the parent Cut-off Creek into Upper and Lower Cut-off creeks allowed the drainage waters from about 260 acres to enter Salt Creek directly, instead of having to flow some two miles farther before entering Salt Creek valley. Upper Cut-off Creek at the time of its diversion must have been perched 90 to 95 feet above Salt Creek valley. This is specifically indicated by the elevation of the old abandoned portion of the parent stream valley which is now the divide between Upper and Lower Cut-off creeks. (Figure 3.) The valley of Salt Creek at the place of the entrance of Upper Cut-offCreek upon it is 515 feet above sea level. The abandoned portion of the parent stream valley at the Cut-off Col is 595 feet above sea level. The col is thus 80 feet higher than the valley-flat of Salt Creek. But the col is at present some distance west of the place where the piracy was effected, and in that distance the parent stream had a fall of 10 to 15 feet. Thus, Upper Cut-off Creek at the time it was diverted was perched 90 to 95 feet above Salt Creek flood-plain. At the time of diversion the waters of Upper Cut-off Creek entered Salt Creek valley over a fall 90 to 95 feet high. This fall may have endured for some time, but the nature of the rock is such that the fall could not have persisted. The rocks are easily eroded and weathered, and there are few or no ledges of superior hardness. The correction of this peculiar gradient of the diverted stream has deeply entrenched the valley, having cut it some 90 to 95 feet deeper than the valley of the parent stream. Thus the Upper Cut-off Creek drainage basin furnishes an excellent example of a stream basin that has been statically rejuvenated.[2]

Migration of the Cut-Off Col.—At the time that the parent Cut-off stream was divided into two parts by the lateral planation of Salt Creek the divide between the two parts was probably immediately west of the place where the cut-off was effected. The rejuvenation of the upper stream basin was followed by its intrenchment far below the former fairly well graded valley-level. The tributary stream which comes in from the south near Phillips School was probably for a time a tributary to Lower Cut-off Creek. But the rejuvenation brought about by the piracy gave rise to a condition favorable for normal headward erosion piracy. Rainwash and gullying on the west brought about the capture of the somewhat sluggish stream from the south, thereby enlarging the basin of Upper Cut-off Creek. Headward erosion continued westward down the course of the parent stream, and the small ravines on either side were captured in succession. The divide has now migrated by this headward erosion process about one-fourth mile west of its original position at the time the planation piracy

Fig. 3. View directly across the "Cut-off Col" from the south. The small ravine at the left is the very head of Lower Cut-off Creek.

[2]C. A. Malott, Static Rejuvenation, Science, New Series, Vol. LII, No. 1338, Aug. 20, 1920.

Fig. 4. Oblique view across the "Cut-off Col" from the southwest. The deeply intrenched reversed drainage of the invading portion of Upper Cut-off Creek is shown in the back-ground.

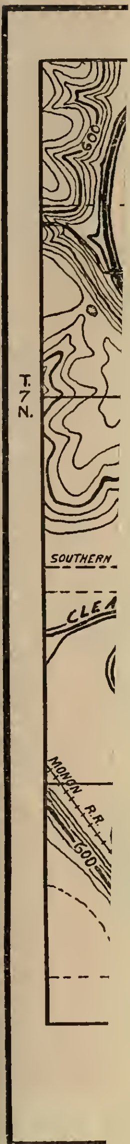
took place. Thus, this planation piracy started normal successive headward erosion piracy.[3] This type of piracy is not yet complete in the area. Other small ravines to the west of the col will eventually be taken into the upper stream system. This successive piracy proceeding down the course of the old parent stream will continue until the gradients of the new reversed stream and Lower Cut-off Creek are in a balanced condition. Thus Cut-off Col may be expected to migrate west of its present position probably as much as a half-mile before the balanced condition is attained.

The whole basin of former Cut-off Creek had an area of some 1,040 acres. Immediately following the planation piracy this area was divided into an upper basin of approximately 260 acres in area and a lower basin of about 780 acres. On account of the headward erosion piracy following the planation piracy, Upper Cut-off Creek stream system now consists of a drainage basin of approximately 400 acres in area, while the lower stream basin has dwindled to approximately 640 acres in area. When the gradients of the present invading portion of the upper stream and the lower stream have reached a balanced condition, it is probable that the basins of the two stream systems will be approximately equal, as it appears that some 120 acres in area will be taken from the lower system by the invading part of the upper system.

Summary and Conclusion.

The subject matter of this paper is introduced by a definition of stream piracy and a classification of the types. The classification simply defines

[3]The writer has described a case of successive headward erosion stream piracy in detail in a paper entitled "Some Special Physiographic Features of the Knobstone Cuesta Region of Southern Indiana", Proceedings of the Indiana Academy of Science, 1919. The expression "successive headward erosion piracy" is rather bunglesome, but should be easily understandable.



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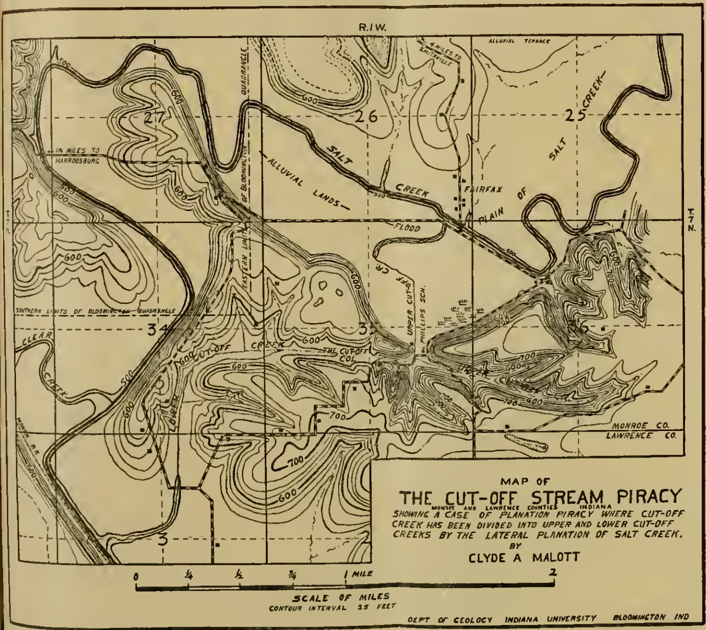
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EASTERN LIMITS OF BLOOMINGTON QUADRANGLE
SALT CREEK
FAIRFAX
PLAIN OF SALT CREEK
FLOOD
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PHILLIPS SCH.
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34
35
36
CLEAR CREEK
CUT-OFF CREEK
THE CUT-OFF COL
LOWER
LOWER CUT-OFF CR.
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MONROE CO.
LAWRENCE CO.
3
MAP OF
THE CUT-OFF STREAM PIRACY
MONROE AND LAWRENCE COUNTIES INDIANA
SHOWING A CASE OF PLANATION PIRACY WHERE CUT-OFF CREEK HAS BEEN DIVIDED INTO UPPER AND LOWER CUT-OFF CREEKS BY THE LATERAL PLANATION OF SALT CREEK.
BY
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the fairly common types of stream piracy as phases of stream adjustment. The ideas presented are probably not new, but they are conveniently brought together and fairly clearly stated and differentiated. The three types of piracy briefly are the headward erosion type, the subterranean type, and the planation type. The main body of the paper deals with the details of the planation type of piracy. Following the method chosen by the writer as the most satisfactory method in presenting a physiographic subject, a complete view of the area is given before the details of the main subject are presented. The geographic position, the topographic condition, the pertinent geologic factors and the physiographic development of the area are presented in order before the details of the stream piracy are undertaken.

Planation piracy consists of the diversion of the upper portion of a stream by the invasion of its valley by the lateral planation of a neighboring stream. Usually the diverted stream is a minor stream and the pirate stream is much larger and is widening its valley by lateral planation. The case described is that of Cut-off Creek in southern Monroe County, Indiana, a short distance east of Harrodsburg. It is shown that the topographic condition of the area, the courses of the streams concerned, and the passage of glacial waters down the course of the master stream (though the area is distant from the glaciated portion of the state), were important factors favoring the development of the piracy. The principle of static rejuvenation is applied to the diverted and revived Upper Cut-off Creek. It is shown that the rejuvenation of the stream basin brought about by its diversion gave opportunity for further piracy to take place; but piracy of the headward erosion type. The upper. diverted part of the parent stream has grown at the expense of the lower part.

Planation stream piracy is rather common. An excellent example is shown on the Lockport, Kentucky, Quadrangle, where Kentucky River has invaded the drainage basin of Cedar-Sawdridge Creek and diverted that stream some three and one-half miles above its former entrance into the main stream. The lower portion of the divided valley is occupied by Pond Creek, a stream far too small for the size of the valley. Judging from the present gradient of Cedar-Sawdridge Creek, this stream at the time of its diversion was approximately 60 feet higher than Kentucky River at the place of diversion. The old valley at the divide between Pond Creek and the small reversed stream that is etching its way into the Pond Creek system is approximately 60 feet above the Kentucky River. A potential case of planation piracy is shown on the Buckhorn, Kentucky, Quadrangle, which in many respects resembles Cut-off Piracy. Mace Fork Creek, like Cut-off Creek is small. It will be divided into approximately equal parts, or rather far up stream. When the Kentucky River finishes cutting the narrow divide between Mace Creek valley and its own valley, the Upper part of Mace Creek will enter Kentucky River as a waterfall approximately 110 feet high, a fall similar to the fall of the newly diverted Upper Cut-off Creek. Salisbury, and Atwood is Professional Paper No. 60, U. S. Geol. Surv., call attention to Couler Valley North of Dubuque, Iowa, which is described as the former line of the discharge of Little Maquoketa River, which stream was diverted principally by the planation of the Mississippi River. Bowman[4] has described a case in detail along the Huron

[4]Isaiah Bowman, "A Typical Case of Stream-Capture in Michigan", Journal of Geology, Vol. XI, pp. 326-334, 1904.

River in Michigan, and calls attention to a number of other cases that have been described. But in this paper this particular type of stream piracy is given the name *planation stream piracy*. The case of the Cut-off planation piracy is a clear one, as is shown by the accompanying topographic map. It has in it all the phases of any case of planation stream piracy. For these reasons the Cut-off planation piracy may well serve as the type case of planation stream piracy.

WHAT PUTS "POP" IN POP CORN?

R. H. Carr and E. F. Ripley, Purdue University.

"What puts the 'pop' in pop corn?" is a question which is often joked about and one which seems never to have been considered seriously enough to lead to any investigation. Some think the subject is not worth study while others look upon it as one of the mysteries of nature which can never be unfolded and to them it is in the same class as the question, "Why is the grass green"? Pop corn has been a very popular food from very early times and is becoming more common as improved methods of preparation render it more and more appetizing.

Theories of Popping.

The writer formerly was led to think the cause and degree of popping was in proportion to the hygroscopic water contained in the corn when heated, but a little investigation convinces one that popping is quite independent of the water content except between very wide limits, besides other kinds of corn such as dent or sweet do not pop wide open at any moisture content. Some have thought the action to be similar to that of Professor Anderson's puffed corn or wheat, etc., in which the outer covering holds tenaciously enough to expand without breaking. This, however, is not the case with pop-corn as it is possible to drill holes in the grain or slit the sides of the hull with a sharp knife and still have the grain pop wide open on being heated in a proper way.

Scope of Investigation.

The study of this subject is still going on but the points investigated so far concern mainly the mositure and protein contents, percent of popping, time of heating for best popping, microscopical appearance of popped and unpopped corn and changes in composition after popping.

The 50 corn samples tested were secured from various sources. Many were from the farmers who grew the corn, some were obtained in grocery stores in different Indiana towns. They were mostly of the rice corn variety. Some of the samples are known as Australian Hulless, and some as California Golden. The percent of moisture, pop and protein content of the samples are given in the table which follows:

Table 1 Showing Percent of Moisture, Pop, and Protein in Corn Samples

Sample No.	Moisture	Pop	Protein
1	8.9	67.	....
3	8.15	90.5	....
4	8.21	95.0	....
5	8.41	86.	....
6	8.20	....	....
7	9.42	9.42	....
8	8.18	82.5	....
9	7.38	98.3	....
10	9.93	80.5	....
11	10.75	83.5	....
12	11.28	94.0	12.5
13	10.84	95.0	13.7
14	11.18	80.0	13.5
15	11.25	78.0	10.7
16	12.45	91.0	13.1
17	8.83	56.0	13.1
18	10.38	84.0	11.5
19	11.37	87.0	9.4
20	8.20	92.0	10.0
21	8.7	74.0	10.6
22	9.08	83.0	11.7
23	9.12	76.5	11.2
24	9.0	83.5	12.3
25	8.27	69.0	8.8
26	9.14	77.5	11.8
27	8.95	69.0	13.2
28	9.53	83.5	13.9
29	9.70	89.5	13.6
30	8.50	80.0	12.3
31	9.45	72.5	13.8
32	11.79	89.5	11.5
33	12.3	77.5	13.4
34	10.22	55.0	9.9
35	11.97	95.0	8.2
36	14.67	89.0	11.6
37	10.71	92.0	14.4
38	10.58	58.0	14.0
39	9.39	69.5	11.6
40	8.95	90.5	12.8
41	8.88	87.0	13.4
42	8.76	81.0	11.6
43	10.59	85.5	12.1
44	8.64	88.0	13.3
45	7.57	88.0	8.3
46	8.78	74.0	11.0
47	7.85	63.0	12.6
48	8.78	83.5	11.7
49	10.31	85.0	12.8
50	8.71	83.0	13.4
51	7.70	85.5	13.4
52	9.57	74.0	11.4

It was found that the time consumed in popping had much to do with the completeness to which any sample of corn could be popped. For this test a definite amount of corn (30 c c) in a sheet iron popper was always used and different heats of gas flame applied, the time varying from 1 to 9 minutes. It was found the best results were secured when the popping was finished in 2.5 to 3 minutes. This was obtained by measuring the volume of the popped corn shown in Photograph I below. When popped in lard it was found that popping started at 340° F and proceeded rapidly when a temperature of 380° F had been reached. If less time than 3 minutes was consumed in popping the volume would be lessened because many kernels would be only partly popped while if a greater time was used the corn would be dried out too much and good popping made impossible.

Effect of Moisture on Popping.

An attempt was made to subject a series of samples of the same corn to extremes of moisture and dryness and then test their ability to pop. The results of these tests are given in the table below.

Table 2 Showing the Relation of the Moisture to Popping of Corn

Sample Duplicate	Percent Moisture	Percent Pop
1	11.34	93.0
2	16.23	87.0
3	18.92	85.0
4	24.3	84.0
5	21.4	60.5
6	20.84	25.0
7	4.15	4.0

It will be noted from Table 2 that the moisture content is not a prime factor in popping of corn except when extreme limits are reached.

There is a difference in the appearance after it is popped and the way of popping between high and low moisture corns. The former gives a muffled sound when popping whereas the latter pops with a loud sharp report and emits very little fragrance compared to the former. The photographs 2 and 3 will serve to show the moisture effect on popping and the appearance of the popped grains.

Effect of High and Low Protein on Popping.

It was surmised that the great differences noted in popping might be due somewhat to the horny protein layer surrounding the starch in some samples, hence the protein contents of the samples were obtained, but this clue was found false as shown in Graph I. in which the protein, moisture and percent of pop are graphically illustrated and no relation seems to be apparent between the percent of popping and the protein content.

Microscopical and Chemical Studies.

In order to study the changes going on within the cells it was thought worth while to make some photomicrographs of a cross section of the pop corn grains both before and after being popped. These differences are shown in photomicrograph 1, 2, 3 and 4. It will be noticed that the cell walls and the contents of the cells are very greatly expanded and more clearly defined in the popped corn than in the unpopped indicating extensive molecular rearrangement in the cellular structure.

The chemical analysis seems to indicate that the most pronounced change due to popping corn is that which the starch undergoes forming soluble starch and dextrin. This is shown by the increase in blue color given by the iodine test for starch as well as by the increased solubility of starch and dextrin when extracted by cold water.

It was found also that there is considerable increase in the amount of fat extractable with ether after the corn is popped. This is probably due to the thorough disruption of the cellular structure making more complete extraction possible. It was noted too that there is a slight increase in the fiber content when corn is popped. The action of malt diastase on the popped corn shows that over half of the starch has been converted to a form capable of reducing Fehling's solution.

It is well known that a large amount of steam escapes when corn is popped but it is usually considered that this comes only from the moisture contained in the corn. This does not seem to be entirely the case. Since the loss in weight on popping is slightly greater than that of the moisture in the corn, and since there is no carbon dioxide gas produced, the excess water may come from a partial breaking down of the starch molecule to a less complex structure through the loss of water of constitution as shown in the table which follows:

Table 3 Showing the Loss of Water of Constitution in Popped Corn

Sample No.	Percent Moisture	Percent Loss on Popping	Percent of Water of Constitution
A	7.96	8.68	0.72
B	10.21	11.71	1.50
C	8.56	9.60	1.04
D	14.31	15.50	1.19
E	14.04	14.50	0.46

The change taking place seems to be one of hydrolysis due to the action of steam under a considerable pressure. The cellular starch wall is very elastic permitting of wide distention, and loss of some cell granules, without breaking. Other corn grains split open without much cell elasticity being shown.

Summary.

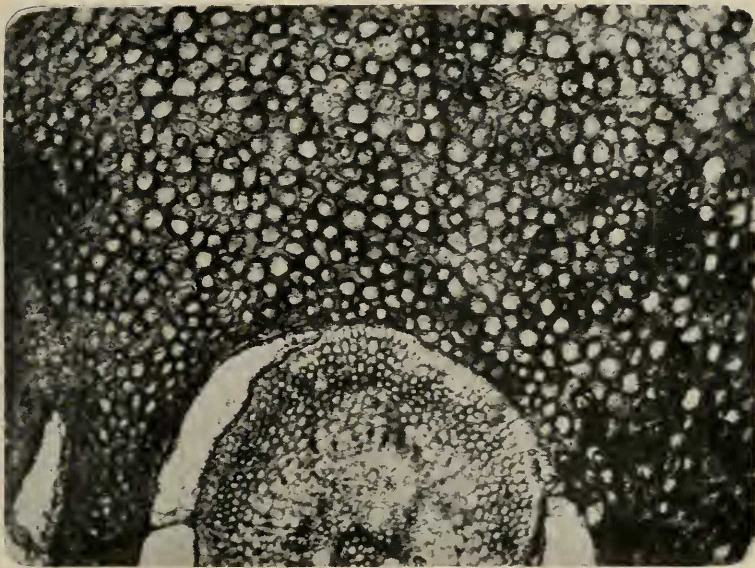
I. The amount of moisture is not the determining factor in popping of corn except in cases of extremes wet or dry samples.

II. The time consumed in popping corn is an important factor; when heating has been too rapid the corn does not have a chance to become dextrinized throughout the grain, when heating is too slow the moisture content becomes too low to explode the grain.

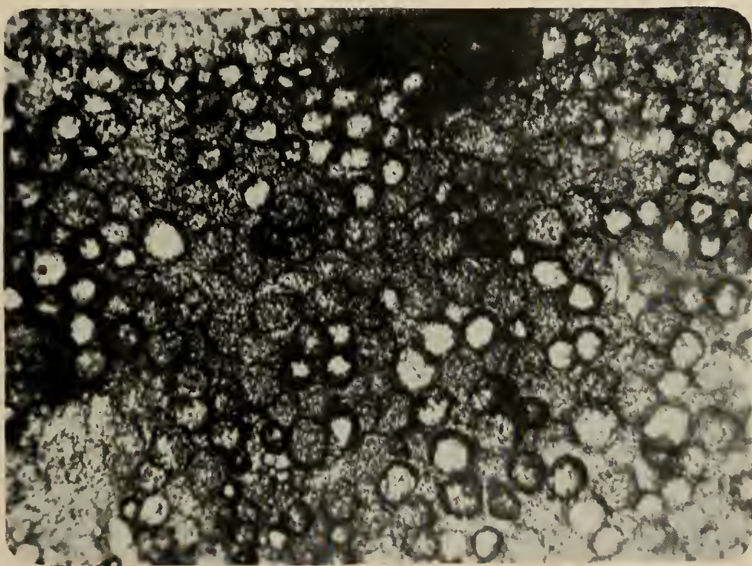
III. Photomicrographs of popped corn show the cells to be greatly enlarged and a considerable part of them disrupted releasing some starch granules which may be stained blue with iodine solution.

IV. Popping corn increases the ether soluble fat, also the soluble starch and dextrin and decreases the starch while the fiber is slightly increased.

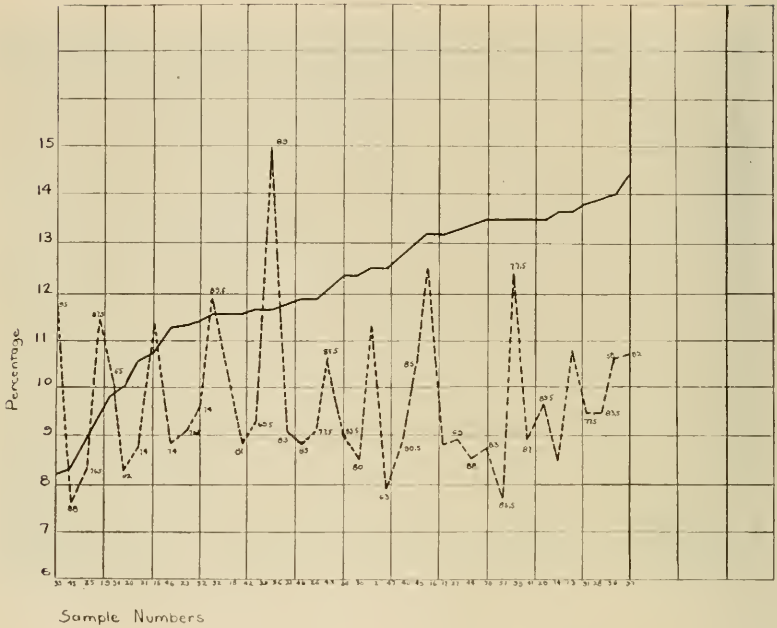
V. The popping of pop corn seems to be caused by the multiple cell explosion of steam derived from water of constitution and from hygroscopic moisture.



Photomicrograph I showing germ and nucleus also starch grains of the unpopped corn. X 50 by Dr. E. G. Mahin.



Photomicrograph 4.—Showing starch grains in unpopped corn, as white dots and the cell walls as black circles. X 100 by Dr. E. G. Mahin.

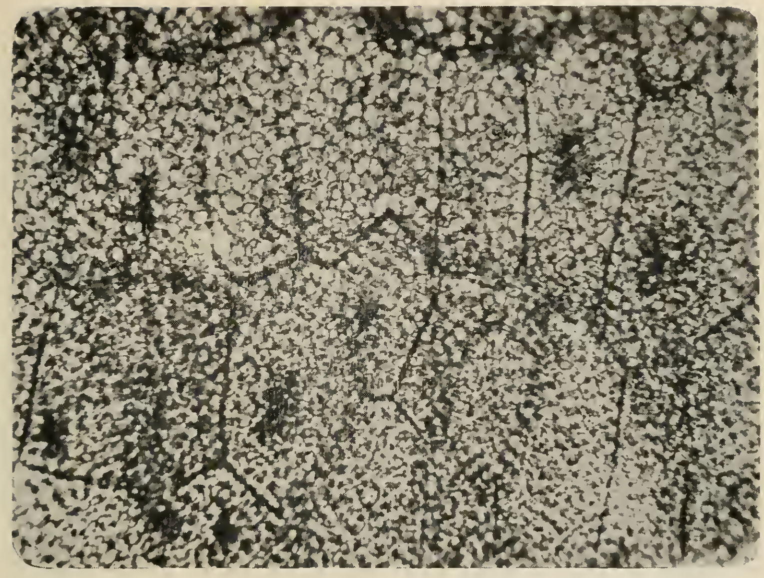


Graph— showing relation of Moisture, Protein and Pop.

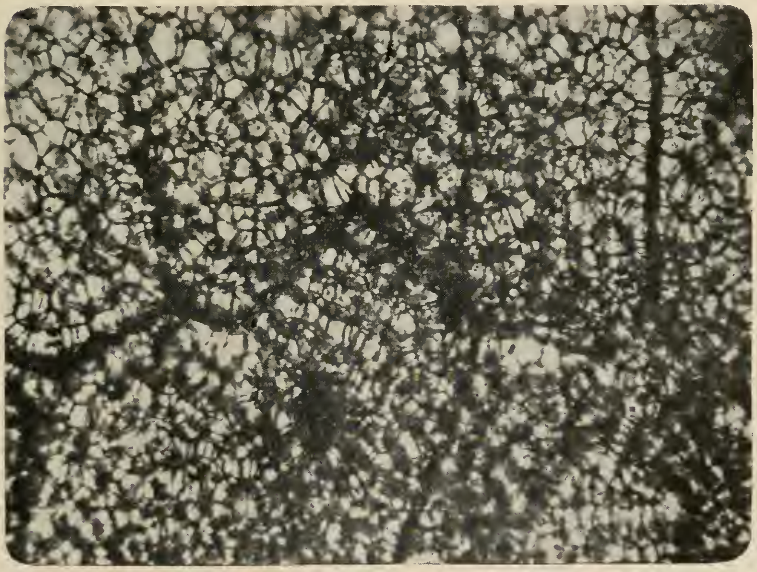
Protein % ———

Moisture % - - - - - - - -

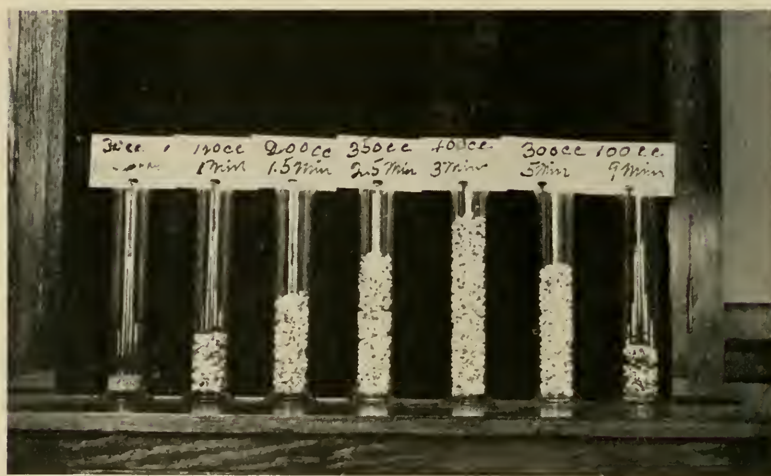
Pop Numerals



Photomicrograph 2.—Showing contents of the expanded starch cell due to popping of corn. The outline of cell wall can be distinguished by the black lines. X 50 by Dr. E. G. Mahin.



Photomicrograph 3.—Showing higher magnification than number 2. X 100 by Dr. E. G. Mahin.



Photograph I.—Showing volume of popped corn when 30 cc sample is popped at different time intervals.

Photograph II.—A group of typical low moisture kernels. Note large pieces peeled back, the unexpanded centers and smooth surfaces.

Photograph III.—A group of typical high moisture kernels. Note ragged edge, rough surfaces, fragmentary, flakey and irregular texture.

RECENT PROGRESS IN THE USE OF OZONE IN VENTILATION.

F. O. ANDEREGG, Purdue University.

The name ozone is associated with freshness in the air such as is experienced after thunderstorms; and in the open country at almost all times. Great interest has been taken in the observation of "ozone days" in the past and a large amount of data has been accumulated, mostly of little value. With these associations the name possesses good advertising value and advantage has been taken of this to exploit the use of ozone to an extent comparable almost with gold mining or oil well prospects. The great number of extravagant claims, which have been made, have tended to bring this activated form of oxygen in considerable disrepute with scientists and others who like to be careful as to the truth of the statements they accept. The reaction has been so great that a good many people have come to think that the term "ozone" and all it signifies is merely a snare and delusion. Just because bad oil stock has been sold is not a good reason for believing that all oil stock is worthless; nor is it right to allow oneself to be completely prejudiced by extravagant claims of certain unscrupulous persons. Let us first of all, consider the actual facts of the case.

Ozone *does* seem to have a stimulating effect if taken at the correct concentration. Thus, right after a thunderstorm, when the air is exhileratingly fresh, ozone is present at a concentration of about one part in ten million. This is sufficient to act on a sensitive photographic plate. Such a concentration is not at all harmful but is actually stimulating. But this stimulation is not one with harmful after effects, since it consists in the addition to the blood of a more active modification of oxygen which is then used in oxidizing the fuel in the body, thus making available more energy for muscular work.

Other stimulants like alcohol have injurious side actions which often cause a great deal of harm. But even here the claim is made and supported by considerable evidence that alcohol in small concentrations is practically harmless and may even be possibly beneficial. The ill effects of highly concentrated alcohol are too well known to need more than mere mention. In a similar manner ozone of a concentration of more than one part in a million becomes harmful. It begins to attack the mucuous membrane with very disagreeable results. Headaches are produced which are apt to be very disagreeable. It does not take very much ozone to make more than one part in a million of air, so that the mistake that has been made by most exploiters was to use apparatus of too high a capacity. With the production of too much ozone disagreeable results have followed.

For office ventilation there are manufactured by many concerns in this country and abroad cabinet ozonizers which produce a lot of ozone for a very small power consumption. Since a large part of the price of the apparatus depends upon the size, the tendency has been, partly through greed and partly through ignorance to make ozonizers too big. I have known of a great many cases where these cabinets have been installed in banks and offices where after a while they have had to be discarded because of the concentration being much too great. To be successful, the amount of ozone should be so low that the ordinary person does not notice its presence on entering the room where it is used. Most of the cabinet forms of ozonizers have had perhaps ten times too great a capacity.

There are certain places where it would be very desirable to have better air. The crowded office and school room, the well attended movie theater and church, or the basements of the large department stores, all have trouble in securing proper ventilation. There seem to be exhaled from the human body certain substances which tend to make the air feel "close" and after they have been breathed a little while a person becomes drowsy and feels uncomfortable. To provide fresh air the atmosphere in a crowded room has to be renewed sometimes as many as eight times in an hour. In the cold weather this means that a lot of coal is required to warm up all of this air which does not remain behind very long before it is discarded. If some means could be provided for removing the deleterious substances from this air allowing it to be recirculated there would be a great saving in coal. The question then arises as to whether ozone will accomplish this desirable result. About this question there has been waged quite a little controversy pro and con. Emphatic statements have been made on both sides so that it is somewhat difficult to decide just what the truth of the matter is and a careful survey of the literature does not settle the question either way, for there are not sufficient results of decisive experiments to allow one to decide. Until the question has been cleared up by high class experimental work, which will analyze the problem into its different factors, we shall have to fall back upon certain positive results which have been actually obtained in practice.

In St. Louis, and the same thing must hold true here in Indianapolis, the school rooms where colored children or the children of the "great unwashed" portion of the population gather are rather hard to ventilate. In St. Louis a number of the teachers in such schools were complaining of ill health and great discomfort from the inadequate ventilation. The children too, would become drowsy and the school work did not go forward as it should. When some of the teachers threatened to resign the problem was put up to Mr. Hallett, the chief engineer of the school board. He recommended the use of ozone and had it installed in two of the worst schools. After that complaints ceased and a questioniare sent out to the teachers found them enthusiastic about the new system. Not only were they relieved from the almost nauseating bad odors but the children were also taking an interest in their work which they had not shown previously. The experiment has been so successful that the use of ozone has been extended to many other school buildings in that city and when a new building is put up an ozone system is always included.

Economically, the big advantage of the system is that the air can be recirculated so that a large part of the heat is saved. The writer visited a school in the city of St. Louis where air was recirculated with the aid of ozone. The odor of ozone was barely perceptible so that it was not at all disagreeable. The children were not at all drowsy as they so often are in the middle of the afternoon, but were very wide awake. The teachers on being questioned, all were quite enthusiastic about the ventilation, and one dear old frail lady said that she had not lost a day since the introduction of ozone, whereas before she had lost a great deal of time.

Successful installations have also been made in the offices of The Brown Shoe Co. and in the system for ventilating the great basement of the Grand Leader department store. Usually in the basement of a large department store the ventilation is very bad, but none of that is to be noticed in this place. The air that enters from the outside is partially ozonized, passes over one set of heating coils, through a humidifier, and then over another set of heating coils and out into the room. The odor of ozone can barely be detected by a sensitive nose. The people employed there are unaware that ozone is being used but they also have no complaint to make about the ventilation.

That there is a great field for improvement in the ventilation of most of our crowded buildings almost no one will deny. But that ozone would give relief is strongly doubtedly by a great many people. The reason for the doubt has been that, while a little ozone is a good thing, a great deal of ozone is too much of a good thing. In most installations the trouble has been that not *little* enough ozone has been used. Like perfumery the best effect is secured by the use of almost vanishingly small quantities. If the ozone treated air is allowed to come in contact with water, as in a humidifier, most of the ozone is decomposed. During the decomposition the opportunity to oxidize any organic matter present would be very great so that a very high percentage of bacteria and bad odors would be removed and destroyed.

Ozone, moreover, has a tendency to cling to the clothes and to the skin which are the source of many of the bad odors. The writer has noticed the smell of ozone clinging to his fingers and clothes for a couple of hours after working with the substance. Such an accumulation of ozone near the origin of the deleterious substances would be especially effective in preventing them from getting out into the air. Before these ideas are accepted generally, however, very carefully controlled experimental work must be done. It is believed by many who have gone into the matter carefully and without prejudice that ozone can be successfully used to solve a large number of the problems of ventilation provided constant care is taken to allow for its peculiar properties and the resulting limitations placed on its use.

TRAINING RESEARCH CHEMISTS IN INDIANA.

E. G. MAHIN, Purdue University.

During the few years just past we have heard it stated, and many times reiterated, that scientific research is the one all important activity for national progress, national achievement and national self-preservation. The lessons of the great war pointed unmistakably to this conclusion and an impetus has been given to research in a multitude of fields. One result of this has been a growth of confidence on the part of scientific leaders and a feeling that this one great lesson of the war would never be forgotten. But a similar confidence has been felt that other lessons of the war would not be forgotten. It was said that we were learning thrift, self-denial and self-sacrifice, economical habits of living, altruism and other splendid things. And yet with the relaxation of tension after the close of the great international struggle we, as a nation, plunged into a riot of extravagance and wastefulness such as we had probably never before known. It has even seemed probable that we were relapsing into a permanent state of national selfishness and aloofness from the troubles of the rest of the world. Can it be that we are now to lose also the research spirit, to lapse into the mere "business as usual" habit of considering of value only the investigation that makes for immediate profit?

Whatever the answer to this question may be, it is generally conceded that scientific research cannot go on, either with or without material support, unless we can somehow continue to give to an intelligent and able body of men and women who have shown special aptitude for this kind of work, special training in the necessary methods of scientific investigation and, at the same time, to inspire them with enthusiasm for this high sort of endeavor. Quoting from a recent circular issued by the National Research Council, "It" (the Council) "hopes - - - - to encourage the interest of universities and colleges in research work and workers so that the inspiration and training of American youth for scientific work may never fall so low as to threaten to interrupt the constantly needed output of well-trained and devoted scientific talent in the land".

This brings us, at once, to the examination of the question of what things are necessary to provide opportunity for such training and of what we in Indiana are now doing in the way of providing this opportunity.

I have a notion that what I am here to say will apply in considerable measure to nearly all branches of pure and applied science. But in order to forestall, if possible, certain criticisms that I might, through ignorance, be unable to meet, I shall confine myself to the one matter covered by the subject of this paper: the training of *chemists* for research.

My first proposition is that such procedure must be based upon a very broad and thorough drill in the fundamentals of the science. No chemical research problem, however narrow or limited in its application it may seem to be, can be investigated with efficiency and thoroughness by one who has only a smattering of basic laws and facts, of this and of related sciences. He will almost immediately find himself balked by ignorance of scientific principles, following false trails or endeavoring to obtain experimental proof of matters that are already well known and of common knowledge to better informed researchers. With this training in fundamental facts, laws and theories of modern chemistry and, indeed, as a necessary part of it, must be a good knowledge of chemical literature and a familiarity with the important journals containing original papers on subjects of chemistry and, so far as possible, physics, biology, medicine, engineering, etc.,—subjects closely allied to or involving the applications of chemistry.

This thorough knowledge of the science and of the recorded labors of a multitude of investigators cannot come from necessarily brief and circumscribed courses of lectures and laboratory work involved in a four-year course in a college. No matter how enthusiastic, intelligent or industrious the student may be, or how able and inspiring the professor, it is a human impossibility to absorb *and assimilate* even a major fragment of the complex material of a science as highly developed as is chemistry, in the time that is allotted to this subject in a well balanced college curriculum. This is recognized by practically every one who has been through the undergraduate work of the liberal arts or science courses of the college, and who has later gone out to apply his knowledge to practical purposes, and every good teacher knows that his courses, wisely administered, can at best provide a moderately good training in the outstanding fundamentals of specified and limited fields of the science and teach the student something of the methods of independent and effective study. Real accomplishment, on the part of the student, usually comes some years after graduation and then only in case patient study and clear thinking have produced a certain maturity of mind,—which comes to a too small number of college graduates at any period.

As looking toward the development of research chemists, the great work of the college is then to teach the main fabric of the science as well as possible and to develop industrious habits and logical, orderly minds, capable of clear and independent thinking. This effort usually encounters many obstacles. The student must necessarily pursue a number of studies in addition to his major work and this does not make for concentration of thought and energy. We do not, by any means, propose that undergraduate work should be limited to a single science or that entirely unrelated studies should be ignored. At this period in his education the student is not prepared for specialization to any considerable extent and the broadening influence of the study of mathematics, English literature and foreign languages, and of other sciences than his own, is too well understood and too universally conceded to require any detailed argument.

In addition to this impracticability of concentration upon a single science, one may remark the great multitude of "activities" which serve to divert the attention of the student and to generate in him an attitude toward his studies which does not promote concentration or tend toward clear and profound thinking, which we have recognized as essential to the efficient investigator, or toward a recognition of comparative values of men and things. Many of these activities are in themselves harmless, or even wholesome and desirable but their influence is, undeniably, as I have stated and this has been a subject of frequent comment. A single example may be cited. Our own college daily (The Purdue Exponent) carries a feature column headed "The Inquiring Reporter". This curious individual daily asks of five students, chosen at random, a given question and the answers are published, verbatim. On a certain day the question was "What, in your opinion, would serve as the best advertisement for our college?" (or words to that effect). With one accord the five answers stated that winning athletic teams would be the best possible advertisement. One answer included also a successful body of alumni as a second best advertising medium but this was the nearest approach to a recognition of the possibility of any other fine thing, the heralding of which might serve to attract a desirable class of prospective students, or to win the support of public opinion and public purses. Apparently no one thought of a high class, devoted faculty, whose members can not only know and teach, but *do* also; or (with one exception) of a great body of graduating students who take an important and dignified place in the work of the world, or of increased equipment for the administration of high grade scientific work. These five answers may possibly not be considered as representative of student opinion but I am inclined to think that they are. I do not mean that our students look down upon the e other things or hold them in contempt. They simply ignore them when the great question is to be considered. I do not even particularly blame them for their attitude. It is perhaps natural, under the circumstances. It is certainly almost universal and this is a fact that must be considered,—explain, excuse or condemn it as we will. Also it is an attitude that persists after graduation. The average body of college alumni, desiring in their hearts above all things to "boost" their alma mater, will give the major portion of their discussions to the problems of improving athletic conditions and of developing winning teams.

If I have made myself at all clear in what has been said, my next proposition seems a logical conclusion. It is this, that it is not only a difficult matter to give college undergraduates proper training and drill in the methods of chemical research, but it may also be undesirable to attempt such training, in the majority of cases. Real research is a long, hard, toilsome business, rich in rewards but calling for preparation, energy and application such as the average undergraduate does not possess. Far better to keep him on the fundamentals of pure and applied science, of which he will absorb a woefully small amount under the best conditions, than to give him the false notion that after a matter of three or three and a half years of intermittent study of an intricate and complex science, he is prepared to solve scientific problems that have baffled others, or even to know how to try to solve them.

The undergraduate thesis, in the large majority of cases, is little more than a piece of more or less mechanical following of directions given by the supervising professor, and it rarely develops any dependable results that may be considered as new. It is conceded that the material may be new to the student and that the psychological effect may thus be desirable. But so are all of his studies new to him. They are all, for him, original research in practically the same sense that the the is investigation is original research and if, in his regular studies, he is properly directed in the use of the library and if the inspiration to real study is provided, there is little real difference between the thesis and the regular study, so far as this sort of training is concerned.

It may be objected that a large proportion of our undergraduates will then never have any training at all in the methods of research and will never enter this field, since a comparatively small number ever pursue graduate studies. Well, we might, with equally good logic, conclude that a large proportion of these undergraduates will never be physicians or professional actors, or will go to China or be bank presidents. We do not expect large numbers to do any one of these things. On the contrary we know that only a comparatively small number could be efficient and successful if their work were confined to chemical research, rather than to the hundred other lines of endeavor in pure or applied chemistry. But we do desire that a certain respectable minority of the men and women who leave us shall distinguish themselves, in at least a modest way, by carrying on successful work in scientific investigation and that, being effective in this work, they shall continue it through their best years and thus aid in the development of science and bring some reward of honor to themselves and to their college. How this can best be done is the question before us.

If we leave out of consideration a comparatively small minority of college men who develop notable research ability in their technical work after graduation, we may say that the great bulk of our important research work is being done by men who have had graduate training in the universities or, to be strictly accurate, by graduate students or industrial fellows working under the direction of such men. One is not to suppose that the end of the senior year in college marks a sharp division between completed mastery of the science, on the one hand, and development of research ability, on the other. But the recent graduate has at least had fair scientific training in theory and manipulation and he is now free from the necessity of carrying other studies. Also he should have an attitude of more complete devotion to the one absorbing subject of chemical investigation. Given the proper research atmosphere, an inspiring and able director and the will to work, he can now begin to know something of the meaning of research.

In addition to the benefit to be derived by the graduate student from devotion to the work of scientific investigation under proper direction, there is to be considered the reaction of this upon the undergraduates of the same school. For the undergraduate to be denied the opportunity to carry on research is not then in the nature of a discouragement. Rather, it should be a constant source of inspiration to him to see a relatively small but enthusiastic body of graduate students doing effective research work and providing material suitable for presentation before critical scientific bodies and for publication in important scientific journals. This kind of work is kept before the undergraduate as a possible and desirable future activity for him as an individual and he is likely better to appreciate the necessity for a thorough preparation in the necessary foundation for such work.

When we inquire what Indiana is doing to provide facilities for graduate work in chemistry, we are led to see why it is that our Indiana colleges are turning out so few chemists who are prepared to do independent research work of an enduring character. Apparently neither of the two major State colleges is prepared, in equipment, buildings or professorial staff, to give extensive or serious graduate courses in chemistry, leading beyond the degree of Master of Science. At Purdue we are, candidly, not attempting to do it. We have no organized graduate school and we have never conferred the degree of Doctor of Philosophy or any other doctorate, excepting an honorary degree on two or three occasions. It is recognized that the existing limitations in available funds makes it difficult to provide instructional staff, buildings and equipment to meet the needs of the ever growing undergraduate departments and that it would be impossible, under the circumstances, to conduct a creditable graduate school which would attract any considerable number of students. As a result we have available for experimental research, practically no one except graduate assistants who are proceeding to the Master's degree.

At our sister institution (Indiana University) a graduate organization is maintained but examination of most of the catalogues for a dozen years back fails to show that any one has ever received the degree of Doctor of Philosophy, with major work in chemistry, from that institution. I have not discussed this matter with any member of the chemical faculty of Indiana University but I have an idea that their story would be about the same as ours,—that they are unable to provide adequate facilities for the administration of high grade graduate work in chemistry and so choose to devote their energies to undergraduate training.

The State is losing, incalculably, as a result of this policy. Compared with the important universities of other states, our state colleges are accomplishing a painfully small amount of chemical research. The time and energies of our professors are consumed in routine teaching of large classes of undergraduates. Even at that, many of our more ambitious professors could and would be productive researchers if they could have a reasonable number of graduate students available for doing the experimental work of research problems under their personal direction. Every one who is at all informed on this subject knows that the great mass of university research work of today is done in this manner. The directing professor, through his extensive knowledge and experience, originates the basic idea and plans the research, in the main. The graduate student carries out these plans in the experimental laboratory, makes observations and obtains necessary data. Also, if he is the right sort and has the "stuff" in him, he catches the inspiration of his teacher and, through intimate contact and numerous discussions, learns his methods of reasoning, of planning investigations and of arriving at conclusions.

As a State we therefore lose, also, the opportunity to send forth into useful service a body of young men and women, trained in the methods and inspired with the purposes of scientific research. Our chemical graduates are a splendid asset to the State and to the nation but their work, for the most part, lies elsewhere than in the lines of research.

It is my personal belief that Indiana has not yet awakened to the needs of higher education. We deal in a niggardly fashion with the only institutions that we have legally provided for keeping the lamp of education burning. I have been reliably informed that the President of the University of Michigan is asking his state, this year, to furnish over eight million dollars, merely to provide for immediate and pressing needs, and that there is every prospect that this money will be given. What might out two State universities do with half, or even one quarter of this amount?

I should like to close this brief discussion by stating it as my firm conviction that, do what we will or try what plan we may, Indiana will never succeed in training any considerable number of chemists for research, or in accomplishing any very large amount of research in her colleges until really adequate provision is made for the best modern graduate departments. And may I recall the statement made at the beginning of this paper, to the effect that this conclusion may possibly apply, in a measure, to sciences other than chemistry.

SLOW RECOVERY AND PERMANENT SET IN COPPER, ALUMINUM, AND LEAD.

ALBERT E. WOODRUFF.

When a copper wire is strained and the stress is removed there is an instantaneous recovery followed by a slow recovery with time. This slow recovery may be accounted for by the hypothesis that it is due to the recrystallization of the metal. The fact that there is a recovery with time is not new. Even the magnitude of the recovery as a function of time has been investigated experimentally and is fairly definitely known. But so far no one seems to have been sufficiently interested to seek for an explanation of the cause of recovery.

Andrade (1) has done much experimental work on the flow of soft metals under stress. Knowing from the micro-photographic work of Quincke (2), Ewing and Rosenhain (3), and Beilby (4) that when a metal is strained there is a breaking down of the crystallar structure of the metal, he reasons that since the two take place simultaneously the one is due to the other, and he is able to substantiate his theory by experiment, both from observed phenomena of a strained wire and by looking into a microscope and seeing what actually takes place in the metal.

But the work of Quincke, Ewing and Rosenhain, and Beilby does not stop with the observation that the crystallar structure of a metal breaks down under excessive strain. They find that as soon as the stress is removed that the crystals of the metal begin to reform. For copper at ordinary temperatures this process is very slow. But if the temperature is raised, to say three or four hundred degrees the process of recrystallization is exceedingly rapid, almost instantaneous, and the specimen becomes annealed. The object of this paper is to present facts which show that slow recovery is due to recrystallization of the metal.

Plate I shows that an unannealed specimen of copper has a much more decided recovery than an annealed specimen subjected to the same strain. Plate III shows the same thing for aluminium. Plates II, IV and VI show that for all three metals investigated the larger the stress applied, other conditions being equal, the greater the recovery. Plates I, III and V show that the longer the time of applying the stress the greater the recovery, the stresses being equal. It will be noticed from these same curves that per unit of length per unit of stress the amount of recovery of the different metals is in the same order as the temperatures at which the metals anneal. All these facts support the hypothesis that the recovery of a metal after the stress has been removed is connected with the process of recrystallization.

In the first instance the material of a drawn wire that has not been annealed is largely reduced to the amorphous phase. Such crystals and parts of crystals as remain are under strain which is the result of drawing. Most of the strain was relieved when the tension of the drawing process was released. But the fine amorphous particles fill the spaces about the remaining crystals leaving the metal still in a state of strain. Annealing or recrystallization immediately begins and the amorphous particles begin to attach themselves to surrounding crystals. As the crystals build up there is a shrinking in the length of the specimen. This shrinking continues until the more easly occupied spaces are filled, the displacement gradually becoming less and less until it is not detectable. But there is still strain left for not all metals anneal perfectly at ordinary temperatures. When more strain is produced by applying stress there is an agitation of the particles of the metal and the shrinking starts again, as soon as the stress is removed. Since in the drawn wire a large per cent of the metal is in the amorphus phase it is only logical to expect that there would be a greater recovery for a given immediate strain than in an annealed specimen.

It is easily seen from this viewpoint how increased stress and increased time of applying stress produce greater recovery. Starting with an annealed specimen, the greater the stress applied the more crystals there are broken down and the more amorphous substance there is to take part in the process of crystal formation, hence the greater contraction. The same argument holds for increased time of applying stress.

There is no legitimate basis of comparison of the rapidity of contraction of two different metals. A suspended aluminium wire a meter long meets but comparatively little opposition to contraction due to its own weight. A piece of lead wire a meter long suspended by one end, when freshly annealed flows of its own weight. This indicates the great force that must be overcome, in the case of lead, by the forces of recrystallization, even to maintain the original length. Since experimental results show that there is actually greater recovery for lead per unit of length per unit of stress applied, other conditions being the same, in spite of this handicap, than for either copper or aluminium we see how much greater must be the forces that cause the shrinkage in lead. But lead anneals perfectly at ordinary temperatures, aluminium at higher temperatures and copper at still higher temperatures, just the order that must be expected if recovery is to be accounted for by recrystallization. The fact that greatest recovery takes place where greatest activity of recrystallization is involved is a strong point in favor of the hypothesis that the one is dependent on the other.

This idea fits exactly Prof. Michelson's (5) picture of elastico-viscous recovery. The force that causes the shrinkage is an elastic force but produces no instantaneous effect for just the same reason that a rubber band stretched on a block of wood cannot contract to its original length. But cause the block of wood to contract gradually by any means whatsoever and the rubber band follows it. In just the same manner the elastic forces which are contained within the remaining crystalar structure cannot act because they encompass the amorphous phase of the material. But let this phase begin to reform into crystals. It is wedged between the crystals and fills all the spaces between them. As it joins neighboring crystals or forms new ones the original crystalar structure begins to make a readjustment because of the strain which it is under. The more active the amorphous phase is the more rapidly the whole structure contracts.

Such a conception of the state of a metal after strain will account for what Prof. Michelson (5) calls "Lost Motion", the failure of a strained metal to return to its original configuration when the stress is removed. It is found that the more nearly perfect the process of annealing is, the greater is the "Lost Motion". When a wire is stretched the crystals break down and are drawn out in the direction of the length of the wire. The amorphous phase that is produced in the breakdown fills up such crevices as may be created due to the displacement and breaking up of the crystals. When the stress is removed such crystals as remain intact cannot return to their original position because of the presence of the amorphous phase. The broken crystals have lost much of their elastic property. Both of these causes tend to produce a permanent set or permanent elongation in the specimen.

Acknowledgement is made to Prof. Lemon of Ryerson Physical Laboratory for his suggestions and help on this problem. I am also indebted to the Physics Department of Chicago University which provided the equipment necessary.

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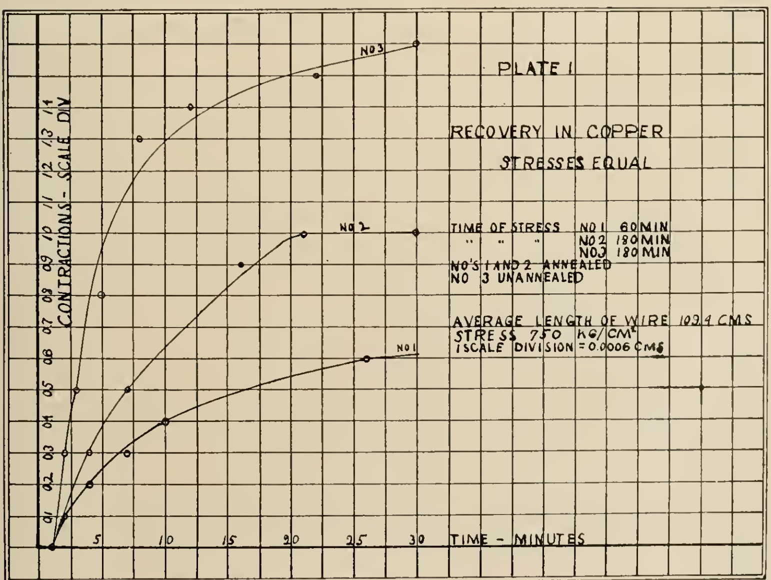

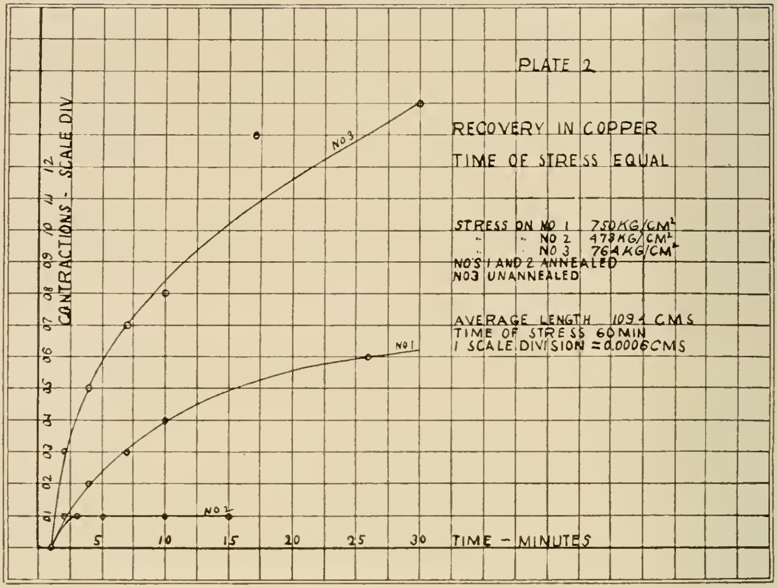
PLATE 2
RECOVERY IN COPPER
TIME OF STRESS EQUAL
STRESS ON NO 1 750 KG/CM²
" " NO 2 478 KG/CM²
" " NO 3 764 KG/CM²
NO'S 1 AND 2 ANNEALED
NO3 UNANNEALED
AVERAGE LENGTH 109.4 CMS
TIME OF STRESS 60 MIN
1 SCALE DIVISION = 0.0006 CMS
CONTRACTIONS - SCALE DIV
TIME - MINUTES
NO 3
NO 1
NO 2

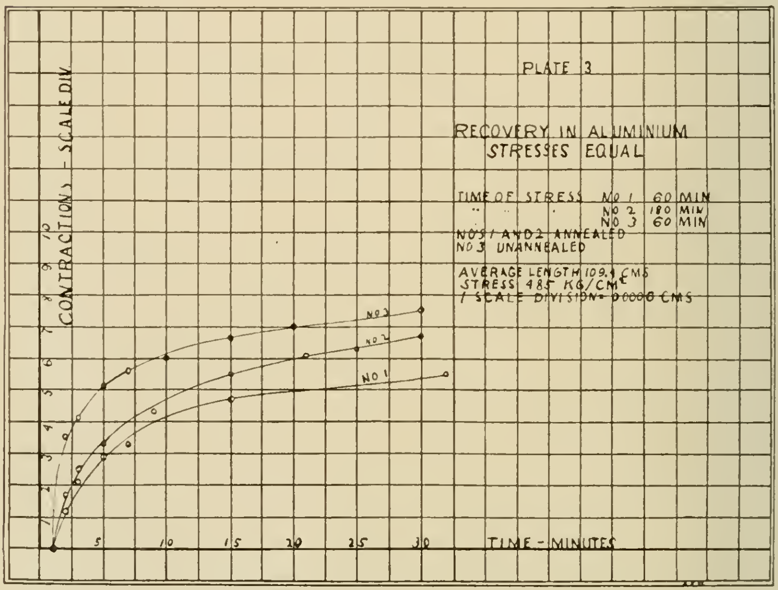
PLATE 3
RECOVERY IN ALUMINIUM
STRESSES EQUAL
TIME OF STRESS NO 1 60 MIN
" " " NO 2 180 MIN
" NO 3 60 MIN
NO'S 1 AND 2 ANNEALED
NO 3 UNANNEALED
AVERAGE LENGTH 109.4 CMS
STRESS 485 KG/CM²
1 SCALE DIVISION = 0.0006 CMS
CONTRACTIONS - SCALE DIV
TIME - MINUTES
NO 3
NO 2
NO 1

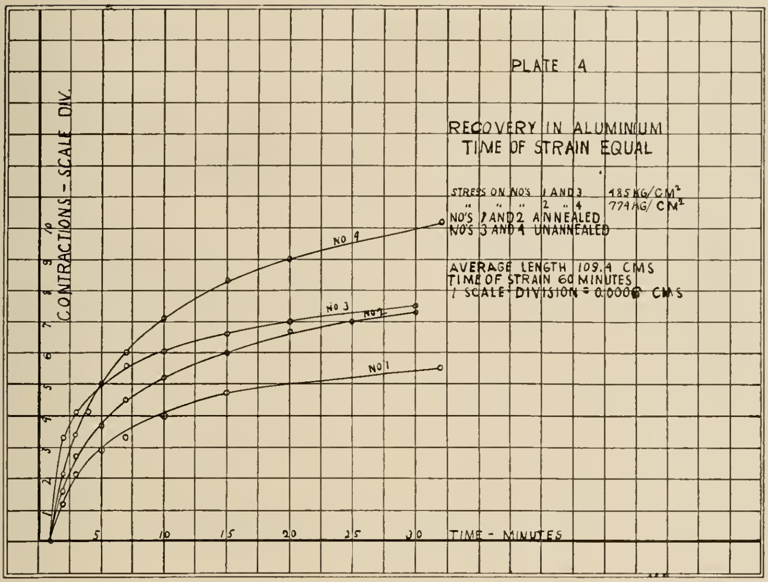
PLATE 4
RECOVERY IN ALUMINIUM
TIME OF STRAIN EQUAL
STRESS ON NO'S 1 AND 3 185 KG/CM²
" " " 2 " 4 774 KG/CM²
NO'S 1 AND 2 ANNEALED
NO'S 3 AND 4 UNANNEALED
AVERAGE LENGTH 109.4 CMS
TIME OF STRAIN 60 MINUTES
1 SCALE DIVISION = 0.0008 CMS
CONTRACTIONS - SCALE DIV.
TIME - MINUTES
NO 4
NO 3
NO 2
NO 1
5
10
15
20
25
30

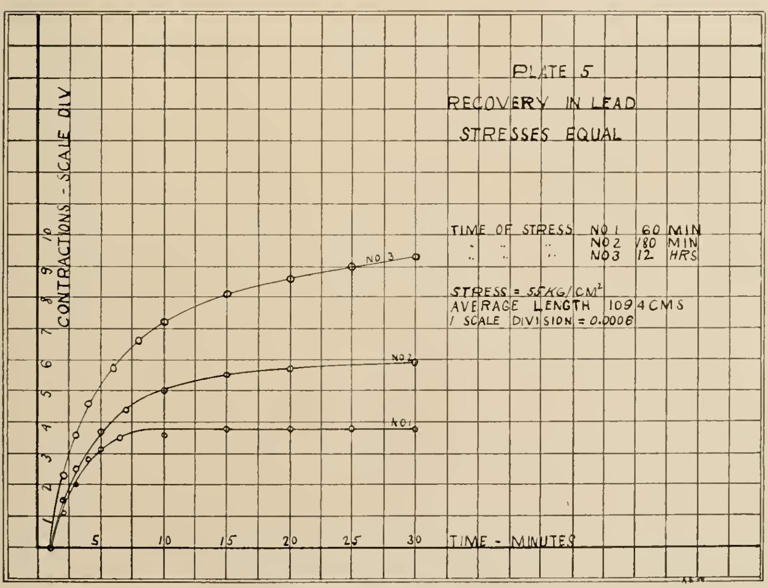
PLATE 5
RECOVERY IN LEAD
STRESSES EQUAL
TIME OF STRESS NO 1 60 MIN
" " " NO 2 180 MIN
" " " NO 3 12 HRS
STRESS = 55 KG/CM²
AVERAGE LENGTH 109.4 CMS
1 SCALE DIVISION = 0.0006
CONTRACTIONS - SCALE DIV
TIME - MINUTES
NO 3
NO 2
NO 1
5
10
15
20
25
30

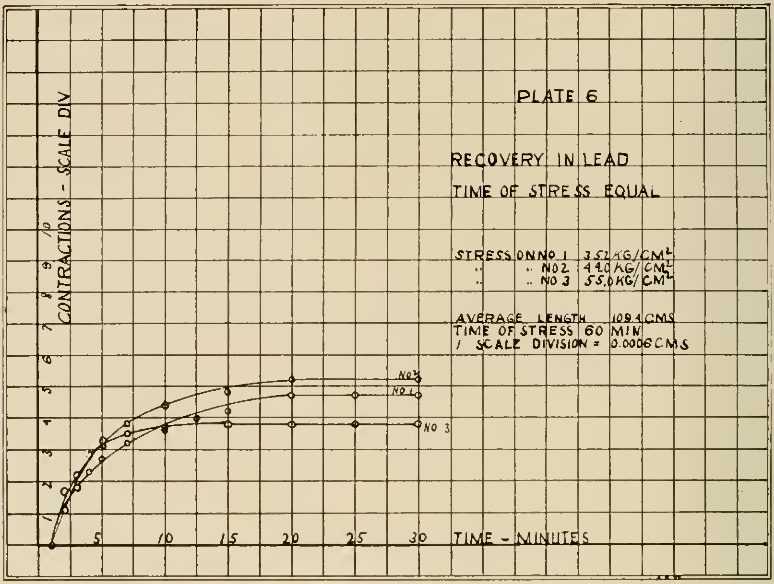
PLATE 6
RECOVERY IN LEAD
TIME OF STRESS EQUAL
STRESS ON NO 1 35.2 KG/CM²
" " NO 2 44.0 KG/CM²
" " NO 3 55.0 KG/CM²
AVERAGE LENGTH 109.4 CMS
TIME OF STRESS 60 MIN
1 SCALE DIVISION = 0.0006 CMS
CONTRACTIONS - SCALE DIV
TIME - MINUTES
NO 2
NO 1
NO 3
1 2 3 4 5 6 7 8 9 10
5 10 15 20 25 30

A RESISTANCE RADIO TELEPHONE.

R. R. Ramsey.

In radio telephones we have a source of alternating current of high frequency which sends current out into the aerial. The disturbance in the ether which is caused by this current is called the carrier wave. The amplitude of this wave is changed or varied by some means which is controlled by the voice. This device is known as the modulator.

Since the three electrode vacuum tube has come into use, tubes are used as generators of the carrier wave and also as modulators. This is usually accomplished by connecting the telephone transmitter to the tubes with tuned or untuned inductance coils. In the case of the tuned coils, each set of coils must be separately tuned for every change of wave length. The untuned inductance method avoids this difficulty with a certain loss of efficiency. In either case one coil is liable to affect the second coil so that disagreeable cross squeals are set up in the set.

The cascade amplifying receiving sets have the same defects so that all amplification is produced by audio coils, untuned iron core coils, or by resistance amplification. Tuning being in the main circuits alone.

With the idea of simplicity and cheapness, I have devised a wireless tele-

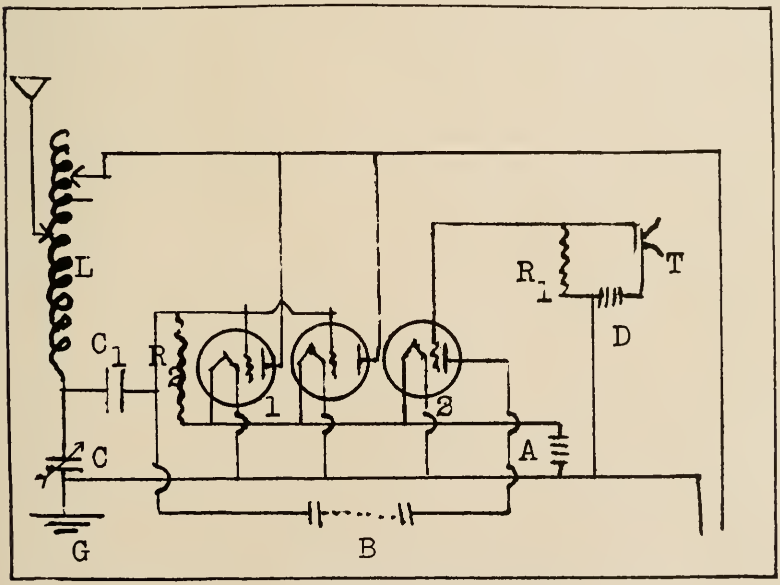

Fig. 1.—A Resistance Radio Telephone.

phone connection in which the modulation is accomplished by means of resistances alone. The circuit is diagramed in figure 1. The oscillating circuit consists of the aerial, the inductance, L, and the variable oil condenser, C, connected to the ground at G. All tuning is accomplished by varying the connections to the coil. L. and by changing the capacity at C. Two tubes or two sets of tubes are used. 1. is one or more power tubes or hard tubes connected in parallel. Two power tubes are shown in the figure. These tubes are the oscillating tubes by means of which the energy is sent out into the aerial. 2. is an ordinary receiving or amplifying tube by means of which the current from the telephone transmitter, T, is amplified. The transmitter. T. is connected in series with a resistance, R_1 and a battery, D. of two or more ordinary dry cells. The resistance R_1 should have a resistance equal to that of the transmitter, T. The variation of the current through the carbon transmitter causes a variation of the potential difference at the terminals of the resistance. R_1. This varies the potential of the grid of tube. 2. and causes a coresponding variation of the current of the plate circuit of tube, 2. This current flows through the grid leak resistance. R_2 and thus modulates the amplitude of the current sent into the aerial by the tubes, 1. R_2 should be a resistance comparable to the impedance of tube 2. The battery B is an ordinary plate battery of 20 or 40 volts. H is a source of high potential. about 300 volts.

This circuit has been tried out using an aerial of poor construction. The results compare very favorable with some of the standard connections. With an antennae current of 200 milliampers the voice was transmitted to a coil aerial of six turns 2 meters square at a distance of one-half mile. This should lead one to expect the range should be five or ten miles with a good receiving aerial.

The resistance. R_1. was an ordinary resistance box. R_2, was made of card board painted with india ink.

NOTE ON ANTENNAE RESISTANCE.

R. R. Ramsey.

Attention is called to the fact that in the modern oscillating receiving circuits using telephones as current indicators the "half deflection method" of resistance measurements will not give correct results.

A LONG WAVE RECEIVER.

R. R. Ramsey.

In wireless work all wave lengths are used from 200 meters or less, amatures, to 20,000 meters in transcontinental transmission. It is customary to limit the wave length range of reception of any receiver to a comparative small band of this range. This is due to the fact that in order to keep the natural frequency of the coil high, which involves the necessity of the distributed capacity of the coil being low, it is usual to wind the coils with one layer of wire. Single layer coils in order to have a high inductance must be made of large dimentions of very fine wire which necessitates a very large resistance.

In the coil which I have made I have endeavored to avoid this difficulty by winding the coils of relatively large wire in banks or coils one inch in width and five layers deep. The distributed capacity is kept to a low value by separating each layer by means of heavy card board. The coils are wound on card board tubes whose length is seven inches and whose diameters are, primary coil 14 cm. and secondary coil 10 cm. Each coil consists of six banks one inch wide, five layers deep. Each layer containing twenty turns of No. 20 wire. The total number of turns per coil is 600. The original design of the coil called for No. 24 wire 30 turns per inch or about 1.000 turns in all. This would give an inductance of about .07 henrys or a wave length of about 20,000 meters using an ordinary .001 microfarad condensed. The smaller wire was not available so the larger wire was used and the lack of inductance was made up by using a variable condenser whose maximum capacity is .01 microfarads.

On the secondary coil ten taps are brought out. The taps are arranged as follows. Tap No. 1 contains 1 turn; 2, 3 turns; 3, 7 turns; 4, 15 turns; 5, 1 layer; 6, 2 layers; 7, 1 bank; 8, 2 banks; 9, 4 banks; 10, the entire secondary coil. Cut out or dead end switches are inserted between taps No. 6 and 7, and taps 8 and 9. The windings of the primary are arranged after the same plan as that in the secondary except that there are 8 taps instead of 10. The coils are mounted so that the secondary will slide into the primary coil according to the well known plan of the slide tuner. A feed back or regenerative coil of 425 turns of No. 30 wire is mounted so as to slide into the primary coil from the opposite end from the secondary coil. This coil is seldom used as it is found that an "auto feed back" connection on the secondary gives better results. This consists of a switch by means of which the filament of the tube can be connected to a point near the middle of the secondary coil. The diagramatic connections are shown in figure 1.

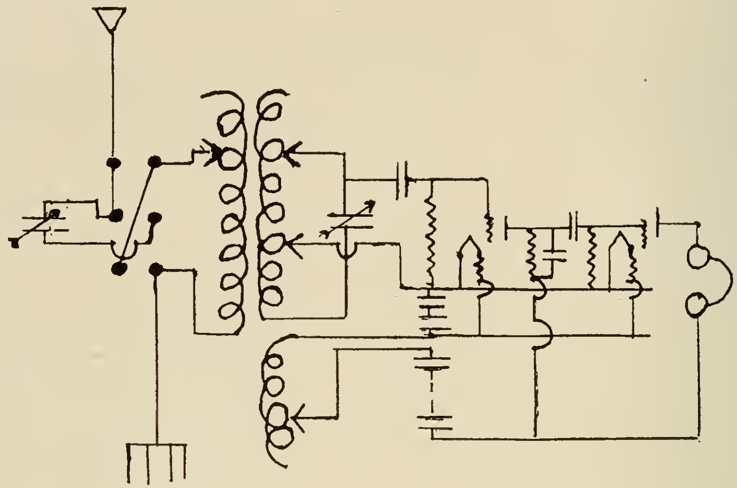

Figure 1.

The tuning of the primary coil is by means of a variable condenser in series or in multiple with all or a portion of the primary coil.

The inductance of the coils as wound is secondary, .0185 henry; and primary, .0228 henry. The total resistances are, 8.1 ohms and 9 ohms respectively. The natural wave length of the entire secondary coil as measured with a wave meter is 1100 meters, which corresponds to a distributed capacity pf .000019 microfarads. The dead end switches break this so that the energy absorbed is a minimum.

As mounted as a slide tuner the length over all is 22 inches. The total weight is 15 pounds. An equivalent long wave receiver coil of the single layer type would require five times as much wire and would be 25 times as long or a length of about 45 feet.

Thus we have in small dimensions a receiver for any wave length from Annapolis 17000 meters to amateur stations 200 meters. European stations are received with one bulb using an aerial 125 feet long stretched among the trees of the Indiana University campus.

SEGREGATION AND RECOMBINATION OF THE GENES FOR TINGED, BLOOD, BUFF, AND CORAL IN DROSOPHILA MELANOGASTER.

ROSCOE R. HYDE.

From the Department of Immunology, School of Hygiene and Public Health, Johns Hopkins University, Baltimore.

Contents.

In a previous paper I reported the origin of blood and tinged, two sex-linked eye mutants in Drosophila. Both mutants gave complete linkage with white, eosin and cherry and consequently formed with the red of the wild type a sextuple system of multiple allelomorphs. Safir and Lancefield later reported buff and coral, two other members of this system, as shown by their linkage to white. T. H. Morgan has kindly supplied me with stocks of buff and coral and this paper records the combinations made with these two stocks to my stocks of blood and tinged. The results of these crosses bear out the expectation that, since blood and tinged are allelomorphic to white and buff and coral are allelomorphic to white, the mutants buff, coral, tinged and blood should show allelomorphism to each other.

The evidence from such a system is significant as it bears on the nature of the change that takes place in the chromosomes of mutant stocks. If the different mutants are a result of losses of materials that lie at different levels on the sex-chromosome, then the wild type eye should result in the daughters on crossing any two of these mutants, since the daughter receives two sex-chromosomes and each would restore the missing allelomorph of the other. As a matter of fact the daughters from all combinations are compounds, with eyes intermediate in color between the parent types. If the genes for these different eye colors are allocated at different levels on the sex chromosome there should appear among the grandsons eyes of the wild type as a result of the phenomenon of crossing over. The evidence presented from these combinations is consistant with that obtained from other tests in showing that this does not occur.

The nomenclature employed is that used in other publications for the members of this system.—white w, tinged w^t, buff w^{bu}, eosin w^e, cherry w^c, coral w^{co}, blood w^b, red W.

The female is expressed by the formula XX, the male XO, consequently the formula for a tinged eyed female is $w^t w^t XX$, a tinged eye male $w^t XO$.

The following tables give the results of the combinations made between the different members of this allelomorphic series. The genetic composition of the parents (P), the children (F_1), and grandchildren (F_2) are expressed in terms of the nomenclature stated above. The numbers indicate the number of flies realized from the different combinations.

1. *Linkage of Buff and Tinged*

(a) Buff ♀ by Tinged ♂.

P.	$w^{bu}w^{bu}XX$.	w^tXO
F_1.	$w^{bu}w^tXX$	$w^{bu}XO$
(1).	52	58
(2).	200	185
(3).	406	301

F_2	$w^{bu}w^{bu}XX$ $w^{bu}w^tXX$	$w^{bu}XO$ w^tXO.
1	135	112
1a..............	155	110
2	84	56
2a..............	58	28
3	129	136
3a..............	83	65
4	136	118
4a..............	45	53
5	91	70
5a..............	130	93
6	75	115
6a..............	85	96
7	23	30
7a..............	95	108
Total.......	1324	1190

The buff females and the tinged-buff compounds are practically inseparable. The two classes of males can be separated into buff and tinged males but are here classified together. The wild red eyed form did not appear in the F_1 or F_2 generation. The F_1 males and females show a slight variation in color although we were unable to separate the two on a color basis.

(b) Buff ♂ by Tinged ♀

P.	$w^{bu}XO$.	$w^t w^t XX$
F_1	$w^t w^{bu} XX$	$w^t XO$.
(1)	30	31
(2)	256	200
(3)	94	85

The tinged males and the tinged-buff compound females of the F_1 are inseparable on a color basis as one might expect since the two colors are separated by such a small margin.

F_2	$w^t w^t XX$ $w^t w^{bu} XX$	$w^t XO$ $w^{bu} XO$.
1	72	48
2	127	103
3	113	65
4	242	186
5	68	47
6	112	82
Total	734	531

The F_2 males can be separated with difficulty.

2. *Linkage of Buff and Blood.*

(a) Buff ♀ by Blood ♂.

P.	$w^{bu} w^{bu} XX$.	$w^b XO$
F_1	$w^{bu} w^b XX$	$w^{bu} XO$
	202	198

F_1 Females compounds uniform deep red—males like buff.

F_2	$w^{bu} w^{bu} XX$	$w^{bu} w^b XX$	$w^{bu} XO$	$w^b XO$
1	51	72	50	69
2	45	46	49	37
3	130	148	117	119
4	158	152	168	139
Total	384	418	384	364

Males and females in the F_2 are easily separated into the different classes.

(b) Buff ♂ by Blood ♀.

P. $w^{bu}XO$. $w^{b}w^{b}XX$

F^1 $w^{bu}w^{b}XX$ $w^{b}XO$

117 104

F_1 Males typical of blood eyes—light when young—turn very dark with age. Females lighter than blood and do not turn so dark with age.

F_2	$w^bw^{bu}XX$	w^bw^bXX	$w^{bu}XO$	w^bXO
1.	79	83	60	58
2.	66	79	45	54
3.	139	182	147	112
4.	79	67	74	77
Total	363	411	326	301

3. *Linkage of Coral and Tinged.*

(a) Coral ♀ by Tinged ♂.

P. $w^{co}w^{co}XX$. $w^{t}XO$

F_1	$w^{co}w^{t}XX$ 27		$w^{co}XO$ 22	
F_1 Flies	Lighter than coral stock		Same color as coral stock	
F_2	$w^{co}w^{co}XX$	$w^{co}w^{t}XX$	$w^{co}XO$	$w^{t}XO$
1	79	94	79	84
1a	78	70	75	56
1b	46	40	33	29
2	74	78	65	47
2a	57	62	62	58
3	40	43	51	54
Total	374	387	365	328

(b) Coral ♂ by Tinged ♀.

P. $w^{co}XO$. $w^{t}w^{t}XX$

F_1	$w^{t}w^{co}XX$ 44		$w^{t}XO$ 36	
F_2	$w^{t}w^{t}XX$	$w^{t}w^{co}XX$	$w^{t}XO$	$w^{co}XO$
1	31	48	33	35
1a	63	60	61	60
1b	5	7	4	8
2	68	54	74	52
2a	68	68	53	61
2b	24	18	9	14
Total	259	255	234	230

4. *Linkage of Coral and Blood.*

(a) Coral ♀ by Blood ♂.
P. $w^{co}w^{co}XX$. $w^{b}XO$

F_1	$w^{co}w^{b}XX$ 18		$w^{co}XO$ 18	
F_1 Flies	Female just a hint lighter than male.		As these flies become older the sexes are indistinguishable.	
F_2	$w^{co}w^{co}XX$	$w^{co}w^{b}XX$	$w^{co}XO$	$w^{b}XO$
1	116		103	
1a	159		135	
2	49		81	
2a	180		178	
Total	945		497	

The two classes of males can be separated when young. Females cannot be separated with certainty. They show a variable range as is true of blood which overlaps the coral.

(b) Coral ♂ by Blood ♀.

P. $w^{co}XO$. w^bw^bXX

F_1	$w^bw^{co}XX$ 18		w^bXO 17	
F_1 Flies	Females and males same color; dark as males. A mere hint that females are lighter.			
F_2	w^bw^bXX	$w^bw^{co}XX$	w^bXO	$w^{co}XO$
1	103		116	
1a..................	143		107	
1b..................	21		27	
2	162		146	
2a..................	126		122	
2b..................	82		70	
Total..........	637		588	

5. *Linkage of Coral and Buff.*

(a) Coral ♀ by Buff ♂.

P. $w^{co}w^{co}XX$. $w^{bu}XO$

F_1	$w^{co}w^{bu}XX$ 31		$w^{co}XO$ 29	
F_1 Flies	Much lighter than coral		Same color as stock coral.	
F_2	$w^{co}w^{co}XX$	$w^{co}w^{bu}XX$	$w^{co}XO$	$w^{bu}XO$
1....................	57	40	49	44
1a....................	50	56	45	40
Total............	107	96	94	84

(b) Coral ♂ by Buff ♀.

P. $w^{co}XO$. $w^{bu}w^{bu}XX$

F_1	$w^{bu}w^{co}XX$ 44		$w^{bu}XO$ 37	
F_1 Flies	Lighter than buff Lighter than coral Lighter than blood?		Same color as buff stock.	
F_2	$w^{bu}w^{bu}XX$	$w^{bu}w^{co}XX$	$w^{bu}XO$	$w^{co}XO$
1	57	41	46	45
1a....................	253	233	239	277
1b....................	45	25	33	29
2	198	203	166	175
2a....................	20	19	29	20
Total............	573	521	513	446

Compound ♀ much lighter than ♂.

6. *Linkage of Tinged and Blood.*

(a) Tinged ♀ by Blood ♂.

P. w^tw^tXX . w^bXO

F_1	w^tw^bXX 33		w^tXO 20	
F_1 Flies	All lighter than blood, but darker than tinged.		Males like tinged stock.	
F_2	w^tw^tXX	w^tw^bXX	w^bXO	w^tXO
1	74	98	71	78
1a....................	109	105	104	97
2	37	36	21	32
2a....................	57	52	46	63
2b....................	29	22	26	28
Total............	306	313	268	298

(b) Tinged ♂ by Blood ♀.

P. w^tXO . w^bw^bXX

F_1	w^tw^bXX 18		w^bXO 17	
F_1 Flies	Females much lighter than males.		Typical of blood stock Sexes easily separated on color basis.	
F_2	w^bw^bXX	w^bw^tXX	w^bXO	w^tXO
1	52	55	41	45
1a....................	68	68	47	61
1b....................	9	9	5	4
2	35	31	42	47
2a....................	164	160	112	136
2b....................	45	45	26	33
Total............	373	368	273	326

7. *Linkage of Coral to Eosin.*

(a) Eosin ♀ and Coral ♂.

P. $w^e w^e XX$. $w^{co} XO$

F_1	$w^e w^{co} XX$ 108 200		$w^e XO$ 94 200	
F_1 Flies	Indistinguishable from coral compound does not seem to modify.		Typical of eosin; slight color change with age.	
F_2	$w^e w^e XX$	$w^e w^{co} XX$	$w^e XO$	$w^{co} XO$
9a..................	60	55	60	57
	40	54	71	47
11a..................	30	30	24	35
	60	68	65	70
11b..................	15	10	14	16
	62	60	59	48
F_2 Flies	Like Eosin ♀ ♀	Slightly darker than ♀ but not as dark as males.	Like eosin ♂.	Much like blood when old but not as dark

(b) Eosin ♂ by Coral ♀.

P. w^eXO . $w^{co}w^{co}XO$

F₁	$w^ew^{co}XX$ 125		$w^{co}XO$ 115
F_1 Flies	The eye colors are hard to distinguish. The females seem to be a little lighter than the males; darker when old.		
F_2	$w^{co}w^{co}XX$ $w^{co}w^eXX$	w^eX	$w^{co}X$
1	166	70	90
1a	59	36	40
1b	107	17	34
2	196	98	97
3	87	40	50
3a	80	31	41
Total	695	292	352

8. *Summary.*

The genes for buff and coral known to be allelomorphic to white have here been tested with tinged and blood, two other genes allelmorphic to white. The expectation is that since both are allelomorphic to white, they will be allelomorphic to each other. The results of the different combinations made verify the expectations. Sufficient evidence has accumulated to show that these are members of the same allelomorphic series. The fact that the red eyed fly does not appear in the F_1 or F_2 bears out the assumption that the different members of this multiple allelomorph series are but different expressions of the same material particle and that they occupy identical loci on the sex-chromosome.

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BEHAVIOR OF THE GENE FOR THE MUTANT CURVED OF DROSOPHILA MELANOGASTER IN CROSSES INVOLVING GENES IN THE SAME AND OTHER CHROMOSOMES.

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Contents.

A wing mutation in Drosophila melanogaster which has proved to be identical with curved, a mutant found by Bridges in rudimentary stock, appeared in my wild cultures in the latter part of November, 1914. The culture was one of a large number of wild stocks that were taken during the fall of 1913 in Indiana. Twelve curved of both sexes appeared simultaneously in the culture bottle. The mutant has been kept in pure culture since that time. A number of crosses with mutants known to belong to different chromosome groups are here recorded.

I. Behavior of the curved winged mutant with normal wild stock. Chromosome I.

1. Curved ♀ by wild ♂.

A curved wing female bred to the normal long wing male produced 18 sons and 13 daughters,—all with wings typical of wild stock. These when inbred gave in the F_2 generation 107 curved and 348 wild type flies. Table I. Both sexes are affected. This result demonstrates curved to be a recessive, non sex-linked mutant giving a Mendelian ratio of approximately 3 to 1. It is evident that the gene for curved is not carried by chromosome I, since it does not show sex-linkage.

Table I. F_2 generation from curved ♀ by wild ♂.

Number	Normal ♂♂	Normal ♀♀	Curved ♂♂	Curved ♀♀
1	48	46	8	11
1a	52	32	21	18
1b	46	55	13	13
1c	24	45	13	10
Total.	170	178	55	52

II. Behavior of curved with bent. Chromosome IV.

1. Curved ♀ by bent ♂.

Bent is a wing mutant first described by Muller who demonstrated that its gene belongs to Group IV. The curved female by bent male gave all normal flies of the wild type in the F_1 generation. These inbred produced in F_2 the different classes given in table II.

Table II. F_2 generation from curved ♀ by bent ♂.

Wild type ♂♂	Wild type ♀♀	Curved ♂♂	Curved ♀♀	Bent ♂♂	Bent ♀♀
66	90	37	29	33	31

This cross should give a ratio of 9:3:3:1 if the gene for curved is in a chromosome other than IV. Bent is a poor character with which to contrast curved since both characters involve the wings and the double recessive cannot with certainty be distinguished. A few forms appeared, however, which I took to be curved bent. Counting the double recessive with curved and bent a ratio of 9 to 7 should result. The table gives approximately this ratio and a tentative conclusion reached that the gene for curved is borne by a chromosome which gives free assortment with IV.

III. Behavior of curved with spineless. Chromosome III.

1. Curved ♀ by spineless ♂.

Spineless, a mutant characterized by the absence of bristles on the thorax, was first described by Bridges. Its gene belongs to Chromosome III. All children from the curved ♀ by spineless ♂ were characteristic of the wild type. These when inbred in pairs gave in the F_2 generation the different classes as shown in table III.

Table III. F_2 generation from curved ♀ by spineless ♂.

Number of Mating	Wild type	Normal wing spineless	Normal spines curved	Curved Spineless
1	75	21	22	5
2	57	14	11	4
3	57	17	19	8
4	58	18	13	8
5	89	16	22	2
6	58	15	14	4
7	61	22	13	5
8	9	2	2	0
9	39	14	8	4
10	55	1	11	1
11	42	2	12	0
12	77	24	20	10
13	63	2	14	0
14	35	9	9	4
15	82	25	24	5
16	46	13	14	6
17	78	20	18	8
18	87	25	28	8
19	49	1	24	0
20	48	11	14	5
21	60	23	14	4
22	48	18	8	4
23	40	2	13	0
24	47	17	13	1
Total......	1360	332	360	96

2. Spineless ♀ by curved ♂.

The reciprocal cross in which the spineless ♀ is paired to the curved ♂ is given in table IV. All the F_1 were like the wild type.

Table IV. F_2 generation from spineless ♀ by curved ♂.

Number of Mating	Wild type	Normal wing spineless	Normal spines curved	Curved spineless
1	72	31	27	10
2	82	23	22	2
3	79	3	26	0
4	70	22	18	8
5	50	17	18	7
6	79	23	19	6
7	72	8	20	0
8	73	17	27	1
9	83	19	16	2
10	72	17	28	3
11	76	29	27	11
12	73	15	15	5
13	82	8	23	1
14	75	15	24	2
15	61	16	21	8
16	72	22	24	11
17	13	1	7	1
18	21	7	7	5
19	68	37	8	6
20	80	15	11	4
21	78	21	25	7
22	42	20	17	1
23	20	3	10	2
24	62	15	17	10
Total......	1546	404	457	113

Tables III and IV give evidence of free Mendelian assortment of curved and spineless since the classes approximate a ratio of 9:3:3:1. We conclude that the gene for curved is borne by a chromosome other than III.

3. *Deficiency of the double recessive curved spineless in crowded conditions.* These combinations have been made many times with the same result except that when the cultures are crowded there is a marked suppression of the double recessive. Table V gives an F_2 count from crowded conditions. It is to be noted that only approximately half the number of double recessives appear under unfavorable conditions.

Table V. F_2 generation from spineless ♀ by curved ♂.

Number	Normal wild type	Normal wing spineless	Normal spines wingless	Curved spineless
1	34	5	0	0
2	197	43	44	11
3	250	28	59	7
4	253	56	56	8
5	264	50	67	10
6	242	66	71	12
7	216	35	29	5
8	50	27	11	5
Total[2]......	1496	310	337	58

The F_1 were made up in mass cultures July 10, 1916, transferred to new bottles July 16. The final count was made July 24, 1916.

IV. Behavior of curved with vestigial. Chromosome II.

Vestigial, a member of group II, was described and the linkage of the gene reported by Morgan and Lynch. The double recessive does not appear among the offspring on mating the F_1 from a cross involving two simple recessives whose genes are allocated in the same chromosome. This is due to the fact that in this species there is no crossing over in the male.

1. Vestigial ♀ by curved ♂.

The F_1 from this combination had long wings typical of wild stock. Table V gives the different classes that appeared in the F_2.

Table VI. F_2 generation from vestigial ♀ by curved ♂.

Number	Wild type		Curved		Vestigial	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
1	46	32	16	13	11	9
1a	40	55	29	26	27	26
Total..	86	87	45	39	38	35

[2]Six flies in this group were minus one eye.

2. Curved ♀ by vestigial ♂.

All the F_1 generation from this combination have long wings of the wild type as is the expectation. These when inbred produced the different classes as given in tables VII and VIII.

Table VII. F_2 generation from curved ♀ by vestigial ♂.

Number	Wild type		Curved		Vestigial	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
1	208	203	89	82	69	90
1a	81	97	38	40	30	32
2	154	130	74	69	62	56
2a	89	112	30	34	9	17
3	156	124	61	64	63	78
3a	128	139	61	53	36	36
4	104	88	51	39	49	48
4a	70	83	21	37	17	24
5	193	208	76	96	78	87
5a	84	105	15	19	7	9
6	40	51	22	20	16	10
6a	36	39	17	22	17	19
7	41	49	9	9	15	12
7a	52	47	16	8	17	19
8	64	78	40	34	41	39
8a	71	93	22	16	23	29
9	93	75	35	26	38	35
9a	58	64	27	24	20	27
Total..	1722	1785	704	692	607	667

3. *Back crosses between the hybrid of curved and vestigial to the parent stocks.*

The genetic relation between curved and vestigial was studied in various combinations of back crosses between the hybrids and the parent stocks. Tables VIII—XV shows the different combinations made and the classes realized.

Table VIII. Hybrid ♀ (curved ♀ by vestigial ♂) by curved ♂.

Number	Wild type		Curved	
	♂♂	♀♀	♂♂	♀♀
1	87	84	53	62
1a	116	160	101	84
2	104	125	63	74
2a	3	11	2	0
3	87	107	66	77
Total......	884		582	

Table IX. Hybrid ♂ (curved ♀ by vestigal ♂) by curved ♀.

Number	Wild type		Curved	
	♂♂	♀♀	♂♂	♀♀
1	155	141	103	98
2	83	93	61	94
Total......	472		356	

Table X. Hybrid ♀ (curved ♀ by vestigial ♂) by vestigial ♂.

Number	Wild type		Vestigial	
	♂♂	♀♀	♂♂	♀♀
1	82	92	43	58
2	55	53	54	38
3	90	91	35	33
4	45	28	29	29
Total......	536		319	

Table XI. Hybrid ♂ (curved ♀ by vestigial ♂) by vestigial ♂.

Number	Wild type		Vestigial	
	♂♂	♀♀	♂♂	♀♀
1	45	41	34	34
1a	89	87	44	48
2	26	18	19	11
2a	10	7	4	2
3	95	118	92	83
3a	72	87	37	45
Total....	695		453	

Table XII. Hybrid ♀ (vestigial ♀ by curved ♂) by vestigial ♂.

Number	Wild type		Vestigial	
	♂♂	♀♀	♂♂	♀♀
	85	101	35	31
Total......	186		66	

Table XIII. Hybrid ♂ (vestigial ♀ by curved ♂) by vestigial ♀.

Number	Wild type		Vestigial	
	♂♂	♀♀	♂♂	♀♀
	74	87	32	22
Total......	161		54	

Table XIV. Hybird ♀ (vestigial ♀ by curved ♂) by curved ♂.

Number	Wild type		Curved	
	♂♂	♀♀	♂♂	♀♀
	14	18	15	24
Total......	32		39	

Table XV. Hybrid ♂ (vestigial ♀ by curved ♂) by curved ♀.

Number	Wild type		Curved	
	♂♂	♀♀	♂♂	♀♀
	50	68	43	52
Total......	118		95	

It is evident that in order to bring out the linkage value the double recessive vestigial curved should be used in the back crosses.

V. Behavior of curved with crosses involving black. Chromosome II.

Black, a body color mutation, was found by Morgan. Its linkage shows it to belong to Group II. The contrast between the two characters makes black a good character against which to test curved.

1. Black ♀ by curved ♂.

The gray (wild type color) curved ♂ mated to the straight (wild type wing) black ♀ gave 12 wild sons and 13 wild daughters. These inbred produced an F_2 generation classified in table XVI.

Table XVI. F_2 generation from straight black ♀ by gray curved ♂.

Number	Straight gray	Straight black	Curved gray	Curved black
1	80	39	20	0
2	114	30	36	0
3	219	104	67	0
Total......	413	173	123	0

2. Curved ♀ by black ♂.

The reciprocal cross in which the curved ♀ is mated to the black ♂ gave all wild type in the F_1 generation. These inbred gave results as given in table XVII. These results show very clearly that there is linkage between black and curved since the double recessive does not appear in F_2.

Table XVII. F_2 generation from gray curved ♀ by straight black ♂.

Number	Straight gray	Straight black	Curved gray	Curved black
1	131	41	31	0
2	139	45	31	0
3	104	58	34	0
Total......	374	144	96	0

3. Curved ♀ by black purple curved ♂.

Tables XVIII and XIX give additional data in which curved was crossed to the triple recessive black purple curved obtained from Morgan in the fall of 1918. The curved ♀ by the black purple curved ♂ gave 200 gray red eyed curved sons and 218 gray red eyed daughters. The fact that all the F_1 had curved wings is conclusive proof that Morgan's curved stock and mine are identical. The independent change affecting the germ plasm had changed identical genes. Matings were made from the F_1 with the results recorded in table XVIII.

Table XVIII. F_2 generation from curved ♀ by black, purple curved ♂.

Number	Gray red curved	Black purple curved	Black red curved	Gray purple curved
1	128	35	6	6
1a	180	35	10	7
2	199	45	10	8
2a	116	32	5	2
3	123	30	7	8
3a	119	32	1	2
4	165	43	2	5
4a	44	14	1	3
Total......	1074	276	49	42

4. Black purple curved ♀ by curved ♂.

The F_1 from the reciprocal cross to that in 3 gave 202 gray red eyed curved sons and 231 gray red eyed curved daughters. These inbred gave in F_2 the different classes in table XIX.

Table XIX. F_2 generation from black, purple, curved ♀ by curved ♂.

Number	Gray red curved	Black purple curved	Black red curved	Gray purple curved
1	248	52	6	25
2	273	59	14	11
3	313	77	11	7
4	263	59	13	6
Total......	1097	247	44	49

The fact that all the flies in the F_1 and F_2 are curved shows that the two mutants are identical. The last two tables give data on the linkage of purple and black. There are 184 cross overs in a total of 2878 a linkage of 12.8.

5. The Black, purple vestigial was crossed to a new wild stock from Arlington, Md. Over 500 sons and daughters were like the wild type. Since crossing over does not take place in the males, F_1 females whose composition was (b p v B P V) were back crossed to black purple vestigial (b p v). The

females produce non-crossover gametes (b p v) and (B P V) and crossover gametes of the composition b P V—Bpv—bpV—BPv—bPv and Bpv. The males to which they are mated produce gametes of the composition b p v. The different classes realized are given in table XX.

Table XX. Classes realized on back crossing the bpv ♂ to the hybrid ♀ of composition bpv BPV.

No.	Vestigial				Long			
	Black		Gray		Black		Gray	
	Purple	Red	Purple	Red	Purple	Red	Purple	Red
	bpv	bPv	Bpv	BPv	bpV	bPV	BpV	BPV
1	95	2	15	23	16	13	1	119
2	62	4	6	5	8	14	2	78
3	111	4	14	9	15	16	2	89
4	179	2	12	26	62	36	4	301
Totals.	447	12	47	63	101	79	9	587

VI. *Summary.*

The independent origin of curved, a wing mutant identical with the one reported by Bridges, is here given. The data obtained with the various crosses is in agreement with the great mass of evidence which shows that the chromosome conception of inheritance offers the only rational basis upon which such data can be interpreted. Genes carried by different chromosomes give free assortment with Mendelian ratios, those in the same chromosome show linkage with no crossing over in the male.

It is evident that the factor grouping of a new mutant can be determined by the failure of the double recessive to appear in the F_2 generation. Morgan has made use of black-pink flies for testing a new mutant type. Black is in the second group and pink in the third. If the new factor belongs to either of these groups it will fail to show the double recessive among the grandchildren from the cross. The sex relations from such an experiment will readily determine whether or not it belongs to the sex-linked group. If it belongs to none of these groups it is by exclusion placed in the fourth group.

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NOTES ON THE BIRDS OF CARROLL, MONROE, AND VIGO COUNTIES, INDIANA.

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Director of the Museum of the California Academy of Sciences.

It has been my aim to bring together and put on record in this paper such notes as I now have concerning the birds of Carroll, Monroe, and Vigo counties, Indiana. I began recording my observations on the birds as long ago as 1877. The greater part of the records made prior to 1888, were, however, lost in the fire which destroyed the Indiana State Normal School building on March 8 of that year. Fortunately, some of my note books were saved. The present paper is based chiefly upon the notes contained in them and such as were made subsequent to that date.

CARROLL COUNTY.

Carroll County was my home during boyhood and until August, 1879. I was in the county during part of the summers of 1881 and 1882, and almost continuously from March, 1883, to July, 1885. Since 1885, I have in some years been able to spend from a day to a week or more in the county.

Up to 1877, my interest in birds was merely such as is taken by most country boys with a more or less decided "bent" for natural history. In the spring and summer of 1877, my wife, Meadie Hawkins Evermann, was a student of Dr. David Starr Jordan's at Butler University, and, through Dr. Jordan, Mrs. Susan Bowen Jordan, Dr. and Mrs. Alembert W. Brayton, and Mr. Charles H. Gilbert, all of whom then lived in Irvington and all of whom were then enthusiastic collectors and students of birds, she, too, became interested in natural history, particularly botany and ornithology. From them she learned to skin birds and when we returned to Camden in the fall, I also became interested in natural history studies, and from that day to this we both have retained our interest in birds.

Our field work in Carroll County was chiefly in the vicinity of Camden and Burlington; however, from March, 1883, to July, 1885, my work was such as took me, in buggy or sleigh, all over the county. I was thus afield on practically every day continuously for nearly two and one-half years, and thus had exceptional opportunities to observe the birds in every part of the county, during all seasons and at all times of the day. Mrs. Evermann was constantly and enthusiastically associated with me in all this work, sometimes accompanying me on long trips over the county, more often joining the short trips afield. She always joined in the study and identification of the specimens collected and did practically all the taxidermy work incident to the preparation of the specimens.

Among our students were several that became more or less interested in birds and who assisted us in field observations and the collecting of specimens. Among these I may mention particularly the following: First of all, Ami, Addison, Sidney T., and Otway C., Sterling, four brothers living southwest of Camden on Bachelor Run, all with a natural history "bent". Ami and Addison, fine young boys they were, and promising young naturalists, made a small collection of nests and eggs, which doubtless would have grown to considerable size and value if the boys had lived, but they both died while yet in their teens. The other two brothers also were good observers and I am indebted to them, particularly to Sidney, for many records of rare or uncommon birds noted. Frank C. Porter, a cousin of the Sterling boys, and living on a farm near them, also was interested in birds and contributed many observations of value. I spent many a day pleasantly with these boys hunting in the Deer Creek bottoms. My nephew, Edwin C. Evermann, of Burlington, another promising young naturalist who died while yet a boy in 1888, made a small collection of bird eggs which is now in the Museum of the California Academy of Sciences. Two other Burlington boys who showed some interest in birds were the brothers, William and Dalton Wright now of Los Angeles, California. Still others who have communicated to me observations or data of value, or specimens, may be named: D. C. Ridgley, now professor of geography in the state normal school at Normal, Illinois; Harry C. Van Der Volgen of west of Pittsburg; James Milton Beck (my brother-in-law), of Burlington; Miss Ava Evermann (my niece), then of Burlington, now of Kokomo; and Frank C. Groninger, one of our students at Camden, now a prominent lawyer of Indianapolis. And recently my young great nephew, Donovan Beck of Burlington, has sent me notes and specimens.

Favorite collecting places about Camden were the following: Along Deer Creek in the woods from the Vandalia railroad to Leonard's mill, a distance of two or three miles; the woods and hillside thicket at the southeast edge of Camden; the Deer Creek bottoms from Camden to below the Porter mill, a distance of perhaps three miles; along the lower course of Bachelor Run; in the heavy forest on the Wise farm southwest of Camden; on and about the Wm. R. Stewart farm southwest of Camden; in the open woods just north of the Frank Thomas farm south of town; in the woods northwest and north of the town; and about the Armstrong pond at the south edge of Camden.

The localities about Burlington most frequented were the following: My father's farm and the farms adjoining it, about a mile south of town; along Wild Cat Creek from a mile below Burlington to the dam about the same distance above town; and the Maple Swamp near Lexington. Many observations were made also along the road between Camden and Delphi and along the Wabash River near Delphi.

Monroe County.

From August, 1881, to March, 1883, and again from July, 1885, to July, 1886, while students in Indiana University, we devoted much of our spare time to the birds of Monroe County, particularly of the region within a radius of 15 or 20 miles of Bloomington. During those years our pleasure and enthusiasm in ornithological studies were increased through association with several other students of kindred tastes. Among these may be mentioned the following: Willis S. Blatchley, afterward teacher of biology in the Terre Haute high school and later the able State Geologist of Indiana for many years; Charles H. Bollman, a very promising young naturalist interested chiefly in myriopods but also deeply interested in birds and fishes, whose untimely death at Waycross, Georgia, July 13, 1889, while studying the fishes of southern swamps for the United States Fish Commission, just as he was entering upon what promised to be a brilliant scientific career, was a great loss to zoological science; G. G. Williamson of Muncie; W. A. Millis, now the able president of Hanover College; Chase O. DuBois, now prominent as a superintendent of schools in Illinois; W. W. Norman, afterward professor of zoology in DePauw University and the University of Texas, whose untimely death at Woods Hole, Mass., in the summer of 1894, was a severe loss to American science; Robert J. Aley, now the energetic president of the University of Maine; and Joseph Swain now the able president of Swarthmore College. Nor must I fail to mention Miss Annie Turner of Bloomington who aided us materially in our collecting. All of these were then enthusiastic students of birds and all would no doubt have attained distinction in ornithological studies, had not the Fates cast their lines in other fields.

Vigo County.

While residing at Terre Haute from July, 1886, to July, 1891, our interest in ornithology continued and we were able to pay considerable attention to the birds of the region within a radius of some 20 miles of Terre Haute. During the school year it was my custom to spend Saturday of each week somewhere in the country, a practice which was kept up regardless of weather conditions; rain, storm and snow were never permitted to interfere. Usually accompanied by one or more of my students, I would drive afield early every Saturday morning, spend the day in woodland, along some stream, or in and about some pond or swamp, returning home late in the evening, or frequently not until the next day. The late Dr. Josiah T. Scovell, an all-round naturalist, was my companion on hundreds of trips, and a more delightful companion, or one more enthusiastically and intelligently interested in all nature, no one ever had. Dr. Scovell's interests were many. Indian mounds, old river channels, the evidences of glacial action, the geology of the region, the soils, building stone, coal mines, oil, the topographic features of the county,—in short, everything geologic, geographic, topographic, hydrographic, and climatic, interested him; and his knowledge of these subjects was such as enabled him to discuss them all intelligently and interestingly. He was also a good botanist and a fair zoologist, especially interested in ecological relations. In systematic zoology he perhaps knew most about the freshwater mussels (the Unionidæ), but he also knew a good deal about the local birds. The hundreds of trips I took with Dr. Scovell over Vigo County I look back upon as among the most delightful of my life.

Among my students who took special interest in these trips I may be permitted to mention a few: Ulysses O. Cox, for many years head of the department of biology and dean in the Indiana State Normal School whose untimely death at Denver, Colorado, August 20, 1920, took from the faculty of that institution one of its ablest, most useful and best loved members; J. Rollin Slonaker, a boyhood chum of Cox, now assistant professor of physiology in Stanford University; L. J. Rettger, now head of the department of physiology in the Indiana State Normal School; D. C. Ridgley, now head of the department of geography in the Illinois State Normal School at Normal; Bessie O. Cushing (Mrs. D. C. Ridgley); Flora Hartley, now wife of Dr. Charles W. Greene, professor of physiology in the University of Missouri; Albert J. Woolman, for many years a science teacher in the high schools of South Bend and Duluth, later business man in Urbana, Illinois, who died in 1918; Thos. F. Fitzgibbon, now prominent educator, superintendents of schools, Muncie, Indiana; Cloudsley Rutter, for a number of years one of the most able scientific assistants in the United States Fish Commission, whose death in 1903, deprived ichthyological science of one of its most promising young men; J. C. Cunningham, now prominent farmer and business man in Miami County; and W. D. Hamer, prominent lawyer at Huntington. Many others might be named. I must not forget to mention my life-long, most intimate friend and predecessor in the Indiana State Normal School, Dr. Oliver P. Jenkins who, though at DePauw University, frequently came over to Terre Haute, and many a delightful trip did we take together along the Wabash and its small tributaries in search of things in which we were both interested. Dr. Jenkins was also deeply interested in the birds of Vigo County, and at one time had in mind the publication of a report thereon. Mention must be made also of W. S. Blatchley who during the several years of his connection with the Terre Haute high school, gave much attention to the natural history of Vigo County.

I regard the following annotated list as valuable chiefly because of the records of definite dates and places. To some, these may seem trivial and of little consequence, but to the future student of the migration, geographic distribution, and habits of our birds, it is believed they will serve a useful purpose.

A statement that a certain species was seen on a certain date in a certain place does not mean that it was not seen on many other dates and in other places; it simply means that that particular note was not lost in the fire of 1888. While these records are, in many instances, unrelated, they will, nevertheless, it is believed, prove useful. I have advisedly made the records as definite and detailed as possible as to dates, places, persons and circumstances, in the belief that their value will thereby be enhanced.

It is regretted that the Vigo and Monroe counties records are not more numerous, but it was the note-books of those counties which were most completely lost in the fire of 1888.

I am glad to mention the considerable number of my former students and associates whose observations and assistance in other ways have contributed to our knowledge of the birds of Indiana, and I take this opportunity to express my high appreciation of their interest and helpfulness. Without their comradeship afield, which gave opportunity for discussion and exchange of views, much indeed would have been lost.

Annotated List of Species.

In the following annotated list of species the nomenclature and sequence agree with the last (third) edition of the Check-List of North American Birds published by the American Ornithologists' Union in 1910. The species and subspecies are numbered consecutively. The number in parenthesis following the scientific name is the serial number of that species in the Check-List.

1. Colymbus auritus (Linnæus). horned grebe. (3)

A rare spring and fall migrant, probably in all the counties, though I have no definite record for Carroll or Monroe. The only record for Vigo is of one brought to Professor Blatchley in the fall of 1890 by a boy who found it tied as a decoy in the Wabash River near Terre Haute.

2. Podilymbus podiceps (Linnæus). pied-billed grebe. (6)

Any one who has spent much time in the spring or fall about any of the small lakes with which northern Indiana is so abundantly supplied, or along the larger streams of the state, has doubtless become familiar with the queer little duck-like birds which he probably called "helldivers".

The most common and best known species is the Pied-billed Grebe, otherwise known as helldiver, dabchick, or waterwitch. It is a summer resident in the ponds about Terre Haute and elsewhere along the Wabash River.

Vigo County: Usually a few were seen every time a visit was made to the Five-mile Pond or the Goose Pond; occasionally seen along the old canal. When at the Goose Pond, nine miles south of Terre Haute, May 3, 1890, Mr. U. O. Cox and I found a nest of this curious, witch-like little diver. It was a floating mass of dead flags and Scirpus stems, more or less matted together with mud. The eggs, of which there were seven, were covered up with nest material when found, and were very dirty. Incubation had slightly advanced. Four of the eggs measured, in inches, 1.66 x 1.12, two 1.70 x 1.12, and one 1.66 x 1.09.

Doubtless other nests could have been found in this pond had we searched thoroughly. It no doubt nests in the Five-mile Pond, in Greenfield Bayou, and in other similar places in the county.

Carroll County: A few said to remain through the winter in open places in the Wabash near the Georgetown mill. I do not remember ever to have seen it on Deer Creek or Wild Cat, but it was seen on the Wabash occasionally. On February 21, 1885, my friend, Charles Metsker, saw one in the Wabash near the Pittsburg dam, and Wm. Coble told me that a few usually remain all winter in air-holes in the Wabash near the Georgetown mill.

I never saw this species in Monroe County.

3. Gavia immer (Brünnich). loon. (7)

A rare spring and fall migrant.

Carroll County: Seen once on Wild Cat Creek many years ago.

Vigo County: One seen on the Wabash November 6, 1886, and another a short distance below Durkee's Ferry, in April, 1889. No record for Monroe County.

4. Larus argentatus (Pontoppidan). herring gull. (5)

Rare spring and fall migrant.

Carroll County: Occasionally seen on the Wabash about Pittsburg and above.

Vigo County: There was a specimen in Dr. Scovell's collection obtained on the Wabash near Terre Haute many years ago. No Monroe County record.

5. Larus delawarensis (Ord). ring-billed gull. (54)

A rather common spring and fall migrant; usually seen in small flocks of two to six or seven, following the course of the river. Noted in Carroll and Vigo but not in Monroe.

6. Larus philadelphia (Ord). bonaparte's gull. (60)

An uncommon spring and fall migrant, following the course of the river. This gull may usually be distinguished from the preceding by its black head and bill, the head of the Ring-billed Gull never being black and the bill being yellowish, with a black band near the end.

Noted in Carroll and Vigo but not in Monroe.

7. Sterna forsteri (Nuttall). forster's tern. (69)

Spring and fall migrant; rare.

This beautiful tern is sometimes seen in small flocks flying up or down the river. It may be known by its widely forked tail and black head.

Carroll County: Occasionally seen on the Wabash near Delphi.

Vigo County: One seen April 28, and another May 19, 1890, on the Wabash, near Terre Haute. No record for Monroe County.

8. Sterna hirundo (Linnaeus). common tern. (70)

Spring and fall migrant.

Carroll County: A specimen was taken at Adams' mill on Wild Cat Creek, October 28, 1898, by Charles Hill of Adams' mill. It is now in the possession of Messrs. Meyer and Eaton, Flora, Indiana, where I saw it some years ago, and took the following notes:

Length of bill 1¼ inches; gape 1½; wing 10; tail 4; tarsus ¾; middle toe and claw ⅞; bill nearly straight. Color white, washed with bluish or grayish, nape dark, primaries bluish, feet yellow.

On May 2, 1884, I saw about a dozen flying up the Wabash, near Delphi.

No records for Vigo or Monroe.

9. Sterna antillarum (Lesson). least tern. (74)

Spring and fall migrant along the Wabash in Carroll and Vigo counties; not noted in Monroe County.

10. Hydrochelidon niger surinamensis (Gmelin). black tern. (77)

The most common spring and fall migrant of any of the terns. A flock of six or eight seen May 19, 1888, on the Wabash just above Terre Haute. A similar flock seen on the Wabash, near Delphi, in the spring of 1883. No Monroe County record.

11. Phalacrocorax auritus floridanus (Audubon).

florida cormorant. (120a)

Spring and fall migrant; not often seen. Noted by Dr. O. P. Jenkins, near Terre Haute. A fine specimen got by Mr. Kendry at a pond just north of Terre Haute, April 14, 1888. Length, 33.5 inches.

No record for Carroll or Monroe.

12. Pelecanus erythrorhynchos Gmelin. white pelican. (125)

Very rare spring and fall migrant. I have never, myself, seen this species in Vigo County, but I have been told by various persons that they had seen it years ago. Dr. Scovell examined a specimen shot near Terre Haute, about May 12, 1888. One was secured on Tippecanoe River, Carroll County, by my friend W. W. Black, in the spring of 1881. No records for Monroe.

13. Mergus americanus Cassin. merganser. (129)

Rather common spring and fall migrant; frequently seen on the Wabash and on various creeks. The first duck to arrive in the spring and the last to pass through in the fall.

Carroll County: March 1, 1878, a female taken on Deer Creek, near Camden. March 1, 1879, several seen on Deer Creek; others seen and a male gotten four days later; and, on March 14 of same year, several seen in the market in Lafayette. A fine male, in splendid plumage, obtained on Deer Creek, above Camden, March 23, 1885. The shot fired merely winged it slightly. The creek was covered with ice except in a few places. The duck, in attempting to escape, dived and, coming up under the ice, swam along some distance. The ice was clear and it was easy to follow the bird. After swimming perhaps a hundred yards under the ice, it came up against the bank in shallow water, where it was captured by cutting a hole through the ice above it.

Flocks of five to 20 seen on Deer Creek or the Wabash, February 13 and 18, and April 21 and 22, 1883; February 13 and 17, and March 10 to 18, 1884; March 10 to 15, 1885, several seen on Deer Creek daily, and on the 18th, they were abundant.

A favorite place for them in Deer Creek was the long stretch of quiet water just below the old Leonard mill, east of Camden. Here the left, or south bank of the creek, is a high bluff, and, in the creek under this bluff, from a few to several of these large interesting birds might be seen almost any day in spring after the ice had disappeared. Other places that were favorite haunts of this species were the open water, just above the drift or log-jam, above the old Dillen mill site, and at the Adam Porter mill, a mile below Camden.

On February 17, 1885, I saw six or seven at Fry's mill in Adams township, where the creek was open. The day was very cold, the snow deep and more falling. Mr. Wm. Coble, of that neighborhood, said that a few of these ducks usually remain all winter in open spaces in the Wabash, near the Georgetown mill.

Vigo County: Seen occasionally in the markets. March 9, 1888, a female gotten on the Wabash, near Terre Haute.

14. Mergus serrator Linnæus. red-breasted merganser. (130)

A rare migrant; noted only in Carroll and Vigo; no records for Monroe.

15. Lophodytes cucullatus (Linnæus). hooded merganser. (131)

A not very common spring and fall migrant; possibly a few breed, but of this I have no positive evidence, although I have often met with single pairs about swamps and ponds in midsummer, and have seen them on Deer Creek in July. A young male obtained and seven or eight others seen on Deer Creek, near Camden, April 8, 1885. Three seen near Terre Haute, March 9, 1888.

16. Anas platyrhynchos Linnæus. mallard. (132)

Formerly a rather common summer resident; now chiefly a spring and fall migrant.

I have not seen it often in Monroe County; my only record is of several seen on Griffy Creek near Bloomington, March 5, 1886.

In Vigo County, it was, and doubtless is, more common. In early spring and again in the fall, Mallard ducks might be seen on any of the ponds or bayous along the Wabash River, and occasionally, in protected cover, in the river itself. Favorite places were the Five-mile Pond, near old Fort Harrison, the Goose Pond, and Greenfield Bayou. February 26 and 29, 1888. I have no definite record of the Mallard nesting in Vigo County, but it no doubt did so in earlier days.

In Carroll County, the Mallard was a common species during my boyhood days. It was then, of all the ducks, the most familiar species to me. In the spring, in all the quiet reaches of Wild Cat Creek, and in every woodland pond, however small, one or more pairs could be found. In those days a good many pairs were permanent summer residents, making their nests on some relatively dry tussock in the small ponds. In the summer and early fall, the family of old and young could be seen swimming about over the pond, or skurrying to cover in hidden places among the button-bushes. Noted in the Lafayette market March 14, 1879.

17. Anas rubripes Brewster. black duck. (133)

I have never seen this duck in Monroe or Vigo County, but in March, 1879, I saw an example in the Delphi market which was said to have been shot on the Wabash, near by.

18. Chaulelasmus streperus (Linnæus). gadwall. (135)

A very rare spring and fall migrant.

I have no record for Monroe or Carroll County. My only record for Vigo County is of a single specimen seen about 1887, in the possession of a resident of Terre Haute.

19. Mareca americana (Gmelin). baldpate. (137)

A rare spring and fall migrant, most often seen on the creeks. I never observed it in Monroe County. As to Vigo, my notes simply mention the species without giving definite places or dates, except for March 24, 1888, and March 26, 1889 and 1890. In Carroll County, it is not uncommon during the spring migrations. A flock of about a dozen was observed on Deer Creek near the Leonard mill, March 26, 1884, from which a female was shot. Another flock of six was seen at the bend in the same creek opposite the W. R. Stewart farm below Camden, March 24, 1885; and a fine pair was obtained, also on Deer Creek, at the Porter mill-dam, in April, 1885.

20. Nettion carolinense (Gmelin). green-winged teal. (139)

A not uncommon spring and fall migrant. A few were seen in Monroe County, near Bloomington, March 5, 1886.

In Vigo County, it was quite frequent in spring and fall; March 14, 1879, seen in Lafayette market; February 29, 1888, March 9, 1889, and March 9, 1891, several noted each day.

Although it is doubtless rather common in Carroll County during the migrations, my only definite record is of a female which I took on Deer Creek, April 8, 1885.

21. Querquedula discors (Linnaeus). blue-winged teal. (140)

I have no record of the Blue-winged Teal in Monroe County. In Vigo, it is a fairly common spring and fall migrant. In Carroll, I never took any specimens myself, but I have seen specimens in the Delphi market in the spring of 1883, 1884, and 1885. I have also observed it on the Wabash River, near Pittsburg, and just above Lockport, early in the spring, soon after the ice went off.

22. Spatula clypeata (Linnaeus). shoveller. (142)

Rather common spring and fall migrant; often seen on the river and on the larger creeks, usually in March. In Monroe County, one obtained by W. S. Blatchley on Clear Creek, May 8, 1886. In Vigo, I have often noted it in spring on the Wabash River, and in the Terre Haute market. In Carroll, I obtained a fine male, March 18, 1879, on Deer Creek just below the W. R. Stewart farm, below Camden. Several were seen on Deer Creek, March 26, 1885, one of which was collected. Seen in the Lafayette market, March 14, 1879.

23. Dafila acuta (Linnaeus). pintail. (143)

A rare migrant. In Monroe County a specimen obtained, February 26, 1886, on a little creek near the University campus. In Carroll County, it has been noted as a rather rare spring and fall migrant. In Vigo County I have noted it February 29 and March 9, 1888, and March 9, 1891.

24. Aix sponsa (Linnaeus). wood duck. (144)

Formerly a common summer resident, breeding about ponds and along creeks and rivers; now very rare.

In 1886, the Wood Duck was probably the most common duck in Monroe County. At rather distant points on each creek, a pair could be found during the summer, and I have noted it on White River, near Gosport.

In Vigo County, it was a not uncommon summer resident, breeding in holes in trees in the bayous and swamps along the Wabash. One obtained on Honey Creek, south of Terre Haute, February 29, 1888.

In Carroll County, it was rather common, at least as late as 1880. In my boyhood days (1864-1875), one might safely expect to find a pair at every secluded reach of Wild Cat and other creeks of the county, and at every permanent woodland pond. Noted on Deer Creek in July, 1877. March 1 and 14, 1879, and on March 26, 1885, I saw a pair flying up Deer Creek. On the Kankakee, in northern Indiana, this most beautiful of all our ducks, is still a common species.

25. Marila americana (Eyton). redhead. (146)

A rare spring and fall migrant. I have few definite records, but I remember distinctly to have seen it in the Terre Haute market in 1886-91. March 9, 1888, two males taken near Terre Haute.

26. Marila valisineria (Wilson). canvas-back. (147)

A rare spring and fall migrant. Although rarely seen on the river, it is one of the most abundant ducks on the lakes in the north part of the state, especially in the fall. One brought me by Mr. Ed. Tetzel, of Terre Haute, in the spring of 1889.

27. Marila marila (Linnaeus). scaup duck; big bluebill. (148)

Spring and fall migrant, at least in Carroll and Vigo counties, much less common than the Little Bluebill. I have no definite records. Never known as Scaup Duck in Indiana.

28. Marila affinis (Eyton). lesser scaup duck; little bluebill. (149)

Common spring and fall migrant; very abundant on Lake Maxinkuckee and other small northern Indiana lakes, especially in the fall; less common in Carroll and Vigo, and still less so in Monroe. A good many killed each fall along the Wabash. I obtained one on Deer Creek, near Camden, April 18, 1885. One seen on White River, near Gosport, May 8, 1886, and several were seen the same day by W. S. Blatchley on Clear Creek, Monroe County. Three seen March 9, 1888, near Terre Haute. Noted also by Dr. Scovell and Dr. Jenkins. The name Lesser Scaup Duck is rarely or never heard in Indiana.

29. Clangula clangula americana Bonaparte. golden-eye. (151)

I have noted this only in Carroll County, as a very rare migrant in March and April; no definite record.

30. Clangula islandica (Gmelin). barrow's golden-eye. (152)

The only record I have is of a female which I shot on Deer Creek, near Camden, March 19, 1885. It is a very rare duck in this part of Indiana.

31. Charitonetta albeola (Linnæus). buffle-head. (153)

Not common spring and fall migrant in all the counties; a few remaining in open places in the Wabash quite late in the winter. A female collected, February 29, 1888, at Terre Haute.

32. Harelda hyemalis (Linnæus). old-squaw. (154)

The only record I have of this species in the counties covered by this paper is of two specimens obtained in Adams Township, Carroll County, or possibly just over the line in White County, about February 12 and 19, 1895. My information is that given in a special to the Indianapolis News, as follows:

Delphi, Ind., February 22.—Mr. Joseph Clark, of Pine Village, Warren county, is the possessor of two rare birds of the duck species, that fell into his hands ten days ago while visiting at Burnett's Creek, north of this place. During a snow storm the birds evidently became demoralized, and one of them, striking a telegraph wire, was crippled and captured alive, but died soon after. The other was found frozen in the snow a week later. Both are being prepared by a taxidermist. They weigh about two pounds each, have white heads with jet-black rings around their necks, black backs and white breasts. The male bird has two black feathers in its tail, at least twelve inches in length, while in the female bird these feathers are not so long. Mr. Clark has exhibited the birds, and he states that no one has ever seen anything like them.

These specimens were undoubtedly the duck known as the Old-squaw, or South-southerly, a northern species which comes southward rarely as far as southern Indiana in winter. They are said to be quite common on Lake Michigan, off Michigan City where they are frequently caught in the fishermen's gill-nets.

33. Erismatura jamaicensis (Gmelin). ruddy duck. (167)

Rather rare spring and fall migrant. I have noted it in Carroll and Vigo counties, but not in Monroe.

34. Chen hyperboreus hyperboreus (Pallas). lesser snow goose. (169)

I have seen white geese flying over in spring and fall in Carroll County. They were probably this species.

35. Chen cærulescens (Linnæus). blue goose. (169.1)

Rare spring and fall migrant. The only specimen I ever saw was brought to me by Mr. Ed. Tetzel, who killed it near Terre Haute, April 2, 1887.

36. Branta canadensis canadensis (Linnæus).

canada goose; honker. (172)

A common spring and fall migrant in all the counties, much more abundant formerly than now.

In my boyhood days, wild geese were abundant during the spring and fall migrations, and large V-shaped flocks flying high in air, uttering their *honk, honk,* were a familiar sight. Now their numbers are greatly reduced; only a few small flocks may be seen each fall or spring. I have only one definite record for Vigo County (all others, such as I had, having been lost), and that is of a specimen shot near Terre Haute, March 3, 1888, by Mr. Frank Byers, who brought it to us. March 11, 1885, several heard flying over at night, near Camden. They were probably honkers.

37. Olor columbianus (Ord). whistling swan. (180)

Spring and fall migrant, but not often seen, except on the Wabash and Tippecanoe, where one was occasionally killed some twenty to 30 years ago. I have no records for Vigo or Monroe County.

38. Olor buccinator (Richardson). trumpeter swan. (181)

A rare spring and fall migrant. I have no records for Vigo or Monroe County, and only one for Carroll, which is of a specimen shot on Wild Cat Creek, near Burlington, many years ago.

39. Ajaja ajaja (Linnæus). roseate spoonbill. (183)

One said to have been killed near Terre Haute several years ago.

40. Mycteria americana Linnæus. wood ibis. (188)

The Wood Ibis, one of our most remarkable birds, is a southern species, but withal, a great wanderer. Its breeding grounds are in the swamps and bayous of the lower Mississippi valley and southward. After the breeding season is over and the young are able to fly well, small bands stray northward along the larger river courses. Such small flocks or isolated birds are occasionally seen in southern Indiana and Illinois, especially along the Wabash. On September 11, 1888, I saw a flock of 9 of these strange birds sitting solemnly in an old dead tree on the Illinois side of the Wabash, opposite Mackay's Ferry, 10 miles west of Mount Vernon, Indiana.

Mr. Robert Ridgway reports seeing them "soaring majestically in broad circles over the Wabash River, at Mt. Carmel". I have a record of one killed at Greenfield Bayou below Terre Haute sometime in the early 80's.

I have one other record for the counties covered by this paper, and that is of a specimen shot July 30, 1887, in the old Maple Swamp south of Cutler, Carroll County. It was secured by a man named Harmon by whom it was conveyed to Dr. O. A. J. Morrison of Middlefork, Clinton County, where I saw it December 31, 1888.

41. Botaurus lentiginosus (Montagu). bittern. (190)

Summer resident, not rare in suitable places.

In Vigo County, most common at the Goose Pond and the Five-mile Pond. Noted near Terre Haute October 26, 1886. A nest with four eggs found at the Goose Pond, May 31, 1890. The nest was supported about ten inches above the water in a bunch of flags. The eggs were nearly ready to hatch; indeed, one was pipped.

I have no definite records for Carroll County, but I recall having seen it at the Armstrong Pond near Camden, on the Wabash, near Pittsburg, in the Harness Swamp south of Burlington, and once on the old canal near Lockport.

In Monroe County, a very distressing accident happened to one of my young friends, Antone Boisen, of Bloomington. If my note is correct, it was on May 5, 1886, when young Boisen crippled a Bittern and when attempting to catch it, the bird struck at him with its bill, hitting him in the eye and completely destroying his vision in that eye.

42. Ixobrychus exilis (Gmelin). least bittern. (191)

A rather common summer resident in favorable situations such as the various ponds and marshes of Vigo County, particularly the Five-mile Pond and the Goose Pond, in each of which I have found it nesting. Two females obtained, May 21, 1888, at the pond just north of Terre Haute, and another, also a female, the next day at the same pond. Two days earlier, May 19, Prof. W. S. Blatchley obtained a pair, male and female, and I saw five at the same pond; and on May 23, one of my students, Mr. Thomas Frazee, secured a male at the same place. A male in fine plumage taken at the Goose Pond, May 17, 1890. On May 31, I again visited the Goose Pond and found the Least Bittern nesting in considerable numbers. It was just the height of the nesting season. Twelve nests were found, three containing five eggs each, five with four eggs each, two with three each, and two with one each. Incubation had begun in three sets, the others were all fresh.

A week later (June 6), I visited this pond again, accompanied by U. O. Cox, and obtained two more sets, one of five, the other of four, with incubation well begun in each set.

The Goose Pond contains (or did then), several hundred acres. The water was less than three feet deep, in most places not over one or two feet. In the middle or deeper part of the pond was a fine growth of pond lilies (*Nymphæa advena* and *Castalia tuberosa*), both species abundant and blooming in profusion. Around the edges in the shallower parts were rank growths of cattails (*Typha latifolia*), rushes (*Equisetum limorum*), various sedges (Carex), Arrowhead (Sagittaria), and doubtless other forms. And the water was well filled with duckweed (Lemna, Spirodela, Wolffia, etc.), and several species of Potemogeton, Ranunculus, pickerel-weed, Crucifers, Scirpus, etc. The Least Bitterns' nests were usually from a few inches to a foot above the water, and placed upon a few broken-down stems or leaves of cattails, but sometimes they were supported by leaves of Sagittaria.

We did not see a single bird on its nest, so sly were they in slipping away before we discovered them. In one case we saw the bird fly up from flags only a few inches from the nest, and in several cases the birds flew up and thus showed us where to expect to find their nests.

43. Ardea herodias herodias Linnæus. great blue heron. (194)

A not very common summer resident. A few individuals arrive early in the spring and remain in and about suitable locations throughout the summer and till quite late in the fall. Quite solitary in its habits when feeding, rarely ever more than one being seen in one place. In a boat trip from Terre Haute up the river as far as Durkee's Ferry not more than four or five would be seen; and in a similar distance down the river no greater number would be encountered. They doubtless nest somewhere in Vigo County, but I was never able to learn just where. A specimen obtained by Mr. Thomas Frazee near Sullivan in the spring of 1889.

In Carroll County, during my boyhood days, the "Big Blue Cranes", as we then called them, were quite common. The country lying southwest of our house was a dense unbroken forest for a mile or more. Scarcely had it been invaded by the pioneer settlers and little timber had been cut in it except about the edges. Interspersed through this wood were numerous small woodland ponds, some of which became dry in late summer or early fall, others remained with more or less water throughout the year. In and about these ponds was a heavy growth of cottonwoods (*Populus deltoides*), some of them magnificent trees 100 to 150 feet high and three to five feet in diameter. In the tops of these great trees, in one of the largest ponds, was a considerable heron rookery; perhaps there were usually 30 to 50 pairs nesting there. The most frequented feeding ground of these herons was along Wild Cat Creek, about a mile and a half north. During the spring and summer scarcely a day passed that we did not see many of these great birds flying overhead northward in the morning, evidently on their way to their feeding grounds, usually flying in twos or threes, sometimes in greater numbers, but perhaps most often singly; then in the evening, sometimes not until after sunset, they would return. Sometimes they flew quite low; I remember distinctly one morning, a neighbor boy fired at one with his squirrel rifle and brought it down. It proved to be a female with a fully developed egg in the oviduct.

In the early 70's much of this land was ditched and cleared, which caused the herons to abandon that rookery.

Probably the largest heronry that ever existed in Carroll County was in what was known as the Maple Swamp in the southern part of the county between Sedalia and Cutler, near Lexington, about six miles south of Wild Cat Creek, or eighteen miles from the Wabash River to the northwest. This swamp really consisted of a widening of a small creek known as Middle Fork. It covered several hundred acres and the lower portion had a heavy growth of swamp ash (*Fraxinus nigra*) and soft maple (*Acer saccharinum*); and in the tops of these trees a considerable colony of Great Blue Herons had their nests. My first visit to this heronry was on June 12, 1882, when I counted more than one hundred nests, most of them being occupied. As many as thirteen nests were seen in one tree, and several other trees contained from three to ten nests each. Most of the nests contained large young, some nearly able to fly. I again visited this swamp on May 21, of the next year. Climbing to several nests I found young birds in some and eggs in various stages of incubation in others. I was told by farmers living near by that formerly there were many more nests but the birds were so harassed and molested by squirrel hunters and others who annoyed them needlessly that they were being gradually driven away. In the three winters from 1883 to 1885, I had occasion to drive by this swamp several times. The leaves having fallen, the nests showed plainly in the tops of the bare trees and made a striking and very interesting sight.

But the old Maple Swamp, like most of the swamps and woodland ponds which a half century ago afforded a suitable environment for so many species of the native fauna and flora, now alas! all but extinct, and which added so much of real interest to the nature lover, is now a thing of the past. It has been ditched and drained; the attractive forest, underbrush, and aquatic plants have given way to rectangular fields of corn and cabbage. The æsthetic has succumbed to the utilitarian. There will be more corn and hogs but less of beauty and the appreciation thereof.

The same is true of the uplands. The great forests are gone; they have been cut off and there remain only here and there occasional 20, 30 or 40-acre wood-lots, pitifully mutilated and crippled remnants of the once mighty forests, the most magnificent hardwood forests the world has ever seen, which clothed practically the entire state of Indiana 75 years ago.

The only other heronry which I knew in Carroll County was in Adams Township, near the north line of the county, about six miles north of the Wabash River and about the same distance east of the Tippecanoe. I never visited this rookery in the breeding season, but I have, when driving by in the winters of 1883 to 1885, seen the great nests, nearly a hundred of them, in the tops of the maple, cottonwood, and swamp ash trees.

Definite dates for Carroll County are as follows: June 12, 1882, many at the Maple Swamp; May 21, 1883, again at the Maple Swamp where many were seen; April 8, 1884, day snowy, one seen flying north just west of Delphi; February 14, 1885, while driving from Pittsburg to Delphi in the evening I saw one flying up the Wabash, the day being cold, the snow very deep, making excellent sleighing, and the river was covered with ice except in a few places; March first, one seen near David Musselman's trying to reach Deer Creek in the face of a strong northwest wind; and March 18, saw one on Deer Creek east of Camden.

In Vigo County I never knew of any rookeries, but there were doubtless some small breeding colonies along the Wabash. A few solitary individuals might be seen along the river any day between March and November.

In Monroe County, which has no ponds or considerable streams, the Great Blue Heron, like all other waders and water birds, is not at all common. One might be seen now and then along Beanblossom Creek or Salt Creek; noted March 28, 1888.

44. Herodias egretta (Gmelin). Egret. (196)

Rare; probably only a fall visitant. As is well known, this and other species of herons are apt to wander some distance from their regular habitat in the fall, and it may be that all those we have seen in Vigo County in late summer and early fall had wandered up from lower down the Wabash River. Each fall from two or three to a half dozen were seen along the river both above and below Terre Haute. Greenfield Bayou, 10 miles below Terre Haute, was a favorite place. One was shot on Deer Creek near Camden, Carroll County, August first, 1884, by my friend Frank C. Porter, of Camden. Years ago, small flocks of six to ten were occasionally seen flying north in the spring and a few were seen each fall from July to September.

I have seen Egrets occasionally along the creeks in Monroe County, but only in spring. One was killed near Bloomington, April 10, 1887.

45. Butorides virescens virescens (Linnæus). green heron (201)

Summer resident; more common than any other species of heron. Found not only along the river and all the smaller streams, but also about ponds and marshes. This interesting little heron, known locally as "shitepoke", is more tolerant of civilization than the other species, and may frequently be seen about the farms; indeed, I have found it nesting in old apple trees not far from farm buildings. It usually, however, places its nests in the tops of small trees or bushes in thickets along the creek or river.

In Carroll County it arrives from the south at least as early as April 30; the first one noted by me in 1884 was seen on that date. Noted May 18, 1878. On May 13, 1884, my friend Frank C. Porter obtained for me a set of five eggs from a nest in the top of a small bush, perhaps 15 feet up, in a dense thicket on the south bank of Deer Creek opposite the Porter mill below Camden. Incubation had begun. April 29, 1885, got a pair near Camden. One seen June 25, 1905, at a small pond on my father's farm near Burlington.

In Vigo County this little heron is not uncommon in summer along the Wabash and about the bayous and ponds.

In Monroe County it is frequently seen. I have seen its nest in Turner's grove of pines west of Bloomington.

46. Nycticorax nycticorax nævius (Boddaert).

black-crowned night heron. (202)

A rare spring and fall visitant, not often seen. A young female shot near Terre Haute, November 16, 1889, by Mr. Ed. Stoop who presented it to me. I have never seen the species in Monroe County. In Carroll County I have seen it only on three occasions; the first being on April 30, 1878, when, late in the evening, Master Charles Guard, one of Mrs. Evermann's students, came to us in great excitement, saying that he had seen a very strange bird at the Armstrong pond at the south edge of Camden. Taking my shotgun, I went with him to the pond and found the strange bird sitting in an old dead snag at the south edge of the pond. It was not easily frightened and a charge of No. 10 shot brought it down. It proved to be an adult female Black-crowned Night Heron in fine plumage, the first I had ever seen. Since that day, I have seen many of this species in many different countries and have collected many of them, together with their nests and eggs, but my delight has never been greater than it was in the dusk of that April evening 43 years ago. My next specimen in Carroll County was a young female killed November 24, 1884, by my friend Matthew Sterling. The bird had alighted in an apple tree on the Sterling farm, southwest of Camden. The weather had been rather mild, for November, until the 23d, when a heavy rain which began the night before changed to snow. During the 24th it was blustery, gradually growing colder until in the evening the temperature was 6 degrees Fahrenheit. The bird acted as if lost. A third specimen was killed near Camden about September 1, 1887.

I have no Monroe County record of this species.

47. Grus mexicana (Müller). sandhill crane. (206)

A rare migrant, at least in Carroll County, particularly in the northwest portion, where one was seen April 7, 1885.

48. Rallus elegans Audubon. king rail. (208)

A rare summer resident in Vigo County where I have seen it at the Goose Pond and at the Five-mile Pond, April 29, and May 19, 1888.

49. Rallus virginianus Linnæus. virginia rail. (212)

Rare summer resident in Vigo County. Found nesting at the Goose Pond May 31, 1890, and April 21, 1888. Not noted in Carroll or Monroe.

50. Porzana carolina (Linnæus). sora or carolina rail. (214)

Summer resident, not common. Found nesting in the Goose Pond in Vigo County; noted April 21, 1889.

Carroll County: I shot one on my father's farm in April, 1879. May 4 and 5, 1884, saw several in the Armstrong pond at Camden; May 9, 1885, one seen.

Monroe County: May 5, 1886; April 15, 1887.

51. Coturnicops noveboracensis (Gmelin). yellow rail. (215)

Rare migrant; noted only in Monroe County.

52. Gallinula galeata (Lichtenstein). florida gallinule. (219)

Rare summer resident. Noted once at the Goose Pond, where I found a set of five well-incubated eggs, May 31, 1890. A specimen obtained near Burlington, April 28, 1883, by Wallace Gwinn who brought it to us; and I saw another, May 11, 1885, in Stockton's woods northwest of my father's house.

53. Fulica americana Gmelin. coot. (221)

Common spring and fall migrant, and rare summer resident.

I have in my notes recorded the Coot as occurring in Monroe County, but no details are given.

In Vigo County, where there are several ponds and bayous, the Coot is not only a common spring and fall migrant, but a good many breed in the county. A few could usually be seen at the Five-mile Pond north of Terre Haute and several pairs nested each season at the Goose Pond, nine miles south of Terre Haute, where U. O. Cox found a nest with eight eggs, May 31, 1890. Noted also on April 17, 1888.

My first record of the Coot in Carroll County is of three seen on the Wabash just above the feeder dam at Delphi, April 19, 1884. On November 20, of the same year, one was killed on the Armstrong pond at Camden, and brought to us. On April 8, 1885, I saw two on Deer Creek at Porter's dam, where one was taken May 12. I have no evidence that the species breeds in this county.

54. PHALAROPUS FULICARIUS (Linnæus). RED PHALAROPE. (222)

Rare migrant. A specimen obtained by Dr. Scovell, October 23, 1889, near Terre Haute. No records for Monroe or Carroll.

55. STEGANOPUS TRICOLOR Vieillot. WILSON'S PHALAROPE. (224)

One killed near Frankfort about May 1, 1883, according to C. E. Newlin.

56. PHILOHELA MINOR (Gmelin). WOODCOCK. (228)

Formerly a common summer resident, but now quite rare. During my five years' resident at Terre Haute, I do not think I saw a total of more than 15 or 20 Woodcock in the county. One of these was seen March 16, 1888. I found only one nest; that was east of Terre Haute about four miles in an open woodland just north of the Terre Haute—Brazil highway.

My friend Foster Hight took one near Bloomington, Monroe County, in the spring of 1885.

In Carroll County, the Woodcock was quite common forty years ago, but it is now very rare. Nests early in April; young able to fly at least as early as June first.

57. GALLINAGO DELICATA (Ord). WILSON'S SNIPE. (230)

Formerly very common spring and fall migrant in all the counties; now rather rare. Arrives quite early in the spring; returns from the north in August or September and remains until freezing weather drives it on south.

Carroll County: March 18, 1879, one seen; 19th, one secured. May 1, 1884, one seen near road between Delphi and Pittsburg, another seen 14 days later. On April 21, 1885, first of the season seen at the Armstrong pond south of Camden. There were several of them. This was always a favorite place for snipe.

Monroe County: April 15 and 18, 1886.

Vigo County: Quite frequent in spring and fall in suitable places along the river. March 9, 1888, and May 5, 1891.

58. PISOBIA MACULATA (Vieillot). PECTORAL SANDPIPER. (239)

A rather uncommon spring and fall migrant in Vigo County. March 17, 1888, four seen; April 21, 1889. On March 29, 1889, a flock of perhaps 75 seen at the Five-mile Pond north of Terre Haute, from which eight specimens were collected. On April 6, of the same year, about 20 were seen at the same pond, of which one male and one female were secured. Seen again April 21. I found them very good eating. Another obtained May 3, 1890, near the Goose Pond. Locally this species is known as "Jim Snipe".

As to Carroll County, I have it recorded simply as a rare migrant in March and April. For Monroe County I have only two records, March 15 and 26.

59. PISOBIA MINUTILLA (Vieillot). LEAST SANDPIPER. (242)

Rare spring and fall migrant in Carroll and Monroe counties, as it doubtless is in Vigo also; no definite records.

60. Ereunetes pusillus (Linnæus). semipalmated sandpiper. (246)

Spring and fall migrant, not common.

Carroll County: Heard one near the old Oberholser mill, east of Camden, April 24, 1884. On April 21, 1885, saw three or four at Gish's bend in Deer Creek, near Camden.

Monroe County: Recorded as rare migrant.

61. Totanus melanoleucus (Gmelin). greater yellow-legs. (254)

Rather common spring and fall migrant, often heard and seen flying over, and now and then seen along the streams. This applies to all the counties.

62. Totanus flavipes (Gmelin). lesser yellow-legs. (255)

Rare spring and fall migrant, probably less common than the preceding. My only definite record is for Vigo County; May 5, 10, and 12, 1888.

63. Helodromas solitarius (Wilson).

solitary sandpiper. (256)

Rather common spring and fall migrant in all the counties.

Carroll County: June 19, 1882, set of four fresh eggs on sandbar on Wild Cat Creek, a short distance above the Burlington mill.

64. Actitis macularia (Linnæus). spotted sandpiper. (263)

Not rare summer resident; frequent along the river and usually at least one pair about each pond. A female obtained for me near the river above Terre Haute, April 28, 1888, by my student, Mr. J. D. Collins; noted again May 5, 1889.

65. Oxyechus vociferus (Linnæus). killdeer. (273)

A common summer resident in all the counties, arriving quite early in the spring and remaining late in the fall.

Carroll County: Noted February 20 and March 6, 1878; March 5, 1879, one seen flying south; March 15, 1884, first seen at the J. Nettle farm southwest of Camden, they having doubtless just arrived; March 14, 1885, first of the season seen by my friend Frank C. Groninger, near Camden; the next day I saw nine near Deer Creek, south of Camden.

On the home farm near Burlington it was the custom to salt the cattle regularly once a week in a certain place in a pasture near the house, and this place was a favorite resort for the killdeers; one or more pairs could be seen there any day during summer and fall. Nests were occasionally seen in the cornfields.

Vigo County: Very common everywhere; March 16 and 17.

Monroe County: Perhaps less common; arrives as early as March 7, and remains until in November. One noted February 23, 1883.

66. ÆGIALITIS MELODA (Ord). PIPING PLOVER. (277)

A not uncommon spring and fall migrant in Vigo County. There was one specimen in Dr. Scovell's collection, also one in Mr. Blatchley's. Mr. Fred Clearwaters found it common near Greencastle.

No records for the other counties.

67. COLINUS VIRGINIANUS VIRGINIANUS (Linnæus). BOB-WHITE. (289)

During the years of my residence at Bloomington (1881-83 and 1885-86), the Bob-white was rather rare in Monroe County, although it had formerly been quite abundant.

In Vigo County it was never very common from 1886-1891, and it is probably even less so now. A female was collected at Honey Creek, April 20, 1889. A pair (male and female) obtained in the Terre Haute market, November 21, 1889, and another pair, December 1, 1890. In those days market hunting was legal and Quail and other game birds were often seen in the market.

During my boyhood days the Bob-white was a common bird in Carroll County. On practically every farm of 80 to 160 acres several coveys might usually be found during the fall and winter. They would frequent the cornfields in which the fodder was in the shock. There they were usually able to get at some of the ears of corn or to find shelled grains upon which they fed. If not disturbed, the covey would sometimes roost in the base of one of the shocks. Usually, however, their roosting place was on the ground in some clump of briars or thicket in the edge of the woods near the cornfield. At night the birds of a covey huddle or sit very close together on the ground under the protection of a bunch of grass, briars or small bushes, all with their tails toward the center and their heads all pointing outward. Sometimes when the snow is deep the Quail are unable to get the necessary food and, becoming weakened, the whole covey freezes to death. I remember one very cold winter day when I was hunting rabbits and came upon a large covey of Quail, all frozen to death. One taken December 2, 1878; July 4, 1882, nest with 22 stale eggs; June 20, 1883, nest with 11 somewhat incubated eggs.

The winter of 1884-5 in Carroll County was unusually severe and the quail suffered greatly. I found several frozen to death. I recall seeing only one live bird (a male) in January, and that was in Burlington Township, near the Asbury school house. On April 26, I saw a female in a wheatfield near the Camden depot, the only one seen since January. September 14, 1906, six or seven seen by Miss Ava Evermann in her father's orchard in Burlington.

Fifty years ago it was a common practice to trap the quail. A figure-4 slat trap was used. This was set in some suitable place which a flock of quail had been observed to frequent. The snow was carefully cleaned away from under the trap and from a fan-shaped area in front, then corn or wheat was scattered over the cleared ground especially under the trap. The quail coming upon the grain outside would feed upon it and would gradually be led into the trap which would be thrown and often the whole flock captured. This was, of course, a very unsportsman-like method, but it was in those days regarded as perfectly proper. Of course, this method would not be tolerated now.

68. Bonasa umbellus umbellus (Linnæus). ruffed grouse. (300)

Quite common in Monroe County in 1881-1886, especially on the heavily wooded hillsides; doubtless still common in all suitable places in that county.

Formerly rather common in all suitable places in Vigo County but now quite rare. I have seen it occasionally in the woods near Coal Creek northwest of Terre Haute, also on one or two occasions along Honey Creek south of town and in the heavy woods near the Goose Pond.

In Carroll County it was common until about 1885, especially in the heavy woods along Wild Cat Creek and other streams. March 7, 1879, shot one in the Deer Creek bottom near Robert Porter's, southwest of Camden; August, 1881, several seen, and several noted in the winter of 1881-2; January 22, 1885, one killed by A. M. Evermann near Burlington. Nest with several eggs seen in Stockton's woods near Burlington about May, 1883.

69. Tympanuchus americanus americanus (Reichenbach).
prairie chicken. (305)

I have no record of the occurrence of the Prairie Chicken in Monroe County.

The only place in Vigo County where I have seen Prairie Chickens is the considerable area of prairie land at Heckland about 10 miles north of Terre Haute. It was my custom frequently to visit this little prairie with my botany and zoology classes, and sometimes alone. The locality was a very interesting one. Many species of prairie flowers could always be found there which were very rare or unknown in other parts of the county; and then I was always apt to find species of birds not found elsewhere. The Prairie Chicken was one of these. Usually from one to a half dozen could be found in that neighborhood if I took the trouble to hunt for them.

A fine specimen, a male, obtained April 1, 1890, from Raub, Indiana, whence it was sent me by Mr. Ward, one of my students. One, a male, obtained in the Terre Haute market, January 19, 1891; cost 60 cents.

In Carroll County, the species has never been common except in the prairie of the northwestern part. When a boy, I remember to have seen two alight on the top board of a gate across the lane on my father's farm, just east of the Michigan road. They remained only a few moments then resumed their flight, going on eastward. In Tippecanoe and Jefferson townships, in the northwestern part, they have been and still are rather common. In the spring of 1883, and again in 1884 and 1885, when driving over that portion of the county, as I had frequent occasion to do, I rarely failed to see several pairs, or to hear them booming in the morning and evening. Several seen and heard in the prairie near the Evans schoolhouse (Tippecanoe Township), April 17 and 18, 1883; May 8, 1884, one seen in an old cornfield near the Evans schoolhouse; February 9, 1885, two seen by Miss Mary Cunningham near the New Beauty schoolhouse (Tippecanoe Township), snow very deep and day very cold.

70. MELEAGRIS GALLOPAVO SILVESTRIS Vieillot. WILD TURKEY. (310a)

In the early part of the nineteenth century and up, perhaps to about 1860, this magnificent bird, the greatest of all American game birds, was not uncommon throughout all the heavily wooded portions of Indiana. They were especially abundant in the wonderful hardwood forests of the Wabash basin.

In Monroe County, it was doubtless very common at one time and a few might be found in the wilder parts of the county as late as 1886, if not later.

In Vigo County in 1886 to 1891, it was very rare, if present at all, but each winter one or more specimens might be seen in the Terre Haute market. I saw at least six during those years, and was told that they came from the neighborhood of the old reservoir in the southeastern corner of Vigo County.

In Carroll County they were rather common as late as 1864, and frequent up to 1870. The last ones I remember to have actually seen in Carroll County I saw in the woodland on the Stockton farm only a few rods from my father's house, in the winter of 1871-2. In the winter of 1877-8, a small flock was reported as having been seen several times in or about the heavy woods a mile south of Camden, and in February of that winter I saw their tracks in the snow on the Al Rhodes farm near the large forest on the Wise farm.

During my boyhood days wild turkey hunting was one of the great sports in which local Nimrods engaged. Every one who at all enjoyed the sport was quite sure to go turkey hunting at least once each winter. Every hunter had a "turkey call" which he had made from the wing bone of a turkey which he had killed on some previous hunting trip; and right expert did these men and boys become in immitating the turkey's call-note. The long muzzle-loader rifle was the gun used and the hunting was done in a real sportsman-like way. By means of the "call" the turkey could usually be induced to come within reasonable range. As they were easily frightened, the hunter usually fired as soon as the bird came within range, and only those who were pretty good shots were successful in getting the bird.

Another method by which Wild Turkeys were taken was wholly unsportsman-like, albeit quite effective. This was by means of a trap and was practiced when the ground was covered with snow. A square pen was built of ordinary fence rails, thus making the pen a little less than 10 feet square and about eight rails high. The pen was covered over the top with rails or boards. A trench was dug, extending from inside the pen under one side and some feet outside, deepest under the rail and decreasing in depth outside. Corn was then scattered outside the pen in such a way as to lead the turkeys into the trench and into the pen. When the turkeys found the corn they would continue feeding on it, their heads near the ground, passing along the trench until in the pen, when they would become frightened. Then, with heads up, they would walk around next to the rails, a broad board laid over the trench just inside the pen keeping them from stepping into the trench and finding their way out. It was not an unusual thing to capture an entire flock in this way.

71. Ectopistes migratorius (Linnæus). wild pigeon. (315)

In the early part of the nineteenth century excessively abundant during the spring and fall migrations.

I have no records for Monroe County, but tradition says it was an abundant bird there as late at least as 1860. I do not know when the last ones were seen in that county, nor have I that record for Vigo County. I heard of none in that county during my residence at Terre Haute from 1886 to 1891.

But in Carroll County during my boyhood days, at least up to 1870, it was quite common in spring and fall. I can remember great flocks flying northward in the spring and large numbers in the fall feeding on the beech "mast" and acorns. I have a record of one seen in Tippecanoe Township, May 31, 1883, and of several killed in the western part of the county that same year. On May 9, 1884, I saw two southeast of Yeoman. In the 60's it was a common practice to net Wild Pigeons in Tippecanoe and Jefferson townships in the western part of the county. Long nets were carefully adjusted and by using stool pigeons, a whole flock could sometimes be led into the net. On April 6, 1885, I saw several (was not able to determine the exact number) in Farrar's woods at the south end of Lake Maxinkuckee. These were the last I ever saw.

72. Zenaidura macroura carolinensis (Linnæus).

mourning dove; turtle dove. (316)

A common and well-known summer resident, occasionally a few remaining throughout the year when the winters are not too severe.

Carroll County: June 17, 1882, set of two fresh eggs; April 29, 1883, nest with large young in apple tree in Robert Porter's orchard, southwest of Camden; May 21, several nests seen, some with eggs, others with young, in bushes at the edge of the Maple Swamp, south of Cutler; March 16, 1884, common; March 30, 1885, first of season seen; May 9, nest with *three* eggs; December, 1884, and January, 1885, occasionally seen; June 25 to July 1, 1905, three or four pairs noted on the old home farm. April 28, 1919, set of two fresh eggs in nest in a pear tree at Burlington, reported by Donovan Beck.

Monroe County: February 10, 1883, one seen; February 23, 1886, common since middle of March; May 31, 1882, a fresh egg found on ground in a wheatfield in Crawford County.

Vigo County: April 8, 1888, noted; May 3, 1890, nest with two fresh eggs in osage hedge, seven miles south of Terre Haute, and another nest with one fresh egg in same hedge; one egg had been broken and the nest deserted.

73. Cathartes aura septentrionals Wied.

turkey vulture or buzzard. (325)

A rather common summer resident in all the counties, sometimes remaining throughout the year, especially in Monroe and Vigo counties.

In Monroe County, noted near Bloomington, February 21, 1883, and February 22, 1886, and a nest with two fresh eggs in a hollow oak snag near Bloomington, April 17, 1882.

In Vigo County, a nest with 2 eggs, one fresh, the other nearly so, about 30 feet up in hollow of a leaning sycamore on the bank of Honey Creek south of Terre Haute, April 21, 1890; noted also March 30, 1888, and March 31, 1889.

In Carroll County, a nest with two fresh eggs in a hollow sycamore on Bachelor Run southwest of Camden, April 29, 1883; another set of two fresh eggs from same nest April 23, 1884. First noted in 1884, on March 16, when one was seen near Burlington. First noted in 1885 on March 12, when one was seen north of Pittsburg; another two days later west of Camden.

74. Elanoides forficatus (Linnæus). swallow-tailed kite. (327)

The Swallow-tailed Kite is a very rare bird in Indiana. My only records are of a male in fine plumage shot on Beanblossom Creek north of Bloomington by a Mr. Weimar, August 18, 1885, and another seen at same time. One obtained in Vigo County in the fall of 1887. No record for Carroll County. So far as I know these are the only specimens taken in or reported from this part of the state.

75. Circus hudsonius (Linnæus). marsh hawk. (331)

Probably rare summer resident in all the counties. Unfortunately, I have no definite records for Monroe County. In Vigo County, I saw it often, particularly over the marshes about the Five-mile Pond north of Terre Haute. I do not think any remain through the winter.

In Carroll County, I have seen it but rarely and only in the spring. It probably breeds in the county, however, in suitable places.

76. Accipiter velox (Wilson). sharp-shinned hawk. (332)

Rather rare resident; seen oftenest in the spring. A fine male brought us at Camden, October 27, 1884, by Mr. Walter Clark. One seen near Yelpingville schoolhouse, Washington Township, February 22, 1885; day cold, snow deep. I have no definite records for Vigo, though I doubt not it breeds there in limited numbers. My only record for Monroe County is one seen on the campus at Bloomington, February 10, 1883. It is doubtless not rare in this county.

77. Accipiter cooperi (Bonaparte). cooper's hawk. (333)

Resident, perhaps more common than the preceding.

Carroll County: March 5, 1879, one noted near Camden, and one caught next day in a steel trap. A nest with three fresh eggs found May 10, 1883, in a beech tree on J. M. Beck's farm near Burlington. Other Carroll County records are: January 12, 1884, one seen near Camden; January 31, another seen near Delphi; September 17, one brought us at Camden by Mrs. Walter Clark; March 13, 1885, one seen in Tippecanoe Township; March 18, one seen on Deer Creek near Camden.

Vigo County: March 31, 1888, one noted. A fine set of five fresh eggs near Coal Creek, nine miles northwest of Terre Haute, May, 1890. The nest was about 50 feet up in a beech tree. These eggs measured in inches: 1.82x 1.43; 1.76x1.36; 1.82x1.43; 1.82x1.43; 1.83x1.43.

In Monroe County, this hawk did not appear to be common, but it was doubtless a summer resident.

78. Buteo borealis borealis (Gmelin). red-tailed hawk. (337)

In my boyhood days on the farm just south of Burlington, one of the most interesting sights to be observed in spring, summer, and early fall was that of hawks sailing high in air. On our farm, or those adjacent, were usually several pairs. While most of them were Red-tails, some were doubtless the Red-shouldered Hawk. Their nests were in the tops of the tallest oaks, or occasionally in a beech, elm, tulip, or sycamore. On quiet, warm days, particularly in spring, a harsh piercing scream would be heard overhead, and, on looking up, sometimes one, but usually two, of these great birds would be seen sailing high in the air or chasing each other, the while rising higher and higher in more or less spiral curves and uttering their shrill cry. This cry would usually be uttered as one of the pair passed the other. Sometimes one, having risen some distance above the other, would swoop down upon it with a scream that could be heard a long ways; one of the interesting characteristics of these hawks is the wonderful carrying power of their cry. Sometimes the birds would continue circling higher and higher, first one above, then the other, until they could be seen only with difficulty, but the screaming could be distinctly heard, however high the birds might be. Sometimes, after attaining a considerable height, they would cease screaming and simply soar. After reaching a great height they would suddenly descend with partly-closed wings like an arrow to the top of the forest in which their nest might be found. Sometimes they would again ascend; frequently they would alight in one of the tallest trees. My recollection is that these flights were most frequent on quiet afternoons, but they might occur at any time, especially between eight and nine o'clock in the morning and four and five o'clock in the afternoon. While these flights were most frequent in the spring (probably during the nesting season), they might occur at any time from early in the spring until late in the fall.

Another common and familiar sight was that of one of these hawks sitting quietly on a dead limb of some old tree at the edge of a field or on a fence stake, waiting for some field mouse, rabbit or other small mammal which it might capture. The length of time a hawk would thus remain on watch is remarkable. I have no definite notes on the matter but I believe it within the truth to say that it was often more than an hour.

The Red-tail Hawk is still common in each of the three counties with which this paper is concerned. Records from Carroll County are: December 31, 1878, one found dead near Burlington; March 1, 1879, one seen; March 5, two seen. April 15, 1883, nest with three young about four days old, in top of a large white oak a short distance southwest of my father's house. Quite common in the winter of 1883-4; January 28 and 31, and February 19, 1884; and February 20 and March 12 to 14, 1885. I have seen young in the nest, April 15, 1885.

79. Buteo lineatus lineatus (Gmelin). red-shouldered hawk. (339)

This beautiful hawk was scarcely less common and familiar to me in my boyhood days than was the preceding species; indeed, in some years I am inclined to think it was the more common species. They, too, built their nests in the tops of the tallest oaks, beech, and sycamores. I remember climbing, in the spring of 1884, to a nest well toward the top of a large white oak (*Quercus alba*), in the woods southwest of our house, only to find in the nest three newly-hatched young instead of a set of nice fresh eggs for which I had hoped.

I think the habit of circling high in air and screaming the while is quite as characteristic of this species as it is of the Red-tail.

While the Red-shouldered Hawk is probably a permanent resident of each of the three counties considered in this paper, the majority of the individuals go south in the winter. On their return northward in the spring, they are sometimes gregarious, as evidenced by a scene which I witnessed in Clay County, just east of Terre Haute, April 3, 1879. In a large meadow at the side of the road, I saw a great number of hawks—I estimated the number at 150 to 200—flying about over the meadow. They were flying low, sometimes circling about as if hunting, but the general movement was northward. They were certainly doing some hunting, Hylas and garter-snakes being the principal victims. The majority of these hawks were the Red-shouldered, but some were doubtless Red-tails. This is the only time I have ever seen hawks together in anything like such numbers.

Both of these species were commonly known as chicken-hawks, and were commonly regarded as being very destructive to poultry. They doubtless do invade the barnyard now and then, but their destructiveness to domestic poultry has been greatly exaggerated.

Sometimes a certain individual hawk will acquire the "chicken habit", just as some dogs become "sheep-killing dogs", and then the only way out of it for the farmer is to kill the hawk. On the whole, however, the great majority of each of these species kill so many injurious rodents that they must be classed with the useful birds.

As I have already said, the Red-shouldered Hawk was common in Carroll, Vigo, and Monroe counties, though I have but few actual records. On March 15, 1885, I saw one near the Armstrong Pond at Camden. There was a good specimen in the collection of Dr. Scovell, of Terre Haute, taken by him near that city, and I noted one April 1, 1888.

80. Buteo platypterus (Vieillot). broad-winged hawk. (343)

Rare summer resident. I have seen it only on a few occasions. One of these was on October 30, 1886, when Prof. O. P. Jenkins, Mr. Louis J. Rettger, and I saw one on Eel River in Clay County, near the Vigo County line. I saw another on Coal Creek in April, 1889. I have seen it rarely in Carroll County, and only in spring or autumn. I have no record of the species for Monroe County.

81. Archibuteo lagopus sancti-johannis (Gmelin).
rough-legged hawk. (347a)

Probably a rare spring and fall migrant; possibly a summer resident. One seen northeast of Terre Haute, in October, 1889. A rare winter visitant in Carroll County. No record for Monroe County.

82. Aquila chrysaëtos (Linnæus). golden eagle. (349)

Rare straggler. One killed in the eastern part of Carroll County in December, 1883. One seen near Terre Haute in the fall of 1887. A young female sent us November 22, 1889, from Bloomington by Moses Kahn of that place. These are the only records I have for the three counties.

83. Haliæetus leucocephalus leucocephalus (Linnæus).

bald eagle. (352)

Not infrequent as a winter visitor.

Carroll County: One seen near Camden in March, 1879; a young one seen just west of Pittsburg, November 21, 1883, and another young bird shot in Washington Township in January, 1884, by David J. Hardy; about the same time another was caught alive in White County and brought to Delphi; an adult seen near Bald Hill Church in Democrat Township about February 15, 1885, by James H. Shaffer; another adult was shot near Rossville the preceding month; a fine adult male was caught in a steel trap near Pyrmont February 20, 1885, and brought to us by our friend James H. Lyons on March 28, it having died; still another adult was killed about this time near Pittsburg by a Mr. McCord.

Vigo County: Seen occasionally along the Wabash in fall and winter. One at Durkee's Ferry in September, 1889. No definite records for Monroe County, though it doubtless occurs there.

It is said a pair of Bald Eagles nested on the Kankakee in northwest Indiana recently, but this report has not been verified. Of frequent occurrence at Lake Maxinkuckee.

84. Falco sparverius sparverius Linnæus. sparrowhawk. (360)

Of all the hawks found in the counties covered by this paper, the Sparrowhawk is the most abundant, best known, and most useful. It is a permanent resident in all the counties, usually rare in winter but very common in summer.

On every farm one or more pairs of sparrowhawks could be found. A favorite resting place for them is on the top of some fence stake at the edge of a meadow or other field; another is on a limb near the top of some old dead tree at the edge of the woods. From such vantage points as these they watch the fields and open places for any luckless frog, snake, or field mouse that ventures into the open. At other times they may be seen flying about over the fields searching for their prey, now and then "hovering", that is, remaining stationary in the air over some particular spot which they wish to examine more carefully. If any suitable prey is seen, the Sparrowhawk drops upon it with incredible swiftness, seizes it in its talons, and flies away with it to some convenient perch and proceeds to make a meal of it. Gartersnakes are among the most frequent victims of the Sparrowhawk, and field mice come next among vertebrates. But grasshoppers and other insects constitute a large part of the food of this hawk. I have never seen a Sparrowhawk catch a bird of any kind; if they ever do it must be very rarely indeed.

The name "Sparrowhawk" is a misnomer; it would be far more appropriate to call it the "Grasshopper Hawk". Because of its usefulness in destroying noxious rodents and insects, the Sparrowhawk should be carefully protected.

The nesting habits of this hawk are quite different from those of most hawks, in that it nests in holes in trees like yellowhammers and woodpeckers. The nest may be in a natural hollow or in a deserted Woodpecker or Yellowhammer hole. In California, the Sparrowhawk sometimes lays its eggs in a deserted Magpie nest.

Carroll County: Noted May 11, 1878; March 1, 1879; January 10, 1884, one noted in Madison Township; March 25, common; December 18, one seen flying overhead in Bringhurst, which alighted on the side of a barn near the Vandalia station where it clung to the side of the weather boarding for some seconds; the day was very cold and the snow deep.

Vigo County: March 31, 1888, and April 1, 1889, several seen.

Monroe County: Quite common.

85. Pandion haliaëtus carolinensis (Gmelin). fish hawk. (364)

Occasionally seen in spring or fall along the rivers. Seen on White River near Gosport, and frequently on the Wabash, near Terre Haute. Noted in Carroll County as follows: In the summer of 1883, seen on two or three occasions on Wild Cat Creek near Burlington; September 21, one seen flying up Deer Creek near Camden; April 22, 1884, one seen on Deer Creek west of Camden; September 22, one noted on Wabash River near Pittsburg; April 14, 1885, one seen near Pyrmont.

86. Aluco pratincola (Bonaparte). barn owl. (365)

The Barn Owl does not appear to be very common anywhere in Indiana. I have record of only a few individuals that came under my personal observation.

In Carroll County, it is very rare. One taken near Frankfort in December, 1889. About the middle of December, 1898, Mr. George Van Der Volgen captured one near his home in Adams Township, Carroll County, and recorded the fact in the Delphi Journal of December 31, 1898. In June, 1919, Dale Haun of Burlington captured one near the Logan Johnson farm, west of Burlington. On June 20, 1890, I found a pair nesting in a hollow in a large white oak near the Five-mile Pond north of Terre Haute. One was killed in November, 1889, near the Curry schoolhouse in Vigo County, and another was shot in the county about the same time. In July, 1890, a nest with three young just able to fly was found near the Big Four railroad bridge at Terre Haute. On November 19, 1889, we received a specimen from our friend Mr. J. R. Stahl of Dana, Vermilion County, north of Terre Haute.

87. Asio wilsonianus (Lesson). long-eared owl. (366)

Rather common resident, but not often seen. In January, 1883, one was shot in the pine grove at Mr. Turner's at the west edge of Bloomington, and another was seen in the same grove a few days later.

The records for Carroll County are as follows: On January 29, 1884, one was received from John W. Hamilton of Bringhurst near which place it had been shot January 25. Another was seen at the same time and place.

On February 5, 1886, one was received from S. W. Barnard of Deer Creek. On January 14, 1888, I saw one in a spruce tree in my father's yard near Burlington.

On December 30, 1890, Mr. E. E. Slick of Kewanna, Fulton County, sent us a specimen which he collected near that place.

88. ASIO FLAMMEUS (Pontoppidan). SHORT-EARED OWL. (367)

Resident in all the counties but not often seen.

We obtained two specimens in Monroe County in the fall of 1885, and one October 18, 1886. February 1, 1890, Mr. Fletcher M. Noe of Indianapolis, sent us a female taken January 31, 2½ miles north of that city. December 1, two females obtained near Terre Haute by Dr. T. C. Stunkard, and two others obtained by Mrs. Geo. Brosius at Paris, Illinois, one of which was brought to us. In the fall of 1888 (probably in October), I saw one at the Five-mile Pond north of Terre Haute. February 13, 1891, we received a pair (male and female), in the flesh from Frankport, Clinton County, where they were collected by Mr. Al. Keys. On December 27, 1902, one was seen near a tamarack swamp two miles southwest of Lake Maxinkuckee.

89. STRIX VARIA VARIA Barton. BARRED OWL. (368)

One of our most common owls, and a permanent resident in all the counties considered. Although I noted it frequently in Monroe, I collected no specimens. In Carroll, I noted it very often. Several were obtained in the winters of 1877 to 1879; one near Camden, February 18, 1878, and a female January 27, 1879. Whenever I made a trip to any of the heavily timbered regions about Camden or Burlington, especially in the Deer Creek bottoms, I was quite sure to see one or more of these interesting owls. In the heavy woods southwest of my father's farm near Burlington, they were very common and in the spring of the year, their crazy notes could be heard, quite terrifying to the small boy who at times was sent into the edge of those woods to bring the cows home in the evening. A pair had their nest for several years in the hollow of a large elm not far from the house, and I have often seen the whole family, old and young, in the old elm or other trees near by. February 14, 1885, a female brought us by Mr. John Cline from near Camden. On the previous evening I saw one in the woods 2½ miles south of Camden. February 21, a female was sent us by S. W. Barnard of Flora. March 9, I found a male dead in the woods southwest of my father's farm. On December 7, 1889, I secured a female at the Goose Pond, 9 miles south of Terre Haute. On January 4, 1890, another female was brought us by Mr. J. E. McGilvrey from near Clinton, Parke County. This owl was being pursued by crows when Mr. McGilvrey shot it. An examination of the ovaries showed eggs not larger than peas.

The Barred Owl never kills chickens. Its food consists almost entirely of noxious rodents, insects, and the like. It is therefore a very useful bird and should be rigidly protected.

90. Cryptoglaux acadica acadica (Gmelin). saw-whet owl. (372)

This little owl is apparently very rare in Indiana. We have two specimens, both adult males, obtained at Terre Haute, March 25, 1890. One of them was seen sitting on the edge of a cradle in the children's room of the house of my neighbor, Judge Stimpson, on South Seventh Street. When the children awoke in the morning, they saw the little owl as it sat on the cradle and as it flew from the room through an open window and alighted on a tree in the yard. One of the boys struck it with a stone from a "nigger-killer".

On May 8, 1883, I found a nest of this species in a dead elm snag in Stockton's thicket near Burlington. The snag was about 20 feet tall but had fallen over and lodged in the fork of a small soft maple. About half-way up the snag was a hole in which a flicker had her nest with three fresh eggs, while a little higher up in another hole I found six young Saw-whet Owls just about ready to leave the nest. I took four of the young owls, hoping to make pets of them. Later that evening, I returned to the nest, hoping to find the parent birds but neither they, nor the two young which I had left, could be found.

About this same time Mr. Fletcher M. Noe of Indianapolis reported receiving one from near Pyrmont, Carroll County.

On Thanksgiving day, 1887, one was found dead in the engineer's room at the University, at Bloomington, and brought to us.

91. Otus asio asio (Linnaeus). screech owl. (373)

The Screech Owl is the most common and best known owl in the state. It is a permanent resident and quite common in all the counties in which I have had opportunity to make ornithological observations. I have the following definite records: May 8, 1886, a female in gray plumage obtained in the White River bottom near Gosport. While walking through the weedy woods near the river, I flushed the owl from the ground. It flew into a small tree, where I shot it. A short distance away another, also in gray plumage, was seen to fly into a hollow limb. One in gray plumage at Terre Haute November 2, 1886. December 30, 1887, a female in gray plumage, received from Seelyville, Vigo County. March 2, 1889, one brought to us alive by Mr. W. J. Whitaker of Terre Haute. January 11, 1890, a female in red plumage found in the hollow of an oak tree on the Baur farm three miles north of Terre Haute. Two others also in the red plumage were captured by James McTaggart at Terre Haute about December 12. January 13, 1891, a female, very light gray, brought by Miss Irene Christian, from near Terre Haute. December 4, 1884, a female brought us by Schuyler Ray of Camden. A week later (December 12), another specimen in gray plumage was shot by Philip Ray from a tree in Chas. E. Rice's yard in Camden. February 17, 1885, a female in gray plumage was caught in D. T. Sanderson's barn at Camden. January 14, 1888, a male in red plumage caught by me in my father's barn near Burlington.

In the winter of 1878 and '79 screech owls were unusually common in Carroll County; a great many specimens were collected or brought to us from the vicinity of Camden, Flora, and Burlington. October 19, and December 1, 9, 14, 19, 24, 26, 29, and 31, 1878, one secured on each date; January 8, 1879, two taken, one red, one gray; 14th, one gray; 16th, one gray; and February 25, one gray.

The red and the gray color phases appear to be about equally common.

The food of the Screech Owl is chiefly small rodents and insects; it never takes chickens. A pair of screech owls about a farm are worth much more than a cat in destroying mice. This species should be thoroughly protected.

92. Bubo virginianus virginianus (Gmelin). great horned owl. (375)

Resident, but not now very common, as a result of indiscriminate and senseless persecution to which it has been subjected.

Carroll County: October 5, 1878, one taken near Camden; on February 21, 1884, I saw one in a large sycamore tree on Deer Creek east of Camden. On March 6, 1885, a very large female was sent to us from Flora by Mr. S. W. Barnard. November 4, 1889, a female taken near Burlington by J. M. Beck who sent it to us. A male gotten east of Terre Haute, April 27, 1888, by Mr. A. H. Kelso, one of my students. Another brought us in the fall of 1888 by Mr. Ed. Tetzel of Terre Haute, and another about the same time by Mr. Frank Byers. A fine female caught in a steel trap near Sullivan, Indiana, and brought to us December 4, by Hon. Murray Briggs.

During my boyhood days at Burlington, the Great Horned Owl, Cat Owl, or Hoot Owl, was quite common. They frequented the dense woods and their *whoo, whoo, whoo-hoo,* was a familiar sound, most frequent in the spring and fall, but often heard in summer and winter. Their presence in the deep woods was frequently made known by crows, or jays. These species seemed to have no love whatever for the Great Horned Owl. When a jay or a crow discovered one of these owls quietly dozing in the thick foliage or protection of some tree, it would at once set up a cry which soon brought to its assistance all the other jays or crows within a radius of a mile or more. They would all, or in turn, fly at the owl, perhaps sometimes striking it, and all the time keeping up such a din with their cawing and "rough language" as only crows and jays are capable of. When the owl could stand it no longer and attempted to escape by flying away, its tormentors, especially the crows, would follow it closely, and renew the attacks when it stopped again. These attacks are sometimes kept up for an hour or more.

That the Great Horned Owl is guilty of occasional forays on the poultry yard must be admitted. An owl which has once met with success in its visit to the chicken roost is quite apt to repeat the visits at intervals of a few days and usually with disastrous results to the poultry. Perhaps the most successful method employed by the farmer in meeting these raids was by trapping the owl. A tall stout pole was set in the ground in the chicken lot. A board was nailed on top of the pole and a set steel trap placed on the board. An owl coming to the chicken lot would be quite apt to alight on the top of the pole and be caught in the trap.

While the Great Horned Owl does do some damage to the farmer's poultry, this can be excused when we consider the great good they do in the destruction of noxious rodents.

93. Nyctea nyctea (Linnaeus). snowy owl. (376)

The only certain record I have of the occurrence of this magnificent owl in Vigo County is that of an adult male captured November 20, 1889, by Mr. Elijah Liston, 2½ miles southeast of Pimento, or about 14 miles south of Terre Haute. Liston saw it alight upon a strawstack. Firing at it with a small Flobert gun, the tip of one wing was broken, which enabled Mr. Liston to capture it. The owl died December 9, and was brought to us. It is very white and is, withal, a very fine specimen.

While this is the only example of this species known to me from Vigo County, in the winter of 1887-8 as many as eight were taken in Indiana, all before Holidays. About the same time this specimen was taken in Vigo County, we received in the flesh, two other fine examples,—one from Prof. F. M. McFarland, Olivet, Michigan, December 2, and one from Vermilion, South Dakota, whence it was sent us by Dr. S. G. Agersborg, January 5, 1890. I have a report of the capture of one near Camden in the winter of 1865.

94. Coccyzus americanus americanus (Linnaeus).

yellow-billed cuckoo. (387)

A common summer resident; usually more numerous than the Black-billed species.

The cuckoos are among the most strange and interesting of our birds. They are very quiet, noiseless and ghost-like in their movements. One may remain for an hour or more in an apple-tree over your head without attracting your attention, although it may be moving about all the time from limb to limb, gleaning caterpillars of which they are very fond. You learn of its presence only when it flies to another tree, and you see it only then if you happen to be looking in the direction of its flight, for it is as noiseless in its flight as it is while feeding.

With us, its favorite nesting sites are on horizontal limbs of old apple trees. The nest is a poorly constructed affair, suggesting that the time *may* come, in the evolution of the species, when our cuckoos will abandon the building of any nest whatever and degenerate to the level of their European cousins, which drop their eggs in the nests of other birds.

Both of our species of cuckoos are generally and usually called Rain Crow in Indiana. This has some justification in the fact that their doleful song, if it may be called a song, is most often heard on quiet days in summer and early fall when clouds are forming and rain is imminent. Besides this note which presages rain, they have another note or call which plainly suggests the noise made by water pouring from a jug.

Carroll County: May 11, 1878, one taken at Camden; June 30, 1885, full set of fresh eggs; seen at many other times.

Monroe County: May 5, 1886, noted. *Vigo County:* May 18, 1888, noted.

95. Coccyzus erythrophthalmus (Wilson). black-billed cuckoo. (388)

A common summer resident. Up to about 1884, this species appeared to be less common than the Yellow-billed Cuckoo, but since then it seems to have become relatively as common.

Vigo County: May 3 and 15, 1888.

Carroll County: May 11, 1878, one taken; May 13, 1882, May 16, 1883, May 30, 1884, and May 20, 1885, noted.

96. Ceryle alcyon (Linnæus). belted kingfisher. (390)

Common summer resident, arriving quite early in the spring soon after the ice goes off, and remaining until late in the fall; a few sometimes remain in favorable situations all winter.

Carroll County: Common along the Wabash and all the creeks, nesting in all suitable banks. March 4, 1878, one taken on Deer Creek near Camden; March 5, 1879, one noted; May 17, 1883, one noted on Deer Creek; April 3, 1885, first of season seen near Camden; May 18, nest with six well incubated eggs; May 21, noted.

Vigo County: Several pairs could always be seen each summer along the river near Terre Haute, and one pair at the gravel-pit east of town; March 31, 1888, noted.

Monroe County: Not common, doubtless because of the few streams.

97. Dryobates villosus villosus (Linnæus).

hairy woodpecker. (393)

A fairly common resident, seen in the edge of woodlands where there are old dead trees and snags; also about the barn-lots and orchards; less abundant than the Downy and not so confiding or well known. Perhaps about equally common in all three counties.

Carroll County: February 15, 1879, noted near Camden; March 18, 1885, observed to be very common in Deer Creek bottoms above Camden. In the winter of 1884-5, one or more individuals might be seen in Carroll County almost any day.

Monroe County: Quite common, especially in the spring.

Vigo County: Noted practically every time I went to the woods.

98. Dryobates pubescens medianus (Swainson).

downy woodpecker. (394c)

A common and familiar permanent resident, perhaps, next to the Redhead, the best known of all our woodpeckers. The Downy is a cheery little bird, quite tolerant and unsuspicious of man, coming about our orchards and yards and making itself very much at home. I would say it is about equally common in all three counties. Nesting in late April to early June.

Carroll County: February 15, 1879, noted at Camden; May 28, 1883, a nest in a hole in an old apple tree near Camden with five young nearly able to fly; March 18, 1885, observed to be very common in the Deer Creek bottoms near Camden. Noted November 11, 1906, on an elm near her home in Burlington, by Miss Ava Evermann who saw another Downy December 31, in a maple on the street.

Monroe and *Vigo Counties:* Equally common and well known.

99. Sphyrapicus varius varius (Linnæus).

yellow-bellied sapsucker. (402)

A rather infrequent fall and spring visitant, sometimes a winter visitor. In Monroe County frequently seen in late fall and early spring; one noted March 26, 1886. In Vigo County apparently less frequent. Perhaps more common in Carroll County. An adult female shot, December 15, 1884, from an apple tree in my garden at Camden. It was feeding on a frozen apple. A very heavy snow had fallen the previous night, but the day was not cold. A month later, January 11, an adult male was shot from a wild cherry tree in the hen lot on the home farm near Burlington. On April 4, I saw a male at Camden; and on April 16, I saw a male near my house in Camden.

100. Phlœotomus pileatus pileatus (Linnæus).

PILEATED WOODPECKER. (405)

Formerly a not uncommon permanent resident, but now very rare. Until destroyed in the Normal School fire of March 8, 1888, Mrs. Evermann and I had in our collection three specimens of this fine species,—one taken in the fall of 1885, on Beanblossom Creek near Bloomington, Indiana, (where another was taken at the same time), one (an adult male) taken near Metamora, Greene County, by our friend Edwin Corr who brought it to us in the flesh Christmas day, 1885; and a third (a male) taken November 5, 1886, in the heavy woods near Coal Creek north of Terre Haute.

When I was a small boy I often saw these big Black Log-cocks, as we called them, on my father's farm near Burlington. They could be heard oftener than seen, their loud sonorous tatoo coming from out the dense forest, which, to us small boys, seemed very somber and full of many sorts of strange and dangerous animals. One might sometimes surprise one of these big birds beating his tatoo on the dead top of some old elm, maple or oak, and then see it fly away with a wild, frightened call.

Sometimes these birds would come about the fields and pastures if there were any old dead trees, snags or stumps in them. I remember quite distinctly seeing one on a large and tall rotten stump within a few rods of our house, many years ago, perhaps in the early sixties. It was industriously hunting for grubs in the rotten wood. I had learned that yellowhammers and other woodpeckers could sometimes be killed or captured by slipping up upon them from the opposite side of the stump and striking around the stump with a flexible brush. I tried the experiment with this Log-cock. Securing a much-branched beech limb about four feet long, I stealthily approached the stump. The Log-cock was so intent upon its quest for grubs that it was oblivious to my approach. When at the stump a smart blow on the side of the stump caused the flexible ends of the brush to strike the bird and stun it so severely that I had no difficulty in capturing it.

101. Melanerpes erythrocephalus (Linnæus).

RED-HEADED WOODPECKER. (406)

From my earliest recollection the Red-headed Woodpecker has been to me perhaps the most familiar and best known of our native birds. In my boyhood days in Carroll County, it was excessively abundant and much detested by every farmer who had fields of corn or apples and cherries upon which it might feed. And that it was very destructive to the ears of corn while in the milk or roasting ear stage, can not be denied. To convince one of this fact, it was only necessary to take a look at the outer rows in any corn field, particularly on the side next to a woodland. In these rows not an ear escaped; every one showed the husk torn away at the distal end and from three to 10 square inches of the grains eaten more or less completely. The young woodpeckers, those hatched the previous spring, seemed to have reached their most voracious age just when the young ears were in the condition to suffer most. The damage done the whole country over was very great indeed. A little earlier in the fall or summer the Red-heads paid their respects to the ripening cherries and the early harvest apples. It is probably a very conservative estimate to put their destruction of early apples at 10 per cent.

But we had a very unique way of somewhat lessening their destruction of apples. The method may be described as follows: A long, slender pole (gray ash was the best), was set firmly in the ground under the apple or cherry tree which it was desirous to protect, the pole being long enough to project two or three feet above the top of the tree. Woodpeckers coming to the tree would almost invariably alight first upon the side of the pole. The boy who was "out for woodpeckers" would station himself under the tree at the base of the pole where, with a heavy axe or maul in hand, he would await the coming of the bird. The foliage of the tree was thick enough to prevent the woodpeckers from seeing him, yet not so dense as to prevent the boy seeing the upper part of the pole upon which the birds would alight. When one arrived and alighted on one side of the pole a smart blow on the same side of the pole would knock the breath out of the bird and it would fall to the ground where it would be promptly killed, if not already dead. In this way it was an easy matter for one person to kill a dozen or more woodpeckers in a forenoon.

Another interesting method by which an occasional woodpecker or flicker could be killed was by means of the horsehair snare. These birds were in the habit of alighting on the upper end of the stakes of the stake-and-rider fences with which most of the fields in those days were surrounded. With a 2-inch auger, a hole was bored an inch or two inches deep on the upper side near the upper end of a stake which woodpeckers had been observed to frequent. Two or three grains of corn were placed in the bottom of the hole and then a strong horsehair snare was placed around the hole so that it was a trifle smaller in one diameter than the hole, yet rested upon the wood either at the top and bottom or on the sides of the hole. This hair snare or slip-noose was tied to a short stout cord or small wire which was firmly fastened to the stake. The woodpecker, alighting on the stake, spies the corn and at once puts his head in the hole to get it, but on withdrawing his head the horsehair catches under the feathers of his neck, draws tight and soon chokes him to death. While this method was hardly as sure a thing as the pole and axe, it was nevertheless quite effective, albeit not at all humane.

In those days, the multitude of dead trees in the "deadenings" on the farms, to say nothing of the hundreds of acres of primeval forest and open woodland, afforded exceptionally favorable nesting sites for the Red-heads and the other woodpeckers. These have now almost entirely disappeared and with their passing the woodpeckers also have gone, so that now none of the woodpeckers is nearly so abundant as they were 30 to 50 years ago.

Another thing which has had much to do with the decrease in the abundance of the Red-headed Woodpecker was the destruction of the oak and beech forests which produced such a great part of the winter food of these birds. One of the pretty sights of the fall months was that of the woodpeckers busily engaged in storing away nuts of various kinds, particularly beechnuts and the smaller acorns, such as the Chinquepin Oak (*Quercus michauxi*). On quiet autumn days the woodpeckers would work incessantly gathering and storing nuts, placing them in natural cavities in certain trees or driving them into holes which they themselves had made. The constant flying back and forth, interrupted only by occasional chasing of one another, and the accompaniment of their loud, not unmusical, chatter, was a scene quite familiar to every farmer's boy and one which never failed to interest him.

The Red-headed Woodpecker is still common in each of the three counties, and in each of them a few usually remain throughout the year. The majority, however, go further south in the fall. In Carroll County, they remain through only those winters following seasons of abundant mast and such as are not especially severe. Noted by Miss Ava Evermann at Burlington as follows: January 5, 1907, several in woods; October 27, three or four seen in woods; October 28, a young one seen on a hickory tree in woods, its back mottled and its head only slightly red. A great many adults seen on this date, in the woods. January 1, 1908, two or three seen in the woods, and on January 25, one seen in same woods.

Their nesting season is in May. A nest with three fresh eggs, May 15, 1888, in an oak snag at the forks of the road near Mr. Smith's near Honey Creek south of Terre Haute. One taken east of the fairgrounds at Terre Haute, April 25, 1888. Another with five fresh eggs, May 10, 1883, in a hole in a hickory snag on my father's farm near Burlington.

During the winter of 1881-82, they were very numerous in Carroll County, but since then, as well as before, they have been very rare in winter. December 13, 1884, one seen. A few evidently remained all that winter, though not many were noted. One observed March 18, 1885. Several noted near Bloomington, January 12, 1883.

102. Centurus carolinus (Linnaeus). Red-bellied Woodpecker. (409)

A moderately common resident in all the counties, perhaps most numerous in Monroe. This species, locally sometimes known as "Sapsucker" and "Guinea Woodpecker", was, like the Red-head, quite destructive to the ripening corn and to the early apples and cherries, and, like the Red-head, it could be killed by striking with an axe or maul, the pole on which it had alighted.

Carroll County: February 15, 1879, noted near Camden.

Monroe County: January 12, 1883, three or four noted.

Vigo County: Noted at Terre Haute March 24, 1888, and April 1, 1889.

103. Colaptes auratus auratus (Linnaeus). Flicker. (412)

An abundant and well-known bird, resident throughout the year, locally known as "Yellowhammer". This is one of the most useful of birds. It lives chiefly on grubs and other insect larvæ, and upon noxious insects. The little harm it does to the corn in roasting-ear time is trivial in comparison with the great good it does in destroying insect enemies of cultivated crops.

A sight with which every country boy or girl is familiar is that of yellowhammers on the ground in the meadows, pastures and lawns, hunting for large white grubs and other insect larvæ which are so destructive to the lawns. I remember one fall when the large white grubs were so abundant in a certain yard that the sod could be pulled up and rolled back like a carpet, leaving hundreds of grubs exposed; and these attracted several yellowhammers which feasted upon them.

The flickers nest in holes which they dig in dead trees or limbs. The nesting season in Vigo County begins late in April. The eggs, five to eight in number, are a crystalline white. Sometimes the flicker can be induced to lay a large number of eggs. On May 4, 1885, I found a nest in a hole in a large buckeye tree in the Dr. Armstrong pasture in Camden. The nest contained two eggs, one of which I took, leaving the other as a nest egg. This was repeated daily until June 22, when some one destroyed the nest. In all 37 eggs were laid by the bird from May 3 to June 22. On 14 of the 51 days no egg was laid. How many more I would have gotten if the nest had not been destroyed will never be known. The most remarkable record of the laying capacity of the Flicker has been furnished by Charles L. Phillips of Taunton, Massachusetts. In a period of 73 days, he obtained 71 eggs.

Carroll County: May 8, 1883, two fresh eggs in hole in dead elm snag in Stockton's thicket in which I found a nest with six young saw-whet owls.

Miss Evermann contributes the following notes: October 7, 1906, one seen in maple tree near house; 28th, several seen and heard in woods; November 30, one heard near house and its note was "wiechen" which Dr. Chapman says he does not remember hearing a Flicker utter when alone. January 25, 1908, three or four seen in the woods; 19th, one seen in tree near house, only one seen away from the woods this winter.

Monroe County: January 12, 1883, two noted near Bloomington.

104. Antrostomus vociferus vociferus (Wilson). whip-poor-will. (417)

Not uncommon summer resident, arriving in the last half of April and remaining until in September.

During quiet evenings in spring and early summer the interesting call of this strange bird may be heard, most commonly in or at the edge of heavy woods, especially hillside. It repeats the syllables *whip-poor-will*, in rapid succession and so many times without a break, that it would become monotonous were it not so strange, so weird.

Carroll County: September, 1877, specimen collected; May 8, 1884, first heard this evening near the Evans schoolhouse in Tippecanoe Township, but others had heard it May 4; April 22, 1885, first of season heard in evening near Yeoman; heard again next evening near Joseph Trent's east of Camden. Charles Metsker heard one near Yeoman, April 21. I never found a nest of the Whip-poor-will.

Vigo County: Noted April 11, 1888, and May 1, 1889.

105. Chordeiles virginianus virginianus (Gmelin). nighthawk. (420)

The Nighthawk or Bullbat is a common spring and fall migrant, and possibly a rare summer resident. Of this last I am not sure, as I have never found its nest nor have I any record of seeing it in July. It may frequently be seen in May and early June circling about over the fields and pastures in the dusk of evening or even on dull cloudy days, but it is most abundant in August and early September, when considerable numbers may sometimes be seen flying about over the meadows and other open places.

Carroll County: August 31, 1883; May, 1884; May 10, 1885.

Monroe County: May, 1886.

Vigo County: May 8, 1888.

106. Chætura pelagica (Linnæus). chimney swift. (423)

An abundant summer resident. Formerly nesting in hollow trees and similar situations, but now almost invariably in chimneys. The only nest I ever found in a tree I discovered in the hollow of a hickory stub on my father's farm near Burlington in the spring of 1883. The chimney of our house on the home farm always had its colony of four to six or more pairs of chimney swifts every summer, and it was astonishing the noise they would make, not only throughout the day but also at night, seriously interfering with one's sleep.

Carroll County: July 14, 1882, set of four fresh eggs. In 1884, first noted April 27; common next day.

In 1884, a pair of chimney swifts fastened their nest to the inside of the door of an outhouse at the Vandalia depot in Camden. The birds entered the building through a small hole in the gables. The building was in daily use, but those who visited it were cautioned by the railroad agent to open the door carefully so as not to jar the eggs. Usually the bird sitting on the eggs would leave the house when any one entered, but sometimes she would remain on the nest. Four eggs were laid, one of which was jostled from the nest, the other three hatched and the birds grew to maturity. This nest was repaired and used again in 1885, and in 1886, and a brood raised in each of those years. April 17, 1885, noted.

In the fall of the year the chimney swifts resort in great numbers to some one chimney in the neighborhood. At Bloomington, they frequented the chimney of the University engine house; in Terre Haute, vast numbers used the chimney of the Baptist church on North Sixth street; while in Carroll County, they have for many years resorted to the chimney of the Methodist church in Flora.

Monroe County: April 11, 1886.

Vigo County: April, 1888, ten or 15 noted; April 7, 1888, and April 6, 1890.

107. Archilochus colubris (Linnæus).

ruby-throated hummingbird. (428)

This beautiful little bird is a rather common summer resident in all the counties considered in this paper. Noted at Bloomington, May 13, 1882; at Camden, May 8, 1883, where it was common by May 23; May 4, 1885, two or three seen. At Terre Haute noted May 3 and 5, 1888.

108. Tyrannus tyrannus (Linnæus). kingbird. (444)

A common summer resident in all the counties.

Carroll County: June 19, 1882, set of three fresh eggs, nest in an apple tree in home orchard; June 18, 1883, set of four fresh eggs; first observed in 1883 on April 29; in 1885, on April 22.

Monroe County: Common in the orchards about Bloomington in the summers of 1882, 1886 and 1888.

Vigo County: April 22, 1888, ten or 15 noted; April 7, 1889, and April 6, 1890.

109. Myiarchus crinitus (Linnæus). crested flycatcher. (452)

Fairly common summer resident, most often seen in woodlands at the edge of open fields. Nests in holes in trees and has the curious habit of almost invariably using at least a part of a cast-off snake-skin in its nest. In 1882, a pair nested in a section of an old pump-stock which I placed some 20 feet from the ground in a beech tree in my father's barn-lot.

In Carroll County arrives about the last of April; noted May 18, 1878; May 3, 1883; June 18, 1883, set of three fresh eggs; April 28, 1884, and again on April 28, 1885, in Adams Township. Noted at Bloomington, April 26, 1886. Noted at Terre Haute April 21, 1888, and April 25, 1889.

110. Sayornis phœbe (Latham). phœbe; pewee. (456)

A common and familiar summer resident. Appears in spring as early as the middle of March and remains quite late in the fall. Builds its nest of mud and moss, placing it under some bridge or culvert, under the eaves of a house, shed or barn, on the side of a cliff, or sometimes in a hollow tree. On May 9, 1890, I found a nest on the side of a sandstone cliff in a gorge at Fern, near Greencastle. It contained three fresh Pewee eggs and two fresh eggs of the cowbird.

Carroll County: March 8, 1879, six or eight seen; April 21, 1883, set of four fresh eggs; first one seen March 17, 1884, near Pleasant Valley, and March 31, 1885, near Camden depot. Noted building, March 26, 1884. For many years a pair placed their nest on a projecting board over the door of our granary near Burlington.

Monroe County: Arrives about the first of March; found nesting April 21, 1882, a set of four well incubated eggs.

Vigo County: Noted March 17, 1888, March 21, 1889, and March 30, 1890.

June 2, 1882, a set of four in nest in a deserted house near Wyandotte Cave, that were very unusual in color, they being indigo-blue over about one-third of the surface.

111. Myiochanes virens (Linnæus). wood pewee. (461)

A rather common summer resident, most frequent in the open woods. Arrives in Carroll County about the last week in April. One seen near Joseph Trent's east of Camden, April 24, 1885; common in the woods on May 22, 1883. Nest with full complement of eggs in beech tree on home farm, June 18, 1883. Noted at Bloomington, April 28, 1886.

Noted at Terre Haute April 30 and May 2 and 5, 1888.

112. Empidonax virescens (Vieillot). acadian flycatcher. (465)

A fairly common summer resident. Arrives in Carroll County about the middle of May. Full sets of eggs by June 15. June 17, 1882, set of three well incubated eggs; June 14, 1883, nest with two eggs and one of the cowbird, incubation begun: May 4, 1885, noted. This bird is one of the most frequent victims of the cowbird.

In Monroe County arrives about the middle of April and is very common during the summer. June 2, 1882, nest with one fresh egg at Wyandotte Cave. A partial albino taken at Sand Hill east of Terre Haute in June, 1890.

113. Empidonax trailli alnorum (Brewster). alder flycatcher. (466a)

Rather rare summer resident. Nest found June 10, 1885, near Camden. Five noted at Terre Haute May 3, and others May 5, 1888.

114. Empidonax minimus (W. M. & S. F. Baird).

least flycatcher. (467)

Not very common summer resident in all the counties.

Noted May 6, 1885, near Camden.

115. Otocoris alpestris praticola Henshaw.

prairie horned lark. (474b)

Carroll County: I remember distinctly the first time I ever recognized this species. It was in December, 1877, when Mrs. Evermann, one of our young lady students, and I were spending a morning observing the birds along Deer Creek just below Camden. On the south side of the creek just below the Porter dam we saw several horned larks in a small enclosure where some hogs were being fed. Snow covered the ground nearly everywhere and the shore larks had come to this place in search of food.

Since that day I have noted this bird frequently in nearly all parts of Carroll County, most rarely in the southeastern part, most abundantly in Tippecanoe and Jefferson townships which are largely prairie. May 4, 1878, collected specimens at Camden; March 17, 1879, noted. I noted them frequently in March, April, and May, 1883. On January 5, 1884, (a very cold day, 30 degrees below zero), I saw a flock. During April and May they were common. On December 19, I saw several in Lenon's hog-lot east of Camden. During the winter of 1884-5, they were moderately common. During March, 1885, they were pretty common. On December 12, 1916, while on an automobile trip with my nephew Claude Hawkins, from Russiaville, through parts of Howard and Carroll counties, a great many shore larks were seen. They were in small companies from two or three to 20 or more. They were feeding in the road and would fly up and out of the way only reluctantly as we came upon them. The ground was covered with snow and most of the trip was made in the teeth of a fine blizzard. Miss Evermann saw one in the road south of Burlington December 16, 1909, the only one she had seen up to that time.

It is certain this species is much more common in these counties now than it was 30 to 40 years ago. In all probability it nests in Carroll County, but I have never found its nest there.

Monroe County: I have never seen them in any considerable numbers in this county except in winter. On February 10. 1883, and again two days later, I found flocks of several hundred in a large meadow northwest of Bloomington. The days were cold and stormy and snow covered the ground everywhere except in situations such as in this meadow where the wind tended to keep the ground more or less bare. The birds were moving about in great flocks, alighting on and spreading over the bare spots where they searched for food, or, at times, stopping at patches of short weeds upon the seeds of which they fed.

Vigo County: These birds were usually common in winter or late fall and a few might be seen even in the summer particularly north of Terre Haute on the road to the Five-mile Pond, also south of the city, and in all other prairie parts of the county.

These birds doubtless find the public highways good feeding grounds, and the habit is so well marked that in some places they have received the very appropriate name of "roadsters". I heard this name applied to them in Merced County, California, in 1918.

116. Cyanocitta cristata cristata (Linnæus). Blue Jay. (477)

Of all our native birds the Blue Jay is perhaps the best known permanent resident. Every one knows the Blue Jay. We all enjoy seeing him about, albeit, his pert, not to say unmannerly, ways, somtimes seriously tax our patience. And then we often have a suspicion that his presence about the house or in the orchard means harm to the eggs or young of other birds that enjoy a greater measure of our confidence and respect.

But at times I have found the blue jays quite useful. When out collecting, if I heard one or more jays, about a hole in some old tree, using a lot of Blue Jay profanity and raising a general hullaballoo, I could be sure that there was a screech owl in that same hole. I have secured many a fine specimen with the aid of the blue jays in this way.

I think the Blue Jay is about equally common in all the counties covered by this paper. In Carroll County, it is quite common throughout the year. It is quite disposed to nest in the fruit trees and other trees about dwellings. April 21, 1883, nest with three eggs. On April 4, 1884, a pair observed building in a shade-tree in Dolph McKinney's yard in Camden. Others seen nesting on April 10. On my old home farm one or more pairs usually nested in one of the cedar or spruce trees in the front yard, and for some years at least one nest might be found in an apple tree in the orchard. On this farm the jay birds appear to be much less common now than formerly. While spending the week of June 25 to July 1, 1905, there I saw only one Blue Jay. Noted by Miss Ava Evermann of Burlington October 28, 1907, when several were seen in the woods, and again on New Year's day, 1908, when one was seen in the woods. They were common in town all winter.

Favorite nesting sites for the Blue Jay were in the large hawthorns which were common in the edges of the woods and in the more open places along the creeks.

In the South there is an interesting superstition, especially among the negroes, who say that you never see any blue jays on Friday because they are all away carrying sticks to the devil!

In Monroe County, the jays are common and begin to nest as early as the first of April. April 13, 1882, a set of three fresh eggs near Bloomington; February 16, 1883, common.

In Vigo County, also, they are a common bird. Their nests may be found in the hawthorns, locusts, and similar trees.

117. Corvus corax sinuatus Wagler. raven. (486)

Formerly common, but now rare, if it has not entirely disappeared. In my boyhood days I have seen ravens in Carroll County. I am not sure I ever saw one in Monroe or Vigo County.

118. Corvus brachyrhynchos brachyrhynchos Brehm. crow. (488)

A common and familiar permanent resident. In the winter the crows gather up in great numbers and have permanent roosting places. One of these rookeries was located near Ridge Farm on the west side of the Wabash River, a few miles north of Terre Haute. When visiting this region in February, 1889, I saw what I estimated at 2,000 crows flying to this rookery in the evening. During the day they scatter over the surrounding country, covering a radius of several miles, feeding in the fields and other open places, and return in the evening to the roosting place. The winter of 1884-5, in central Indiana, was one of unusual and continued cold and deep, drifted snows. The crows, however, like the poor, were ever with us and, seemingly, in unusually great numbers. At Camden they were noted flying east in the morning and west in the evening; rarely or never north or south. I did not succeed in locating their roosting place or places. They were usually more or less scattered in their flight, but often they flew in rather compact bodies of 10 to 50 birds. Sometimes, usually about 4 P. M., the flocks were much larger. On March 4, 1885, Mr. Will Hough of Delphi, saw what he estimated at 400 to 500 flying west over South Delphi. They flew in a pretty compact body. The evening was very cold, the temperature being 12 to 15 below zero. Two evenings later (March 6), at 4 o'clock, I saw about 60 in one flock flying west near Delphi.

The Crow nests early in the spring. Full sets of eggs taken near Bloomington, March 20, and near Burlington, April 16.

Crows have a bad reputation, doubtless far worse than they deserve. They are charged with pulling up newly planted corn which they probably do to some extent; also with destroying the eggs of various species of wild birds, and domestic fowls, which also is doubtless true. I, myself, have often seen crows visit a strawstack in which several hens had their nests, search for eggs and, when found, impale the egg on their bill and fly away to some distant tree or other safe place where the egg would be devoured.

A nest with three fresh eggs near Burlington, April 16, 1883; another nest with four fresh eggs found in an apple tree near Burlington, April 28, 1919, by my young grandnephew, Donovan Beck.

A nest with two addled eggs and one large young near Bloomington, April 29, 1882. Common January 12, 1883.

January 8, 1920, four seen north of Cutler and two more just north of Camden. While traveling on this day by train from Terre Haute to Logansport, the Crow was the bird most frequently seen from the car window. A good many were seen, usually in the cornfields or meadows, hunting for food. There was some snow on the ground, especially between Terre Haute and Frankfort.

119. Dolichonyx oryzivorus (Linnaeus). bobolink. (494)

A spring and fall migrant, usually rare, but sometimes seen in large migrating flocks.

Monroe County: Thirty or more seen, May 6, 1882, in a meadow at north edge of Dunn's woods (the present Indiana University campus), and again on May 8, 1886, in meadows north of Bloomington, were several in full song.

Vigo County: Considerable flocks seen in the spring by Professor Blatchley and by me, usually in the meadows south of town or along the old canal north of the city.

Carroll County: On May 10, 1883, I saw five or six on the old Michigan road near Henry Appenzeller's, north of Burlington. These were the first I ever saw in the county and I am confident the species was then a new arrival. On May 6, 1884, several were seen near Deer Creek, and others near Burlington about the same time, once in a meadow on the Fullwider farm south of Burlington, and two or three times on my father's farm. James Milton Beck tells me he has seen bobolinks in summer in the meadow on this farm, which would indicate that the species breeds there now.

120. Molothrus ater ater (Boddaert). cowbird. (495)

A fairly common summer resident in all the counties.

The Cowbird is the only species of our birds which builds no nest of its own but habitually lays its eggs in the nests of other birds. Among the species in whose nests I have found cowbird eggs I may mention the following:

Common Pewee, Fern, Putnam County, May 9, 1890, three pewee and two cowbird eggs; *Kentucky Warbler*, Eel River Falls, Owen County, June 1, 1888, three warbler and one cowbird eggs; *Wood Thrush*, near the dam on Wild Cat Creek above Burlington, Carroll County, May 24, 1883, two thrush and three cowbird eggs; *Oven-bird*, near Burlington, May 28, 1883, three oven-bird and two cowbird eggs, found by Vern Beck; another by me on Turkey Run, Parke County, May 23, 1890, two cowbird eggs, incubation begun, no oven-bird eggs; and *Maryland Yellowthroat*, near Bryant's Ford, Parke County, one cowbird and three Maryland yellowthroat eggs, May 23, 1890.

Other species in whose nests I have found cowbird eggs are: Cardinal grosbeak, towhee, red-eyed vireo, warbling vireo, scarlet tanager, Acadian flycatcher, indigo bunting, worm-eating warbler, yellow warbler, American goldfinch, catbird, song sparrow, vesper sparrow, kingbird, Baltimore oriole, red-winged blackbird, and wood pewee. Definite dates besides the above are:

Carroll County: March 17, 1879, seen; June 17, 1882, one fresh egg; May 24, 1883, three eggs in nest of brown thrasher with four of the latter; incubation begun. March 31, 1884, first noted; April 5, 1885, both males and females, first of season, noted near railroad bridge on Deer Creek, east of Camden; June 29, 1905, four seen in barnyard on old homestead near Burlington.

121. Agelaius phœniceus phœniceus (Linnæus).

RED-WINGED BLACKBIRD. (498)

Summer resident, abundant in all suitable situations. About the marshy places along the rivers, at woodland ponds and in marshy meadows, will usually be found from a few pairs to a hundred or more of these beautiful birds. They are among the first to arrive in the spring, often coming as early as the first of February, and their cheery call is one of the most delightful and musical sounds of early spring.

They begin nesting by the last of April, full sets of eggs often being completed by the first of May. The nests are placed near the ground among, and fastened to, the cattails and grasses about the swamps.

Monroe County: Not very common in this county, doubtless because of the absence of swamp land and other suitable environment.

Vigo County: Abundant summer resident, breeding in all suitable places, such as Greenfield Bayou, the Goose Pond, Five-mile Pond, and along the river wherever there are cattails and tules. On May 3, 1890, at the Goose Pond south of Terre Haute, several nests were found, one with four fresh eggs, one with two, and another with only one. Two weeks later this pond was again visited. The nesting season was at its height as attested by many nests seen. Of seven nests examined four contained four eggs each, two had three eggs each, and one had only one egg, all fresh.

Carroll County: February 23, 1878, noted; March 5, 1879, four or five seen; 6th, many seen flying north. May 21, 1883, common nesting at the Maple Swamp; May 26, nest with eggs found near Burlington by Edwin C. Evermann; May 28, nest with four eggs found on my father's farm. February 12, 1884, saw a flock of 30 or more south of Delphi; February 19, Professor John W. Hamilton and I saw a hundred or more on the Ayres farm between Bringhurst and Cutler. They were feeding on the ground in a hog corral. The morning was very cold. The day before had been pleasant but in the evening grew very stormy and cold. May 5, found many nests in the Armstrong pond at Camden, in all stages from nests not yet completed to young birds a day or two old. March 5, 1885, saw first flock of 10 south of Camden. By the 12th they had become abundant. June 25 to July 1, 1905, only one pair seen on the old homestead near Burlington where they formerly were very abundant.

Other favorite breeding grounds in Carroll County were the tule patches along the old canal, in the Harness swamp south of Burlington, in the Leonard Smith swamp and the Maple swamp, west of Burlington, in the feather-bed prairie south of Logansport, the Runyan marsh east of Burlington, and in and about all the small inland ponds.

122. STURNELLA MAGNA MAGNA (Linnaeus). MEADOWLARK. (501)

A common and much loved summer resident, a few remaining throughout the winter in favorable situations. Returns from the south by the middle of February and is common by the middle of March. Nests on the ground in the meadows and grassy fields. One of the most useful birds to the farmer.

Carroll County: February 20, 1878, noted; March 1, 1879, seen; June 27, 1882, set of four nearly fresh eggs; May 27, 1883, Vern Beck found a nest with two young and a fresh egg lying at the side of the nest; December 23, several seen. February 18, 1884, saw one at the Hiram Gregg farm north of Camden. They were apparently present all winter. March 15, common; March 6, 1885, first of season seen at the John Snoeberger farm west of Camden. By March 13, they had become common. June 25 to July 1, 1905, only six or eight were seen or heard on the old homestead. Noted by Miss Evermann at Kokomo March 3, 1920, the first seen since the preceding Thanksgiving.

Monroe County: An abundant summer resident, rare in winter; returns from the south about February 24. February 16, 1883, four or five seen.

Vigo County: Common in summer, rare in winter; returns from the south about the last of February. February 20, 1888, six seen.

123. ICTERUS SPURIUS (Linnaeus). ORCHARD ORIOLE. (506)

A not very common summer resident, arriving about the last of April. Most frequent about orchards, nesting in apple trees, using green grass in the construction of its nest.

Carroll County: May 3, 1878, specimens taken; June 17, 1882, nest with one fresh egg; May 2, 1883, saw a male, first of the season, in an orchard on the Delphi-Burlington road. April 30, 1884, saw several; pretty common. May 4, 1885, considerable flock of both males and females seen. I have frequently seen nests in various apple trees in the orchard on the old homestead and in other orchards in various parts of the county. A pair of adults seen in my father's yard June 25-July 1, 1905. I am inclined to believe the Orchard Oriole is fully as common here now as it has ever been. I do not remember seeing it in my boyhood days, although it was doubtless present then. The first I recall were seen in the orchard about 1878; from then on two or three pairs have nested there or in the trees on the lawn each year, always constructing the nest of grass picked green, which, when dry, gives the nest the appearance of having been made of hay which had been rained on while curing.

Monroe County: Becoming more common every year. May 13, 1882, five or six seen.

Vigo County: Returns from the south in early May or late in April. April 28, 1888; May 3, 1889; and May 5, 1891.

124. ICTERUS GALBULA (Linnaeus). BALTIMORE ORIOLE. (507)

Common summer resident, arriving about the middle or 20th of April, and remaining until in September; most frequent about farm houses and in open woodlands; one of our most beautiful and attractive song birds.

Carroll County: April 28, 1883, first noted today, in the Delphi school yard; May 12, first females noted. April 24, 1884, heard one in morning near my house in Camden. April 21, 1885, saw four or five, all males, in an orchard, near my house, the first of the season. June 25-July 1, 1905, one pair nesting in a maple tree in yard at old home.

This is one of the beautiful birds with which I have been familiar since my earliest recollection. Its brilliant colors and its confiding domesticity, coming as it does about the house and fields, make it a bird quite sure to attract the attention of any one. About the middle of April the males arrive from the south. A few days later the females arrive, and soon nest-building begins. The favorite trees selected in which to hang their beautiful pensile nests are maples, elms, poplars (*Lircodendron tulipifera*), and cottonwoods (*Populus*). A small poplar tree stood in the barn lot close to the house on the old home farm. In it a pair of orioles were quite sure to nest each year. It was a very safe place. The first limbs were 30 feet from the ground. The nest was usually hung well out toward the end of a slender limb, and always on the north side of the tree, where no cat could get at it and so near the house that no hawk or other marauder would dare molest it. In all the years I do not recall a single failure to raise a brood each year. I do not think a second brood is raised unless the first meets with accident. A new nest was built each year, and sometimes one or even two, old nests might be seen alongside the new; but usually the nest was not able to stand the winds and storms of winter so that, by the new home-building time, the tree would be free of old nests. In 1901, this old poplar tree blew down in a severe storm. Another tree in which the Baltimores were quite sure to build was a hard maple that stood in the lawn near the house,—a beautiful shade-tree, full-branched and symmetrical, in which the nests were usually placed well toward the top on the north side where, on account of the dense foliage, they were not easily seen. I think the Baltimore Orioles are now less abundant in this county than they were 20 or 30 years ago.

Monroe County: Probably more common here than in Carroll County. In 1882 to 1886, the first arrivals from the south were noted April 20, 21, 20, 21, 23. On April 23, 1886, several were seen in the University campus.

A few years ago a lady sat under a tree in her yard in Bloomington one afternoon unravelling an old stocking. She was called away for some reason, leaving the yarn lying in the yard. Next morning when she came to get the yarn it could not be found. The next fall, after the leaves had fallen and the trees were bare, an oriole's nest was seen in one of the trees. It was gotten down and was found to have been made largely of yarn which the lady readily recognized as the long-lost stocking ravellings.

Vigo County: Very common summer resident, even nesting in the shade trees on the city streets. April 24, 1888, a male seen; April 24, 1889, and April 28, 1891, noted at Terre Haute.

125. Euphagus carolinus (Müller). rusty blackbird. (509)

Usually a rather rare spring and fall migrant. I have not seen it very often. Although I am sure I have seen it in Carroll County, especially when I was a boy, I have no actual definite record. In Monroe County, it occurs as a migrant, but I have no definite data. In Vigo County, I saw several large flocks October 26, 1886, and still others in the spring of 1889 along the old canal, north of Terre Haute.

126. QUISCALUS QUISCULA ÆNEUS Ridgway. BRONZED GRACKLE. (511b)

An abundant summer resident, but much less common than it was 30 to 50 years ago.

In Monroe County, very abundant about Bloomington, nesting in the pine trees in the yards; a few doubtless remain all winter some years.

Very common in Vigo County along the river, also nesting in the pine trees in Terre Haute. March 10 and 11, 1888, more than 100 seen.

In Carroll County, very abundant. May 21, 1883, nests with large young in the Maple swamp. March 15, 1884, first of season seen at the Jacob Nettle farm southwest of Camden; very common a few days later. March 25, 1885, saw several, the first of the season, soon became common.

Thirty to 40 years ago this region was heavily wooded. A more magnificent hardwood forest than that which covered the Wabash valley, the world has never seen; great oaks of several species, splendid maples, ashes and elms, each of several species, stately black walnuts, yellow poplars and sycamores, beautiful beeches and buckeyes, and a score or more of other hardwood trees, with a dense underbrush of smaller trees, shrubs and vines, and yet under these, tangled thickets of spice-brush, button-bush, wild roses, briars, and other smaller growth of many kinds. And lavishly distributed through these umbrageous forests were hundreds of small ponds, many of them only a few yards or rods, and none more than half a mile in length or width. Many of them, indeed, were mere wet-weather ponds which dried up late in summer or early fall, while others were more permanent and held more or less water throughout the year. Besides these there were many swamps, large or small, which furnished excellent breeding and roosting grounds for vast numbers of crow blackbirds and red-shouldered blackbirds. The crow blackbirds made their nests in the trees and snags, placing them in the forks of the larger limbs, on the tops of snags, in decayed places in the trunks, and sometimes even in hollows in the trunks or larger limbs. The height of the nests above the ground varied from a few to many feet. I have seen a nest on the top of a stump not two feet above the water, and another fully 50 feet from the ground in the crotch of a swamp maple.

In those days millions of crow blackbirds were hatched and grew to maturity in and about these swamps and ponds. Hundreds of thousands came up from the south every spring, built their nests and reared millions of young. It is not believed these figures are at all extravagant. The enormous numbers were never more noticeable than during roasting-ear time, when the green corn was in the milk, sweet and toothsome. Then the vast hosts, old and young, would make daily invasions of the cornfields, settling down on the ears as did the locusts on ancient Egypt, or as do their relatives, our grasshoppers, on the fields of Kansas.

So great was the damage done to the corn that the farmers made every effort to drive the birds away. One of the duties of the farmers' boys was to keep the blackbirds out of the cornfields, which the boys attempted to do by making all sorts of noises, such as shouting, calling, throwing clods and clubs, firing guns, beating tin pans, and by grinding out music (God save the mark!), on that invention of the devil, known as the horse-fiddle. A more diabolical instrument was never invented; nor one that could make noise more discordant or more terrifying.

In its essential construction this machine consisted of a cylinder about eight to ten inches in diameter and a foot to 18 inches long, made of hard-wood, perhaps beech or oak. Teeth two to three inches long of hard but flexible hickory were set in holes arranged spirally around the cylinder as are the teeth in the cylinder of a threshing machine. The cylinder was then placed in a box from at least one side of which teeth projected inward. The ends of the box and the side in which the teeth were set were made heavy and strong, the three other sides being of thin resonant boards. The cylinder was provided with an axle which fitted in a hole in each end of the box, the axle at one end being long enough to have a handle or crank fitted to it by which the cylinder could be turned. Turning the crank caused the teeth of the cylinder to strike the strong teeth fixed to the box, and the noise made by the release was about the most discordant, ear-splitting, and terrifying that can be imagined. A more effective means of stampeding blackbirds has probably never been devised. It was also effective in frightening horses, cattle, and other live stock on the farm, and causing a runaway now and then if used near a public highway. This instrument of terror also did excellent service in the callithumpian concerts (or "bellings" or "shivarees" we called them), with which newly married couples in that land were usually honored.

Carroll County: February 27, 1879, two seen, one collected; March 1, a large flock seen near Camden. In the early days, favorite nesting regions were the Harness swamp south of Burlington, the Maple swamp west of Burlington, and in and about all the small woodland ponds. After the swamps and ponds had been drained, these birds resorted to the pine, spruce, cedar and other trees about the farm houses and even in the towns.

Monroe County: May 13, 1882, nest with two eggs incubated perhaps four days; February 27, 1883, several seen. A number of pairs nested each year in pine trees in Bloomington and in Turner's grove.

127. Hesperiphona vespertina vespertina (W. Cooper).

EVENING GROSBEAK. (514)

An erratic, usually rare, winter visitant.

On January 22, 1887, Charles H. Bollman shot one (a male) of this rare species on the University campus at Bloomington. On the same day Cal. Meridith and a companion saw a flock of 12 from which they collected five near Frankfort (near the south line of Carroll County). A few days later two examples were seen near Frankfort. On April 27, 29 and 30, examples were noted at Bloomington by G. G. Williamson. On February 1, 1890, H. N. McCoy captured one from a flock of 20 to 30, near Lafayette.

128. Carpodacus purpureus purpureus (Gmelin). PURPLE FINCH. (517)

In Carroll County frequently seen late in the autumn and again early in the spring. Taken March 5 and noted October 12 and 19, 1878; January 25, 1879, a male taken, only one seen; April 22, 1884, saw a flock on Deer Creek east of Delphi and another on the John Wise farm west of Camden. On February 13, 1885, shot a female from a flock near the Frank Thomas pond south of Camden. While these are the only definite dates I have in my note-books, I have seen the species on many other occasions, perhaps most often in the spring when they would be feeding on the green buds of elms and other trees.

In Monroe and Vigo counties, this bird was often seen in early spring; it is probably a common winter visitor; it was quite common about Bloomington in the winter of 1882-83. January 12, 1883, several dozen seen near Bloomington. One of the sweetest notes that one may hear in early spring is the song of the Purple Finch as, perched in the top of some tall elm, he divides his time between feeding on the fresh tender flower buds and warbling forth his joy of living.

129. Loxia curvirostra minor (Brehm). red crossbill. (521)

In *Monroe County*, this interesting bird has been noted frequently, usually as a winter visitant. February 10, 1883, shot a pair in the grove of pines at Turner's at west edge of Bloomington, and on 23d secured another at same place. The next winter they were unusually abundant. In the winter of 1884-5, they were again abundant about Bloomington, especially in the Turner grove where 25 specimens were collected, March 7-10, by Miss Anna Turner. I, myself, have never seen this species in Monroe County in the summer, but the late Charles H. Bollman reported seeing a few July 10, 13, and 14, 1886.

In *Vigo County*, I observed it frequently in the winter of 1887-8 (February 2 and 6, April 25, and May 3 and 5), and in 1888-9, among the pine trees at St. Anthony's hospital in Terre Haute.

In *Carroll County*, I have noted it a few times. On December 26, 1884, I saw perhaps half a dozen feeding among the pines in the Court House yard at Delphi. Beginning with December 11, the weather was cold and heavy snow falling, reaching a depth of 18 to 20 inches, the deepest for several years. On the 27th, it began raining and by January first, most of the snow had gone. On March 27, 1885, saw four or five in Camden, of which I shot a male and crippled a female which I kept as a pet for a week. It became quite tame and would eat apple-seeds, cooked rice, hickory nuts, hemp-seeds, etc., from my hand. April 3, saw one flying over; April 23, heard a large flock flying north.

130. Loxia leucoptera Gmelin. white-winged crossbill. (522)

This species is of rather rare occurrence in Indiana.

Monroe County: February 6, 1883, I saw 15 or more in Bloomington, of which I secured several; noted again February 10. From that date until late in March it was common.

Carroll County: It has been noted several times. Late in March, 1883, I saw one at the old nursery in South Delphi. On March 3, 1885, a female seen at Camden, in a pine tree near my house; March 8, watched a female feeding on the cones of a tamarack tree in A. M. Evermann's yard in Burlington. It was very tame, and, desiring a specimen, I secured it by tapping it with a stick. March 16, I saw what I believed to be a female of this species in Camden. It was snowing hard and the bird was flying from tree to tree in a small grove of pines.

I have no record of its occurrence in *Vigo County.*

131. Acanthis linaria linaria (Linnæus). redpoll. (528)

A rare winter visitor.

Carroll County: November 5, 1878, shot a male in fine plumage as it was flying overhead at the thicket on the hillside at southeast edge of Camden; another seen at Camden April 21, 1885. These are the only specimens I ever noted in this county.

Monroe County: January 30, 1883, one seen flying overhead.

Vigo County: I have no record for this county, but it has been noted there by others.

132 Astragalinus tristis tristis (Linnæus). goldfinch. (529)

Common summer resident; a few may remain through the winter in favorable seasons.

Sometimes these beautiful and familiar little birds gather up in great flocks.

Carroll County: Common; October 24, 1878, noted. On December 25, 1884, I saw a flock of about 20 in the Deer Creek bottoms just above Camden. On April 22, 1885, first noted in summer dress. Noted by Miss Ava Evermann at Burlington September 4 and 10, and October 5 and 14, 1906, and October 28, 1907. Those noted in September were feeding on beet tops and sunflower seeds. That of 4th was still in summer plumage; that of 10th was a young bird. Those of October 28 were high up in the tree tops. In April, 1879, I saw a flock of several thousand in the White River bottoms in Bartholomew County, near Columbus. They were all in summer plumage and as they actually filled the tops of the trees and were in full song, a prettier sight could scarcely be imagined.

Monroe County: Common from February until late in the fall. May 13, 1882, several noted.

Vigo County: Very common. February 22, 1888, several seen.

133. Spinus pinus (Wilson). pine siskin. (533)

A rare winter visitant. Common at Bloomington in February and March, 1883. February 6, 1883, thirty or more seen in Howe's yard; several collected; seen again February 10. On February 12, 1885, I saw two at Camden, the only time I ever noted it in Carroll County. I have no records for Vigo County.

134. Plectrophenax nivalis nivalis (Linnæus). snow bunting. (534)

One of our most erratic and most beautiful winter visitors, coming down from the north usually only in the severest winters. I have seen it only in Carroll County. My first were a male and a female which I shot in the road near Wm. Fisher's west of Pittsburg, January 15, 1884. In January, 1885, I saw two more near the Allen schoolhouse in Carrollton Township, feeding about a strawstack. The day before, my friend J. C. Trent, while on his way to church, saw over a hundred in a cornfield near Wheeling. The weather was very cold and had been so for several days. On February 13, 1885, I saw three about two miles south of Camden, two of which I collected. The snow was very deep and it had been very cold for a month. Ten days later (February 23-24), I saw two (possibly three), others near the Cullom schoolhouse in Jefferson Township. Of these I secured a male and a female.

135. Calcarius lapponicus lapponicus (Linnaeus).

LAPLAND LONGSPUR. (536)

The only records I have for this species in Indiana are of a fine male taken by my friend, Frank Hunter, at Bloomington, February 10, 1883, and another taken by me two days later, also near Bloomington. The day was cold and stormy. There were several inches of snow covered with a slight crust. In the afternoon I went collecting northwest of Bloomington, and came upon a flock of two or three hundred shore larks feeding in a small meadow about a mile from town. Watching the flock a few minutes I could see that besides the shore larks a number of some other species were mixed with them. Among the several specimens secured was one Lapland Longspur.

136. Poœcetes gramineus gramineus (Gmelin). VESPER SPARROW. (540)

Fairly common summer resident in all the counties where I have made observations. From my early boyhood days I was quite familiar with this bird on the old home farm. In the spring, summer and early fall, as one passed along the road, or through pastures, or in the fields, one or more of these plain-colored, albeit very attractive little sparrows, would be flushed, the white outer tail feathers showing plainly as they flew, and serving as a mark for ready identification. Their nests were often found in the meadows, open pastures, and in other grassy places. The species was equally common about Camden and Delphi and all parts of Carroll County; also in Monroe and Vigo counties.

Carroll County: May 21, 1883, nest with one egg seen near Burlington. March 30, 1884, and March 31 and April 1, 1885, several noted.

Vigo County: Several seen near the Five-mile Pond, April 18, 1888.

Monroe County: May 13, 1882, nest with three eggs near Bloomington, incubation begun.

137. Passerculus sandwichensis savanna (Wilson).

SAVANNAH SPARROW. (542a)

A not very common spring and fall migrant in each county. April 12, 1888, noted in Vigo County. April 30, 1884, noted between Camden and Delphi. Not often seen in Monroe County, but doubtless a common migrant.

138. Ammodramus savannarum australis Maynard.

grasshopper sparrow. (546)

A rather rare summer resident in each county. April 17, 1888, two or three seen near Terre Haute.

139. Chondestes grammacus grammacus (Say). lark sparrow. (552)

Summer resident, not common; most often seen in old pastures or along roads. Have seen it in Carroll, Vigo, and Monroe counties.

May 13, 1883, saw one in edge of field on road east of Delphi. May 8, 1884, saw several on prairie in Tippecanoe Township, Carroll County. May 13, saw two or three between Camden and Delphi; April 28, 1885, noted.

In Vigo County it usually arrives from the south early in April; in 1888, two males collected, April 18, at the Five-mile Pond.

This finch is evidently becoming more numerous than formerly.

140. Zonotrichia leucophrys leucophrys (J. R. Forster).

white-crowned sparrow. (554)

A common spring and fall migrant, in the spring about the first of April and passing on north by the middle of May. Most common about thickets of undergrowth and along old unkempt fence-rows.

Carroll County: May 3, 1878, two taken; May 8, 1883, very common; March 30, 1884, a good many in a deadening near Chas. Bowman's, southwest of Camden; April 13, several in my yard in Camden; April 9, 1885, saw and heard three or four near Deer Creek; April 22, saw one. Equally common in the other counties.

Vigo County: April 29 and May 3, 1888, noted.

Monroe County Often noted in spring and fall.

141. Zonotrichia albicollis (Gmelin). white-throated sparrow. (558)

Spring and fall migrant, less common than the White-crowned, and found in similar situations. About equally abundant in all the counties.

Carroll County: October 12 and 19, 1878, abundant; May 8, 1883, very abundant in open woods, associated with great numbers of the White-crowned Sparrow. May 3, 1884, first noted; April 4, 1885, noted.

Vigo County: Several noted, April 14, 1888, and again on April 21.

142. Spizella monticola monticola (Gmelin). tree sparrow. (559)

An abundant winter resident, arriving from the north late in November or about the time of the first snow and remaining until the last of March or even later. It most delights in open brushy, weedy woodlands and old fence-rows, where it finds abundant food in the seeds of the weeds.

Carroll County: November 5, 1878, abundant; March 5, 1879, very many noted; December 12 to 29, 1884, pretty common, coming into the gardens to feed on seeds. Very abundant during the winter of 1884-5, coming about the gardens, orchards and yards. March 18, 1885, still very abundant, as it was all winter; common in the yards and gardens in Camden.

Vigo County: March 9, 1889, still abundant; day coldest for some time.

Monroe County: January 12, 1883, several seen, and on February 10, many scores noted; noted by Professor Blatchley as late as April 19.

One of the prettiest sights one may see in early winter is a flock of these cheerful little birds, just arrived from the north and feeding along some brushy fence row or at the edge of some weedy field. They are very busy and very happy as they fly from the low trees and bushes down among the rag weeds or other seed-bearing plants where they find an abundance of seeds that seem just to their taste. They glean very industriously, the while chirping or singing merrily; now and then taking short flights into the bushes or up into the trees near by but returning promptly to the weeds or to the ground beneath, not remaining long in one place but moving through the copsy tangle by easy stages, feeding as they go. And then again in early spring while snow still lies among the weeds and bushes and in all protected places, and the birds begin to prepare for the return to their summer home in the north, the tree sparrows are even more interesting than they were in the fall. They glean among the weeds as before but spend more time in the trees singing their sweet little song which means they will soon leave us, not to be seen again until next fall after the first snows have come.

143. Spizella passerina passerina (Bechstein).

chipping sparrow. (560)

A common and very familiar summer resident, coming about the yards and orchards and building its nests in the small cedars and similar trees about the house. The nest is usually constructed largely of horse-hairs, hence "Hair bird", a name by which this bird is often known.

Carroll County: May 29, 1883, set of two fresh eggs; March 27, 1884, first seen; April 3, 1885, several seen, first arrivals. May 14, 1919, set of four fresh eggs, nest in woodbine vine, at Burlington, reported by Donovan Beck.

Monroe County: Common summer resident, nesting commonly in the small cedars which are abundant in old pastures and open woods about Bloomington.

Vigo County: Very common summer resident. April 1, 1888.

144. Spizella pallida (Swainson). clay-colored sparrow. (561)

Probably a rare spring and fall migrant. One shot by Mr. Blatchley September 27, 1890, near Terre Haute; it was with a flock of tree sparrows. Not noted in any of the other counties.

145. Spizella pusilla pusilla (Wilson). field sparrow. (563)

Common summer resident. Nests on the ground in old fields and similar places.

Carroll County: In the spring of 1883, unusually common and singing sweetly in the evening on the prairie farms in Tippecanoe and Jefferson townships. May 28, 1883, nest with four nearly fresh eggs, placed near the ground. Apparently less common in the other counties.

Monroe County: Quite common.

Vigo County: April 1, 1888, four noted.

146. Junco hyemalis hyemalis (Linnæus).

SLATE-COLORED JUNCO; BLACK SNOWBIRD; SNOWBIRD. (567)

Abundant winter resident; perhaps our most familiar winter bird. Arrives from the north about the middle of October and remains until about the middle of April. During the winter these cheery little birds are everywhere,—in the weeds and thickets along the rivers and creeks, in the woods and fields, along the fence-rows, and about the orchards and farm buildings, —in short, wherever there are weeds upon the seeds of which they feed. They even come about the house and pick up any stray crumbs or food that may be put out for them.

There is in Indiana a belief, common among the less well informed, that the black snowbirds suddenly change their dress in the spring and become song sparrows, and that the sparrows in the fall change back to snowbirds!

Carroll County: October 14, 1883, first of the season seen; April 1, 1884, still present but restless as if about to leave; April 13, a few still present; October 14, first of the season seen. March 18, 1885, still very abundant; April 21 left today; common up to a few days ago.

Noted by Miss Ava Evermann near Burlington as follows: January 5, 1907, a few seen in woods with chickadees; October 28, a dozen or more in piles of brush and among low bushes. January 1, 1908, several among brush piles in the woods; February 6, a dozen or more came into the garden, rested a few minutes on the grape vines, then flew away.

Monroe County: January 12, 1883, common.

Vigo County: March 9, 1889, still abundant about Terre Haute.

In July, 1878, I found Juncos nesting on Whiteside Mountain in southwestern North Carolina.

147. Peucæa æstivalis bachmani (Audubon).

BACHMAN'S SPARROW. (575a)

A rather rare summer resident in Monroe County. I knew of perhaps five or six nests in open woodland north of Bloomington between 1882 and 1886. Most frequent in brushy spots in open woodlands.

Not known from Carroll or Vigo.

148. Melospiza melodia melodia (Wilson). SONG SPARROW. (581)

A common summer resident, usually a few remaining through the winter. Every one knows the Song Sparrow. It comes about our gardens, nesting on or near the ground wherever there are vines, weeds, or small bushes to afford protection.

Carroll County: February 16, 1878, collected at Camden; February 6 and 8, 1879, numerous and in full song; noted also on 15th, 25th and 27th (a very cold day), and on March 5 when it was abundant; June 17, 1883, set of three fresh eggs. December 25, 1884, several seen in Dillen's cornfield near Camden, one collected; day cold and snow very deep. Noted by Miss Ava Evermann as follows: October 28, 1907, eight or nine about piles of brush; later the same day saw four or five in a tree top. January 1, 1908, saw five or six in a brush pile in the woods; March 1, one singing in the orchard.

Monroe County: April 21, 1882, set of three eggs, somewhat incubated; February 10, 1883, several noted.

Vigo County: Very common, especially along the river.

149. Melospiza lincolni lincolni (Audubon). lincoln's sparrow. (583)

Rare migrant; noted in Carroll, Monroe, and Vigo counties. Several seen near Terre Haute, April 17, 1888, and again on May 5.

150. Melospiza georgiana (Latham). swamp sparrow. (584)

A rare spring and fall migrant; noted most often in Vigo County, where I have frequently seen it in the marshy ground about the Five-mile Pond.

151. Passerella iliaca iliaca (Merrem). fox sparrow. (585)

A common spring and fall migrant, arriving early in March while the snow still lingers in protected places. Then it may be seen in the copses and underbrush, scratching among the dead leaves that cover the ground.

Carroll County: March 5, 1878, taken; October 25 and November 6, noted; March 8, 1879, common, one collected; March 30, 1884, many noted on the Charley Bowman farm southwest of Camden. March 18, 1885, one seen and collected in Deer Creek bottom above Camden; ground covered with snow in most places.

Monroe County: Appearing about the middle of March and remaining a week or more.

Vigo County: Common early spring and late fall migrant. One of my favorite walks about Terre Haute was along the old canal bed north of town, and there I was always sure to find many fox sparrows any day in March or early April, scratching among the leaves under the low bushes.

152. Pipilo erythrophthalmus erythrophthalmus (Linnæus).

towhee. (587)

A common summer resident, sometimes remaining all winter, as it did in 1888-89, in Vigo County.

Carroll County: March 8, 1879, a pair seen; May 22, 1883, found a nest with five young nearly able to fly; March 19, 1884, first one seen, near Burlington; March 26, 1885, first (a male), seen; April 12, pretty common; on July 12, 1881, found a nest with four fresh eggs, on the home farm. The nest was about 10 inches from the ground in a small bush. This is an unusually late nesting date for this species. Noted at Burlington by Miss Evermann as follows: October 28, 1907, about six in the woods flying from one brush pile to another. January 1, 1908, six or eight seen in thickets; January 3, only one seen in woods where saw six or eight on the first.

Vigo County: Four noted, March 17, and several, March 21 and 24. Nest with three fresh eggs taken near Terre Haute, May 20, 1888.

Monroe County: January 12, 1883, one heard.

In Indiana this bird is known as Marsh robin, French robin, towhee, or joreé.

153. Cardinalis cardinalis cardinalis (Linnæus).

CARDINAL; REDBIRD; KENTUCKY CARDINAL. (593)

Permanent resident in all the counties. One of our most beautiful, interesting and best known birds. Common about old thickets, open woodlands with underbrush, along unkept fence rows, and about the borders of swamps.

Carroll County: Usually rather common, especially along Wild Cat and Deer Creek, even coming into the villages wherever there is suitable cover. May 24, 1883, nest with eggs near Burlington, found by my nephew, Edwin C. Evermann. In the winter of 1883-4, they were exceedingly abundant in Tippecanoe Township, but much less so the following winter, though rather common March 11-18. Less common now than formerly; during a week, June 25 to July 1, 1905, spent on my old home farm, only one was seen. Ava Evermann contributes the following records from Burlington: December 1, 1907, one seen in cedar tree near house; 16th, one on fence covered with a sarsaparilla vine the berries of which it appeared to be eating. January 1, 1908, "while walking in the woods along a deep ravine, I came suddenly upon a bunch of song sparrows, juncos, and chewinks and while listening to their mingled calls, a series of distinct 'tsips' rang sharply above the other notes. After searching for a few minutes, a female Cardinal was discovered high in a tree across the ravine"; February 5, one seen near the house; March 1, the characteristic sharp 'tsip' heard and a male Cardinal discovered not far away.

In 1877, I had a pair of cardinals as pets. I bought them from a man in Hamilton County, August 18, for $2.00 plus $2.50 for the cage! One day the male was let out of its cage and allowed the freedom of a room in the house. Happening to find a parlor match on the mantle, the bird picked it up in its strong bill, when it went off with a loud report which greatly frightened the bird. A short time afterward, I held another match near him which he snapped with disastrous results; for the bird fell over dead, whether from fright or from inhaling the sulphur fumes, I do not know.

Vigo County: A fine male collected near Grant, April 14, 1888; another near Terre Haute, March 2, 1889, by A. J. Woolman, and a pair south of Terre Haute, November 16, following. A nest with one egg in a thorn tree southwest of Terre Haute, April 27, 1890.

Monroe County: April 29, 1882, a nest with two fresh eggs; January 12, 1883, four or five seen. Probably most common in this county. A fine male collected near Bloomington in June, 1888.

154. Zamelodia ludoviciana (Linnæus). ROSE-BREASTED GROSBEAK. (595)

Rather common spring and fall migrant and rare summer resident, arriving from the south about the first of May.

Carroll County: I well remember the first specimen of this beautiful species I ever collected. It was in September, 1877, just when I had begun to take a real interest in birds, and as I was collecting in an open wood on the present J. Milton Beck farm south of Burlington. It was a female in good plumage and was feeding in the top of a tall elm. On May 3, 1883, I saw several, both males and females, in Stone's woods near Burlington. On May 24, I shot a fine plumaged male at the "drift" on Wild Cat Creek above Burlington. A nest with eggs found in a buttonbush (*Cephalanthus occidentalis*), in a swamp west of the Michigan road on the north bank of Wild Cat Creek, in spring of 1882. On May 5, 1884, several seen in Wise's woods southwest of Camden; May 4, 1885, several seen near my house at Camden.

Vigo County: Several seen near Terre Haute, April 28 and 30, and again on May 5, 1888. A female collected on Honey Creek, five miles southeast of Terre Haute, May 12.

Monroe County: Noted, April 23, 1886. Rather common migrant but rare summer resident.

155. Passer domesticus hostilis Kleinschmidt. english sparrow.

This miserable pest is all too common in and about Terre Haute and all over Vigo County, as well as in Carroll and Monroe counties, and the less said about it the better. It made its appearance at Camden in 1877; now abundant in all the counties.

Carroll County: June 17, 1882, set of four fresh eggs. January 8, 1920, as I passed north on the train through Bringhurst, I noted 20 to 30 English Sparrows about a warehouse near the railroad station.

156. Passerina cyanea (Linnæus). indigo bunting. (598)

A common summer resident in all the counties, perhaps most abundant in Monroe and Vigo.

Carroll County: May 18, 1878, collected; June 23, 1882, nest with two nearly fresh eggs; May 13, 1883, first of the season seen near the Air Line bridge on Deer Creek, east of Delphi; May 24, a nest with three fresh eggs found near Burlington, by Edwin C. Evermann. May 6, 1885, a male seen; June 29 to July 1, 1905, one male seen on home farm near Burlington.

Vigo County: Noted at Terre Haute, April 28, May 3 and May 5, 1888.

Monroe County: An abundant summer resident. Noted, May 13, 1882 and April 24, 1886.

157. Spiza americana (Gmelin). dickcissel. (604)

A fairly common summer resident.

Carroll County: I remember distinctly the first specimen of this species I ever recognized. It was a fine male sitting in a small walnut tree in a field at the turn of the road south of Camden, just before reaching the creek. It was singing in its animated way and doubtless had its nest in the field somewhere near by. This was on May 20, 1878. Since then the species has become more common in Carroll County. May 10, 1885, noted. On the last days of June, 1905, two or three were seen and heard singing on the fences about the meadows and along the road at the old home farm.

Vigo County: Equally common summer resident; often noted in the fields north, east, and south of Terre Haute.

Monroe County: Probably more common than in either Carroll or Vigo. Several pairs could be seen any fine day in late spring or early summer in or about the fields north or east of Bloomington.

158. Piranga erythromelas Vieillot. scarlet tanger. (608)

A common summer resident; chiefly in open woodlands and along the streams.

Carroll County: Arrives from the south about the middle of April to the first of May, and remains until in September. October 5, 1878, taken; June 17, 1882, set of three fresh eggs; May 3, 1883, saw several males near Camden; May 12, first female seen; June 11, found a nest with five eggs, two of which were Cowbird's, about 30 feet from the ground in a beech tree in the east woodland on my father's farm near Burlington; incubation had begun. May 5, 1884, first noted, a male and a female; May 11, saw a female building her nest, 50 feet up in a tree in Dillen's woods southeast of Camden; April 23, saw a female in Little Deer Creek bottom near Joseph Trent's; June 25-July 1, 1905, a male seen in pasture west of house on home farm.

This beautiful bird is of especial interest to all ornithologists and others who know about it, as being the bird that kindled in Elliot Coues, when a child, an undying interest in bird life. Dr. Coues's story of the event is so interesting and so charmingly written that I cannot refrain from giving it here. He says: "I hold this bird in particular, almost superstitious, recollection, as the very first of all the feathered tribe to stir within me those emotions that have never ceased to stimulate and gratify my love for birds. More years have passed than I care to remember since a little child was strolling through an orchard one bright morning in June, filled with mute wonder at beauties felt, but neither questioned nor understood. A shout from an older companion—"There goes a Scarlet Tanager!"—and the child was straining eager, wistful eyes after something that had flashed upon his senses for a moment as if from another world, it seemed so bright, so beautiful, so strange. What is a Scarlet Tanager? mused the child, whose consciousness had flown with the wonderful apparition on wings of ecstasy; but the bees hummed on, the scent of flowers floated by, the sunbeam passed across the greensward, and there was no reply—nothing but the echo of a mute appeal to Nature, stirring the very depths with an inward thrill. That night the vision came again in dreamland, where the strangest things are truest and known the best; the child was startled by a ball of fire, and fanned to rest again by a sable wing. The wax was soft then, and the impress grew indelible. Nor would I blur it if I could—not though the flight of years has borne sad answers to reiterated questionings—not though the wings of hope are tipped with lead and brush the very earth, instead of soaring in scanted sunlight."

It was the thoughtless killing of a Scarlet Tanager that gave me my first pang in relation to the destruction of useful birds. It was many years ago.

I was a mere child, but I remember it distinctly, so deep was the impression made upon me. With several older companions we were going, one Saturday afternoon, to the old swimming hole at the mill-dam on Wild Cat Creek above Burlington. One of the older boys had a gun, and as we passed along the edge of the woods at the side of a field a male Scarlet Tanager—it seemed to me the most beautiful bird I had ever seen—appeared on a limb overhanging our path. The boy with the gun, to show his skill, fired and brought it down, not dead but sorely wounded and calling piteously—I can hear it yet; I have never forgotten its cry or the protest which the other boys and I made to our thoughtless companion. I am sure our protest did good, for he is now a kindly, sympathetic man who would protest as strongly as we did then should he see any one needlessly taking the life of any wild bird.

Monroe County: Perhaps even more common than in the other counties. On May 6, 1882, a score or more seen at the north edge of Dunn's woods with unusual numbers of bobolinks and Baltimore orioles, feeding in a small meadow. Noted again in numbers in the same place, April 22 and May 8, 1886. June 2, 1882, a nest with five partially incubated eggs at Wyandotte Cave.

Vigo County: Quite common. First seen in 1888, on April 30, near the Fair grounds. A fine male collected May 12, 1888, near Sand Hill, three miles east of Terre Haute. On April 26, 1890, my student, D. C. Ridgley, shot an unusually beautiful specimen at Sand Hill. It was probably a one-year-old male. The black of wings and tail was very glossy, the red quite clear but pale; back, breast, and sides with numerous patches of yellowish, and in the black of one shoulder was one red feather. This was the first tanager seen that season. Three days later, April 29, near the same place, I secured another unusually marked and very beautiful male. There were three very small patches of olive on the head and five or six larger ones on the rump; from middle of belly backward slightly more than half was light yellow; the shorter under tail coverts were bright red, the others clear yellow. A male noted April 30, another May 2, and May 5, 1888.

159. Piranga rubra rubra (Linnaeus). Summer tanager. (610)

This beautiful tanager is common throughout southern Indiana but apparently does not go much, if at all, north of Vigo County.

In Monroe County, it is a rather common summer resident, arriving from the south in the latter part of April and remaining until late in September. It most delights in the open woodlands of beech and maple. I have seen it most frequently north and east of Bloomington, perhaps merely because my trips afield most often took me in that direction. Although I saw this species often in the seasons of 1882, 1885, and 1886, I find but two entries in my notes—May 20, 1882, shot six (males and females); not very common; April 28, 1886, seen. A female obtained north of Bloomington, May 4, 1886, was remarkable for its very bright plumage, the throat, breast, and crissum being rich orange, while the tail above, and the entire head, were quite red. The sex was determined by dissection and was certain. While on a walking trip to Wyandotte Cave in June, 1882, I saw the Summer Tanager frequently between Orleans and the Ohio River.

In Vigo County I have seen it frequently but never north of Terre Haute. I have the following definite records: A male taken, April 25, 1888, east of the Fair grounds, it being the first of the season. Another male at Sand Hill, May 12, and still another male at Sand Hill, April 29, 1889. May 3, 1891, noted.

160. PROGNE SUBIS SUBIS (Linnaeus). PURPLE MARTIN. (611)

Common summer resident arriving late in March. March 28, 1884, first of the season observed at Camden; April 2, 1885, first of the season in Camden. A week later they were common. April 2, 1888, at Burlington.

In Monroe County, very common; noted at Bloomington, March 28, 1886. Noted at Terre Haute, April 4, 6, and 8, 1888.

Originally nesting in hollow trees, now preferring the martin boxes which many thoughtful people put up for them. In the Southern States it is a common practice to hang large gourds (in the side of which a suitable hole has been cut), on a cross-piece at the top of a tall pole set firmly in the ground in the yard, barn-lot, or garden. One may sometimes see several of these gourds on one pole, and a pair of martins for each of them.

161. PETROCHELIDON LUNIFRONS LUNIFRONS (Say). CLIFF SWALLOW. (612)

Very abundant summer resident and well known bird in all the counties, arriving about the middle of April and remaining until late in September. Nesting commonly under the eaves of barns or other farm building, sometimes on cliffs wherever suitble ones are found.

In Carroll County, noted April 18, 1884, between Delphi and Pittsburg, and on April 23, near Camden. Noted at Terre Haute, April 14, 1888.

162. HIRUNDO ERYTHROGASTRA Boddaert. BARN SWALLOW. (613)

Carroll County: Equally common with the preceding as a summer resident, arriving about the middle of April. July 1, 1882, set of three fresh eggs. April 24, 1884, first of the season noted at Camden; April 16, 1885, four or five seen at Camden. Abundant also in Vigo County. Noted April 8 and 15, 1888. Equally common in Monroe.

This swallow usually nests inside of barns or other buildings attaching its nest to the rafters.

163. IRIDOPROCNE BICOLOR (Vieillot). TREE SWALLOW. (614)

A rare spring and fall migrant. Arrives about the first of April. Most often seen about ponds and streams where it will circle about over the water in search of insects. On April 6 and 7, 1885, this swallow was abundant at Lake Maxinkuckee, flying about over the edge of the lake in pursuit of insects, alighting now and then on the limbs of a dead tree on the shore, prospecting for suitable holes in which to nest; common about the lake in spring and fall in all years from 1899 to 1913, on which observations were made. I have seen it near Camden early in April, flying about over the Armstrong pond. In Monroe and Vigo counties, I have noted it only in the spring and even then only rarely. Probably nests in the northern part of the state, but not in Carroll, Vigo or Monroe County.

A beautiful and attractive little swallow, readily known by its white belly.

164. Riparia riparia (Linnaeus). bank swallow. (616)

A common summer resident: most abundant along the river and creeks, nesting in holes in the banks. Arrives early in April; April 6, 1884, on Deer Creek just above Camden, and April 8, 1885, three or four seen on Deer Creek near Camden cemetery. Not so common in Monroe County, but quite common in Vigo. Noted April 10, and 15, 1888. Very abundant at Lake Maxinkuckee nesting in holes in the bluff at the gravel-pit where the young are often seen in large numbers in summer and fall sitting on the telegraph wires along with even greater numbers of cliff swallows.

165. Stelgidopteryx serripennis (Audubon).

rough-winged swallow. (617)

Summer resident in all the counties but not so common as the Bank Swallow. At Gosport north of Bloomington nearly completed nests were found May 8, 1886. At Terre Haute many noted, April 21, 1888.

The habits and general appearance of the two species are very similar and it is difficult to distinguish them except with specimens actually in hand.

166. Bombycilla garrula (Linnaeus). bohemian waxwing. (618)

I have noted this beautiful bird only in Carroll County, and that many years ago when I saw a flock of perhaps a half dozen in some cedar trees in my father's yard.

167. Bombycilla cedrorum Vieillot. cedar waxwing. (619)

Common summer resident, arriving rather late in spring but remaining quite late in the fall: sometimes present all winter. Usually going in small flocks. Nesting late in the summer, the nest often placed on a horizontal limb of some apple tree in an orchard.

Carroll County: December 31, 1878, observed; February 27, 1879, a large flock seen in an orchard feeding on frozen apples that were still hanging on the trees; many were seen again on March 1 and 5, feeding in hackberry trees in Deer Creek bottoms east of Camden; June 26, 1882, set of 5 fresh eggs, nest in an apple tree in orchard on home farm. On May 24, 1883, several seen at the drift on Wild Cat Creek above Burlington, where I had noted them as being quite common the summer before. They were at rest and remained most of the time in some soft maples which overhang the creek. From these trees they would frequently dart out over the creek in pursuit of insects which they were quite expert in capturing. In the summer of 1883 and 1884, several nests, usually in apple trees, were found near Burlington. During the winter of 1883-4, these birds were common about Camden. On February 8, 1885, saw a flock of a dozen in cedar trees in Dr. Armstrong's yard in Camden.

Vigo County: Equally common and well known; numbers observed about Terre Haute every summer.

Monroe County: Noted every summer; small flocks often seen in winter; February 10, 1883, a dozen or more seen near Bloomington.

168. Lanius borealis Vieillot. great northern shrike. (621)

I have seen this species only in Carroll County. On January 8, 1884, I saw one in Madison Township just west of Daniel H. Schnepp's, and ten days later I shot one from an apple tree at Mr. Noble's, two miles northeast of Camden. The weather had been very cold with much snow for two weeks, and the snow very deep.

169. Lanius ludovicianus excubitorides Swainson.

white-rumped shrike; butcher-bird.. (622a)

A rather common resident, especially in Carroll and Vigo counties.

Carroll County: In the summer of 1882, noted several in the prairie west of the Wabash, and one or two along an osage orange hedge northeast of Delphi. On November 13, one seen near Woodville, and the next day one seen on the Dayton pike near Pyrmont. J. Milton Beck saw one near Burlington about the same time. On May 11, 1883, one seen in field between Delphi and Pittsburg. On March 27, 1884, one seen just south of Camden; May 10, nest with six eggs somewhat incubated, in hedge west of Pittsburg; May 27, saw one on Michigan road north of Burlington. The species is increasing in this county.

Monroe County: A very rare resident in 1881-86. I have no definite records.

Vigo County: Quite common, especially in the prairie parts of the county. I have seen several nests. On April 26, 1890, one with six well incubated eggs 10 feet from ground in a honey locust southeast of Terre Haute. Several others seen in osage orange hedges south and southeast of Terre Haute. A set of six gotten near Frankfort, April 21, 1888, by Al. J. Keyes; nest in hedge, only six feet from ground.

170. Vireosylva olivacea (Linnaeus). red-eyed vireo. (624)

A common summer resident. Frequents the open woods and the edge of forests. Of all our singing birds this is the one which sings most continuously throughout the day. Even in the heat of the day when most birds are quiet this vireo, often called "preacher", may be heard.

Carroll County: 1883, May 3, first seen, but already common; June 18, nest with two fresh eggs. In 1884, first noted, May 2; noted again, May 5, south of Camden. First seen in 1885, on May 4. On June 10, 1883, found nest with two cowbird eggs and one vireo, which was slightly broken, apparently picked by the cowbird.

Vigo County: A male collected, April 28, 1888, five miles southwest of Terre Haute; many seen. Others noted April 30.

Monroe County: One of the most common residents from the last of April to late in September.

171. Vireosyla philadelphia Cassin. philadelphia vireo. (626)

Spring and fall migrant, possibly a rare summer resident. Arrives in Carroll County from the south early in May. On May 13, 1884, collected one in a thicket on the hillside opposite Porter's mill on Deer Creek. Several others were seen. They were not as mute as stated by some observers.

In Vigo County I took a male near Hunt's, three miles southeast of Terre Haute, May 15, 1888; another was seen May 5. I have noted the species in Monroe County.

172. Vireosylva gilva gilva (Vieillot). warbling vireo. (627)

This cheery little bird is a rather common summer resident in all the counties, often coming about the house and nesting in the trees in the orchards and yards. In Carroll County I noted it frequently from the early part of May onward. May 25, 1878, seen; June 19, 1882, set of three well incubated eggs; June 20, 1883, nest with three fresh eggs; in 1884, first observed on May 2; again seen on May 7. In 1885, noted on May 6; on June 16, found a nest with two fresh eggs in an apple tree in our orchard.

In Vigo County I collected a pair (male and female), near Hunt's three miles southeast of Terre Haute, May 15, 1888.

In Monroe County it was noted, April 26, 1886, and at many other times.

173. Lanivireo flavifrons (Vieillot). yellow-throated vireo. (628)

A fairly common spring and fall migrant; seen most frequently on wooded hillsides. Noted near Camden, May 5, 1884. A male taken near Sand Hill three miles east of Terre Haute, May 12, 1888. A pair (male and female), taken at same place, April 30, 1890. A male taken in woods northeast of Bloomington, May 4, 1886; others seen, April 17.

174. Vireo solitarius solitarius (Wilson). blue-headed vireo. (629)

A fairly common spring and fall migrant; usually seen in deep woods and along the streams.

Carroll County: Collected two males in an oak grove in the prairie near the New Beauty schoolhouse in Tippecanoe Township, May 10, 1884. I think I saw a few others. These were the first of the season.

Monroe County: A female taken in Ferris woods northeast of Bloomington, May 4, 1886; first one noted.

Vigo County: It occurs in Vigo County during the migrations but I have no definite records.

175. Vireo griseus griseus (Boddaert). white-eyed vireo. (631)

A rather common spring and fall migrant; possibly a rare summer resident. I have seen it often in all the counties.

Carroll County: April 28, 1885, two seen.

Vigo County: One specimen taken near Terre Haute May 12, 1888.

Monroe County: One noted. April 28, 1886, near Rocky Run road north of Bloomington. It was on a hillside and warbling joyously.

176. Mniotilta varia (Linnæus). black and white warbler. (636)

A rare summer resident, but more common during the migrations. An interesting little bird, climbing around the tree trunks after the manner of a creeper. Nests on the ground in the woods, at the base of some small shrub or bunch of weeds.

Carroll County: 1884, April 28, first noted and common. May 10, one collected near the New Beauty schoolhouse, Tippecanoe Township; 1885, April 26, first of season seen, on Deer Creek above Camden.

Vigo County: A male collected, April 26, 1888, by J. D. Collins near the river north of Terre Haute; another by me May 10, 1890, at Sand Hill east of Terre Haute; and a week later still another at the Goose Pond nine miles south of Terre Haute.

Monroe County: Common; often seen on the densely wooded hillsides northeast of Bloomington.

177. Protonotaria citrea (Boddaert). golden swamp warbler. (637)

This is to me the most beautiful and interesting of all our warblers Except for one fine male collected and two females seen, May 7, 1885, at a little pond near the Leonard mill east of Camden and, possibly, one in a willow swamp southwest of Terre Haute in May, 1889, I know this bird only from the old Maple Swamp between Sedalia and Cutler, Carroll County and just east of the Vandalia railroad. I visited this swamp on May 21 1883. Soon after entering the swamp I caught a glimpse of a bright-colored bird as it flew from a hole in a small dead snag not far away and disappeared in a thicket near by. Soon it reappeared, evidently solicitous for its treasures which were in the nest in the old snag. By short flights and with much anxiety, it approached the snag and I saw that it was the Golden Swamp Warbler. Its nest contained five beautiful fresh eggs. Later in the day several other nests were found which we did not molest, one of four, one of three, and five or six not yet completed. They were all in deserted sapsucker holes, or similar holes in small dead snags or trees and four to ten feet above the water.

In another part of the swamp were several of these birds not yet mated. The pairing season was on, and the birds were in active courtship. Many a combat between rival males was witnessed. Near the center of the swamp was an acre of comparatively open water, a pond in fact, covered with a thick growth of water-lilies. From the edge of this pond a couple of males darted by us across the open space, then circled about the pond, the one in close pursuit of the other. Often they crossed and recrossed the open water, circled around its margin, then darted off through the trees and disappeared from view, only to return again after a time and repeat the same performance. Sometimes the one was not a coward and stood his ground. Then a fierce conflict occurred; frequently they would clinch and fall nearly to the water before letting loose. Then they would ascend in a spiral flight far up among the tree tops, only to return promptly to the pond again. Then they separated, one of them flying in a slow fluttering sort of way across the open space to an old snag in which the female was building the nest. With wings bent downward and tail outspread so as to show plainly the white outer feathers, he would give expression to his happiness in an excited but pleasing little song which I wish I could describe, were I good at that sort of thing. Then he perched upon a limb just above my head, where, with dropping, tremulous wings, and head erect, he warbled very prettily his delicate little song of love, oblivious of all except of her who was so busy at the old willow snag. Although she seemed very busy indeed, she doubtless heard the little song and understood full well its subtle meaning.

I again visited this swamp, May 21, 1885. Several Golden Swamp Warblers or Prothonotarias were seen chasing about, across and around the open spaces among the trees that stood in water one to three feet deep. The season was evidently later than it was in 1883. Several nests were found but laying had not yet begun. The males were in full song and a very pretty sight they made.

The nests, examined critically on my first visit, were, as already stated, always occupied deserted sapsucker or similar holes usually in small rotten trees, saplings or snags, and varied from four to ten feet above the water. One examined was about six feet up in a very rotten snag not over four inches in diameter. The shell left by the excavation of the hole was very thin, less than half an inch. The cavity was but four inches deep and was filled nearly to the top by the nest which was composed almost entirely of some species of moss. Several other nests situated in similar places and constructed from similar materials were seen.

178. Helmitheros vermivorus (Gmelin). worm-eating warbler. (639)

Common summer resident in Monroe and Vigo counties; not noted in Carroll. Nests on the ground. I have seen nests in the woods east of Terre Haute, also near Coal Creek northwest of that city. April 20, 1887, nest with three eggs at Pine Hills, Montgomery County. On April 28, 1888, I collected a fine specimen about five miles southwest of Terre Haute.

On May 4, 1886, I collected a pair about two miles northeast of Bloomington. The first (a male) was in a thicket on a hillside near an old road. When first seen it was near the ground, then it flew into a bush about eight feet up. About a half mile further north I obtained a female. When first seen it was on the ground at the bottom of a small cañon. Besides these two, several others were observed on the same day. One pair seen building a nest at the foot of a small maple sprout on a hillside facing west. The nest was not nearly completed. One of the birds, probably the female, was carrying dead leaves with which she made the bottom and outside walls. She would come near the nest while I was sitting within 20 feet of it, eye me suspiciously, fly away some distance, return by short flights, then fly away again, only to repeat the maneuvers again until I moved farther away, then she came to the nest and proceeded with the building.

On May 13, I found a nest with five eggs plus two of the cowbird. Prof. W. S. Blatchley found a nest with six eggs of the warbler and one cowbird. Both of these nests were on a hillside and each was at the base of a small shrub. All the eggs were fresh.

179. Vermivora pinus (Linnæus). blue-winged warbler. (641)

Common spring and fall migrant; and rare summer resident at least in Carroll County. About the first of July, 1883?, I saw a nest of young nearly able to fly. The nest was in a clump of wild rose bushes on the home farm, just west of the house. The old birds were seen and positively identified. Noted April 28, 1884. Specimens were taken May 10, 1884; and May 4, 6, 11, and 21, 1885. A fine adult male collected April 27, 1886, north of Bloomington. It was feeding among the young buds in the top of an elm. Every now and then it would utter a weak grasshopper-like note. It was alone and the first one seen that year. Several others were seen the next day. I have no records for Vigo County.

180. Vermivora chrysoptera (Linnæus). golden-winged warbler. (642)

A rare spring and fall migrant. The only specimen I ever collected in Carroll County, I shot in the grove just north of the railroad bridge at Camden, May 6, 1885. G. G. Williamson obtained one at Bloomington in the spring of 1886. On May 2, 1888, I secured a fine male near Terre Haute.

181. Vermivora rubricapilla rubricapilla (Wilson).

nashville warbler. (645)

Common spring and fall migrant; arrives from the south about the first to tenth of May; usually frequenting the upper parts of the tree-tops, not so common near the ground.

On May 9, 1883, shot two on home farm near Burlington; after this date many others seen. May 13, 1884, shot one in an old orchard near Porter Sterling's, southwest of Camden; first of season. Common May 4-7, 1885. A male collected April 30, 1888, near the fair grounds east of Terre Haute; a female at Sand Hill, ten days later. One noted April 27, 1886, near Bloomington.

182. Vermivora celata celata (Say). orange-crowned warbler. (646)

Apparently a very rare migrant. I have but one record and that is of a specimen I collected May 5, 1888, on Honey Creek, 5 miles southeast of Terre Haute.

183. Vermivora peregrina (Wilson). tennessee warbler. (647)

A common spring and fall migrant.

Carroll County: May 22, 1883, shot two near Burlington. Noted also May 12, 1884, and May 4 to 19, 1885, when it was very common.

Vigo County: Many noted at Sand Hill May 9-12, 1888, and a male collected May 12; another male collected at the Goose Pond May 3, 1890.

Monroe County: Very common; often noted in May, usually high up in tree-tops.

184. Compsothlypis americana americana (Linnæus).

PARULA WARBLER. (648)

A fairly common spring and fall migrant. Especially common in Carroll County May 4 to 10, 1885; collected a male May 6, 1885.

In Vigo County many noted May 9, 1888, and a brilliantly colored male collected at the Sand Hill, April 24, 1890.

Noted also in Monroe County especially in the spring.

185. Dendroica tigrina (Gmelin). CAPE MAY WARBLER. (650)

A common spring and fall migrant. Arrives about the middle of May; most common in low trees along streams. Noted in Carroll County May 8, 1885, and on many other dates. Noted in Vigo County May 8 and 9, 1888; also on May 10 when a female was collected at Sand Hill; again on May 17, 1890, when a pair were collected at the Goose Pond. Equally common in Monroe County; often noted along Griffy and Beanblossom creeks. ,

186. Dendroica æstiva æstiva (Gmelin). YELLOW WARBLER. (652)

A fairly common summer resident. Arrives from the south in the latter part of April and remains until in September.

This beautiful little bird is our most common and familiar summer resident warbler. One or more pairs may usually be seen in any patch of willows along the river or any creek or about ponds. It is also frequently seen in the orchards. It builds a very pretty nest of grayish vegetable fiber, fastening it to twigs of fruit or shade trees or willows or low shrubbery of any kind.

Carroll County: May 22, 1883, shot one in yard on home farm; first of season noted. In spring of 1883, obtained several at Miller's pond near Burlington, the only one seen there prior to May 8, 1884. May 8, 1885, saw one in old orchard near Springboro, first of season; two seen on 12th and one got in Dolph McKinney's yard in Camden; on 13 saw two and got one in an old orchard near Porter Sterling's south of Camden; April 28, 1885, saw one or two near Pittsburg, and again May 4.

Vigo County: April 22, 1888, two seen; May 15, a female collected southeast of Terre Haute; May 1, 1890, a male collected 5 miles south of Terre Haute; May 17, a female shot at the Goose Pond; April 28, 1891, noted.

Monroe County: May 13, 1882, several; May 4, 1886, a male collected in orchard north of Bloomington, first of season; 6th, two seen, one collected, in White River bottoms near Gosport.

187. Dendroica cærulescens cærulescens (Gmelin).

BLACK-THROATED BLUE WARBLER. (654)

A fairly common spring and fall migrant. Most often seen on or near the ground in low shrubbery in open woods.

Carroll County: May 3, 1883, one seen near Burlington, and again on the 8th; on 10th and again on 13th, saw one or more between Camden and Delphi; May 7, 1884, saw a few and collected one near the Frank Thomas pond south of Camden, first noted; noted again May 4, 1885.

Vigo County: April 28, 1888, a male shot 5 miles southeast of Terre Haute; May 17, 1890, a female collected at the Goose Pond.

Monroe County: Frequently noted in the small wooded gulches northeast of Bloomington and along Griffy Creek.

188. Dendroica coronata (Linnæus). myrtle warbler. (655)

Perhaps our most abundant warbler. Sometimes a few individuals may remain all winter. I think I have seen them every month in the year except in January. They may be seen almost anywhere, in low bushes, in tall trees, about the yards and orchards, in the hedges along the roadside, and particularly along the streams.

Carroll County: April 30, 1878, first taken at Camden; October 5, again taken at Camden. April 20, 1884, many noted near feeder dam on Wabash River at Delphi; 23d, seen on Deer Creek above Camden, shot a male; 21st to 26th, common, first female noted on 26th.

Vigo County: April 14, 1888, shot a male at Grant; May 5, 1889, noted; April 30, 1890, two males and a female collected at Sand Hill.

Monroe County: February 10, 1883, saw eight or 10. During the winter of 1882-3, I think this warbler could be seen at any time; I saw one or more every time I went into the woods.

189. Dendroica magnolia (Wilson). magnolia warbler. (657)

A common spring and fall migrant. Most usually seen feeding among the lower branches of trees.

Carroll County: May 4, 1878, took the first specimen I ever collected, in a woods northwest of Camden. May 9, 1883, shot one near Burlington; 23d, got two near Burlington; April 20, 1884, first noted; 7th, collected one near the Thomas pond south of Camden; May 7, 1885, saw two or three, collected one.

Vigo County: May 2, 1888, collected a male; 5th, noted; 12th, shot a female at Honey Creek five miles southeast of Terre Haute; 15th, collected a male on the Hunt farm; and 17th, obtained a male at the Goose Pond.

Monroe County: Frequently seen, especially along the creeks.

190. Dendroica cerulea (Wilson). cerulean warbler. (658)

A common spring and fall migrant; a few may remain to breed. Arrives in the first days of May.

Carroll County: May 9, 1883, quite common; 23d, shot one near Burlington. May 5, 1884, first noted, got two; 8th, common.

Vigo County: May 2, 1888, got a male east of the fair grounds; April 28, 1890, got a male on Cruft's commons in Terre Haute; 30th, got two males at Sand Hill. May 3, collected a male at the Goose Pond.

Monroe County: Common migrant; most frequent rather high up in the trees.

191. Dendroica pensylvanica (Linnæus).

CHESTNUT-SIDED WARBLER. (659)

Common spring and fall migrant. Arrives about the middle of May. Frequents the tops of tall trees.

Carroll County: May 22, 1883, first of the season noted, got two. May 7, 1884, first of season. May 4, 1885, first noted, several seen, two collected. One of the best places to find these beautiful warblers was in the woodland in the bend of Deer Creek just below Camden.

Vigo County: First noted in 1888, on May 5, when got a male on Honey Creek; 7th and 12th seen again, collected three at Sand Hill. May 3, 1890, a male at the Goose Pond; 10th, a male collected at Sand Hill.

Monroe County: I noted it May 4, 1886, when I saw several northeast of Bloomington, and collected one male.

192. Dendroica castanea (Wilson). BAY-BREASTED WARBLER. (660)

Common spring and fall migrant. Arrives early in May; most frequent along the streams or in the apple trees about the house.

Carroll County: May 4, 1878; May 22, 1883, saw three; 24th, collected one; May 5, 1884, first of season noted near Camden, which I collected; May 5, 1885, collected a male. Abundant in May in the woods in the creek bottom just below Camden.

Vigo County: May 5, 1888, one seen; 9th, noted; 11th, noted; 10th, male collected at Sand Hill; 17th, a pair obtained at the Goose Pond.

Monroe County: May 4, 1886, a male collected in the Ferris woods, first of the season noted by me, but Chas. H. Bollman noted it a few days earlier; 6th, a fine male collected in the same woods.

193. Dendroica striata (J. R. Forster). BLACK-POLL WARBLER. (661)

Common spring and fall migrant. The last of the warblers to arrive in the spring; when the Black-polls appear the migrations are about over.

Carroll County: I first took this species May 3, 1878, near Camden. May 21, 1883, got a pair in the Maple swamp; noted daily from 23d to 25th; saw others and collected some May 21, 1885.

Vigo County: I recorded this warbler May 8, 1888, 12th (collected a male at Sand Hill), and 17th when got a female at the Goose Pond.

Monroe County: Apparently not very common, but at least a few seen every spring, usually well toward the tree-tops.

194. Dendroica fusca (Müller). BLACKBURNIAN WARBLER. (662)

Rather common spring and fall migrant. Often seen in the fruit trees about the house; appearing just when the apple trees are in full bloom, about the last of April. Of all our warblers, I think this was the first to attract my attention. More years have passed than I care to remember since, as a small boy, while playing one morning in the yard in the rear of my father's house near Burlington, I was fascinated by the beauty of an apple tree that had burst into full bloom over night as it were. While gazing in rapt wonder at the beautiful tree with its fresh waxy green leaves and its even fresher delicately beautiful flowers. I was startled and delighted by the arrival in the tree of what seemed to me the most beautiful bird I had ever seen. Its rich colors as it moved about among the blossom-laden branches charmed me. Of course, I did not then know what it was; I knew only that it was a bird, and the prettiest I had ever seen. But the vision has remained most distinct in my memory to this day, although it was many years afterward before I became especially interested in birds; and then, one day, while collecting, I secured an adult Blackburnian warbler in full plumage. Then the vision came back to me and I realized that this was the same bird that had so charmed me on that sweet morning in early May long ago.

In Carroll County, I collected one near Burlington, May 24, 1883, another near Pittsburg, April 28, 1885, and saw another May 8.

In Vigo County, I have noted it May 5, 1888, also May 8. May 17, 1890, collected two males at the Goose Pond.

In Monroe County, a few might be seen each spring, especially in the orchards and open thickets. One collected April 27, 1886.

195. Dendroica dominica albilora Ridgway. sycamore warbler. (663a)

Spring and fall migrant: not common: perhaps a few remain to breed. Arrives as early as the middle of April.

Carroll County: May 9, 1883, one noted; May 24, shot one on Wild Cat Creek near the dam above Burlington. April 20, 1884, one or two seen on the Wabash near Delphi; April 23, one seen on Deer Creek west of Camden. April 23, 1885, collected two on Little Deer Creek near Joseph Trent's.

Vigo County: My only record is of a male taken and another seen at Grant, April 14, 1888.

Monroe County: Apparently a summer resident, breeding near water courses, though I never actually found a nest. A specimen collected April 16, 1886, on Griffy Creek.

196. Dendroica virens (Gmelin). black-throated green warbler. (667)

One of our most abundant spring and fall migrants; arrives in spring in the last days of April, and in the fall early in September.

Carroll County: May 3, 1883, several seen, one collected. May 5, 1884, first noted, one collected on Deer Creek below Camden. April 28, 1885, one or two seen near Pittsburg; next seen May 4.

Vigo County: May 2, 1888, a male taken at the fair grounds, first of season noted; 15th, a female taken at the Hunt farm. April 24, 1890, noted, and 30th, a male taken at Sand Hill; May 17, a female at Goose Pond.

Monroe County: Common everywhere in thickets and low forests and underbrush in April and May, and again in September. Collected May 4, 1886.

197. Dendroica vigorsi (Audubon). pine warbler. (671)

Spring and fall migrant: not common. My only definite record is of a pair collected near Camden, April 29, 1885. I had other specimens collected in Carroll County, also specimens collected in Vigo County, but they, as well as the records, burned up in the fire of March 8, 1888. I have no record for Monroe County.

198. Dendroica palmarum palmarum (Gmelin). palm warbler. (672)

Migrant; much more common in spring than in the fall. Most frequent along fence-rows, near and on the ground.

Carroll County: Several seen and a few collected in the Deer Creek bottoms east of Camden, April 21, 1885. Among the places where I remember to have seen these interesting little birds in unusual numbers is along the road east of Camden just where it comes down to the creek above the old Dillen farm. I remember on one occasion (probably in April) there were a score or more along the fence and even out in the road. On another occasion many were seen along the road from Camden to Delphi at the old Bragunier farm.

Vigo County: April 21, 1888, one seen; April 30, 1890, two males collected at Sand Hill; May 1, four males and one female collected at the 5-mile pond north of Terre Haute.

Monroe County: Not common; one taken May 6, 1886.

199. Dendroica discolor (Vieillot). prairie warbler. (673)

One specimen taken in Monroe County, April 26, 1885, by the late Charles H. Bollman.

200. Seiurus aurocapillus (Linnæus). oven-bird. (674)

A common summer resident; frequenting the deep woods where its loud ringing note may be heard on any quiet day during spring and early summer. The Oven-bird is one of the frequent victims of the parasitic habits of the cowbird. On May 28, 1883, a nest with full complement of Oven-bird eggs and two eggs of the cowbird was found by Vern Beck, near Burlington. Incubation was well advanced in all.

On May 23, 1890, I found an Oven-bird's nest at Turkey Run, Parke County, which contained 2 cowbird eggs in which incubation had begun, but there were no Oven-bird eggs. Noted in Carroll County May 4, 1885, and on many other occasions. Noted in Vigo County April 25 and May 3, 1888, three miles southeast of Terre Haute; and May 10, 1890, a male collected at Honey Creek south of Terre Haute. Common in Monroe County; noted April 24, 1886, near Bloomington.

201. Seiurus noveboracensis noveboracensis (Gmelin).
water-thrush. (675)

A rather infrequent spring and fall migrant; most often seen along the streams. May 5 and 12, 1888, seen near Terre Haute; a male collected at Sand Hill on 12th and a female on 15th at the same place. It occurs also in Monroe County.

202. Seiurus motacilla (Vieillot). louisiana water-thrush. (676)

A rather rare summer resident, breeding along the banks of streams or about woodland ponds.

Carroll County: Noted May 6, 1884, and May 5, 1885, near Camden. A nest found many years ago among the roots of a large tree that had been blown down, on my father's farm.

Vigo County: April 11, 1888, noted; 17th collected a male east of the fair ground at Terre Haute; April 14, 1889, and May 1, 1890, noted.

203. Oporornis formosus (Wilson). kentucky warbler. (677)

A not very common summer resident. Perhaps more common in Monroe and Vigo counties than in Carroll. Bloomington, May 6, 1886; June 4, 1886, Mr. Blatchley found a nest with large young. Found breeding north of town in June. A nest with five fresh eggs and one cowbird egg at Eel River Falls, Owen County, June 1, 1889.

204. Oporornis agilis (Wilson). connecticut warbler. (678)

A rare spring and fall migrant. Arrives about the middle of May.

I have few records of this bird. May 21, 1883, shot one near the Maple swamp in Carroll County, and noted another May 21, 1885, in same locality. I have seen it also in Vigo and Monroe counties.

205. Oporornis philadelphia (Wilson). mourning warbler. (679)

A rare spring and fall migrant; most often seen in heavy underbrush in woodlands and along old fence-rows.

I have only one record, and that is of one taken May 21, 1885, near the Maple swamp in Carroll County.

206. Geothlypis trichas trichas (Linnæus).

maryland yellow-throat. (681)

One of our most common and interesting summer residents among the warblers; most often seen in the low shrubbery, marsh grasses and vines about creek borders and ponds and marshes.

Carroll County: May 11, 1878, one collected; set of three fresh eggs taken May 22, 1883, nest in edge of a pond on home farm, and on June 12, young able to fly; May 5, 1885, first of season, a female, seen near Burlington; April 24, 1885, a pair noted in a thicket in Carrollton Township, first of season.

In Parke County, found a nest with four eggs and one of the cowbird, about a foot from ground in weeds in edge of a field at Bryant's Ford, eggs all fresh.

Vigo County: April 28, 1888, many seen, a male collected, five miles southwest of Terre Haute; May 3, a female collected three miles southeast of Terre Haute on the Hunt farm.

Monroe County: Common; one collected April 28, 1886.

207. Icteria virens virens (Linnæus). yellow-breasted chat. (683)

A tolerably common summer resident, frequenting dense thickets, vine-covered fence-rows, and similar places. Apparently this curious and interesting bird has become more common in recent years. Prior to 1879, I never observed it in Carroll County.

Carroll County: May 8, 1883, I heard and saw this bird for the first time in Carroll County. It was in Stockton's woods near Burlington. The next day I heard it again on the same farm. These two were the only places where I heard it that year. The next year a pair remained all summer in a thicket on the Armstrong hill southeast of Camden; they evidently nested there. Noted again May 5, 1885, near Camden, also near Burlington.

Vigo County: I noted it April 4, 1888, when I saw four or five, and again, May 3, when I collected a male three miles southeast of Terre Haute.

Monroe County: Noted near Bloomington May 13, 1882, and doubtless seen at other times.

208. Wilsonia citrina (Boddaert). hooded warbler. (684)

Rather rare summer resident.

My only Carroll County records are of two males collected near Camden, May 5, and others seen May 18, 1885. And the only Vigo County record is of a male taken east of the fair grounds, May 2, 1888. Mr. G. G. Williamson found a nest with six young in Monroe County, May 26, 1886. One seen by me May 8 of the same spring.

209. Wilsonia pusilla pusilla (Wilson).

wilson's warbler. (685)

Somewhat more common than the preceding as a spring and fall migrant.

I have but one Carroll County record, May 18, 1885, when I collected a specimen near Camden. In Vigo County, I obtained a male at the Hunt farm, May 3, 1888, two males at Sand Hill, May 12, and another male at Hunt's, May 15. My only Monroe County record is of one collected May 8, 1886.

210. Wilsonia canadensis (Linnæus). canada warbler. (686)

Rather rare migrant.

Carroll County: May 24, 1883, shot two, the first I ever saw, near Burlington; May 12, 1885, got one; several others obtained May 12 to 18, near Camden.

Vigo County: May 2, 1888, got a male; May 3, saw one; and May 12, got a male on Honey Creek five miles southeast of Terre Haute.

Monroe County: May 4, 1886, got a female northeast of Bloomington; only one seen.

211. Setophaga ruticilla (Linnæus). redstart. (687)

This beautiful little bird is one of our most common summer residents. It is usually seen in the deep woods especially near water.

Carroll County: June 12, 1882, nest with three fresh eggs in a small elm in the Maple swamp. Arrived from the south on May 3 in 1883, and by the 19th, both sexes were common. On June 13, I found a nest with three partially incubated eggs, 15 feet from the ground, in a beech tree in Stockton's woods near Burlington. On May 21, a nest with five fresh eggs was foun about eight feet from ground in a small elm tree in the Maple swamp near Lexington. Noted May 6, 1884, and May 4 and 6, 1885.

Vigo County: May 3 and 5, 1888; May 12, a male collected on Honey Creek.

Monroe County: Usually a common summer resident, but not many seen in 1885 or 1886.

212. Anthus rubescens (Tunstall). pipit. (697)

Spring and fall migrant; not very common; goes north early in the spring and may be seen along the streams even before all the snow has gone.

One of my earliest and most pleasant recollections of this interesting little bird is of a walk one afternoon, March 19, 1879, along the banks of Deer Creek above Camden. Snow still covered the ground everywhere except in a few small areas here and there and along the immediate shores of the creek. Just east of the railroad was a narrow strip of naked ground on the north bank of the stream and there I came suddenly upon a flock of about 20 Pipits feeding near the water's edge. They were not easily frightened and permitted me to approach within a few yards of them, thus giving a good opportunity to observe them closely. They were feeding busily and seemed to find their food chiefly close to the water. After they had apparently exhausted the supply at that place they flew, singly or in twos or threes, to a similar place farther down the creek.

In Vigo County I have recorded the Pipit on April 12, 13, and 15 to 25, 1888. It doubtless occurs in Monroe County, but I have no record.

213. Mimus polyglottos polyglottos (Linnaeus). mockingbird. (703)

A very rare summer resident. We have seen it in Vigo County only three times; twice south of Terre Haute near Honey Creek, and once just south of the blast furnace about an osage orange hedge.

In Monroe County, we have seen it but once, on April 29, 1882, a fine male in full song in the cemetery just west of Bloomington. Charles H. Bollman had seen it previously near Bloomington. A month later—May 29—while on a geological and natural history tramp to Wyandotte Cave, we saw one in Orange County about 35 miles south of Bloomington. It has never been observed in Carroll County.

214. Dumetella carolinensis (Linnaeus). catbird. (704)

Perhaps our most familiar and best known summer resident among our songbirds; common about the gardens, orchards, fields and open woods wherever there are thickets or briar patches. Arrives from the south April 20 to May first. Nests with full sets of eggs by May 15 or 20.

Carroll County: July 14, 1882, nest with three fresh eggs. May 3, 1883, first noticed this morning, rather common; May 21, nests with two and four eggs near the Maple swamp; several others seen. After this date the species was common. April 27, 1884, two or three seen between Camden and Burlington. April 23, 1885, Mrs. Evermann saw two in our garden at Camden and the next day I saw two east of Camden.

Vigo County: April 28, 1888, saw several and collected a female near the Wabash above Terre Haute. Very common summer resident in Vigo, as it is also in Monroe County.

215. Toxostoma rufum (Linnæus). brown thrasher. (705)

Next to the catbird, this is our most familiar summer resident songster, frequenting much the same sorts of places as the catbird chooses, and much resembling it in song. Arrives about the first of April, begins nesting early in May. Young birds ready to leave nest by May 25 to 30. Favorite nesting places for the Brown Thrasher are the osage orange hedges. Numerous nests could be seen each spring in the hedges south of Terre Haute. Another place where nesting birds could be found was in the briar patches and thick under brush along the old canal.

Carroll County: June 19, 1882, nest with two fresh eggs; May 28, 1883, saw young birds nearly full grown. April 3, 1884, three seen in barnyard at my old home near Burlington, the first of the season. Heard others at Camden the next day. April 2 was very stormy, raining and snowing all day, but the 3d, was pleasant. May 21, found several nests, some with young, others with eggs, in briar patches and thickets at edge of the old Maple swamp south of Cutler. April 5, 1885, heard first of the season this afternoon at Camden. In 1883, I found a nest on the end of a fence rail protected by a rather dense clump of rose bushes.

Vigo County: April 8, 1888, ten noted; seen again on 10th and 11th; 21st, collected a female at Honey Creek five miles south of Terre Haute. April 27, 1889, a male collected near Terre Haute. May 3, 1890, four nests, with 4, 4, 3, and 5 eggs, respectively, all fresh or nearly so, in osage orange hedge 7 miles south of Terre Haute.

Monroe County: May 22, 1882, nest with two fresh eggs. Very common in Monroe, as it is in Vigo and Carroll counties.

216. Thryothorus ludovicianus ludovicianus (Latham).

carolina wren. (718)

A rather rare permanent resident in each of the counties, most evident in the fall or early winter; apparently increasing in abundance.

Carroll County: First noted in the fall of 1877, October 10 to November 16. Heard February 27, 1879, a very cold day; noted singing sweetly March first. Noted often in the winter of 1883-4, especially February 8 to 24.

Vigo County: One (female) obtained near Terre Haute April 29, 1890, by W. J. Whitaker. A male and female collected at Sand Hill January 24, 1891. Obtained one and saw another May 13, 1882.

Monroe County: Very common in the winter of 1882-3. A male collected January 12, 1883, north of Bloomington. One seen May 2, 1888.

This is a southern species, least common in Carroll County and more abundant the further south one goes in the state. As one wanders along the brush-lined streams or through the woods in winter, there is no more cheery song to be heard than that of the Carolina Wren. It matters not how deep the snow may be or how cold the air, if there be no wind, the loud, clear, bell-like, ringing notes of this active little bird are sure to be heard.

217. Thryomanes bewicki bewicki (Audubon). bewick's wren. (719)

A rather rare summer resident in Vigo and Monroe counties; not noted in Carroll.

A male collected at Sand Hill, Vigo County, April 5, 1890, the first of the season. One seen in my yard in Terre Haute two days later.

218. Troglodytes aedon aedon Vieillot. house wren. (721)

One of our most sociable little summer residents; trusting us by coming close about our houses, building its nest in any suitable box or hole anywhere about the house; perhaps driving away the bluebirds.

Carroll County: On the home farm near Burlington one of the outbuildings (a woodshed) was built of logs, one of which was hollow, and in this hollow a pair of wrens built their nest every year for many years. Another pair built annually in a clothesline box that stood in the kitchen yard; while still another pair built their nest in a hole (air shaft) in the large chimney built in the north end of the house. Noted at Camden April 28, 1884; common the next day. Noted April 21, 1885, also on April 26 and 28. On June 25, 1905, a pair observed building in the clothesline box at the old home, but for some reason they abandoned it; perhaps the pestiferous English sparrow was the cause.

Vigo County: Quite common, especially about farmhouses.

Monroe County: Common summer resident, but probably less so than the Bewick's Wren.

219. Nannus hiemalis hiemalis (Vieillot). winter wren. (722)

A rare resident, doubtless breeding, though we never found its nest. On April 9, 1885, collected a female in Deer Creek bottom below the Porter mill, west of Camden. Others noted at various times in the winter in the thick underbrush about fallen trees and rotten logs, along the streams. Frequently seen at such times and in such situations in each of the three counties.

Next to the Carolina Wren this diminutive bit of fluffy feathers is one of our most cheerful winter residents.

220. Cistothorus stellaris (Naumann).

short-billed marsh wren. (724)

Noted in Vigo County May 8, 1889, by J. Rollin Slonaker.

221. Telmatodytes palustris iliacus Ridgway.

prairie marsh wren. (725d)

A not uncommon summer resident, breeding in some numbers among the cattails and scirpus patches in the Five-mile Pond, the Goose Pond, and in other similar places in Vigo County. A female collected at the Goose

Pond May 17, 1890. One seen in Monroe County May 13, 1886. Not noted in Carroll County, although it doubtless occurs there among the tules along the old canal.

222. Certhia familiaris americana Bonaparte. brown creeper. (726)

A spring and fall migrant, going north very early in the spring and returning south quite late in the fall.

One of our most curious little birds, readily known by its small size, brown speckled suit, long slender, curved bill, and its habit of always hunting on the trunks of trees, starting in near the ground, gradually working upward until a considerable height is reached, then flying to the base of another nearby tree and again working upward as before.

Carroll County: A pair (male and female), taken from a tree near Camden, February 1, 1879; day cold and snowing hard. On February 15, another pair taken on same tree, the day very much colder than on first; one seen March 5. April 6, 1884, two seen in heavy timber just above the Graham mill on Deer Creek, these being the first seen for some time. On April 23, one noted in Deer Creek bottom below the Porter mill. One seen November 3, 1906, by Miss Evermann on a tree in the yard at her home in Burlington; not seen again until January 28, 1908, when she saw two in same yard.

Vigo County: Noted near Terre Haute, March 30 and 31, 1888.

Monroe County: One collected, October 10, 1885; noted by G. G. Williamson, May 31, 1888.

223. Sitta carolinensis carolinensis Latham.

white-breasted nut-hatch. (727)

A common and familiar permanent resident.

Carroll County: On our home farm near Burlington, we always had, in the fall of the year, a large pile of fine pumpkins in the corner of a lot near the house. Some of these were daily thrown over the fence into a pasture where, after being broken or cut open, they were eaten by the cows. Several nuthatches were always about, ready to feed on the pumpkinseeds which they would usually carry away and hide in holes or crevices in some nearby tree. So intimately associated with the pumpkins were these amusing little birds that we always called them "pumpkinseed" birds. They are also called Tomtit. Collected a male May 6, 1885, in Deer Creek bottoms near the old Dillen millrace. June 25 to July 1, 1905, a pair noted in pasture west of house on home farm. Ava Evermann contributes the following records: January 5, 1907, several seen in the woods with titmice, chickadees, and woodpeckers. Throughout the winter (1906-7) nuthatches were seen on the trees in the orchard and on an ash tree near the house; October 28, one heard high up in an elm; another seen same day. January 1, 1908, two seen running up and down the trunk of a large hackberry tree; their soft but distinct twitter disclosed their presence; January 3, one heard.

Vigo County: January 11, 1890, a pair collected northeast of Terre Haute, and a male obtained a week later on Honey Creek.

Monroe County: January 12, 1883, one or two noted near Bloomington.

224. Sitta canadensis Linnæus. red-breasted nuthatch. (728)

Spring and fall visitant and probably rare summer resident.

Carroll County: In August, 1878, three or four young just able to fly, seen at a small pond on the home farm; one was collected. May 3, 1883, one seen and heard near same place; May 7, 1885, a pair collected near the Leonard mill on Deer Creek, east of Camden.

Vigo County: A female collected at Sand Hill, May 10, 1890.

Monroe County: One collected on Thanksgiving Day, 1882, near Bloomington. One got in Turner's grove, February 10, 1883. A pair or more might have been seen in this grove at any time in the winter of 1882-3.

225. Bæolophus bicolor (Linnæus). tufted titmouse. (731)

A common permanent resident. Of all the birds that remain with us during the cold, blustery days of winter, connecting that cheerless season of ice and sleet and snow with summer's sunshine and flowers, perhaps the most common, as well as the best known, is the Tufted Titmouse. Everyone knows this saucy, plain-colored little bird. He is not at all a gaudy bird, but quite Quakerish in his plain suit of leaden gray. He is a hardy bird, enduring, indeed, seeming to enjoy, the rigors of our severest winters without any desire to plume his wing for that distant flight which takes from us most of our musical summer birds when the autumn days come on. No! little cares he if the storms do come, the wind howl, the leaves fall, and the temperature go to zero and below, for here he stays and seems really to enjoy the cold. He may be seen on almost any day in the old apple trees near the house, about the woodpile, or in the depths of the forest, flitting about in that saucy, bravado-like way of his, gleaning from the crevices of the bark and the freshly split wood his daily food, the while keeping up an almost incessant whistling or scolding, should you intrude too closely upon his hunting ground. He has an omnivorous taste, feeding upon almost anything and everything, animal or vegetable, and thus is he able to procure food of some kind or other at any season of the year.

The mating season begins early in April. The nests are in deserted woodpecker holes or natural cavities in trees or old dead stubs in deep or open woods, or in the apple or other trees about the house. The eggs are usually five to eight in number and are pure white or sometimes light cream ground-color, profusely speckled with reddish-brown.

These birds will sometimes nest in boxes put up for the purpose and may thus be brought and kept about the house during the nesting season.

Carroll County: 1877-1879, noted often. January 22, 1879, one collected. Miss Evermann noted a few near Burlington January 5, 1907, and says they can be seen almost any time of the year near her house; October 28, two heard; December 16, one seen in porch and on grape arbor. January 1, 1908, noted in the woods; 2d, one seen in lilac bush near house; March 1, two seen in garden; they have been about the house all winter; one flew into the porch after some wahoo berries that were hanging on the wall.

Vigo County: Permanent resident; seen often. April 19, 1888, a male collected; 30th, a male obtained near the fair grounds. April 24, 1890, a female secured at Sand Hill.

Monroe County: Quite as common and well known as in the other counties.

226. Penthestes atricapillus atricapillus (Linnæus).

CHICKADEE. (735)

A rather common winter visitor in all the counties, coming down from farther north late in the fall and remaining until spring. Not always distinguished from the Carolina chickadee. Ava Evermann gives the following record from Burlington: November 17, 1906, two seen. January 5, 1907, several seen in woods with nuthatches, titmice, and woodpeckers; October 28, one heard in woods.

227. Penthestes carolinensis carolinensis (Audubon).

CAROLINA CHICKADEE. (736)

Common permanent resident in all the counties. Could be seen any day in the year. Nests in old sapsucker holes or other cavities in dead trees or even in fence-posts and other similar situations.

228. Regulus satrapa satrapa Lichtenstein.

GOLDEN-CROWNED KINGLET. (748)

A rather common late fall and early spring migrant; a few remain all winter. In the winter of 1882-3, a pair remained in a grove of evergreens at the Turner place just west of Bloomington.

Carroll County: Specimens collected at Camden, November, 1877; two secured April 9, 1885, common three days later. Miss Evermann on October 27, 1907, saw two in a little hawthorn bush near Burlington. They were very busy looking for insects and insect eggs and paid no attention to observation. On November 12, one flew into the porch against a screen, then to an apple tree where, after regaining its strength, it began to search for insects and eggs or other food.

Vigo County: March 27, 1888, one seen; noted again March 31 and April 1; April 17, one got east of the fair grounds. April 12, 1890, a male got on Honey Creek.

Monroe County: February 10, 1883, four or five seen in Turner's grove.

229. Regulus calendula calendula (Linnæus).

RUBY-CROWNED KINGLET. (749)

Like the preceding, a not uncommon late fall and early spring migrant in all the counties.

Carroll County: October 5, 1878, one taken near Camden. October 12, three collected; October 19, one secured.

Vigo County: April 19, 1888, five or six noted and a pair (male and female) taken west of Terre Haute; April 21, a male taken on Honey Creek; April 12, 1890, a male taken on Honey Creek; April 28, a male shot on the "commons" south of Terre Haute.

Monroe County: Noted often in late fall and early spring, especially in Turner's grove.

230. Polioptila cærulea cærulea (Linnæus).

blue-gray gnatcatcher. (751)

A fairly common summer resident. Arrives about the middle of April; begins nest building by the first of May. The nest is one of the most beautiful. It is a small, deeply cup-shaped structure covered on the outside with small greenish or grayish lichens, and is usually placed on some nearly horizontal limb.

Carroll County: April 23, 1884, first seen today in Deer Creek bottom below Camden; May 5, saw two pairs building their nests near Camden; May 8, saw a pair building in a white oak near Springboro bridge west of Pittsburg. The nest was about 18 feet from the ground. It was about an inch deep inside and very nicely made. On the 10th, this nest was still unfinished but the birds were working industriously; May 17, I secured the two nests found on the 5th; each contained five fresh eggs. April 22, 1885, first of the season seen. The species was common on the 26th.

Vigo County: May 10, 1888, a male obtained at Sand Hill; April 14, noted.

Monroe County: August 15, 1885, saw several and collected one in Smith's woods near Bloomington. April 12, 1886, noted.

231. Hylocichla mustelina (Gmelin). wood thrush. (755)

Not uncommon as a summer resident; frequenting deep woods. In all nature there is no sound more beautiful and stirring than the song of the Wood Thrush. The birds arrive from the south in the last days of April and their rich liquid notes may soon be heard in any deep woods you may visit. By the middle or twentieth of May their nests with the full complement of eggs may be found.

Carroll County: June 17, 1882, nest with three fresh eggs, incubation begun. May 3, 1883, quite common near Burlington. The Wood Thrush, with many other species, seems to have returned last night, a great wave of birds having arrived and today the woods are full of birds.

The Wood Thrush is one of the victims of the Cowbird's parasitic habits. On May 24, 1883, I found a nest with four Wood Thrush and three Cowbird eggs, all nearly fresh. On May 28, I found three nests, one with four eggs just hatching, another with four nearly fresh. April 28, 1884, returned last night. Saw several in Stone's woods near Burlington. After May 5, they were quite common. April 23, 1885, saw and heard three or four on the Joseph Trent farm in Carrollton Township,—the first of the season.

Vigo County: May 6, 1886, one noted; noted again May 3 and 5. Quite common in Vigo as it also is in Monroe County.

Monroe County: May 6, 1886, nest with full set of eggs near Bloomington.

232. Hylocichla fuscescens fuscescens (Stephens). veery. (756)

Rare spring and fall migrant.

Carroll County: April 10, 1885, noted as especially common.

Vigo County: May 3, 1888, three seen, one collected, at the Hunt farm three miles southeast of Terre Haute; 12th, a female collected near Terre Haute. May 14, 1890, a female at the Sand Hill.

Monroe County: May 13, 1886, several seen near Bloomington.

233. Hylocichla aliciæ aliciæ (Baird). gray-cheeked thrush. (757)

A not uncommon spring and fall migrant; observed in all the counties but I have only a few definite records.

Vigo County: May 3, 1888, one seen. April 29, 1890, one secured at Sand Hill; May 3, a female collected at the Goose Pond, another male on Honey Creek May 10, another at Sand Hill May 14.

234. Hylocichla ustulata swainsoni (Tschudi).

olive-backed thrush. (758a)

Carroll County: April 9, 1885, several seen, one secured.

Vigo County: April 24, 1890, a male collected at Sand Hill; May 10, a male collected at Sand Hill. No record for Monroe County.

235. Hylocichla guttata pallasi (Cabanis). hermit thrush. (759b)

A rather common spring and fall migrant. Arrives in the spring about the twentieth of April, or perhaps earlier, and may be seen at least as late as the middle of May. A quiet, retiring bird, not often seen except by those who are curious and know when and where to look for it.

Carroll County: October 5, 1878, one collected. May 11, 1883, found one dead near the Evans schoolhouse, Tippecanoe Township. March 30, 1884, a thrush believed to be this species seen today; April 23, several seen along Deer Creek near Camden.

Vigo County: April 1, 1888, three seen; 17th, collected two females east of the fair grounds; 19th, shot a female west of Terre Haute. October 15, 1889, Dr. J. T. Scovell collected one near Terre Haute. April 12, 1890, four males collected on Honey Creek; 16th, one male and two females secured at Sand Hill; another female at the same place on 24th, and a male on 30th.

Noted also in Monroe County but I have no definite records.

There is among the songs of birds none more deliciously sweet than that of the Hermit Thrush.

> In the swamp in secluded recesses,
> A shy and hidden bird is warbling a song.
> Solitary the Thrush,
> The hermit withdrawn to himself, avoiding the settlements,
> Sings by himself a song.
>
> —Whitman.

236. Planesticus migratorius migratorius (Linnæus). robin. (761)

Of all our birds the common Robin is the most familiar and best loved. In all the counties covered by this paper it is a common summer resident, and, usually a few remain all winter in favorable places along the rivers and creeks, particularly where there are wild grapes, hackberries, and other trees, shrubs or vines that furnish it with food.

The robins are among the first to return from the south. They are always hailed as harbingers of spring, and their coming is always an event that brings pleasure to all who are at all observing. Even as early as the first day of March, or sometimes as early as January, they may be seen.

Our January or February "thaw" seldom fails to bring back a few to us. In early March, while snow still lingers in all protected places and flurries of snow are still frequent, one may sometimes see large numbers of robins scattered over the fields and pastures picking up such bits of food as they can find, the while uttering their call notes but not yet their song. They hop about over the ground and usually continue feeding until late in the evening when they take wing, resuming their northward flight, which they continue through the night. Sometimes the flock may be made up wholly or in part of birds that will remain in the vicinity to breed; if so, they soon scatter more or less and ere long begin preparations for nest building.

In this part of Indiana one of the favorite places for robins' nests was on rails of the old Virginia rail fences. The nest was usually placed on the third to fifth rail from the ground and just outside of where the rails crossed. The rail above afforded protection from rain, the height from the ground was some protection against black-snakes and other ground inhabiting enemies, and, besides, the proximity to the crossing of the rails was also a protection. In the books this nesting site is spoken of as unusual, but in my boyhood experience it was the most common. At the beginning of the breeding season they scatter about over the farms and in the villages, rarely entering heavily wooded areas except at the edges of fields or other open places. The orchards, yards, shade trees along the village or town streets, and the borders of the woods are their favorite nesting places. Besides the rail fences, common nesting sites are in the crotches of apple and pear trees in the orchards; of maples, elms and other shade trees in the yards and along the streets; and in the beeches, oaks, and cottonwoods about the barnyards and at the edges of woodlands about the fields. The nest might be placed only two or three feet from the ground (as when the Virginia rail fence was utilized), or six to 40 feet if placed in the crotch or on a limb of some tree.

Usually two, sometimes three, broods are reared each season, and the number of eggs in the set is four or five. I have frequently known the same old nest, especially those placed on a fence rail, to be repaired and used two or even three seasons.

Albinism is of frequent occurrence among robins. In March, 1908, my niece, Miss Ava Evermann, saw an albino Robin about the Barker Stockton home just south of Burlington. It stayed about several days then disappeared. In the fall it was observed again in the same locality. Apparently it had gone farther north for the summer and returned in the fall with other robins in their fall migration. In the fall of 1918, Miss Evermann saw another partial albino Robin at Kokomo.

Miss Evermann has told me an interesting story about a Robin that saw itself in a mirror. She says:

"One of the most interesting observations I ever made concerning the Robin was one winter when one came into our big back porch after some dogwood (*Cornus florida*) berries which I had hung above a mirror, the fall before. The mirror rested on a little shelf and the bird came to the shelf, saw himself in the glass, found by using his bill that he couldn't get to the other bird that way, so, after seeming to study about it for a little while, he hopped to the edge and looked behind the glass. This without results, of course, so he hurried back and surveyed himself again. He grew quite excited and ruffled his feathers as he looked at the bird in the glass. Then he would look behind the glass again and again, each trip seeming more hurried than the one before, as if he were thinking he might, by hurrying, get there before the other bird could get away. Well, I watched that Robin long enough to convince me that it had some reasoning faculty. Don't you think it had?"

Some times robins gather up in great numbers and roost together at night in some selected place. In the fall of 1887 (I think it was; my notes were lost in the Indiana State Normal School fire of March 8, 1888), thousands of robins roosted for several nights in a grove of pine trees near Cataract, Owen County. Just before dusk robins in great numbers were seen coming in from all directions, to spend the night in these trees. Just when and in what manner they left I had no opportunity to determine.

A few definite dates for the various counties follow:

Carroll County: January 25, 1879, a few seen; they acted as if lost; March 5, one seen. June 19, 1882, nest with two fresh eggs. May 24, 1883, nest with four fresh eggs. February 5, 1884, saw two near John T. St. John's on Wild Cat Creek, Democrat Township. The weather had been very cold since December until February 3, and during the night of February 4-5 rain had fallen almost continuously; February 25, saw several in Camden. I think they had come from the north, the weather having been quite cold for the last few days; April 10, saw a pair building a nest in a pine tree in A. A. McKinney's yard in Camden; May 4, this nest contained young birds; May 5, saw a nest on eave of Baptist church in Camden. March 8, 1885, first of season seen at Burlington; March 11-13, common; April 26, found first nest, with four fresh eggs, in a cedar tree in my yard in Camden. February 7, 1908, one seen in orchard in Burlington. While this is the only one I saw, I was told that several remained all winter along the small stream which runs through the village. Miss Evermann saw three at Kokomo March 5, 1920, and several next day.

Monroe County: May 5, 1882, set of four eggs slightly incubated. A few (five or six) seen February 10, 1883, and a great number, perhaps 500, six days later. Full sets of eggs found May 5.

Vigo County: February 23, 1888, one seen; others noted March 3; January 18, 1890, three seen on Honey Creek south of Terre Haute.

An albino was taken at Terre Haute many years ago by the late Dr. J. T. Scovell.

237. Sialia sialis sialis (Linnæus). bluebird. (766)

Formerly an abundant summer resident, now much reduced in numbers as a result of the clearing up of the land with the consequent destruction of favorable nesting places, and of persecutions of various kinds.

With us the Bluebird is always associated with the robin. These are the two birds that were most familiar and best known to country boys and girls in Indiana 30 to 50 years ago. They returned from the south about the same time each spring, frequented the same parts of the farm, were equally familiar and confiding, built their nests close about the homes and, in the fall, departed for the south at about the same time. Their coming in the spring was always hailed with delight and their going in the fall was always regarded as portending the coming of snow and sleet and storm.

Like the robin, a few bluebirds might remain quite late in the fall in seasonable years, sometimes even throughout the winter.

Every field on a typical Indiana farm in those days had scores of stumps on every acre. Many of these stumps were hollow. The hole was usually only a few inches in diameter and 10 to 30 inches deep. These holes were apparently regarded by the bluebirds as ideal nesting sites, if we judge from the frequency with which they were occupied for that purpose.

There was an 18-acre field which was, for several years following that in which it was cleared for cultivation, remarkably well supplied with stumps. The author of these notes has very good reason for remembering these stumps, as he had to dig around every one of them; and how often have his ribs been bruised and his sides made to ache by blows from the plow handles as the plow struck the roots which were far-reaching and ever in the way! He was admonished to plow close and to dig the dirt up loose because the "best corn grows closest to the stump"! This, however, did not prevent the work from being about the hardest the small boy could find on the farm. But there was one compensating pleasure,—the finding of a bluebird's nest now and then in these hollow stumps. Just how many were found memory does not now safely fix, but it must have been more than a score in this one field every year. Usually a second brood would be reared, a new stump being frequently selected for the second nest.

Next to hollow stumps, deserted woodpecker holes in dead trees were oftenest used. Sometimes the hole would be in a stump, sometimes in a stake or post of the fence. Bird boxes put up about the house were sure to be used, especially before the advent of the pestiferous English sparrow. We have found bluebirds' nests in holes in elm, oaks of several species, maple, poplar, cottonwood, beech, walnut, buckeye, ash, wild cherry, hickory, sycamore, butternut, willow, apple, pear, and doubtless in others; also fence stakes, posts and rails, and in various bird houses put up about the habitations of man.

Definite records for *Carroll County* are as follows:

February 20, 1878, seen; October 25, noted at Camden. February 6-8, 1879, three or four seen; 25th, common about Camden; March 5, saw 40 to 50 males; 6th, saw two or three females, first of season. May 22, 1883, Vern Beck found a nest with six eggs. February 12, 1884, first of the season seen and heard; 22d, noted as common since 13th; March 7, noted; April 10, seen building; 25th, Matthew Sterling took a set of eggs near Camden; May 5, took a set of five fresh white eggs from a box we had put up in our yard in Camden; 18th, another set of five, also pure white, from same birds, but in another box which we had provided; June 3, a third set of five, also white, in the first box and by the same pair of birds. March 7, 1885, first of season; 10th and 11th, quite common; April 22, five fresh eggs in box in our garden in Camden; first nest of the season. June 25-July 1, 1905, several pairs seen on the old home farm. Ava Evermann noted the Bluebird at Burlington March 24, 1907, when one was seen, and again on October 28, when one was observed in an open woods, and on March 3, 1920, at Kokomo where she had not noted any since Thanksgiving of 1919.

Monroe County: April 2, 1882, set of five fresh eggs from box put up in my yard in Bloomington; April 4, set of five fresh eggs near Bloomington. January 12, 1883, four or five seen; February 10, noted.

Vigo County: February 18, 1888, four seen; others seen on 19th and 20th; March 3, nine seen. March 13, 1889, a male collected near Terre Haute by J. C. Cunningham. May 3, 1890, set of four fresh eggs in hole in willow near the Goose Pond.

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Proceedings of the Indiana Academy of Science

1921

PROCEEDINGS

OF THE

Indiana Academy of Science

1921

F. PAYNE, Editor

INDIANAPOLIS:
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1922

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 sources and riches of the State; to arrange and prepare for publication such reports of investigation and discussion as may further the aims and objects of the Academy as set forth in these articles.

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

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

ARTICLE II.

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

SEC. 2. Any person engaged in any department of scientific work, or in any original research in any department of science, shall be eligible to active membership. Active members may be annual, life members or patrons. 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. Any person who shall at one time contribute one hundred dollars to the funds of this academy may be elected patron, who shall be a life member of the Academy, free of dues. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Application for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

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

ARTICLE III.

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

SEC. 2. The annual meeting of the Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past President, 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. 2. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

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

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

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

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

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

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

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

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

INDIANA ACADEMY OF SCIENCE.

OFFICERS, 1921

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HOWARD E. ENDERS.

Vice-President,
F. M. ANDREWS.

Secretary,
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Assistant Secretary,
HARRY F. DIETZ.

Press Secretary,
FRANK B. WADE.

Treasurer,
WILLIAM M. BLANCHARD.

Editor,
F. PAYNE, 1921 Proceedings.

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ARTHUR, J. C.
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HESSLER, ROBERT
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PAYNE, F.
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Curators:

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

COMMITTEES ACADEMY OF SCIENCE, 1921.

Program.

R. C. Friesner, Butler College, Indianapolis.
F. B. Wynn, Indianapolis.
Wm. M. Blanchard, Greencastle.

Nominations.

H. L. Bruner, Butler College, Indianapolis.
E. B. Williamson, Bluffton.
Stanley Coulter, Lafayette.

Biological Survey.

H. S. Jackson, Agricultural Experiment Station, West Lafayette.
Richard Lieber, Department of Conservation, Indianapolis.
J. J. Davis, West Lafayette.
Will Scott, Bloomington.

State Library.

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

Distribution of Proceedings.

Walter N. Hess, Greencastle.
Wm. M. Blanchard, Greencastle.

Membership.

Harry F. Dietz, State Entomologist's Office, Indianapolis.
W. A. Cogshall, Bloomington.
Ralph H. Carr, West Lafayette.
M. L. Weems, Valparaiso.

Relations of Academy to the State.

R. W. McBride, 1239 State Life Building, Indianapolis.
Glenn Culbertson, Hanover.
John S. Wright, Indianapolis, care Eli Lilly & Co.
Amos W. Butler, State House, Indianapolis.
D. A. Rothrock, Bloomington.

Auditing.

E. B. Williamson, Bluffton.
Rollo R. Ramsey, Bloomington.

Publication of Proceedings.

Fred J. Breeze, Muncie.
O. B. Christy, Muncie.
Harry F. Dietz, State House, Indianapolis.

Advisory Council.

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

Directors of Research.

John S. Wright.
Glenn Culbertson.
A. L. Foley.
E. B. Williamson.
J. P. Naylor.

Inter-State Meetings.

E. B. Williamson.

Academy Foundation.

Trustees—
Amos W. Butler.
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Archaeological Survey.

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Allen D. Hole, Richmond.
Stanley Coulter, Lafayette.
Chas. Stolts, South Bend.
A. J. Bigney, Evansville.
Glenn Culbertson, Hanover.
W. A. McBeth, Terre Haute.
S. F. Balcom, Indianapolis.

MEMBERS.*

FELLOWS.

Aley, Robert J., Indianapolis....................................1908
Andrews, F. M., 110 E. Tenth St., Bloomington................†1911
Arthur, Joseph C., 915 Columbia St., Lafayette.................1893
Badertscher, J. A., 312 Fess Ave., Bloomington.................1917
Beede, Joshua W., 404 W. Thirty-eighth St., Austin, Texas........1906
Behrens, Charles A., 217 Lutz Ave., West Lafayette..............1917
Bennett, Lee F., 309 S. Ninth St., Janesville, Wis................1916
Benton, Geo. W., 100 Washington Sq., care American Book Co., New York, N. Y..1896
Bigney, Andrew J., Evansville...................................1897
Blanchard, William M., 1008 S. College Ave., Greencastle.........1914
Blatchley, W. S., 1558 Park Ave., Indianapolis...................1893
Breeze, Fred J., Muncie...1910
Bruner, Henry Lane, 324 S. Ritter Ave., Indianapolis.............1899
Bryan, William Lowe, Bloomington...............................1914
Butler, Amos W., 52 Downey Ave., Irvington, Indianapolis.........1893
Cogshall, W. A., 423 S. Fess Ave., Bloomington.
Coulter, Stanley, 213 S. Ninth St., Lafayette....................1893
Culbertson, Glenn, Hanover.....................................1899
Cummings, Edgar Roscoe, 327 E. Second St., Bloomington.........1906
Deam, Charles C., Bluffton......................................1910
Dryer, Charles R., Oak Knoll, Fort Wayne........................1897
Dutcher, J. B., 1212 Atwater St., Bloomington...................1914
Eigenmann, Carl H., 630 Atwater St., Bloomington...............1893
Enders, Howard E., 249 Littleton St., West Lafayette.............1912
Evans, Percy Norton, 302 Waldron St., West Lafayette............1901
Fisher, Martin L., 325 Vine St., West Lafayette.................1919
Foley, Arthur L., Bloomington...................................1897
Hessler, Robert, Logansport.....................................1899
Hufford, Mason E., 710 Atwater St., Bloomington................1916
Hurty, John E., 31 E. Eleventh St., Indianapolis.................1910
Hyde, Roscoe Raymond, 4101 Penhurst Ave., Baltimore, Md........1909
Jackson, Herbert S., West Lafayette..............................1919
Koch, Edward W., Buffalo, N. Y..................................1917
Logan, Wm. N., 924 Atwater St., Bloomington....................1917
McBeth, Wm. A., 1905 N. Eighth St., Terre Haute................1904
McBride, Robert W., 1239 State Life Building, Indianapolis........1916
Markle, M. S., Richmond..1919

* Every effort has been made to obtain the correct address of each member. The omission of an address indicates that mail addressed to the last printed address was returned as undeliverable; 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.

Middleton, Arthur R., 705 Russell St., West Lafayette............1918
Moenkhaus, W. J., Bloomington............................1901
Mottier, David M., 215 Forest Place, Bloomington...............1893
Naylor, Joseph P., Greencastle............................1903
Nieuwland, J. A., Notre Dame............................1914
Payne, F., 620 Ballantine Road, Bloomington...................1916
Ramsey, Rolla R., 615 E. Third St., Bloomington...............1906
Rettger, Louis J., 31 Gilbert Ave., Terre Haute.................1896
Rothrock, David A., 1000 Atwater St., Bloomington..............1906
Schockel, Barnard, Terre Haute............................1917
Scott, Will, Bloomington..................................1914
Shannon, Charles W., 518 Lahoma Ave., Norman, Okla...........1912
Smith, Albert, 500 University St., West Lafayette...............1908
Smith, Charles Marquis, 152 Sheetz St., West Lafayette...........1912
Stoltz, Charles, 530 N. Lafayette St., South Bend................1919
VanHook, James M., 639 N. College Ave., Bloomington...........1911
Wade, Frank Bertram, 1039 W. Twenty-seventh St., Indianapolis...1914
Williamson, E. B., Bluffton...............................1914
Wright, John S., care of Eli Lilly & Co., Indianapolis.............1894

NON-RESIDENT MEMBERS AND FELLOWS.

Abbott, G. A., Grand Forks, N. D., Fellow......................1908
Aldrich, John Merton, Washington, D. C., Fellow................1918
Brannon, Melvin A., Beloit, Wis.
Burrage, Severance, Denver, Colo., Fellow......................1898
Campbell, D. H., Stanford, Cal.
Clark, Howard Walton, U. S., Biol. Station, Fairport, Iowa.
Cook, Mel T., New Brunswick, N. J., Fellow....................1902
Coulter, John M., University of Chicago, Illinois, Fellow..........1893
Davis, B. M., Oxford, Ohio.
Evermann, Barton Warren, Golden Gate Park, San Francisco, Cal.
Goss, William Freeman M., 61 Broadway, N. Y., Fellow...........1893
Greene, Charles Wilson, 814 Virginia Ave., Columbia, Mo.
Hargitt, Charles W., 909 Walnut St., Syracuse, N. Y.
Hay, Oliver Perry, U. S. National Museum, Washington, D. C.
Jordan, David Starr, Stanford, Cal.
Kingsley, John S., Urbana, Ill.
Knipp, Charles T., 915 W. Nevada St., Urbana, Ill.
MacDougal, Daniel Trembly, Tucson, Ariz.
McMullen, Lynn Banks, 641 Euclid Ave., Valley City, N. D.
Marsters, Vernon F., Kansas City, Mo., care of C. N. Gould, Fellow..1893
Miller, John Anthony, Swarthmore, Pa., Fellow..................1904
Moore, George T., St. Louis, Mo.
Noyes, William Albert, Urbana, Ill., Fellow.....................1893
Ransom, James H., Detroit, Mich., Fellow......................1902
Reagan, Albert B., Kayenta, Ariz.
Smith, Alexander, care of Columbia University, New York City, Fellow 1893

Springer, Alfred, 312 E. Second St., Cincinnati, Ohio.
Swain, Joseph, Swarthmore, Pa., Fellow........................1898
VonKleinsmid, R. B., Tucson, Ariz.
Waldo, Clarence A., Fellow (address not known)..................1893
Wiley, Harvey W., Woodward Building, Washington, D. C........1895
Zeleny, Chas., 1003 W. Illinois St., Urbana, Ill.

ACTIVE MEMBERS.

Acre, Harlan Q., Gordon, Nebr.
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Adams, William B., 431 S. College Ave., Bloomington.
Addington, Archie, 801 Atwater Ave., Bloomington.
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Baker, Wm. F., Indianapolis, care of St. Vincents Hospital.
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Barrett, Edward, State Geologist, Indianapolis.
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Bonns, Walter W., Indianapolis, care of Eli Lilly & Co.
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Davis, John H., Agr. Exper. Station, West Lafayette.
Dean, John C., University Club, Indianapolis.
de Forest, Howard, Indianapolis Normal School, Indianapolis.
Demaree, Delzie, Benham.
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Doan, Martha, Earlham.
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Eisenhard, Mrs. Geo. B., Culver.
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Gates, Florence A., 3435 Detroit Ave., Toledo, Ohio.
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Giffen, John W., 361 Garfield St., Valparaiso.
Gillum, Robert G., Terre Haute.
Gingery, Walter G., Shortridge High School, Indianapolis.
Goldsmith, William M., Southwestern College, Dept. of Biology, Winfield, Kan.
Graham, Frank V., State Normal School, Muncie.
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Happ, William, South Bend.
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Hardy, Eugene H., 1230 S. Keystone Ave., Indianapolis.
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Heimlich, Louis F., 495 Littleton St., West Lafayette.
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Hiestand, T. C., 514 S. Lincoln St., Bloomington.
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Hoffman, G. L., Western Pennsylvania Hospital, Pittsburg, Pa.
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Howick, Howard, Indiana State Normal, Muncie.
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Huber, Leonard L., Hanover.
Hufferd, Ralph, Greencastle.
Hull, Julia, St. Anne, Ill.
Hutchinson, Emory, Norman Station.
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Hyslop, George H., 200 Chatterton Parkway, White Plains, N. Y.
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James, Evalyn G., 144 Butler Ave., Indianapolis.

Jensen, Howard E, 360 Downey Ave., Indianapolis.
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Liston, Jesse G., R. F. D. 2, Lewis.
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Malott, Burton J., Indianapolis, care of Technical High School.
Malott, Clyde A., 521 E. Second St., Bloomington.
Mason, Thomas E., 130 Andrew Place, West Lafayette.
Mellon, M. G., 403 Russel St., W. Lafayette.
Miller, John W., 444 Littleton St., West Lafayette.
Moore, Kenneth W., 125 Downey Ave., Indianapolis.
Morgan, Frank W., Science Hall, Valparaiso.
Morgan, Will, University Heights, Indianapolis.
Morrison, Harold, Bureau of Entomology, Washington, D. C.
Morrison, Louis A., East Lansing, Mich.
Muldoon, Hugh C., 361 Garfield St., Valparaiso.
Munro, George W., 202 Waldron St., West Lafayette.
Myers, B. D., 321 N. Washington St., Bloomington.
Nelson, Ralph E., 232 Littleton St., West Lafayette.
Nicholson, Thomas E., 519 N. Fess Ave., Bloomington.
Niles, Edward H., 4450 Guilford Ave., Indianapolis.
Noyes, Harry A., Westfield, N. Y., care Welch Grape Juice Co.
O'Neal, Claude E., Forrest Ave., Delaware, Ohio.
Oberdoerfer, Rev. P. Benedict, St. Bernard College, St. Bernard, Ala.
Oberholser, Harry C., U. S. National Museum, Washington, D. C.
Orahood, Harold, Kingman.
Orton, Clayton R., State College, Pa.
Owen, D. A., 200 S. State St., Franklin.
Painter, Henry R., Box 95, West Lafayette.
Pearson, George B., Box 95, West Lafayette.
Peffer, Harry C., 1022 Seventh St., West Lafayette.

Petry, Edward J., 722 E. Eighth St., Brookings, S. D.
Pickett, Fermen L., Pulman College, Station 36, Washington.
Pinkerton, Earl, Box 411, Walters, Okla.
Pollard, Cash B., 419 W. Wood St., Lafayette.
Prentice, Burr N., 400 Russell St., West Lafayette.
Pressey, S. L., Ohio State University, Department of Psychology, Columbus, Ohio.
Pressey, Mrs. S. L., Ohio State University, Department of Psychology, Columbus, Ohio.
Price, Walter A., 123 Sheetz St., West Lafayette.
Proulx, Edward G., 111 Waldron St., West Lafayette.
Rabb, Albert L., 1354 Lemcke Annex, Indianapolis.
Rawles, William P., 924 E. Third St., Bloomington.
Reagan, Albert B., Kayenta, Ariz.
Records, Ralph L., Edinburg.
Reeves, John R., 1022 E. Third St., Bloomington.
Reichert, Joseph S., 522 E. Indiana Ave., South Bend.
Richards, Aute, Norman, Okla.
Richards, Mildred Hoge, Norman, Okla.
Ridgway, Robert, 1030 S. Morgan St., Olney, Ill.
Rifenburgh, S. A., Valparaiso.
Riley, Katherine, Robert Long Hospital, Indianapolis.
Roark, Louis, Box 1266, Okmulgee, Okla.
Roberts, Chester R., Hougham St., Franklin.
Sheak, Wm. H., 154 N. Twenty-first St., Philadelphia, Pa.
Sherman, George W., 4 Murdock Flats, West Lafayette.
Shonle, Horace A., Indianapolis, care Eli Lilly & Co.
Showalter, Ralph W., Indianapolis, care Eli Lilly & Co.
Siever, Winifred, 14 Audubon Court, Indianapolis.
Silvey, Oscar W., College Station, Texas.
Smith, Charles Piper, 354 S. Tenth St., Jan Jose, Cal.
Smith, Ernest R., Greencastle.
Smith, John E., Route 6, Franklin.
Smith, Paul R., University of Pennsylvania, Department of Physics West Philadelphia, Pa.
Snodgrass, Robert E., 2063 Park Road, Washington, D. C.
Spitzer, George, 1000 Seventh St., West Lafayette.
Spong, Philip, 3873 E. Washington St., Indianapolis.
Stacy, Allan R., 1555 Ashland Ave., Indianapolis.
Stone, Ralph B., 307 Russell St., West Lafayette.
Sulzer, Elmer G., Madison.
Suter, E. M., 1437 Broadway, Ft. Wayne.
Tatlock, Myron W., Indianapolis, care Shortridge High School.
Telfer, Margaret, 403 W. 5th St., Bloomington.
Terry, Dr. Oliver P., 215 Sheetz St., West Lafayette.
Tetrault, Philip A., 607 University St., West Lafayette.
Test, Louis A., 222 North St., West Lafayette.
Tevis, Emma L., 122 W. Eighteenth St., Indianapolis.
Thompson, Clem O., Hanover.
Thompson, James T., 334 Lafayette Ave., Lebanon.

Thornburn, A. D., 105 N. High St., Indianapolis.
Thurston, Emory Wright, 4144 Carrollton Ave., Indianapolis.
Treat, Frank M., Atwater Ave., Bloomington.
Troop, James, 123 Sheetz St., West Lafayette.
Tucker, William Motier, Bloomington.
Turner, B. B., 1017 Park Ave., Indianapolis.
Turner, William P., 222 Lutz Ave., West Lafayette.
Turney, Harold E., Department of Conservation, State House, Indianapolis.
Vischer, Stephen S., 817 E. 2nd St., Bloomington.
Voorhees, Herbert S., 804 Wildwood Ave., Ft. Wayne.
Walker, Enos G., 453 College Ave., Valparaiso.
Wallace, Frank N., Department of Entomology, State House, Indianapolis.
Weatherwax, Paul, 416 S. Dunn St., Bloomington.
Weems, Mason L., 102 Greenfield Ave., Valparaiso.
Wenninger, Rev. Francis J., Notre Dame.
Wiancko, Alfred T., 230 S. Ninth St., Lafayette.
Wildman, Ernest A., Richmond.
Wildasin, Pearl D., Kentland.
Wiley, Ralph B., 227 Russell St., West Lafayette.
Wilhite, Miss Ida B., Butler College, Indianapolis.
Williams, A. A., Valparaiso.
Williamson, Jesse H., Bluffton.
Wilson, Arthur J., 901 W. Wabash St., Crawfordsville.
Wilson, Geo. B., 330 Fowler St., West Lafayette.
Wilson, Mrs. Etta S., 2 Clarendon Ave., Detroit, Mich.
Wilson, Ira T., 520 Kirkwood Ave., Bloomington.
Winkenhofer, Walter, Huntingburg.
Witmer, Samuel W., 1405 Ninth St., Goshen.
Wolfe, Harold E., 314 N. Washington St., Bloomington.
Wood, Harry W., Bloomington.
Woodruff, Albert E., Butler College, Indianapolis.
Wright, William L., Indianapolis, care Eli Lilly & Co.
Wynn, Dr. Frank B., 421 Hume-Mansur Bldg., Indianapolis.
Young, Gilbert A., 739 Owen St., Lafayette.
Young, Paul A., 619 S. Randolph St., Garrett.
Yuncker, Truman G., Wood St., Greencastle.
Zebrowski, George, 521 State St., West Lafayette.
Zehring, William A., 303 Russell St., West Lafayette.
Zerfas, Leon G., Indiana University Medical School, Indianapolis.

Fellows	56
Members, Active	268
Members and Fellows, Non-resident	34
Total	358

Minutes of the Spring Meeting.

Indianapolis, Indiana.

Members of the Indiana Academy of Science, the Indiana Audubon Society, and the Nature Study Club of Indiana met in joint session for the first time in the history of the organizations. This meeting afforded the members of all three organizations an opportunity to meet together in a more or less informal way, and to enjoy the many interesting regions surrounding our capital city.

The meeting was planned for two days, Friday and Saturday, May 27th and 28th.

Friday, May 27.

Members of the three societies and their friends met in Fairview Park at 9:30 a. m., and under the direction of Dr. Wynn, and others, all joined in a hike along the towpath to the home of Dr. Cole, where they walked over the beautiful grounds of this magnificent country estate. From Dr. Cole's place, the party tramped to Holliday Park, where everyone enjoyed a delightful hospitality at the home of John F. Holliday. After picnic lunches were eaten, a short, informal program was held in charge of the Audubon Society.

At 2:00 p. m. the party proceeded across country to Bacon's Swamp, entering from the Fifty-sixth Street entrance, and emerging from the Fifty-ninth. Short talks were given by Dr. Dunn and Dr. Blatchley concerning the history and early formation of the swamp.

At 6:30 o'clock covers were laid for seventy-eight members and guests at Ma-Lo Place, where an excellent checken dinner was greatly enjoyed by all. Immediately after dinner a business meeting was held, followed by talks by Dr. Wiley and lantern slides of South America by E. B. Williamson.

Saturday, May 28.

Starting from Indianapolis at 8:00 a. m., the day was spent at Fort Benjamin Harrison, the Boy Scouts' Reservation and Buzzards' Roost. The visit to the fort gave many of the party an opportunity to see, first hand, an army post.

A short tramp from the fort brought the party to the Boy Scouts' Reservation. Here members of the party were greatly delighted to see the beautiful park that Indianapolis has provided for the enjoyment, yes, preservation, of her boys.

Most of the afternoon was spent at Buzzards' Roost. The chief feature of today's program was the unveiling of a memorial tablet to William Watson Woollen, the tablet being on a large boulder in the wooded tract which has been given by Mr. Woollen to the city of Indianapolis for a nature study park. Although the program was in charge of the Nature Study Club, Prof. Enders and Dr. Coulter represented the Academy on the program. Dr. Wynn announced and requested that hereafter the park, instead of being called Buzzards' Roost, be called "Woollen's Garden of Birds and Botany."

The program was concluded at 4:30 p. m., and the meeting adjourned immediately.

Business Meeting.

Indianapolis, Ind., May 27, 1921.

After the dinner, which was served at 6:30 o'clock at Ma-Lo Place, the meeting was called to order by the President, Howard E. Enders.

The following members of the Academy were present:

Flora Anderson
S. F. Balcom
A. R. Becktel
A. J. Bigney
W. S. Blatchley
H. L. Bruner
Elizabeth Downhour
Howard E. Enders
R. C. Friesner
W. A. Guthrie
J. W. Hadley
Walter N. Hess
Robert W. McBride
F. Payne
J. M. VanHook
Frank N. Wallace
Pearl Wildasin
E. B. Williamson
Jesse Williamson
H. W. Wiley
Frank B. Wynn

In the absence of Mr. Harry F. Dietz, chairman of the Membership Committee, the Secretary proposed the names of six persons who were duly elected to membership:

Emma T. Bodine, 4 Mills Place, Crawfordsville, Ind.
Emil Dietz, 334 Congress Ave., Indianapolis, Ind.
George B. Eisenhard, Culver Military Academy, Culver, Ind.
Mrs. George B. Eisenhard, Culver, Ind.
Winifred Siever, 14 Audubon Court, Indianapolis, Ind.
Harold E. Turkey, Department of Conservation, Indianapolis, Ind.

Dr. Frank Wynn, as chairman of the State Historical and Archaeological Survey Committee, announced that a questionnaire had been prepared for the purpose of interesting as many people as possible in the work of this committee, with the hope that many members of the Academy would co-operate in collecting data of a historical and archaeological nature in the State of Indiana. After discussing the nature and purpose of the questionnaire, a copy was presented to each member.

Prof. Payne announced that the 1919 Proceedings were in press and would be ready for distribution in a few weeks. He called the attention of the Academy to the fact that the failure to get this issue published a year ago was not due to any fault of his, as editor, but that it was due to the inability of the state printer to get the issue printed before the date on which the funds reverted to the State.

The President discussed briefly the history of the spring meetings of the Academy, after which he called for suggestions for next year's meeting.

Mr. Charles Stoltz urged that a meeting be held again, as soon as possible, at the Dunes, in order to stimulate interest in the State relative to preserving the Dunes as a state park.

Mr. Eisenhard invited the societies to Culver. He stated that the school would gladly provide tents for the accommodation of visitors.

Mr. Balcom suggested a certain park near Anderson that is noted for its archaeological remains.

Mr. Robert W. McBride presented a resolution with reference to the preservation of Bacon's Swamp, as follows:

> RESOLVED, "That the members of the Indiana Academy of Science, the Indiana Audubon Society, and The Nature Study Club have inspected Bacon's Swamp and its surroundings, and have been impressed by its fitness for the preservation of many forms of wild life where they are of easy access; therefore, be it
>
> RESOLVED, That we heartily and without reserve approve and commend the suggestion that its ownership be acquired by the State, or by the city of Indianapolis, and that it be set aside and protected, and all of its natural beauties, and all of its wild life be preserved for the benefit of the people."

After a brief talk by Dr. Harvey W. Wiley, the business session adjourned at 9:20 p. m., after which Mr. E. B. Williamson entertained the societies with a large number of lantern slides of the country in South America where he has been collecting dragon-flies.

HOWARD E. ENDERS, President.
WALTER N. HESS, Secretary.

MINUTES OF THE WINTER MEETING.

CLAYPOOL HOTEL, INDIANAPOLIS, DECEMBER 1, 1921.

MEETING OF THE EXECUTIVE COMMITTEE.

The Executive Committee was called to order at 8:00 p. m. in Room 200, by President H. E. Enders. The following members were present.

F. M. Andrews
S. F. Balcom
W. M. Blanchard
H. L. Bruner
F. J. Breeze
Amos Butler
W. A. Cogshall
H. F. Dietz
C. R. Dryer
C. H. Eigenmann
H. E. Enders
R. C. Friesner
Walter N. Hess
R. L. Hessler
H. S. Jackson
Robt. W. McBride
D. M. Mottier
J. P. Naylor
E. B. Wiliamson
John S. Wright

The minutes of the last meeting of the Executive Committee were read and approved.

Committee reports were considered as follows:

Program Committee—R. C. Friesner presented the printed program of 85 titles to be read at the present meetings. He called attention to the fact that this year's program reads "The 37th Annual Meeting" while last year's program read "The 35th Anniversary Meeting". At first, it might seem to some that there is a mistake, but such is not so. A different method of reckoning meetings has been used. A slight change in rooms was announced, in that all meetings scheduled to be held in Parlor B during the forenoon of December 2d, would be held in Room 200. Attention was called to the fact that we need more than one day for our meetings because of the large number of papers that have to be crowded into so short a space of time. No action was taken, but it was the sense of the Executive Committee that the matter should be left with the Program Committee, and that the number of papers presented for reading at any one session should aid the committee in solving this problem.

R. C. Friesner raised the question about the purchase of a lantern. He stated that the Academy now has to rent a lantern each year at a very high cost. No action was taken, but W. A. Cogshall stated that Indiana University would gladly send up a lantern at any time if given two days' notice. W. M. Blanchard made a similar offer for DePauw.

The advisability of holding our meetings in several sections instead of two, as is done at present, was up for discussion. It was shown that if this was done, better facilities than those offered by the Claypool Hotel would have to be sought.

Committee on Nominations—No report until tomorrow.

Biological Survey—H. S. Jackson revised his announcement of two years ago concerning the relation of this work to that of the Conservation Commission. He stated that Mr. Lieber of this commission had been made a member of the Biological Survey Committee. The desirability of making such a survey in the State of Indiana was discussed, after which Mr. Jackson suggested that a definite effort should be made by the Academy to obtain a special appropriation for this work. He urged that a committee, composed of the more influential members of the Academy, should be selected to go before the state legislature to obtain such funds. D. M. Mottier spoke of the advisability of informing the members of the legislature of the past work of a biological survey nature that has been done up to the present time. Amos Butler moved that it be the sense of the Executive Committee that the report of this committee be approved and carried out. Motion passed. He then advised that an effort be made to get the Governor's approval and his active cooperation solicited.

The following members were named to represent the Academy in soliciting the state legislature for funds for the work of the Biological Survey Committee:

R. W. McBride.

F. B. Wynn.

A. W. Butler.

Stanley Coulter.

H. S. Jackson asked for an expression of opinion as to the desired relationship that should exist between this committee and that of the Conservation Commission. It was the sense of the members present that this was a matter for the members of the two committees to determine.

State Library—Amos Butler reported that during the year, 420 items belonging to the Academy were catalogued. Foreign exchanges are behind, but are coming slowly. Due to the high cost of materials and labor, much material is still on the shelves unbound. It was shown that members of the Academy do not use the exchanges very much. The Librarian is very anxious to have the members of the Academy use not only its own publications, but also the general library. Material can be sent to one at his home. The Librarian would be very pleased to receive suggestions from the members of the Academy about books to be purchased for their use. This is done regularly by individuals and colleges, and may as well be done by members of the Academy.

Distribution of Proceedings—Chairman Hess reported that the 1919 and 1920 Proceedings were distributed during October.

Membership Committee—H. F. Dietz reported that he had 54 names to propose at the meeting tomorrow. He suggested that the membership of this committee should be increased so that there will be one member residing at each university and college in the State, together with three members from Indianapolis.

Publication of Proceedings—Editor Payne, 1919 Proceedings, called attention to the fact that there was a deficit in the treasury due to the fact that the state printers did not take into account the cost of preparing cuts. After discussing the difficulties of editing, both from the point of view of the printers and the authors, he advised that hereafter the term of office of editor be for more than one year. He also advised that the Proceedings be cut down so that free copies of reprints can be furnished authors.

Editor Breeze, 1920 Proceedings, spoke of his difficulties as editor, chiefly among them being the lack of co-operation on the part of the state printers.

In view of the previous discussion, it was moved and carried that when the editor is in doubt about the printing of any manuscript, he be instructed to submit the paper to three members who are experts in that field, and then follow their advice.

On motion, the last two editors were appointed to draw up a set of rules for the use of authors in the preparation of manuscripts.

A letter from the Fort Wayne Printing Company was read in defense of the high cost of printing the Proceedings. Estimates were presented by President Enders from the Lafayette Printing Company for the 1919 and 1920 Proceedings, and in each instance these estimates were higher than that charged by the Fort Wayne Printing Company.

Amos Butler urged that editors consult Col. Healey concerning their editing problems. He stated that the wide experience of Col. Healey would be a help to any editor.

Treasurer—

Balance on hand December 1, 1920	$541 67
Dues collected during the year	354 00
Total	$895 67
Total expenditures	596 51
Balance in the treasury	$299 16

Auditor E. B. Williamson reported on the accuracy of the treasurer's report. On motion, the treasurer is authorized to transfer from the treasury to the trustees of the Research Endowment Fund, the sum of $100.

Relation of the Academy to the State—Robert W. McBride stated that our troubles of getting money from the State are now over so far as the publication of the Proceedings is concerned. The last session of the legislature passed a bill appropriating $2,400 for the publication of the 1919 and 1920 Proceedings, which carried with it the provision for a perpetual yearly appropriation of $1,200, and it further provided that any excess remaining at the end of any year shall be carried forward for future use. Judge McBride, at the request of the Academy, wrote this bill and urged its passage.

Concerning the state flower, Robt. W. McBride announced that, at the request of the Academy, he prepared the bill requesting that the flower of the tulip tree be named the state flower. Since this bill passed the legislature, the Academy was really instrumental in naming our state flower.

On motion, the secretary was instructed to write a letter of appreciation to those members of the House and the Senate who favored and worked in behalf of the Academy appropriation bill. The following named representatives and senators were designated:

Representatives	*Senators*
J. L. Kingsbury	A. R. Baxter
J. L. Benedict	C. J. Buchanan
	J. M. Cravens
	J. F. Decker
	Estes Duncan
	C. O. Holmes
	W. Miller
	R. L. Moorehead
	R. M. Southworth
	W. M. Swain

Advisory Council—No report.

Interstate Meetings—E. B. Williamson reported that he had interviewed a large number of the most active members of the Ohio Academy at Columbus, as well as such members of the Michigan Academy. Both parties discouraged such a plan since the meetings of the different academies are very different, both in time and character of meetings. It was moved that the entire matter be dropped and the committee discharged.

Academy Foundation—Amos Butler reported that the money that was turned over to the Endowment Committee a year ago was invested in Liberty bonds. Due to increase in the value of the bonds, together with interest, the investment is now worth about $324.

On motion it was decided that a change should be made in the Constitution in order to define the term "Patron", as contemplated in the efforts to establish an endowment fund for research. The committee recommended the following changes in the Constitution of the Academy:

Article II—Section 2.

(1) At the end of the second sentence add "OR PATRONS".

(2) After the fifth sentence insert: "ANY PERSON WHO SHALL AT ONE TIME CONTRIBUTE ONE HUNDRED DOLLARS TO THE FUNDS OF THIS ACADEMY MAY BE ELECTED PATRON, WHO SHALL BE A LIFE MEMBER OF THE ACADEMY, FREE OF DUES."

The following nominations were made to fill vacancies made by the expiration of the term of office of Robt. W. McBride and H. L. Bruner:

Bruner and Williamson for a term of three years.

McBride and Naylor for a term of four years.

Archaeological Survey—In the absence of the chairman, Amos Butler announced that the committee had been working with the geological survey. A folder had been prepared which was now ready for distribution for the purpose of gathering information of an archaeological and historical nature.

Nomination of Fellows—No report.

Spring Meeting—The secretary read the names of three places which were suggested at the last Spring meeting. No action was taken, it being decided best to leave the matter with the program committee.

New Business—On motion, the secretary was requested to ask Judge Robt. W. McBride for a bill of his expenses in connection with bringing about the passage of the last appropriation bill.

Harry F. Dietz discussed the advisability of preparing an Index Number to all the past issues of the Proceedings. John S. Wright stated that such a number was prepared about 1900 for all previous issues, but he did not think that it was as inclusive as it should be, in that it did not include species names.

On motion, the president was instructed to appoint a Special Committee on Indexing the Proceedings of the Academy. The following committee was appointed:

Harry F. Dietz.

John S. Wright.

W. A. Cogshall requested the privilege of reading a paper by title at the meeting tomorrow, the title being "The Location of the Center of Population of the United States". The request was granted.

Adjourned 10:00 p. m.

GENERAL SESSION.

9:00 a. m., Room 200, Claypool Hotel, December 2, 1921.

Business Session.

The session was called to order by President Enders. Attendance 70. The minutes of the Executive Committee were read and approved.

The Membership Committee proposed the following named persons for membership. On motion, they were duly elected:

Adams, James Edward, 419 W. Wood St., West Lafayette.

Addington, Archie, 801 Atwater Ave., Bloomington.

Armington, J. H., Weather Bureau, Indianapolis.
Blind, Miss Charline, West Lafayette.
Boewer, P. Henry, 116 N. Ellsworth St., Lafayette.
Cain, Stanley A., 30 N. Holmes St., Indianapolis.
Campbell, Arthur, Muncie.
Campbell, Marion S., 29 N. Hawthorne Lane, Indianapolis.
Cleveland, Clarence R., 6 S. Twenty-sixth St., Lafayette.
Coggeshall, Lowell, Zoological Department, Bloomington.
Cottman, Evans W., Lanier Place, Madison.
Crozier, Alice M., 312 Kenmore Rd., Indianapolis.
Davis, Hugh L., 423 Vine St., West Lafayette.
Davis, Ward, Fortville.
DeForest, Howard, Delaware and Walnut Sts., Indianapolis.
Deuker, Henry W., Jr., Y. M. C. A., Indianapolis.
Elkin, Sarah K., 612 Harvey Ave., West Lafayette.
Franklin, Fred F., West Lafayette.
Fraze, James W., 808 W. Williams St., Kendallville.
Gayle, Joseph L., 8 Reifers Apts., Lafayette.
Guernsey, E. Y., 1421 O St., Bedford.
Hansen, Albert A., Agricultural Experiment Station, Lafayette.
Hassenzahl, Elizabeth, 424 Vine St., West Lafayette.
Howick, Howard, Indiana State Normal, Muncie.
James, Charles M., 443 Wood St., West Lafayette.
Jensen, Howard E., 360 Downey Ave., Indianapolis.
Kendrick, James B., Agricultural Experiment Station, West Lafayette.
Larrimer, Walter H., Box 95, West Lafayette.
Mackell, James F., Indiana State Normal, Terre Haute.
McAvoy, Miss Blanche, Muncie.
McDonald, Deloris, 526 E. Fifth St., Bloomington.
McEachron, Karl B., 336 Lutz Ave., West Lafayette.
McGavran, Edward, Downey Ave., Indianapolis.
Mellon, Melvin G., 403 Russell St., West Lafayette.
Moore, Kenneth W., 125 Downey Ave., Indianapolis.
Niles, Edward H., 4450 Guilford Ave., Indianapolis.
Olive, Edgar W., 721 E. Forty-sixth St., Indianapolis.
Painter, Henry R., Box 95, West Lafayette.
Pearson, George B., Box 95, West Lafayette.
Pollard, Cash B., 419 W. Wood St., Lafayette.
Rabb, Albert L., 1354 Lemcke Annex, Indianapolis.
Reinhart, Herbert F., State Board of Health, Indianapolis.
Smith, Ernest R., 711 E. Seminary St., Greencastle.
Stacy, Allan R., 1555 Ashland Ave., Indianapolis.
Stuppy, George W., 1102 N. Sixteenth St., Lafayette.
Telfer, Margaret, 403 W. Fifth St., Bloomington.
Thompson, Miss Dorothy, Dayton.
Twitty, Victor C., 4922 Central Ave., Indianapolis.
Wilhite, Miss Ida B., Butler College, Indianapolis.
Wilkinson, P. D., Indiana State Normal, Terre Haute.
Williamson, Jesse H., Bluffton.

Wilson, Geo. B., 330 Fowler St., West Lafayette.

Witmer, Samuel W., 1405 Ninth St., Goshen.

Zerfas, Leon G., Indiana University Medical School, Indianapolis.

The following members were elected to the Research Committee of the Academy Foundation:

J. P. Naylor for a term of four years.

E. B. Williamson for a term of three years.

On motion, it was decided to reassemble thirty volumes of the 1920 Proceedings and distribute the parts as author's separates.

F. B. Wynn, on behalf of the Committee on Archaeological Survey, stated that blueprint maps had been prepared of about every county in the State, and that these would be mailed to members in their respective counties. He stated that it was the intention of the committee to ask the co-operation of members of different universities in making reports of their respective localities.

Regarding the present deficit in the printing funds of the Academy, it was the sense of the members present that the legislature should not be approached for another appropriation, but that editors should be very careful in the future not to let the printers exceed the $1,200 appropriation. On motion, it was decided that the past two editors should confer with the state printers and the state auditor, and settle the matter in the best possible way.

The proposed amendment to the Constitution of the Academy was read at this time.

Adjourned 10:00 a. m.

GENERAL SESSION.

The papers of the General Session were now taken up in their regular order. At the close of the reading of these papers, the Academy adjourned for luncheon.

1:30 P. M. Business Meeting.

J. J. Davis, as chairman of the committee which was named to investigate the resolution presented by Arthur McDonals of Washington, D. C., consolidating the science bureaus of the various government organizations under the jurisdiction of the Board of Regents of the Smithsonian Institution, begs to report as follows:

> "After carefully studying the plan advocated, as printed in the Congressional Record of the first session of the 67th Congress, Vol. 61, No. 139, October 26, 1921, the committee recommends that the plan not be indorsed, because in our opinion it is not only ill-advised and unnecessary, but undesirable and impracticable."

J. J. Davis.
J. P. Naylor.
D. M. Mottier.

The proposed amendments to the Constitution of the Academy were read and on motion they were adopted.

A resolution was passed that the Academy express its hearty appreciation to the management of the Claypool Hotel for supplying rooms and other accommodations for our meetings.

Committee of Nominations.

The chairman of the committee read the report, as follows:

Officers for 1922.

President—F. M. Andrews, Bloomington, Ind.
Vice-President—C. A. Behrens, West Lafayette, Ind.
Secretary—W. N. Hess, Greencastle, Ind.
Assistant Secretary—H. F. Dietz, State House, Indianapolis, Ind.
Treasurer—W. M. Blanchard, Greencastle, Ind.
Editor—F. Payne, Bloomington, Ind.
Press Secretary—F. B. Wade, Shortridge High School, Indianapolis, Ind.

On motion, the above named officers were elected.

Mr. Lieber called attention of the Academy to the very poor facilities of the present state museum. Discussion resulted in a resolution being passed by the Academy as follows:

Resolved, That it is the sense of the Indiana Academy of Science that a portion of the proposed Soldiers' Memorial should be devoted to the State Museum.

F. B. Wynn suggested that committees from the different science and historical organizations be selected to solicit the Memorial Committee for this purpose.

Adjourned for Sectional Meetings at 2:00 p. m., Biological Section to the Assembly Room; Physical Section to Room 200.

Fifty-seven members participated in the Academy dinner at 6:00 p. m. At the close of the dinner, the Academy met in the Assembly Room for a general session open to the citizens of Indianapolis. The following lectures were presented:

"Winthrop Ellsworth Stone." An appreciation, by Stanley Coulter.

"Topographic Development of Western South America as Indicated by the Fresh Water Fishes." C. H. Eigenmann.

"Some Observational Results Secured at the Lowell Observatory." V. M. Slipher, Lowell Observatory, Flagstaff, Arizona.

At 11:00 p. m. the 37th Session of the Indiana Academy of Science closed.

H. E. Enders,
President.

Walter N. Hess,
Secretary.

Program of the Thirty-Seventh Annual Meeting

of

THE INDIANA ACADEMY OF SCIENCE

held at

THE CLAYPOOL HOTEL, INDIANAPOLIS

Thursday and Friday, December 1 and 2, 1921

OFFICERS.

Howard E. Enders, West Lafayette........................President
F. M. Andrews, Bloomington........................Vice-President
W. N. Hess, Greencastle..............................Secretary
H. F. Dietz, Indianapolis........................Assistant Secretary
F. B. Wade, Indianapolis.........................Press Secretary
Wm. M. Blanchard, Greencastle..........................Treasurer
J. F. Breeze, Muncie...................................Editor

PROGRAM COMMITTEE.

R. C. Friesner. Wm. M. Blanchard.
F. B. Wynn.

OUTLINE OF PROGRAM.

Thursday, December 1.

8:00 p. m. Executive Committee Meeting.

Friday, December 2.

9:00- 9:30 a. m. Business Meeting, Parlor "B."
9:30-12:00 a. m. General Session, Parlor "B."
1:30- 2:00 p. m. Business Meeting, Assembly Room.
2:00- 6:00 p. m. Sectional Meetings: Biological Sciences in Assembly Room, Physical Sciences in Parlor "B."
6:00- 8:30 p. m. Annual Academy Dinner, in Florentine Room. Dean Stanley Coulter, of Purdue University, will act as toastmaster. Members who expect to be present at this dinner will please mail the enclosed card at once, in order that plates may be reserved.
8:00 p. m. General Session, in Assembly Room.

GENERAL SESSION.

Parlor "B," Friday, 9:30-12:00 a. m.

1. Prehistoric Indiana Archaeology; Stone-Age Occupation, Geographically. 12 minutes. Stephen Francis Balcom, Indianapolis.

2. Plans for Teaching Science in Evansville College. 10 minutes. A. J. Bigney, Evansville College.
3. The Popping of Corn. 20 minutes. Paul Weatherwax, Indiana University.
4. Winthrop Ellsworth Stone: An Appreciation. 10 minutes. Stanley Coulter, Purdue University.
5. Alfred Monroe Kenyon: In Memoriam. 10 minutes. Thomas E. Mason and W. A. Zehring, Purdue University.
6. William Watson Woollen: In Memoriam. 10 minutes. Amos W. Butler, Indianapolis.
7. Treatment of Rhus Poisoning. 5 minutes. O. P. Terry, Purdue University.
8. A Moon Rainbow. 10 minutes. Albert B. Reagan, Indian Schools, Kayenta, Ariz.
9. The Aurora Borealis Seen at Kayenta, Ariz., May 14, 1921. 10 minutes. Albert B. Reagan.
10. Songs and Medicinal Receipts of George Farmer Ne-ba-day-ke-shi-go-kay. 10 minutes. Albert B. Reagan.
11. The Origin of the Pacific Slope Fishes of South America. 20 minutes. C. H. Eigenmann, Indiana University.

SECTIONAL PROGRAM.

Friday, 2:00-6:00 p. m.

Physical Sciences—Parlor "B."

Physics and Chemistry.

12. Decrement Measurements. 10 minutes. R. R. Ramsey, Indiana University.
13. Effects of Heat on the Enzyme Peroxidase. 10 minutes. George Spitzer and Naomi C. Taylor, Purdue University.
14. Chemical Structure of High Protein Corn. 10 minutes. R. H. Carr and M. F. Showalter, Purdue University.
15. Ozone in Ventilation: Revivication of Mice. Lantern. 5 minutes. F. O. Anderegg, Purdue University.
16. A Chemical Study of the High Frequency Corona Discharge. Lantern. 10 minutes. F. O. Anderegg.
17. Ozone as a Bleaching Agent for Steam Laundries. 10 minutes. F. O. Anderegg and R. H. Carr, Purdue University.
18. The Simultaneous Electro-Deposition of Lead and Lead Peroxide. Lantern. 10 minutes. M. G. Mellon and H. F. Reinhard, Purdue University.
19. Some Experiments on the Determination of Lead in Lead Amalgams. 5 minutes. M. G. Mellon and H. F. Reinhard.
20. Chlorinating Mixed Silver Halides in Gooch Crucibles. 5 minutes. M. G. Mellon and J. C. Siegesmund, Purdue University.
21. Fertilizer Treatment as Affecting Nitrate Formation. 10 minutes. I. L. Baldwin, W. E. Walters, and F. K. Schmidt, Purdue University.

22. Crop Rotation as Affecting Nitrate Formation. 10 minutes. I. L. Baldwin, U. L. Coble, and J. W. Chamberlain, Purdue University.

Geology and Geography.

23. Archaic Investigations, 1921. 5 minutes. W. N. Logan, Indiana University.
24. The Structural Conditions in the Eastern Indiana Oil Field. 10 minutes. W. N. Logan.
25. A Subterranean Cut-off. 5 minutes. Clyde A. Malott, Indiana University.
26. Lost River and Its Subterranean Drainage. 15 minutes. Clyde A. Malott.
27. The Decline of Lakes near Laporte, Ind. 15 minutes. W. M. Tucker, Indiana University.
28. A Concretionary Zone in the Knobstone. Lantern. 10 minutes. W. M. Tucker.

BIOLOGICAL SCIENCES—ASSEMBLY ROOM.

Botany (Including Bacteriology)

29. Saprolegnia. 5 minutes. F. M. Andrews, Indiana University.
30. Some Abnormal Forms of Spirogyra. 5 minutes. F. M. Andrews.
31. Trillium Nivale. 5 minutes. F. M. Andrews.
32. The Sporangium of Vaucharia. 5 minutes. F. M. Andrews.
33. The Reclamation of Soil by Fungi. 10 minutes. F. M. Andrews.
34. A Pocket Dissecting-scope. 5 minutes. Elmer G. Campbell, Purdue University.
35. A Panorama of Stone Mountain and Its Vegetation. Lantern. 15 minutes. Elmer G. Campbell.
36. Preparation and Use of Collodion Sacs in Exalting Micro-organisms. Charles A. Behrens, Purdue University.
37. Red Cedar in Indiana. 10 minutes. Stanley Coulter, Purdue University.
38. Plants New to Indiana. X. 3 minutes. Charles C. Deam, State Forester, Bluffton.
39. Indiana Fungi. VI. 5 minutes. J. M. Van Hook, Indiana University.
40. Evidences of the Seed Carriage of Certain Euphorbia Rusts. 5 minutes. E. B. Mains, Purdue Agricultural Experiment Station.
41. Observations Concerning *Puccinia Pattersoniana*. 5 minutes. E. B. Mains.
42. The Growth of Tree Twigs. 10 minutes. C. A. Ludwig, Clemson College, South Carolina.
43. Indiana Plant Diseases. 1921. 10 minutes. Max W. Gardner, Purdue Agricultural Experiment Station.
44. On the Endogenous Formation of Flowers. 5 minutes. T. G. Yuncker, DePauw University.
45. Development of Sporogenous Tissue in the Foot of the Sporophyte of *Porella platyphylla* (L) Lindb. 5 minutes. Flora Anderson, Indiana University.

46. Unusual Stipules of *Acer nigrum* Michx. 10 minutes. Flora Anderson.
47. Plants of White County. IV. By title. Louis Heimlich, Purdue University.
48. Peloria in Linaria. By title. Louis Heimlich.
49. Additions to the List of Indiana Mosses. 2 minutes. T. G. Yuncker, DePauw University.
50. Additions to the Fungus Flora of Indiana. 5 minutes. H. S. Jackson, Purdue Agricultural Experiment Station.
51. Methods in Plant Nutrition Studies. 15 minutes. H. A. Noyes, J. H. Martsolf, and H. T. King, Mellon Institute of Industrial Research, Pittsburgh, Pa.
52. Bacterial Indices. 15 minutes. H. A. Noyes, Mellon Institute of Industrial Research, Pittsburgh, Pa.
53. The Flora of the Olympic Peninsula, Washington. 10 minutes. Albert B. Reagan, Indian Schools, Kayenta, Ariz.
54. Annotated Bibliography of Mycological and Phytopathological Literature for Indiana. 5 minutes. H. S. Jackson, Purdue Agricultural Experiment Station.

Zoology.

55. Light Reactions and Photoreceptors of Annelida. 8 minutes. Walter N. Hess, DePauw University.
56. Preliminary Note on Hydrogen Ions in Solution in Ponds. 5 minutes. Will Scott, Indiana University.
57. Life History of *Hyallela Knickerbockerii.* 10 minutes. Dona Gaylor, Indiana University.
58. Food of the Fishes of Winona Lake. 10 minutes. Willis DeRyke, Indiana University.
59. Army Worm Control Through County Organization. 5 minutes. Walter H. Larrimer, U. S. Entomological Laboratory, West Lafayette, Ind.
60. A Preliminary Report of the Hog Lung-worms. 10 minutes. George Zebrowski, Purdue University.
61. The Effect of Temperature upon an Eyeless Race of *Drosophila hydei* Sturtevant. By title. Roscoe R. Hyde, Johns Hopkins University, Baltimore, Md.

GENERAL PROGRAM.

Friday, 8:00 p. m., Assembly Room.

62. Address of the Retiring President, The Problems of Life among Parasitic Animals. Howard E. Enders, Purdue University.

ADDITIONAL TITLES.

(The following titles were received too late to be included in the main printed program. They will be read at the times and places designated below.)

PHYSICS AND CHEMISTRY, FRIDAY 2:00-6:00, PARLOR "B."

63. Fakers in Science. 10 minutes. E. G. Mahin, Purdue University.
64. The Integrating Power of Photographic Plates. 5 minutes. Arthur L. Foley, Waterman Institute for Research, Indiana University.

PHYSICS AND CHEMISTRY, FRIDAY, 2:00-6:00, PARLOR "B."

65. Acyl Derivatives of O-Aminophenol. 10 minutes. R. E. Nelson and H. L. Davis, Purdue University.
66. Beta Sulphur Trioxide. 5 minutes. E. G. Mahin, Purdue University.
67. A Study of Explosions. Lantern. 8 minutes. John B. Dutcher, Indiana University.
68. Some Diffraction Patterns. Lantern. 5 minutes. John B. Dutcher.
69. The Dependence Between Sound Wave Reflection and Frequency. Lantern. 5 minutes. Arthur L. Foley, Waterman Institute for Research, Indiana University.
70. The Amplifying Effect of Horns and Other Sound Receivers. Lantern. 5 minutes. Arthur L. Foley.
71. The Effect of Horns on the Distribution of Sound Energy about a Sounding Body. 10 minutes. Arthur L. Foley.
72. The Actinic Quality of the Electric Spark. 5 minutes. Arthur L. Foley.
73. The Effect of Ultra-Violet Light and X-Rays on the Stability of Matter. Lantern. 10 minutes. Arthur L. Foley.

GEOLOGY AND GEOGRAPHY, FRIDAY, 2:00-6:00, PARLOR "B."

74. A Field Trip Through the Eastern States. 15 minutes. Fred J. Breeze, Indiana State Normal School, Eastern Division.
75. The Hewitt Oil Field, Carter County, Oklahoma. By title. Louis Roark, Okmulgee, Okla.

BOTANY, FRIDAY, 2:00-6:00, ASSEMBLY ROOM.

76. The Toll of Weeds in Indiana. 10 minutes. Albert A. Hansen, Purdue Agricultural Experiment Station.

ZOOLOGY, FRIDAY, 2:00-6:00, ASSEMBLY ROOM.

77. A National Insect Pest Survey and Its Relation to Indiana. 15 minutes. John J. Davis, Purdue University.
78. An Insect Pest Survey for Indiana. 10 minutes. John J. Davis.

All meetings at which papers are read are open to the public. Visitors are especially welcome at the general program to be given Friday at 8:00 p. m. in the Assembly Room.

The program committee will appreciate suggestions with regard to the meetings, especially with regard to the coming spring meeting.

If you have not paid your dues, they should be given to the treasurer during the meetings.

HAVE YOU RESERVED YOUR PLATE FOR THE BANQUET?

SUPPLEMENT TO THIRTY-SEVENTH ANNUAL PROGRAM.

The following titles were received after the printed programs were in the mails. They will be read at the times and places listed below:

GENERAL PROGRAM, FRIDAY, 9:30-12:00, PARLOR "B."

79. Report of the Second International Eugenics Congress, New York, September, 1921. 10 minutes. Arthur H. Estabrook, Indianapolis.

CHEMISTRY, FRIDAY, 2:00-6:00, PARLOR "B."

80. Some Characteristics of a Siemens Ozonizer. Lantern. 10 minutes. Karl B. McEachron, Purdue University.

BOTANY, FRIDAY, 2:00-6:00, ASSEMBLY ROOM.

81. Notes on Indiana Plant Diseases. By title. Harold E. Turley, Department of Conservation, State House, Indianapolis.

ZOOLOGY, FRIDAY, 2:00-6:00, ASSEMBLY ROOM.

82. Distribution of the Mussels of Winona Lake. 10 minutes. William Ray Allen, Municipal University, Akron, Ohio.
83. A New Mutation in the Mouse, *Mus musculus*. 5 minutes. Horace W. Feldman, University of Illinois.

GENERAL PROGRAM, FRIDAY, 8:00-10:00, ASSEMBLY ROOM.

84. Topographic Development of Western South America as Indicated by the Freshwater Fishes. C. H. Eigenmann, Indiana University.

William Watson Woollen.

Let us stop for a moment. I would pay a tribute of appreciation to William Watson Woollen, the oldest of our members.

Our good friend has gone. For some twenty-five years I have had the privilege of knowing him. He was a faithful member of this Academy, regular in attendance upon its meetings, faithful in his duties, enthusiastic in our cause. He was one of the charter members of the Indiana Audubon Society, in which he has filled almost every office. He was the founder of the Indiana Nature Study Club and from its beginning its most enthusiastic and most distinguished member.

He came of pioneer stock, inherited a strong constitution and carried always the spirit of the pioneers. He loved the things of the early days. The trees and woods and their inhabitants were all his friends. He saw with regret the vanishing of our wild life—the wild flowers, the primeval forest and the birds. He believed not only in natural things but also in the simple life. He lived close to nature, a free, happy life, close to the things of God. He was an optimist—a natural thing with one who continually communed with nature. His bit of forest land, in which he had intense interest, he called "Buzzard's Roost." Later he gave it the name, "Woollen's Garden of Birds and Botany." It attracted much attention both at home and abroad. On one occasion I recall how he showed us with much pride an invitation to attend a dinner at Shaw's Garden in St. Louis, and speak on the subject so near his heart. Sometime since he presented it to the city of Indianapolis, to be preserved forever as a natural park. He studied much and wrote for the daily press and for other publications. He published an interesting volume entitled "Birds of Buzzard's Roost," an autograph copy of which I have. It was dedicated to the children and the birds. His contributions were popular in character and helpful to a wide circle of readers.

He is dead—yet he speaks. He speaks in all the good works he did; in all the manifestations of his unselfish spirit, in the lives of little children whose minds were led into a greater appreciation of the works of the Creator and the rights of His creatures. He was interested in children. The children were interested in him. He easily aroused their interest and gained their confidence. He taught them to be humane, to love the birds, the flowers and the interesting things of nature. The seed he planted is growing and will blossom and fruit. It will go on indefinitely reproducing in the minds of other children the lessons he strove to teach. His message to the children was like a pebble dropped into the water. The ripples it started will spread wider and wider until their influence will reach so far that it can not now be predicted. How far-reaching are the results of such devoted and unselfish effort!

To him, the nature lover, the inspiration to many, the teacher of children, our thoughts turn at this hour. The cause he served has lost a noble advocate, our city and State a useful citizen. Our memories of his service and his helpful friendship we would keep green. With bowed heads and sorrowing hearts we pause to offer a tribute of respect to him.

Amos W. Butler.

Winthrop Ellsworth Stone.

Born—Chesterfield, N. H., June 12, 1862.
B. S.—Massachusetts Agricultural College, 1882.
B. S.—Boston University, 1886.
Ph. D.—Göttingen, 1888.
LL. D.—Michigan Agricultural College, 1907.
Assistant Chemist, Massachusetts Agricultural Experiment Station, 1884-1886.
Student at Göttingen, 1886-1888.
Chemist, Tennessee Agricultural Experiment Station, 1888-1889.
Professor of Chemistry, Purdue University, 1889-1900.
Vice-President and Professor of Chemistry, Purdue University, 1892-1900.
President, Purdue University, 1900 to July 17, 1921.

These are the significant dates in a life of unremitting toil and high achievements—a life that meant much to the State and to the cause of education. They are more than mere dates, for they tell of heredity, of natural aptitudes, of training, of ambitions and of achievements. The great, steady sweep of such a life can only be realized by those who through the intimacies of daily association have been able to separate its incidental surface features from its underlying fundamental and basic principles.

To his New England ancestry we can attribute the Pilgrim element in his blood. He had the Pilgrim faith in Almighty God and the Pilgrim faith in his own high mission. In the courage born of these faiths he did his work and lived his life. To the accomplishment of the high purpose to which he felt he was called he devoted every power of body and mind and soul, and no pressure of persuasion or criticism could turn him from the path he had marked out, which was to him the path of duty.

He had also in a very large measure the Pilgrim's instinctive sense of fairness and justice. In all of the years of my association with President Stone, I never heard his fairness questioned. We might feel at times that there was a little too much of the New England granite in him, but we never questioned the absolute fairness and justice of his decisions.

In spite of his manifold duties President Stone was always easily accessible. No member of the University force ever failed to receive a patient and sympathetic hearing. He was indeed essentially democratic; he hedged himself about with no dignities; he was a man among men in the University life, but, *facile princeps*.

It is scarcely necessary to speak of his fine integrity. It pervaded his every act. It was a part of his very being. His acts were as direct and clean cut as his thoughts and words. This ingrained honesty made him a man both positive and aggressive. He never avoided an issue, nor feared a fight for what seemed to him to be right. He was noth-

ing of an opportunist, very little of a politician. He fought in the open and won his battles not by indirection but because of the righteousness of his cause.

He was finely sensitive to the moralities of life and was persistent in efforts to improve the moral conditions surrounding the thousands of students under his direction and for whose welfare he was in a large measure held responsible. He felt the obligations of citizenship as few of us do, and whether called for duty by city, State or nation gave loyal and effective service. If the purpose of our Universities is to develop a trained citizenship, then President Stone was at once a matchless leader and a brilliant example.

If we attempt to measure him by those things which appealed to him in his moments of leisure and relaxation we may perhaps gain a truer conception of his fine and attractive personality. He was an intense lover of music, losing no opportunity of hearing great artists. His was a taste trained to the appreciation of the best both in theme and interpretation. He played no instrument, he did not sing, but he found in music that which answered needs of mind and heart and soul. He loved books, and here again his taste was of the best. It needed but a casual glance at his library to see how wide-ranging were his interests and what his books meant to him. But above all he loved nature. He loved flowers and trees and knew them; he loved birds and animals and understood their ways; he loved the outdoor world and revelled in its beauties, whether it was the serene and quiet beauty of the meadows and lakes and rivers, or the majestic, ineffable grandeur and beauty of glacier-clad mountains. One can readily understand what such a passion for nature meant to the tired man, not merely in satisfying his love for beauty, but as an actual recreation.

If he had to leave us, there is something of comfort in the thought that in full vigor of body and mind, doing that which called him so compellingly, having won the summit he had sought to conquer, he entered upon the "*great adventure*."

President Stone became a member of the Academy in 1889, when he took the chair of Chemistry at Purdue University. In the earlier years of his membership he was regular in his attendance upon both the winter and spring meetings. As administrative duties crowded upon him he found himself unable to attend as frequently as he desired. In spite of this he never lost interest in the Academy, attending its sessions when it was possible for him to do so, and each year urging members of the faculty to an active participation in its affairs. In his early years he published quite largely, as will be seen by the following bibliography, for the compilation and use of which I am indebted to Dr. P. N. Evans:

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STANLEY COULTER, Purdue University.

Alfred Monroe Kenyon.

Alfred Monroe Kenyon was born December 10, 1869, on a farm near Medina, Ohio, not far distant from Cleveland. His boyhood life was spent in a humble but very comfortable country home. He attended the district school near by and later the high school at Medina. After graduating from the high school he taught for two or three years in the country schools. In the fall of 1890 he entered Hiram College and four years later was graduated with highest honors, receiving the A. B. degree. The following two years were spent as principal of the high school at Wellington, Ohio. In 1896-97 he was a graduate student in Western Reserve University and a teacher of freshman mathematics in Case School of Applied Science. The next year he entered Harvard University as a graduate student and university scholar and received his A. M. degree from that institution in the spring of 1898.

Professor Kenyon came to Purdue University as an instructor in mathematics in 1898. On account of the efficient service he rendered the University his promotion was rapid. In 1900 he was made Registrar, an office requiring about an hour a day at that time. In 1901 he was promoted to be Assistant Professor and in 1908 to be Professor of Mathematics, giving up his duties as Registrar. In this year he succeeded Professor C. A. Waldo as head of the department of mathematics, which position he occupied until his death.

Professor Kenyon was called to his former home by the death of his mother. On the return to Lafayette he was taken suddenly ill on an interurban car which he left at Ashland, Ohio, to seek medical aid. His condition became worse and he died within an hour after leaving the car. This occurred on July 27, 1921. The unexpected death of Professor Kenyon coming in the same week with the news of the loss of President Stone added greatly to the shock of the university community. Professor Kenyon was buried at Lafayette on July 29, 1921.

In 1897 Professor Kenyon was married to Grace Greenwood Finch. His wife and three children survive.

The productive part of Professor Kenyon's life was spent at Purdue University and it might properly be said that he gave his life for the University. He had a great part in shaping the policies and in moulding the character of the institution. His logical analysis and fair judgment on all problems of administration were recognized by all. He served frequently on important committees of the faculty and at the time of his death was a member of the executive committee. He was most successful as head of the department of mathematics. He laid down no rules of conduct and did not insist on special methods of teaching or of class management, but by a kind brotherly friendship inspired each member of his department to do his best. He always revealed a genuine human interest in the man as well as in the instructor. This is the thing, that those of us, who knew him best, will miss most in his loss.

Professor Kenyon was a very successful teacher. He was thoroughly prepared for his work and was always able to present his subject in a clear and vigorous manner. He never lost the student's viewpoint and spent much time in working out in great detail problems which interested his students. Professor Kenyon's influence among students was not limited to the class room. He was ever ready to respond to any demand which in his opinion meant an uplift to the student life. He served as a member of the executive committee of the Y. M. C. A. and as financial secretary of the Purdue Union. Professor Kenyon lived as a man among men, he was no recluse. He took a keen and active interest in all matters of church and community.

Whatever ability as an investigator and research worker in mathematics Professor Kenyon may have had was largely covered up by administrative duties. He never lost interest in mathematics but by constant study, by attendance at mathematical meetings, by contact with mathematicians, kept in touch with modern mathematical problems. At intervals he found time to do short pieces of original work, some of which have been published in the Proceedings of this Academy, in the American Mathematical Monthly and elsewhere. He was joint author of texts on trigonometry and of a text for mathematics for students of science and agriculture.

Professor Kenyon was a member of this Academy, elected a Fellow in 1914; of the American Mathematical Society; of the Mathematical Association of America; of the Society for the Promotion of Engineering Education; of the American Association of University Professors; and of the honorary scientific society, Sigma Xi.

T. E. MASON and W. A. ZEHRING, Purdue University.

President's Address.

THE PROBLEMS OF LIFE AMONG PARASITIC ANIMALS.

Howard E. Enders.

The development of parasitology as a special phase of zoology has been made possible through a recognition of its economic applications in agriculture, horticulture, veterinary medicine and public health. The applications in medicine and public health help to re-establish the close relationship to the science of medicine from which zoology originally developed into the importance of a separate science.

Need for the further development of the field of parasitology was thoroughly emphasized in the recent war, through the work accomplished by the parasitologists of the Sanitary Corps in eradication of the lice, which became active agents in the spread of typhus and trench fevers that levied a heavy toll throughout all of Serbia and more or less elsewhere. Before the war few colleges offered courses in this work but with the return of men to the educational duties new courses were undertaken and the older courses were given new life and renewed activities in a field in which so much remains to be investigated.

A generation or two ago, when the presence of amiable flies about the table was a token of the hospitality and general kindliness of the hostess, the louse and the flea and other more or less personal attendants were regarded at most only as petty annoyances. Most of these forms are now regarded as parasites. In its original use the term "parasite" was employed to describe those who sat about the tables of the rich of ancient Greece, by virtue of their fawning and flattery. It does not require a wide stretch of the imagination to understand how a similar relation was ascribed to the animals which lived upon other animals and there maintained a thievish existence at the expense of the host. How they came into being, or how they came to be where they were was as readily accounted for as was the origin of Topsy, in "Uncle Tom's Cabin", and each had as real a purpose in life as was expressed by "David Harum" of the fleas: "A reasonable amount of fleas is good for a dog; it keeps him from brooding over being a dog."

The idea that life could spring suddenly into existence made it as readily possible to account for the origin of any parasite within or upon a host, as for the host itself. The belief in the spontaneous origin of parasites and "other vermin" from filth or other "formative materials", was so firmly held that formulas were given for the production of certain forms of life, and to doubt it was to question reason and truth.

Development within the field of biology in a period possibly only a little longer than the lifetime of the oldest person here, has been made possible through the epoch-making discovery of protoplasm as the physical basis of life; the formulation of the cell-theory; the exposition of the theory of evolution of plants and animals; the development of the science of bacteriology and with it the proofs that life does not arise spontaneously, and finally the formulation of the modern theories of heredity. Thus the old theories have been proven untenable so that now the period from generation to generation represents a definite sequence or a series of steps in a definite life-cycle.

The term "parasite", now one of the common terms in biological literature, is so difficult to define that it seems almost impossible to have two workers agree without a series of qualifications of its meaning. Megnin has defined parasites as those which live at the expense of others which are living. The definition recognizes a symbiotic relationship between the parasite and its host, upon which or within which it may maintain its existence for a shorter or longer time, possibly only for an occasional visit or for the whole of a lifetime.

Whatever the relationship to its host the parasite, if it is successful, lives and grows and in turn reproduces its kind, but to do so it must solve the problems of life. These may be serious ones, and the hazards of gaining a foothold and maintaining itself and reproducing are out of all proportion to those with which man, his domesticated animals and most other free-living forms must cope.

The parasite may be a permanent or a temporary resident upon the outside of a host that mingles little or much with others of its kind; it may live within the digestive tract or kidneys, liver, lungs or in the circulatory apparatus, within which it may move with more or less ease but from which escape to a new host becomes more difficult; it may live within the tissues from which escape seems even less certain, unless the host is eaten by some predaceous form, or its carcass is devoured by some scavenger.

> If it is on the outside of a host how does the parasite maintain its place or avoid dislodgment?
>
> How does it maintain itself inside the body without being strangled, if respiration is necessary?
>
> How does it maintain itself in a digestive tract in which it encounters the inhospitable digestive enzymes that act upon other substances like those of its own body?
>
> How does it perform the fundamental functions of life, as reproducing itself, etc.?
>
> If it or its young find the way to the soil or water how are the new conditions withstood?
>
> If neither it nor its eggs or the young can escape from the host, what of the future?
>
> What chance do the progeny have of securing a foothold and what difficulties do they encounter, or how do the progeny come to find a similar or suitable host?
>
> Above all, how did the particular parasite come to live as it does?

These are some of the problems that the successful parasite solves when it maintains itself and reproduces its kind.

The last of these questions, "Above all, how did the particular parasite come to live as it does?" may be considered first, in a general way, as it applies to a few of the permanent ectoparasites. From the investigations of others and from my own observations I have been able to obtain a large volume of data on various aspects presented in different states of symbiosis which have been included under the term parasitism.

To each of us—though with certain reservations—it has been a matter of common observation that the mosquito, the blood-sucking fly, or the bed-bug and flea, or a tick, may make an occasional levy for blood, but that any warm-blooded animal may serve equally well as a temporary host, only long enough to secure their fill, or until they are interrupted in the act. The length and strength of the piercing beak here seems to guarantee an ample supply of food from any warm-blooded animal whose skin is not too thick to be penetrated, so the food problem is not a difficult one. Sooner or later they lay their eggs which develop apart from the host, and in time the young of only one of these return for the food that is necessary to maintain a livelihood, and for them the food question is simple, for they share the same bed with their host. The progeny of the flea and the mosquito forage in a free environment but the ticks, numbering from two thousand to ten thousand from a single mother, crawl up stems and blades of grass and there wait. If a new, warm-blooded animal passes, or if they chance to attach themselves to a favorable host, they may gain a meal and live, but the hazards are great, and on the average there are no more ticks in one season than in another, which means that a little tick has scarcely one two-thousandth, or even one ten-thousandth of a chance of reaching maturity.

As one leafs over a series of volumes and reprints he may observe little flat-bodied, wingless book-lice that have been disturbed in their meal upon the glue of the bindings, and in them he may recognize the same characteristics of structure that occur in a host of forms that live as parasites, permanent parasites, on our domestic poultry and on our wild birds. Other relatives of these free-living book-lice are found upon the bark of trees, and in some manner they may have found their way to the bodies of the ancestors of our present-day birds. The whole organization and structure is so similar that we have good reason to conlude that the bird-lice, the Mallophaga, fifteen hundred different species, have descended from the ancestors from which the book-lice have come. The food which they now take consists of the small fragments of feathers and dead skin, instead of the glue or other animal or plant products of their free-living relatives.

The eggs of the Mallophaga are glued to the feathers, or to the hairs, for about one hundred of the fifteen hundred known species have taken up their abode on mammals, by a clasping action of the posterior end of the abdomen of the female. The young feed from birth upon hairs or feathers and free scales of skin as the parents do, and neither they nor their parents leave the body of the host except under unusual circumstances. It is only very rarely that straggling lice are found on the perches, or the roosting places on seaside rocks from which scores of abundantly parasitized birds, such as cormorants, gulls or pelicans, have been frightened.

Normal migration from bird to bird occurs when in contact, among gregarious groups, or at mating from female to male, or *vice versa*, or to the fledgling birds at the time of brooding.

Upon the death of the host some of the lice wander off the cold body with little chance ever to become relocated within the three or four days in which they can live under the most favorable conditions. Many usually remain, but only to perish within ten days, firmly gripping feather barbules between their jaws. Those which could have subsisted upon the foods of their ancestors in a free range have long since passed away, and only these remain whose food and living conditions have been unchanged for so long a time that individuals having variable tastes have been bred out.

The Mallophaga are capable of living on certain hosts toward which they have developed a certain physiological fitness. The curious sensitiveness to differences in composition of host hair and feathers or skin and oil, etc., is so marked that those of our number who, in the course of a hunting trip, or in their collection, inadvertently became the temporary hosts of bird- and mammal-infesting mallophaga and anoplura found these parasites as eager to escape as we were to have them do so—or in the failure of which they died in a few hours. The real reasons for failure to live are not apparent and we conclude that it represents a particular physiological fitting in addition to the presence of the number, size and shape of claws and conformation of clinging devices or spine-hairs set at a particular angle to afford security of position on the body. If the species common to wild birds are transferred experimentally to guinea pigs, which ordinarily support two species of mallophaga, or to our common poultry, they are unable to maintain themselves even though the skin and hair, or the feathers, would seem to serve the same purpose, as food. It is likewise true that birds of prey do not fall heir to the parasites which were common to the birds or mammals upon which they prey, though to this there are occasional exceptions.

The progeny of permanent ectoparasites represent a closely inbred strain that is isolated biologically from the rest of the individuals comprising the species which it represents and with it go all the possibilities that are associated with the fixation of hereditary qualities. In a sense the relationship represents an environment that is comparable to island life. On such island the individuals pass a life that is monotonously alike whether the bird is aerial, terrestrial or aquatic.

Kellog, who has described hundreds of new species of mallophaga, asserts that the relative isolation plays a conspicuous rôle in the formation of species. He and other workers ascertained that closely related birds, whatever their geographical range, are the hosts of closely related mallophaga. Thus, the species, *Lipeurus baculus*, which occurs on the domesticated pigeon, has been collected from nineteen of the forty pigeon host-species that range through Europe, Asia, Africa, North America, Malaysia, Australia, Madagascar, and the Galapagos Islands, and that of the twelve species which occur on the domesticated fowl four are commonly found on the reputed wild ancestor, the jungle fowl.

According to Kellog's well-sustained thesis we are led to the conclusion that the progeny of the present-day species of lice are the direct lineal descendants of the lice which began as parasites upon the ancestors of these birds and, in so far as identical species appear upon closely related birds, it implies an alteration of the bird without that of the parasite, while in other instances, on identical species of birds of wide geographical range, mallophaga have been found that exhibit either varietal or even specific differences. It follows, then, that phyletic relationship may be determined in some cases of doubtful relationship of host, by a close study of its wingless, permanent ectoparasites. In this connection it is of interest to recall that certain anthropoid apes harbor two of the three species of pediculid lice which are common to man, and that one of the anthropoids bears another species of the same genus of pediculoid louse, but which does not occur on man.

The blood-sucking lice, or Anoplura, to which the pediculid lice belong, seem to be derivable from the mallophaga from which they differ structurally and chiefly in a modification of the mandibles into piercing organs which serve to perforate the skin of the host and to make the blood available for food. The same general sensitiveness to host relationship exists as was expressed of the mallophaga. The chemical composition, as shown by the blood serum reactions, which indicate a specificity of blood, seems to be one reason why the four hundred known species are as widely distributed on the mammals and that none have been taken from birds. It aids us to understand why man and the anthropoids may have closely related forms.

Migration from parent to young and from host to host occurs as was stated of the mallophaga, and with some of the same limitations. Here, however, the individuals maintain their relation upon the host more by the form and size of their claws than by grasping mandibular structures such as occur among the mallophaga.

The frantic efforts of a vigorous host would serve to dislodge individuals less well prepared to grasp the hairs. One may well conceive that the struggle for life, the free-for-all, in the louse world was one like that in which the stronger Spartans were produced by destruction of the weaklings, and that after an extended period of such elimination a race was bred that could maintain a foothold with clasping claws that fit a hair with the nicety of a caliper. A careful examination of these clasping organs shows that they can be used upon a hair of almost definite diameter and even of a definite shape. A hair much larger than those of the accustomed host frequently would be too large even to permit the presentation of the claspers, while a hair much smaller could not be held tightly at all.

The next large group of ectoparasites which is known principally in the free state, but which has a large number of members that have undertaken to live upon other animals, as well as upon plants, are known as mites. Instead of feeding on dry plant products and dead animal products, or upon the body fluids they have undertaken to go more deeply into the body. We know them as the itch mites, mange and scab, and while some of our number may confess an unfamiliarity with either of these it is more than likely that we may have undertaken unwittingly to raise another variety that grows in the skin of the face, and is referred to as the face mite, or demodex.

I shall not undertake to detail the steps by which the free-living forms, in four instances, may be traced more or less definitely to a parasitic condition. We may readily understand that a mite that served as an active scavenger might maintain the habit, and by its continuance upon an animal could readily find a supply of dead skin, hairs and oils, and without the necessity of any unusual power of locomotion could become the itch mite that burrows into the skin. Imbedded as it is, in the epidermis—as of human itch—it is removed from ready access to air, to a degree that respiration is practically impossible.

Within the bodies of our poultry we find an interesting, relatively large mite that lives and thrives in the lungs, tracheae and the air-sacks of the bird. Their life is rather unusual in that they are able to migrate about the tissues of the host, or even out of the mouth without apparent inconvenience. They are taken in with the food of the bird. The parasites feed upon the tissues of the host and give birth to living young, thus reducing to a minimum the hazards to which many of the other forms are subject.

Experiments to determine the power of mites to carry on respiration yield rather negative results, and it is held that many of these which imbed themselves in the body of the host are able to secure sufficient oxygen from the tissues to maintain their bodily activities. In an attempt to determine whether the total exclusion of air would have an effect upon the organism I mixed in vaseline several hundred of the feather-eating analgesid mites that were secured from a dead ostrich, and compared their activities with control specimens that had migrated from the body of the host to form a dense mass about the ocular of a microscope and the neck and shoulder of a bottle that stood upon the laboratory tables upon which the dissection of their host had occurred. At the close of the tenth day about half of the number were still struggling in an effort to creep out of the vaseline and in the course of the next two days the movements ceased completely. The last of the individuals that were not imbedded in vaseline died within fourteen days after their migration from the host. It would appear that the earlier death of the last individuals, by so much as two days, was due more to the exhaustion of the parasites in an effort to escape from the vaseline than to the complete exclusion of air. Therefore, if species of external mites which live normally in the air are so little affected by complete exclusion of air the effect must be less marked upon those which burrow deeply into the tissues and out of reach of free air. The tracheal respiratory organs are reduced or missing, among mites.

The face mites, demodecidae, seem quite thoroughly adapted to live imbedded in the oily secretions in and about the minute hairs of the face of several mammals, and even of man. Here they feed upon the sebaceous secretion, and I have observed instances in which they seem to have chewed the hair bulbs with their mandibulate jaws. To suggest that a person might unintentionally harbor parasites, whatever the kind, is to invite as vehement a denial as though he were charged with the act of receiving stolen goods. The interest and surprise are even greater when I suggest to you that one-fourth of the faces here have these elongate, six- or eight-legged mites in the pores over the nose, at the side of the nose, and in the furrow between the lower lip and chin, if I may judge from a twenty-eight per cent and a thirty-three-and-one-third per cent infestation in two classes of my students in parasitology.

The face mites are barely able to move about by means of their short, chubby legs. When not in the sebaceous secretion of the hair follicles, therefore, how do they migrate? How do they find a new host? More forceful than the question, "How might they spread from myself to others?" is the one, "How did they spread from others to me?" The substance which one might press out of the skin as a "commedone" or a "blackhead" is not either a worm or a mite, but in that material they may be found in numbers ranging from a single individual to several, if a person is infested. I have found as many as one hundred in a single follicle from a dog infested with follicular mange. It is possible to expel the mites by pressure or by friction applied to these regions of the face, and it is not beyond the realm of the possible that the friction, as of wiping the face with a towel, may serve to dislodge specimens from the pores, or to pick up others that were in the act of migrating from pore to pore over the surface of the face, and thus to my own face, if I chanced to use a towel previously used by an infested person.

A heavily chitinized cuticle, which covers the whole body of the face mite, makes it possible to withstand dessication, or even the effects, for several minutes, of a ten per cent solution of caustic potash, before it is killed. I have observed a mature specimen, while lying on its back in a ten per cent solution of potassium hydrate, to move its four pairs of legs with the rhythm that suggested the co-operative action of the members of a crew of an eight-oared boat.

A brief reference to the parasitic worms will serve to indicate that the hazards of life are such that, in spite of the enormous number of eggs and young, the total number of adult forms does not increase markedly from year to year. It is estimated that *Taenia saginata*, the tapeworm which man may acquire by eating infested rare beef, is capable of producing one hundred and fifty million eggs in a single year; that a liver fluke produces one hundred thousand eggs in its lifetime; and so the numbers might be multiplied at length to indicate that these, and other parasites, must meet handicaps that do not occur in the life of larger animals with which we are more familiar.

The intestinal worms, which by rare chance find their way into the digestive tract of any host, are plunged into digestive ferments that would digest materials like those of the parasite, and in fact this does occur if chance brings them into some animal with a more vigorous digestion, as, for example the introduction of hog lung-worms into the digestive tract of a rat, where a large number are digested. The experimental work of Birge and Birge of the University of Illinois throws some light upon the question of the non-digestion of such forms as tapeworms, and round-worms, ascarids, which occur in the digestive tract of dogs. The digestive juices were extracted from the pancreas of a dog; they were properly activated and kept in containers maintained at the temperature of a dog's body. Live worms that were taken from dogs were unaffected by the fluid, but if worms were added after first killing one-half, or one-third or the whole of the body by passing a strong electric current through it, only such killed portions were digested, the balance remaining active. What could be the assignable reason? To say it occurred "because they were alive" was not a solution, but when a section of the tubular body of the ascarid, which is scarcely the diameter of the quill of a chicken feather, was slipped over a small porous cup coated with platinum black and filled with hydrogen peroxide, such dead portion was not digested by the digestive fluids. Thus we are led to the conclusion that so long as the tissues are saturated with oxygen or that an oxidizing substance is available the digestive enzymes are broken down and are rendered ineffective. It is believed that the body of the live worms produces materials that oxidize the digestive enzymes as effectively as was done by the platinum black and the hydrogen peroxide, in the experiment that has been quoted.

The progeny of the intestinal worms are discharged by way of the digestive tract of the host, either in the form of eggs that hatch in the soil, or only after being eaten by a new host, or they may be in an advanced stage of development when they pass out of the host. In the moist soil they may live and move with almost the same ease as the free-living forms with which they mingle. Here they may remain alive for long periods, whether they remain moist or wholly dried, some to force their way through the skin into the body of the host and finally into the digestive tract, as the hookworms of dogs and cats, or of man; others to be taken up by hogs, and after a devious course to reach the digestive tract or lungs and there to become adults and in turn to discharge other thousands of eggs.

If time permitted one might outline, in a similar manner, the mode of life and adaptations of the parasitic protozoa, the one-celled animals, to show how they also encounter hazards that relate to food, temperature and dispersal, to each of which the parasite must become adjusted in the period of transition from a free-living state to that in which it depends solely upon a host or a series of hosts for its existence.

The problems of life of the successful parasites, whatever their kinds, are numerous and critical, but each, in its free-for-all struggle, survives if it is resistant, and leaves progeny that resemble it, or it fails in the struggle and thus passes out of existence. It has had its thousandth of a chance, or a ten-thousandth of a chance or less, and failed, while some other competitor, only slightly better fitted for the conditions, will survive and perpetuate its heritage.

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Fakers of Science

E. G. Mahin

The salvation of the world depends upon the development and applications of science. This is a statement that may be considered unassailable. But if anyone objects to this use of the word "salvation" I shall not argue the question or become irritated—I shall simply shift my ground somewhat and reiterate: The hope of the world lies in science and its developments. If it should be that other contentious individuals should manifest a doubt as to the propriety of confining "hope" to such materialistic lines, I shall not even reply, but again side-step and repeat: The whole future of the world, animate and inanimate, is held in the hands of scientists, past, present and yet to be born.

In this evasiveness I can indulge with a perfectly clear conscience because I consider all of these statements as meaning essentially the same thing. In such circumstances one can afford to be generous and to allow another, who may not so regard the matter, to select the term, the phrase, the formula that best agrees with his own ideas upon the subject.

Now if my fancied opponent remains obstinate and unconvinced, I fall back upon a vice that has already become apparent in this introduction to my paper—namely, that of over-indulgence in the pronoun, first person, singular. I speak for myself alone. No one else is involved in any of my statements; no one is asked to accept them unless he likes.

So now the way is cleared, technicalities are brushed aside and opposition is trampled down. Exceptions have been noted by the court and the basis laid for an appeal. But you will not find the present speaker there when the case is called. What I have to say, I say now. In the picturesque language of Young America, take it or leave it. It is all one to me. So now let us plunge at once into seriousness.

Can it be that you have forgotten what it is that I have been saying so many words about? Well, I am simply trying, in all seriousness, to stress the idea that studies in science, the concentration of the human intellect, mass action of human *intellects*, upon the problems of the universe has resulted in enormous benefits to the human race and that there is every indication that future efforts will uncover other vast fields for the application of forces and principles of which our brightest minds do not now even dream.

The fact is that every one who observes intently and who thinks deeply knows that what I have said is true—stripped of all verbosity, redundancy and prolixity of every variety, it is essentially true. Then to the next idea.

When we realize what a serious business is the matter of the health and comfort and happiness of the human race, individually and collectively, and how intimately bound up with these is the matter of discovery and correct application of the scientific principles upon which the universe operates, we may ask the question: What of the man who, in the full knowledge of all this, deliberately distorts the truths of science in order to deceive, to harm or to rob human beings of their benefits, and especially if this be done for personal gain, financial or otherwise? What, in short, of the *faker* of science?

Deception and thievery have always proved to be profitable enterprises, in a temporary sense, at least. How much easier and how much more pleasant a job it is to permit others to do the drudgery involved in high achievement and then magnanimously to shoulder the profits or the credit or whatever gain is involved, and to appropriate it to one's self. How simple a proposition to take the discoveries of science and the scientific achievements of men's minds and to misapply them to one's own financial gain or credit and this, frequently, in a quite spectacular manner, trusting to universal ignorance and inexhaustible human credulity for success in the undertaking.

If one were to attempt to give even scant notice to any considerable proportion of individual fakers of science, and of their fakes, that are recorded in literature the result would be a ponderous volume. Far be it from me to inflict any such attempt upon this grave and dignified body. But I should like briefly to discuss a few outstanding *classes* of fakers, using this discussion for the conveyance of certain personal opinions that have long been struggling for expression.

Schemes for accomplishing work without supplying energy or consuming materials have long engaged the attention of pseudo-scientists. These are so familiar to everyone, under the general head of "perpetual motion" contrivances, that we shall waste no time in discussing them. In most cases work and study have been spent upon such ideas as a result of lack of scientific training on the part of the schemers and we can feel only pity for the misguided zealot who spends the best years of his life in chasing such a phantom. It is only when a device of the "perpetual motion" class is actually produced for demonstration for the purpose of obtaining financial aid or credit for the "inventor" that the latter qualifies for the society of fakers. For he must necessarily know, before that event, that the machine will not work and that the scheme is impractical and he becomes then a plain swindler—a real faker of science.

So much for this ancient class of fakers. I should like to give brief mention, now, to the Free-Energy faker. This is truly a clever and audacious individual. The most recent developments of physical and chemical science have given a tremendous emphasis to the possibilities of utilization of energy stored in the individual atom. This energy is a reality and the problem of its practical utilization is one of the many fascinating fields for future exploration. The general, non-scientific public also has caught something of the vision and, with little or no understanding of the real meaning of the discoveries that have already been made, is nevertheless willing to accord a certain doubtful respect to the scientist himself. Here is the golden opportunity for the faker. Ever on the alert and with an eye to the main chance, he (metaphorically) nimbly mounts to the shoulders of the man of science, snatches the banner from his hands and bravely rides his steed into public notice. What with his excessive shouting and his skillful use of language, it is small wonder that he absorbs the principal share of attention, for a time at least.

One example shall be mentioned and then we may pass on. In the year 1917 came one silver-tongued Armenian, styling himself Garabed T. K. Giragossian, before certain Congressmen and secured their attention to an "invention" for obtaining "free energy" from the inexhaustible supply furnished by nature. He gave no description of his machine or of the principles employed in its construction or operation. But his references were so splendid and his language so eloquent that he experienced little trouble in obtaining the introduction and ultimate passage of a joint resolution authorizing the government to accept the free use of "Garabed", as the device was called, for the purpose of bringing a speedy end to the war. A clause was inserted in the resolution to the effect that a committee of scientists should first examine the validity of principles and witness a demonstration of a working model of his machine. This proviso may have been inserted as an after-thought,—or it may have been the work of some brutal materialist whose lack of vision kept his feet on the ground. At any rate the demonstration proved a complete failure and "Garabed" turned out to be only one more of the many pulley-and-flywheel devices for perpetual motion.

Dr. C. H. Herty, former editor of The Journal of Industrial and Engineering Chemistry, adds his own poetic comment, thus:

> "The Garabed's completely dead. 'Twas put to sleep through just one peep by a bloomin' committee that had no pity."

What the motives of Mr. Giragossian were, we are unable to state. In the light of his offer to the government we are inclined to be charitable and to suppose that he was, like many others before him, a self-deluded victim of his own lack of scientific training. But when we observe how nearly he came to hoodwinking an important branch of our government we indulge in a shiver of apprehension for what might have been the result had Mr. Giragossian been less altruistic and more skillful in holding fast to his dupes. The human mind is capable of believing anything, however wild, and even in working up considerable enthusiasm in connection with such belief. To support which statement I offer a part of a speech on Garabed, delivered in the House of Representatives:*

> "Mr. Speaker, the miracle of yesterday is the commonplace of today. There was a time when man was perfect in all his parts and elements. He was complete physically. The poet, the painter, the sculptor, the dreamer, in the wildest flights of superb fancy, never caught more than a fleeting vision of that beauty which was given by the Lord to the first man and first woman.

* Congressional Record, Dec. 15, 1917, p. 358.

"Not only was man complete physically at one time, but he was perfect mentally. He knew all philosophy and all science. Mathematical exactness was instinctive with him. He knew and could interpret bird song. He knew where the flower bloom came from, and why. He understood the passions of the tiger. He saw all problems with clear and unmistakable vision.

"He was complete spiritually. He discussed with the Divine the themes of the divinity. He communed with the angels.

"He was so complete in his structure that he possessed the power to destroy his own perfection, and he exercised this power. He sinned. That is to say, he violated some law of harmony. What it was we do not know. Perhaps we shall never know. But we know that it was the exercise of a power by which the integrity of the triple structure was destroyed. I think that touched his every phase and characteristic. It devitalized him physically. The majestic brow receded; the form became bent. Warts and vile protuberances grew upon the skin. The nerves lost control over the muscles, and these, uncontrolled, fell to hideous expression. And it devitalized him mentally. He lost intellectual excellence. He lost the power of discerning truth clearly amidst every confusion and complexity.

"It devitalized him spiritually. He could no longer look clear-eyed upon the angels nor commune in freedom with the God. And in this condition—a physical degenerate, a moral wreck, an intellectual prostitute—he was cast into the wild amid the wild things over which he had held unrestrained dominion."

This, you will observe, is offered in support of the claims for scientific excellence of "Garabed". If you are sufficiently generous you will admit that it completely establishes the case!

The Keely motor swindle is a classic, so familiar to all that it shall here receive mention only. Also the perennial device for "burning" air instead of expensive fuel. Likewise a myriad of other schemes for obtaining something for nothing, that have deluded and bewildered men of all generations.

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It is time now that we should give some attention to the mineral water faker. This gentleman's business is, perhaps, considerably less obnoxious than many others because, in a general way, some of the results are wholesome. Bear in mind, therefore, that it is only to the extent and in the sense that it is a *fake* that we visit our displeasure upon it. Also please remember that our faker of science is the one who shows people not the real science or a correct application of the real science, but a slightly different one, so like the true one (perhaps even a mirror image of it) that the untrained cannot discern the difference. But this slight variation is the one item upon which is based the success, financial or otherwise, of the faker.

Scientifically speaking, the task of the mineral water faker is comparatively simple. It is a fact well known among medical men that many (if not most) people do not drink enough water and that constipation, with all of its attendant ills, is the consequence of such abstinence. Also it is known that several of the chemical compounds commonly found in ground waters have a pronounced effect (sometimes a wholesome one, if taken in correct quantities) upon the digestive apparatus. Add to this the psychology of illness and health and you have the case. The waters of a given locality are advertised as of a curative nature, the chemist's analysis is published, together with a statement of the physiological effect of each constituent named, and a health resort is established.

Some people suffer from poor health because of overwork (although the number of such is really not as great as we often like to believe), some from *under*-work and great numbers think they are ill when they are not (or are ill because they think they are, which perhaps amounts to about the same thing). These in addition to the people who need more water to drink, as already explained, and to those who chronically disobey most of the rules for caring for their bodies. Induce these folk to believe that a peculiar water from the bowels of the earth, found only in certain famous wells, is the long-sought fountain of health, if not even of youth, persuade them to go to this health resort for a season and a cure is almost certain. They are placed in the hands of skilled dietitians who cause them to eat sensibly and to drink abundantly,—of other attendants who look to it that they shall bathe and exercise regularly and properly,—and the entire atmosphere is made pleasant and cheering. Under the circumstances Nature gets her opportunity and the patient is cured. The cost, in money, has been rather high but it was worth it, wasn't it?

This is all very fine and it is probably true that a cure as the result of deception is better than no cure at all. But I am dogmatic enough to believe that education is better than deception, cure or no cure, and that in the long run it will have a better effect upon the health of our people. The thing that the patient did not understand was that rest, recreation, correct diet, drinking sufficient water (plain monoxide of hydrogen), frequent bathing and rubbing and pleasant thoughts were the cause of the cure, when he innocently considered them mere necessary evils,—and that the mineral content of the water, which he understood to be the curative principle, was only so much bosh and clap-trap, an adjunct to the main business. He could have practiced proper eating, drinking, bathing, etc., at home but did not understand that they were necessary or important. He could have bought at the corner drug store, for twenty-five cents, as much mineral salts as was contained in a thousand gallons of the water he drank, but knew neither this fact nor that the salts themselves had no appreciable effect upon him because of their very small concentration, and that they were therefore unnecessary to the success of the treatment. (Please note that I am not here discussing the so-called "mineral waters" that are found bottled on the market, consisting of ordinary ground waters "fortified" by the addition of quantities of laxative salts.)

And now let me attempt to justify the statement that education is preferable to deception, science to fake, by reminding you that where one sufferer is cured by this benevolent deception, a thousand others fail of cure because they cannot afford the cost of the deception and because they have not been told how to cure themselves at home, at no cost at all.

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Enter now the Patent Medicine faker. This individual has been with us for a very long time and he bids fair to favor us with his presence for some time to come. Again we notice the essential characteristic of the faker family,—the ability to confuse science with *un*-science, truth with a lie, real medicine with pseudo-medicine. The patent medicine faker relies for his success chiefly upon (a) the almost universal knowledge that scientific medical practice has proved its worth to mankind, (b) the almost universal *ignorance* of what is and what is not scientific medical practice, (c) *quite* universal credulity and (d) the strange fascination that seems to be possessed by mankind for self-dosing. And his reliance is not misplaced. How we love to be ill so that we may become well and how we love to prescribe for ourselves,—or so we think we are doing, while in reality we are responding to psychic suggestion, so cunningly conveyed to us by paid advertisements in newspapers, frequently masquerading as news matter and through which the patent medicine faker prescribes for us.

It has been repeatedly pointed out that the worst feature of the patent medicine evil is the fact that money is so frequently squandered for worthless, or worse than worthless, materials by those who can least afford its loss, and that these same people are so frequently the ones who most need the advice of wise, well-trained physicians. Why self-respecting druggists continue to vend the stuff and why self-respecting newspapers continue to accept money for concealed and unconcealed advertisements, used for the deception of the credulous,—passes my understanding. But I long ago gave up trying to understand a number of things.

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Now, with fear and trembling I arise to pay my respects to the Religious faker. My trepidation is based upon the knowledge that any man of science who essays to discuss any matter connected with religion treads upon dangerous ground. People are extremely sensitive concerning the so-called materialism of our scientists. "Atheism in the colleges and universities" is a phrase with which to conjure. Let me say at the very outset that I am not going to attack religion. Neither shall I defend religion. I shall not discuss religion in any way but I am going to say a few things about religious fakers of science. And again please notice (I am very particular here, of necessity) that we have consistently discussed fakers of science as men who pervert or misapply the truths of science in order to bolster up any case which they desire to make, whether this be through ignorance or "with malice aforethought". I believe I am right in maintaining that it is no compliment to religious ideals to fake anything, anywhere in their support.

The "conflict" between science and religion is at least as old as science. Scientific men, accustomed as they are to rigid self-discipline in methods of thought, basing their conclusions upon demonstrated or demonstrable facts, have long manifested impatience concerning the irrational superstitions that have attached themselves to religious thought. Not only have certain scientists attacked these ideas very bitterly but many others have felt a rebellion in spirit, mostly suppressed for reasons of expediency. It has indeed been unfortunate for the cause of religion that its exponents have always been slow to accept scientific principles. Giving ground inch by inch, but always fighting, organized religion has kept itself always in the position of the reactionary instead of in that of the enthusiastic supporter of all search for truth by every available method. Many of the foremost religious thinkers of recent times have seen and regretted this anomalous position and there has, of late years, been noticed a tremendous effort on the part of religious writers and speakers to reconcile the conflicting elements and to remove from the church the stigma of always posing as the obstructionist in matters of scientific advancement.

In casting about for means to this end they have made another unfortunate mistake. "Let us be magnanimous," we can imagine them saying, "and admit that organized religion has been reactionary in the past, dogmatic and intolerant to progressive scientific ideas, and clinging to ancient and mediæval superstitions. But let it be so no more." So we have it now that there is no longer opposition to true science. The chasm is closed, the discord is harmonized. The result? Why, science *proves* the truth of religion! People may now be religious in spite of their doubts, because science and the truths of science corroborate the theories of religion. The church has adopted the "scientific method" of reasoning and the problem is solved.

This course of procedure is a mistake, for the simple reason that never, as long as this world shall endure, can science ever corroborate a single *dogma* of religion, any more than it can corroborate a single dogma of any other kind. This is because religious dogma, like any other dogma, is essentially a non-demonstrable theory. It can be neither proved nor disproved and so science can have nothing whatever to do with it. Science is concerned only with hypotheses that are susceptible of test and when it becomes apparent that any theory lies outside that conceivable possibility, that theory immediately becomes impossible of consideration from any scientific standpoint and it must remain a matter for acceptance or rejection, according to the personal inclination or emotions of the individual.

But here is where our faker takes up the matter. If science will not concern herself with our dogma let us have a science of our own! So it has become fashionable for speakers and writers, eminent and otherwise, to adopt the words and phrases of science and to weave them into discussions of religious theory, creating or attempting to create the idea that because the religious exponent himself is scientific, science is therefore of religion. Scientific terms are bandied about with perfect familiarity and handed out with an effrontery that awes the non-scientific hearer and compels his respect, even if it amazes or amuses the scientist himself. This is particularly true in college towns, where great numbers of young men and women are engaged in the study of pure and applied science. Thanks to the reactionary religious training of the past, these young people have been taught a vast number of things that have to be unlearned when they begin the process of absorbing scientific fundamentals. Now, in order to keep them in the proper channels of religious thought, the possibilities of their scientific training must be counteracted in some manner. They must be impressed with the idea that their "doubts" are only imaginary and temporary and that future training will dispel them because: "I" (the speaker) "have had such doubts and have overcome them, and is it not evident that *I* am scientific?" In addition to this very prevalent vice among the stationary teachers of religion we have numbers of eminent divines going about the country, making a specialty of talks to mass meetings of college students and using the methods above outlined. No doubt they have visited your town as they have ours. These men are usually orators of first distinction. They mix with their addresses a perfectly amazing patter of science. Dinosaurs, relativity, electrons, paleontology, anti-toxins, protoplasm, light-years and gamma rays are the breath of life to them. Even the more or less mature scientist is somewhat hypnotized by the brilliancy of the discourse. It is only on the way home that he begins to realize that the speaker had very little realization of the true meaning and significance of the half of what he said and that he had been guilty of brazenly faking science in order to appear to prove something that, in the very nature of things, can not be proved.

Unfortunately the young student is dazzled by this procedure because he is in a period of his development where he is only beginning to think logically and independently about the deeper things of life and he is very likely to regard his religious instructor as one of his scientific authorities and to be led to put aside real questions that should be decided, if his future training is to be along sane and logical lines. If the student is really serious-minded his doubts cannot be permanently satisfied in this way and he will not be content with the plan of thinking along one set of ideas within the laboratory and another, incompatible with the first, in the pew.

It may appear from this that I regard it as unfortunate that a young man should be won to religion by pulpit orators. Not at all. As it was remarked in the discussion of the Mineral Water faker that a cure as the result of deception is probably preferable to no cure at all, so it may be better that a man should be won to a life of rectitude by a religious faker than that he should ultimately fail to see the real significance of life. Yet here again I adhere to the idea that deception is unnecessary and that in the long run more people will be attracted to religion by the policy of playing fair and telling the truth, for if they think at all they will find out the truth sooner or later.

Why must our religious leaders ever persist in standing upon ground that they will be compelled to abandon later, just as they have stood upon and fought for ground that later had to be abandoned, through all the history of religion? Why must they insist upon giving so much prominence as essentials to the views and theories of men who lived in the very infancy of our civilization, instead of standing upon the simple *and absolutely unassailable* proposition that *religion is* *life and service?* Why, in short, must we have faking of science, where science, with or without faking, has no connection with the subject?

* * * * * *

It may appear that in this discussion I have dealt harshly with well-intentioned classes of people,—that I have magnified a fancied trespass upon our domain into a well-nigh capital offense. But, fellow scientists, in my profession, as in that of many of you, I associate constantly with young people, eager to learn of the whys and wherefores of life. In the college is eternal spring-time of youth. We as teachers, may eventually grow old but, figuratively at least, our classes never do. I cannot look into the faces of inquiring youth day after day, year after year, and forgive myself for any deception regarding the subject I am teaching. How, then, can I forgive deception on the part of other teachers? If we lie to our students we are unworthy of the high duty that is ours.

For all of us who are teachers of science, let us note that science has one insistent demand, which is that we shall teach the truth, according to our best lights, welcome or unwelcome though the truth may be to others.

So for our fakers of science. Their name is legion, though we have discussed but a select few. Wherever there is a truth there is a corresponding untruth that may be made to resemble the truth and if there be any possibility of temporary profit, credit or honor in exploiting the untruth, the faker arises, ready for the job. The work of progress is thus complicated by the efforts of those who persist in pulling in the wrong direction. In this connection I am fond of quoting from Thomas Carlyle, who wrote:

> "We have, simply, to carry the whole world and its businesses upon our backs, we poor united Human Species; to carry it, and shove it forward, from day to day, somehow or other, among us, or else be ground to powder under it, one and all. No light task, let me tell you, even if each did his part, honestly, which each doesn't, by any means. No, only the noble lift willingly with their whole strength, at the general burden; and in such a crowd, after all your drillings, regulatings, and attempts at equitable distribution, and compulsion, what deceptions are still practicable, what errors are inevitable! Many cunning, ignoble fellows shirk the labor altogether; and instead of faithfully lifting at the immeasurable universal handbarrow with its thousand-million handles, contrive to get on some ledge of it, and be lifted!"

Carlyle was discussing neither science nor fakers of science, yet his remarks could scarcely be more apropos of any other subject. Beside this eloquent enunciation of the problem of life and this denunciation of the obstructionist of progress, our remarks are feeble and impotent. Yet, until another Carlyle shall arise to lambast the modern faker of science, we shall have to be content with saying in our own way, the indignation that is in us. This I have tried to do.

Purdue University.

Prehistoric Indiana Archaeology.

S. F. Balcom.

First impressions are responsible many times for our persistent ideas of things. The colored maps of the school atlas, which divided the continent into sections based on political lines, stamped on our minds certain squares and irregular forms as constituting the divisions of what we are pleased to call the new world. Physical Geography corrected our ideas to quite an extent and we remember that there is an eastern and a western mountain chain in our portion of the continent, and that the latter extends through Mexico and Central America and on into South America. But how many are there who, having had opportunities of traveling over the country, take note of its formation and realize how one part after another has developed and is dependent on some other part, as for instance upon the Gulf of Mexico?

In a paper read before the Indiana Academy of Science a few years ago, Mr. M. S. Markle called attention to the fact that the glacial drift reached as far south as the Ohio River, as evidenced by local flora in certain portions of Indiana and Ohio. And that plants common to an Arctic flora still remain in bogs and cool, shady ravines, and at times are surrounded by the southern flora that came in the wake of the retreating ice. A study of the primitive races in our northern continent shows traces of a shifting about, quite similar to these marches and countermarches of nature in building the land. And from remains which the Indians have left we are led to believe that the Indian stoic of the woods in Ohio knew as much of the geographical layout of the country,—that is, its mountain territory, its lake country, its prairie region, its converging valleys and their relationship to the great gulf at the south as do most of his civilized successors, excepting, of course, those who have made a special study of the face of nature in a geological and geographical way. For on the Scioto River in Ohio are remains of a race which speak of an intertribal trade extending to the Atlantic on the east, along the Mississippi to the gulf on the south, and then west to the mountains of Mexico, if not to the canyon country by way of the Red River or other water courses.

Geology explains to us the formation of our continent, and how it has been formed on similar lines to that of the old world, yet it may be said to have an individuality of its own. Anthropology says the same of the primitive American races, for a development peculiar to themselves is indicated, in which certain characteristics of physical make-up and certain elements of the various languages, point to a common origin, and as not having been materially influenced by any old-world culture. It remains for Archaeology to trace the routes by which the branches of that prehistoric Indian race developed,—diverging in some instances, combining in others, and yet through it all leaving traces more or less distinct which point out the paths which they trod.

The director of the Field Museum at Chicago advised me, upon inquiry, that some five distinct cultures are traceable in Illinois; and Prof. Mills, Curator of the Ohio State Archaeological and Historical Society, says that about as many minor cults are said to have existed in Ohio, although they have not been definitely traced. Indiana, in between, must have harbored all of them more or less, and an interesting field, consequently, is here open for investigation.

The great pyramidal mounds at Etowah in Georgia and Cahokia in Illinois, with their associated tumuli, are evidences that a race with great power and high ideals once occupied the Mississippi valley. They seem to have passed up to the headwaters of the Mississippi and also branched off into the comparatively mild valley of the Ohio, leaving traces in Indiana and Kentucky.

In Ohio two quite distinct groups developed, reached their zenith and passed into oblivion, for their characteristics were not common to the native tribes which occupied that section at the beginning of our historical period.

The earlier of these two cultures is marked as peculiar by having been the first to build immense earth walls. The largest of these embankments are located at a point some 40 miles north of Cincinnati, on a headland with steep sides and some 200 feet above the Little Miami River which adjoins it, and is known as Fort Ancient. They inclose about 100 acres of level ground and are over 3½ miles in length; they contain about three million cubic feet of earth which was carried from a distance to construct them. In places they are twenty feet in height with a base about four times the height. Openings were left in the embankment every 200 feet or so and these openings average something like 20 feet. This feature interferes with the inference that they were the walls of a fort, and point rather to their being of a ceremonial nature.

At Marietta, Ohio, at the mouth of the Muskingum River, and at Newark, in the upper Muskingum valley, some 40 miles east of Columbus, were traces of this early Fort Ancient culture in the form of pyramidal mounds at the former place and remarkable earthworks at the latter. These embankments while not being any ways near as large as those at Fort Ancient, being only from about 2 feet to 8 feet in height, were constructed with a wonderful geometrical accuracy. They were in groups enclosing areas of from 2 to 50 acres, and the groups were distributed over an area of four square miles. Many of these groups being connected by passageways outlined by low parallel walls 8 to 12 feet apart, indicating an extensive ceremonial use on a tremendous scale.

Large sepulchral mounds with indications of cremation burial are lacking with the culture or cultures at Fort Ancient and at Newark, but in the Scioto valley a culture developed to an almost unbelievable perfection. Here earth embankments of wonderful geometrical accuracy are accompanied by sepulchral mounds which contain evidences of ceremonial rites in connection with elaborate cremation burial, the most remarkable of artistic pottery and carving in stone which undoubtedly will place them at the forefront of stone-age peoples, and above any others in the delicacy of their pottery and the artistic proportion and finish of the same; and above all the accurate delineation of animal and bird forms carved in pipestone, which show the striking qualities of a master sculptor by presenting the pose and even the facial expression of animals and birds, which were at the same time fashioned in the form of platform pipes. Along with this are evidences of a nation-wide inter-tribal trade, for the mounds contain copper which must have come from the great lakes or Mexico; large quantities of mica probably from North Carolina; hematite apparently from Missouri; galena ore similar to that of Illinois; ocean shells from the Atlantic or the Gulf; and, most remarkable of all, obsidian in very large specimens of spear heads which could not have been quarried closer than Mexico. In all of this they formed a distinct culture far above the Newark stage mentioned.

At Anderson, a county seat northeast of Indianapolis, is a small group of earthworks similar to those at Newark, and are distributed over an area of about five acres. They are known as Mounds Park and are located on a bluff adjoining a beautiful stretch of White River. The park is reached by both traction and street car lines from Anderson; it has a large shelter house and would be an ideal place to invoke the inspiration of the leaders of that unknown race, for the archaelogical researches now contemplated among these examples of their handiwork. One of the circular embankments of this group covers about two acres, in the center of which is a small ceremonial mound; it has a single gateway with level ground leading to this mound. The earth for this embankment was taken from the inside, forming a ditch about 8 feet in depth, which with the height of the embankment added presents from the inside a slope of quite imposing height. This same feature of an interior ditch exists at the embankment in the Fair Grounds at Newark, Ohio.

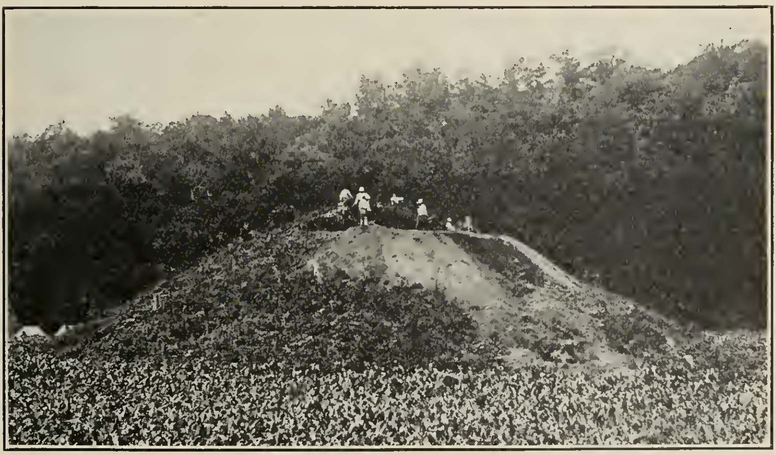

Fig. 1. Exploration of Adena Mound.

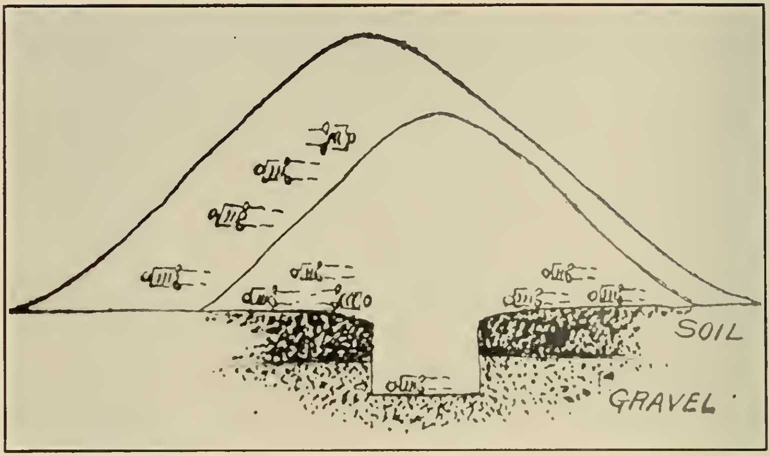

Fig. 2. Cross-section of Adena Mound.

Figure 1 shows the first stage of work in excavating the Adena mound near Chillicothe, Ohio, done some 20 years ago by Prof. W. C. Mills, Curator and Librarian of the Ohio State Archaeological and Historical Society. Figure 2 shows by a cross-section of the mound how it was built at two separate periods. It will be noted that the grave in the middle of the original mound is the only one placed below the ground level, the others being at four different levels, marking

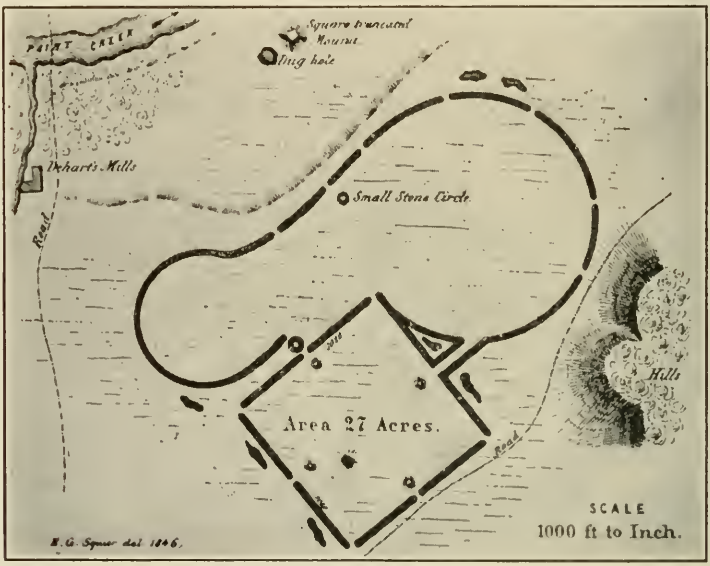

Fig. 3. Square truncated mound and the Baum geometrical earthworks.

apparently that many different periods or stages in the construction of the mound. This central grave was on a large scale, being about 12 by 14 feet and nearly 7 feet in depth, walled with logs, which had decayed, leaving only the space or mold. No copper ornaments were found in this grave, but fine specimens were found in some of the other graves, indicating that the remarkable use of copper came a little later than the date of this the most pretentious of the burials.

At the Baum earthworks and sepulchral mounds, some 14 miles from Chillicothe, shown in Figure 3, a radical change in custom and ceremonial rites was found in the square truncated mound, explored by Squier and Davis in 1846, from those at the Adena Mound. At the latter place logs were used in the formation of sepulchers but here they were used upright, forming an enclosure which was a perfect circle 26 feet in diameter, with the posts set 10 inches apart. It was paved on the ground surface by logs radiating from the center. All interments were within this enclosure and were found at various levels placed upon layers of sand, indicating a progress in the construction of the mound similar to that of the Adena mound. Here to somewhat larger extent than at the Adena mound the practice of cremation was found, but at each place it was incidental and not the general practice. No copper or foreign substances were found, and the few stone articles did not show high aboriginal art and it is inferred that the construction of the mound antedated that of the earthworks. The construction of a square monument around a circular mortuary chamber would indicate a relationship with the early cult which built rectangular truncated mounds in the Ohio and Mississippi valleys. And the incentive prompting the use of an unusual geometrical feature in the construction of this mound would seem to be the governing incentive leading to the construction of the ideal group of earthworks found at this place.

A group of earthworks identical in nature with the Baum group except that the arrangement places the smaller circle adjoining the square enclosure and both connected with the larger circle, is located about 8 miles south of Chillicothe, and known as the Harness mounds, named for the original owner of the land. A very large sepulchral mound is associated with the earthworks, but in this case it is inside of the large circular embankment and at a point such that it forms the prominent feature of all three enclosures. This group was surveyed and examined by Squier and Davis in 1846, and was completely explored by Prof. Mills in 1903. It was elliptical, being 160 feet long, 85 feet maximum width and about 20 feet maximum height. The height of the walls of the large circle was about 4 feet, with the walls of the smaller circle somewhat heavier and those of the square heaviest of all. The walls are unaccompanied by a ditch and the square incloses some 30 acres, the larger circle containing about one-half more than the square. While at the Adena and Baum mounds the practice of cremation was exceptional, the reverse obtained at the Harness mound, for here separate burnt clay or puddled platforms, or basin-like cists, were prepared for the cremated, or more often partially cremated, remains. These receptacles were in most cases for individuals, but in some cases four burials were placed on a platform and occasionally cremated remains and perfect skeletons were found occupying the same platform. As at the Baum mound, the burials were within a mortuary chamber, outlines of which could be traced by the post molds left after the decay of the wood. A wealth of ornaments, utensils, artifacts and weapons were placed with the remains, as may be judged by the fact that Prof. Mills secured 12,000 specimens from the Harness mound after two previous explorations for other institutions had been made. Among these articles were those of copper, flint, obsidian, mica, slate, bone,

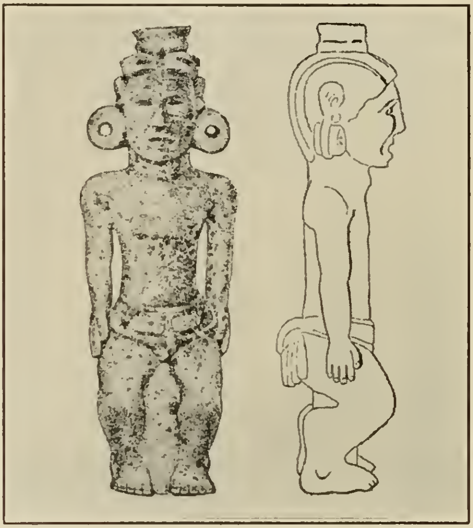

Fig. 4. Effigy pipe from Adena mound.

Fig. 5. Mask of Mexican god Xipe.

ocean shells, pearls, crystals of galenite and large lumps of lead ore, also a few platform pipes of limestone and steatite. Most abundant of the copper pieces were the spool-shaped ear ornaments of various sizes and make, and are most important by indicating an inter-tribal trade extending to Mexico. They were found on each side of the head in the cases of uncremated burials, so were judged to be ear ornaments. That they were used as such is substantiated by an effigy tubular pipe found

Fig. 6. Copper Ear Ornaments.

in the Adena mound (see Figure 4). This figurine is a peculiarly Mexican design, and similar ear ornaments appear in carvings of most Mexican gods or idols. This is plainly to be seen in Figure 5, the mask of a Mexican god in the British Museum. This god Xipe was the Mexican deity known as the God of Sowing, and the invocation to this god is interesting to us here in the land of maize or Indian corn, as it voices the following appeal: "Put on your golden garment; why does it not rain? It might be that I perish,—I, the young maize plant." And yet no similar carving representing a deity or idol has been found among the American Indians. It is said that idolatry was unknown in Mexico previous to the reign of the Aztecs. Possibly this Ohio culture antedates the Aztec period. One of these copper ear ornaments is shown in Figure 6. It is in five separate pieces, hammered from the thin sheets of copper found frequently in the graves. It was a far cry from Ohio to old Mexico, but aboriginal man seems to have been equal to it in more cases than one.

Another characteristic relic of this latter culture is the grooved axe, made of the hardest stones, mostly of granite. They had some special use, for they are peculiar to the Ohio valley and the territory west, of which Illinois is about the center. They range from considerably less than a pound in weight to over thirty pounds, and a majority of them are marvels of symmetrical carving and polishing, and how they had the skill and patience to work them out in granite by hammering and rubbing with other stones is almost beyond comprehension. They are rare in the eastern and southern states and none to speak

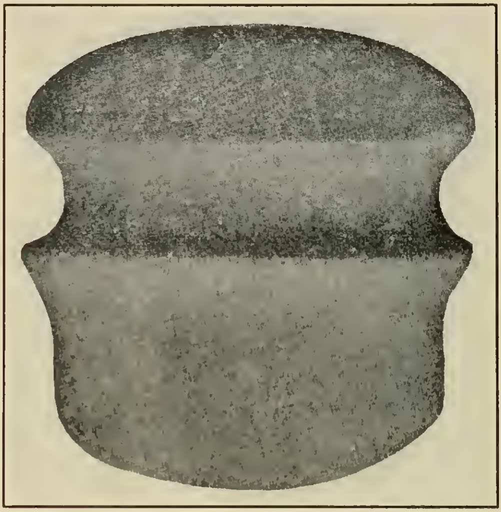

Fig. 7. Grooved Stone Axe.

of are found in Mexico. Figure 7 shows a most symmetrical grooved axe. While its symmetry is most striking, it would not be expected that art features would be worked out in granite. The polls of these axes are usually as carefully proportioned as the blade and seldom show hard wear, although a good many show rough usage. The contrary is usually the case with the blade, as a large proportion show evidences of having been carefully worked over, as in case of the specimen illustrated, which evidently has been worked over and over to give a sharp cutting edge. The deep groove is a problem, for the work to secure it is all out of proportion to what would be necessary to hold a withe wrapped for a handle. The use, whatever it might have been, to which this implement was put, must have been a most important one, and one requiring skill and accuracy. It has been thought that the spalls, flakes or blanks chipped from masses of flint for use in subsequently fashioning arrow and spear heads were secured by knocking them off with hammer stones. This would seem a very crude process for so delicate a requirement. While the writer has not known of the grooved axe or its companion piece, the symmetrical and sharp-edged celt having been mentioned as suitable for this flaking process, that method is offered here as a possible solution. Flint specimens are found which are worked to a knife edge and to a needle point, and it is understood to have been done with a notched bone implement under steady and skilful pressure. It is known that flint and glass work with a cleavage produced by a shock or pressure acting strongly in any desired plane, as in cutting glass with a diamond. It occurs to the writer that a heavy, symmetrical tool with a reasonably good edge, held firmly in exactly the right position and tapped carefully in the proper or necessary way, would come the nearest to producing desired results of any method that the aborigines could have employed. The grooved axe of granite or diorite, to give a tough, homogeneous texture; perfect symmetry in shape, to give a pressure or shock that could be calculated and depended on; a deep groove to provide for a close grip of the handle, that an exact position of the implement might be secured and a firm contact be had with the material to be worked upon; would apparently give an implement exactly suitable to their needs. And great credit should be given them for so perfect a tool and for the remarkably perfect artifacts that were produced in flint, jasper, chalcedony and obsidian.

We, then, here in Indiana, are in the environment of a most wonderful archaeological field which is beginning to claim attention because of its remarkable attainments in the stone age, and further than that we are in the center of a territory which was occupied apparently by a culture antedating the first of the two cultures mentioned in Ohio, that is to say the people who erected embankments and mounds along the Mississippi valley, traces of whom have been found in the lower Wabash valley.

Prof. Moorehead made extensive explorations at the Cahokia mounds, across the river from St. Louis, this past season, and the results will be of great interest. Prof. Moorehead made explorations which gave the exhibit of Ohio archaeology for the World's Fair in Chicago, which is now in the Field Museum at Chicago, and has since then been Curator for the Phillips Academy at Andover, Massachusetts. The Cahokia explorations as reported by him will surely throw much further light on the progress of this ancient aboriginal race from the South to their final abiding place in Ohio.

Why, then, should we not take steps to unravel some of the mysteries connected with a race which stood head and shoulders above the stone-age peoples of the Old World, and who as a people in historical times have shown themselves to have been in the front rank of uncivilized aborigines, having a personality, independence and ability far above other savage races?

We have occupied their lands, turning them into vast wealth. We have used their names of places and things which have given us the most picturesque feature of our language. So it should be with gratitude as well as pride that we take up Prehistoric American Archaeology and make it the beginning of American History.

Indianapolis.

Preparation and Use of Collodion Sacs in Exalting Micro-Organisms.

Charles A. Behrens.

The conception of enhancing the virulence of micro-organisms by growing them *in vivo* in a hermetically sealed permeable membrane introduced collodion sacs. By this method the organisms are enabled to develop unaffected by the action of the phagocytes and at the same time permitting their soluble injurious metabolic products to diffuse more or less out while the highly nutritive body fluids of the living animal pass in.

This idea was first attempted in 1893 by Morpurgo and Tirelli[1] in their cultivation experiments with the tubercle bacillus. The bacteria were placed in celloidin capsules which were introduced either subcutaneously or in the peritoneal cavity of rabbits.

Metchnikoff, Roux and Salimbeni[2] in 1896 really introduced the collodion sac method when they demonstrated that the toxin of the cholera germ would very readily diffuse through the walls of these sacs when placed in the peritoneal cavity of guinea-pigs. Since then this method has received a great deal of attention and notable results have been obtained in increasing the virulence of various micro-organisms.

The year of 1898 is rather memorable for its accomplishments along these lines. The germ of pleuro-pneumonia was successfully cultivated at this time by Nocard and Roux[3] by utilizing the collodion sac method. During this year by using this method Nocard[4] increased the pathogenesis of the tubercle bacillus, which was human in origin, so that it proved fatal to chickens.

At this time Vincent,[5] employing the method, pursued his research upon converting saprophytic bacilli (B. megaterium and B. mesentericus vulgatus) into pathogenic types.

Podbelsky[6] by applying the same principle showed the destruction of the spores of the Hay bacillus *in vivo*. Due to the difficulty of preparing collodion sacs he made tubes out of reeds. A reed sac, which is even more permeable than one prepared of collodion, is made from the tubular membrane lining the central canal of the bulrush.

It is prepared briefly as follows: Common bulrush reeds, if fresh, are boiled for about 15 minutes. If dry, they should be autoclaved for 60 minutes at 115° C. The end of the softened reed is sharpened as

[1] Archives Ital. de Biologie, Vol. XVIII, p. 187—1893. Ref. in Centrabl. f. Bacteriol., Bd. XIII, p. 74—1893.

[2] Annales de L' Institut Pasteur, Vol. X, p. 261—1896.

[3] Annales de L' Institut Pasteur, Vol. XII, p. 240—1898.

[4] Annales de L' Institut Pasteur, Vol. XII, p. 564—1898.

[5] Annales de L' Institut Pasteur, Vol. XII, p. 787—1898.

[6] Annales de L' Institut Pasteur, Vol. XII, p. 431—1898.

one would sharpen a pencil, so as to expose the membrane lining the central canal. A desirable length of this membrane is denuded. One end is tied firmly and by means of a glass rod it is turned inside out. A glass tube is fitted into the open end of the sac and fastened with strong thread. The sac is filled with distilled water and sterilized. The fluid is removed from the sterile sac and replaced with a suspension of the organism. The sac is tied shut and the glass tube removed. The end is covered with melted gum lac. The thus prepared sac is placed in the peritoneal cavity of the animal.

The method of preparing collodion sacs as first carried out by the Pasteur Institute is quite different from the present-day procedure. The collodion of desirable consistency, which is in a cylinder, is inclined at a suitable angle. A glass tube of small diameter with a closed rounded end is inserted into the solution and rotated until a surface of collodion of sufficient thickness has been deposited upon the tube. This tube is then rotated in the air until the collodion has set and is no longer sticky.

With a scalpel the upper edge of the collodion layer is cut circularly. The thumb nail is used to turn back upon itself this even edge of the collodion sac. By turning the sac inside out it can be slowly peeled off like a "glove finger." The sac is then everted and distended. A small piece of glass tubing is fitted into the open end of the sac and fastened with thread which is then coated with collodion. The sac is filled with water, suspended in water in a flask and sterilized.

The water is removed from the sac with a sterile pipette and the suspension containing the germs under investigation introduced. The sac is closed with a sterile rubber stopper. This plug is dried and painted with collodion. Instead of closing the opening of the tube in this manner, the glass tube which is fitted into the sac can be drawn out into a capillary beforehand. After the sac has been sterilized and inoculated with the organism the end of the capillary tube is sealed in the flame, thus closing the sac.

In view of the fact that the sac is liable to break, especially if kept in the animal for months, Novy[7] introduced a perforated glass tube which has been drawn out into a capillary, into the sac. The sac is attached to this tube. The apparatus is sterilized, inoculated and sealed in the usual way.

McCrae,[8] and a little later Harris,[9] who slightly modified the former's method, prepared sacs by introducing the hot end of a small glass tube into a gelatin capsule. When cold the tube becomes fixed and is painted with moderately thick collodion which is allowed to dry. It is then rotated in the air so as to permit the solution to dry. This procedure is repeated several times until the desired thickness of collodion is obtained.

The gelatin inside of the collodion covering is removed by introducing hot water into the tube, and also by placing the capsule in hot

[7] Laboratory Work in Bacteriology, pp. 498, 499—1899.

[8] Journ. Exp. Med., Vol. VI, p. 635—1901.

[9] Eyre, Bacteriological Technique, p. 358—1913.

water. The liquid gelatin is pipetted off. The apparatus is sterilized and prepared for introduction into the animal's body in the afore-described manner.

Grubbs and Francis[10] utilized the perforated tube heretofore referred to, the openings of which are obliterated with gelatin. The outside of this tube is coated with several layers of collodion and the gelatin removed by means of hot water.

The method of preparing collodion sacs as carried out by the Pasteur Institute is difficult. The difficulty is in separating the collodion casing from the glass tube. Gorsline[11] has overcome this and by his method the sac can be prepared with ease. He selects a tube, which may be a test tube, with a 2 mm. opening in its rounded end. The opening is closed with a thin film of collodion. The tube is then rotated in the collodion in the usual way. The sac is removed from the glass tube by filling the tube with water. By constant blowing the water is forced through the opening, allowing it to run between the outside wall of the tube and the inside of the sac, and thus separating the latter from the former. The top of the sac is cut loose from the tube and the sac is slipped off. It is then immersed in water. Its subsequent preparation is similar to that previously described.

The method of preparing the collodion sac for this work is that of Gorsline slightly modified. The technique of sealing the sac containing the suspension of micro-organisms, however, is entirely different from that described by other experimenters.

The procedure of preparing these sacs is as follows: Freshly prepared collodion is used, the consistency of which depends upon whether or not very thin or thick walled sacs are desired. This may be regulated by diluting with a mixture of equal parts of alcohol and ether or by exposing in the air and allowing it to evaporate. This solution must be free from bubbles. A clean tube about 300 mm. by 8, 10, 14, 16 18 mms. with one end rounded with a small opening (2-4 mm.) in the center is used. The outside of the tube is wiped perfectly dry after being moistened with a five per cent glycerin solution. This leaves a very thin film of glycerin on the wall of the tube and facilitates removing the collodion covering from it.

The opening in the end of the tube is closed by painting it over with a film of collodion and allowing it to dry for about one minute. The tube is rotated several times in the collodion, which is in a glass cylinder inclined at a desired angle. The tube is then withdrawn, care being taken that it does not come in contact with the glass container. It is rotated in a horizontal position until the collodion hardens. If a thick walled sac is to be made this process may be repeated several times. The collodion-covered tube is then held under the tap and water is run onto it. By filling the tube with water and by blowing, the sac is removed as in the Gorsline method. At this stage if the collodion

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[10] Bulletin No. 7 of the Hygiene Laboratory of the U. S. Marine Hospital Service —1902.

[11] Contributions to Medical Research, dedicated to Victor Clarence Vaughan by colleagues and former students of the Department of Medicine and Surgery of the University of Michigan, pp. 391-393—1903.

cover has not perfectly solidified, bulging will occur. The sac is then immersed in water, where it is practically invisible.

A properly made sac will not rupture if one were to blow into it with all one's might. They are tested in this way before being used.

By this method sacs for dialysing purposes, as described by the author[12] in a previous article, may be prepared with ease.

The top of the sac is cut even, filled and immersed in distilled water in a cotton stoppered flask or tube. It is sterilized preferably in streaming steam or in the autoclave at 105 or 110° C. for 10 or 15 minutes.

The sac is now ready to be inoculated with a suspension of organisms. A sterile pair of forceps is used to remove the sterile sac from the container in which it was sterilized. This sac is transferred to a sterile short tube or held in an upright position with sterile filter paper. The water is removed from it by means of a sterile Pasteur bulb pipette.[13] With a similar pipette the suspension of organisms is introduced into the sac. The walls of the open end of the sac are dried with sterile filter paper and pressed together with a flat-surfaced sterile pair of forceps. Using a red-hot flattened iron wire or spatula, this surface is seared and then coated with several layers of collodion.

The supposedly hermetically sealed sac is tested by taking hold of it with sterile filter paper and applying gentle pressure. If it is found found to be satisfactory it is placed upon sterile filter paper in a sterile dish and covered.

The finished sac is now ready for insertion into the peritoneal cavity of a desired animal. For this purpose several animals are available. Guinea pigs, rabbits, rats, dogs, sheep and chickens are most frequently used. In this work the first three animals were employed.

In the case of the guinea pig and the rabbit, they may be held firmly upon their backs on an animal-board. If a suitable animal-board is not available they may be tied down in this position, as in the case with rats, by fastening cords to each leg and tying over a bridged board.

The hair is removed from the abdomen with a pair of scissors, and after lathering well with soap and water the area is shaved. Alcohol and mercuric bichloride solution are used to disinfect this surface.

After etherizing the animal a small incision along the median line is made through the skin of the upper part of the abdomen. The abdominal cavity is opened up next. With sterile pressure forceps the abdominal muscles are held up and the peritoneal cavity is exposed.

The collodion sac is picked up with sterile forceps and introduced into the cavity and pushed well back under the aponeurosis. With a curved needle and silk thread the cavity is closed and the surface disinfected. The skin is likewise sewed; also disinfected; dried with alcohol followed with sterile filter paper and finally covered with collodion.

The sac remains in the animal from forty-eight hours to several weeks and in some cases months. After the sac has remained *in vivo*

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[12] Proceedings of the Indiana Academy of Science, pp. 265, 266—1916.

[13] Proceedings of the Indiana Academy of Science, pp. 266, 267—1916.

the required length of time the animal is etherized. The peritoneal cavity is opened aseptically and the sac removed.

If the sac has been in the animal body for weeks it is surrounded with a fibrous sheath. In this case the sheath is removed before the sac is opened.

The bottom of the sac is sterilized by means of a red hot searing iron, wire or glass rod. With a bulb pipette the content, which is milky in color, is removed, examined and resaced or cultivated *in vitro* or used for classroom work.

By this method the virulence of micro-organisms may be enhanced markedly and it is advantageously used to bring out capsule formation, especially when the germs are so attenuated that their pathogenesis cannot be exalted, as may be the case of Micrococcus Tetragenus, Micrococcus Pneumonia and others.

These cocci and B. Pneumonia (Friedländer's) under this condition form enormous capsules which can be used for classroom work.

Purdue University.

Saprolegnia.

F. M. Andrews.

In the Saprolegnieae the sporangium is a somewhat club-shaped cylinder which sooner or later is cut off from the rest of the filamentous structure of the plant by a transverse wall. This sporangium is of varying length, but ordinarily its length exceeds its greatest diameter from four to ten times. Aside from the presence of a transverse wall, one thing that attracts the attention of the observer is the much more grumous or densely granular nature of the protoplasm. This latter condition is generally quite conspicuous in parts or organs that are or are becoming reproductive centers of various kinds.

This dense protoplasm of the future zoösporangium finally divides into more or less polygonal areas. Sometimes these areas show a somewhat rounded appearance and the transverse wall which confines them to the end of the filament is slightly rounded or arched toward the apex. The zoösporangium opens at the end and preparatory changes in the contents lead to the final expulsion of the zoöspores. There are questions, however, concerning this process which are still unanswered and which deserve attention.

The transverse wall above referred to is not always straight at first but may become curved at a later period, in some members of the group Saprolegnieae, as in some cases in Saprolegnia and Achlya. In the latter, especially, it is often straight at first or slightly curved from the tip, whereas later it is curved apically, particularly when the zoospores are escaping. At this time, and even before at times, the thin transverse wall is sometimes curved apically due to greater hydrostatic pressure back of the zoösporangium, notwithstanding the considerable swelling of the contents of the zoösporangium. This curving outward of the transverse wall frequently occurs at first whether a new zoosporangium is to be produced or not in the hull of the old zoösporangium.

"The distinguishing mark of Saprolegnia," says de Bary,[1] "is that the spores are in the motile state as they issue from the sporangium, and that the branch of the thallus which bears the sporangium grows through it when it has discharged its spores." In Achlya a branch is formed laterally and beneath the transverse wall. This new branch becomes the zoösporangium after development.

An illustration of the apically directed or curved transverse wall is also to be seen in Saprolegnia Thuretis at times, as illustrated by Nathansohn,[2] which is due to greater hydrostatic pressure probably from the first in the main filament than in the zoösporangium, notwithstanding the swelling process in the latter. This wall is not form-

[1] de Bary, A., Comparative Morphology and Biology of the Fungi, Mycetozoa and Bacteria, 1887, p. 143.

[2] Nathansohn, A., Allegemine Botanik, 1912, p. 303.

ing a new zoösporangium in the old one, although the old zoösporangium is probably due to external conditions, as stated by Pfeffer,* in various plants, and these may even prevent at times the formation of sporangia. A deficiency of food, says Pfeffer,† may cause the formation of zoospores or oöspores in Saprolegnia, whereas with some substances no reproductive organs are formed and again with other food substances the formation of oögonia are favored.[1] The various conditions also account for the difference in the latent period of the spores of this plant, which, as stated by Pfeffer[2] and observed by different investigators, ranges from 8 to 10 days as observed by Klebs[3] and 45 to 145 days according to de Bary.[4] Also the zoöspores are especially influenced by various conditions, among these being the attraction by certain substances of which the phosphates are very active.[5]

Inasmuch as the representatives of this division of the fungi are, like some other plants, rather susceptible to some or all of the above mentioned conditions, they tend toward some variation from the forms ordinarily observed. In many cases fish of various kinds are attacked by this fungus and extensive epidemics, as stated by de Bary,[6] of fish in the English and Scottish rivers and elsewhere have occurred. The writer has observed, however, and can confirm de Bary's[7] statement, namely, "that healthy gold fish may continue lively and free from the Fungus for months in water in which Saprolegnieae kept purposely in large quantities were forming an abundance of spores."

The writer has observed insects of various kinds on which, on one occasion, a heavy growth of Saprolegnia was present. The zoösporangia of all of these were formed in the usual manner at first, but when new sporangia were being produced in the first ones some departures from the usual order were noticed. This will be made clear by an observation of Figure 1. Usually, as is well known, but one new zoösporangium is formed by growing up through the hull of the old one in the ordinary way. In this case, however, four new zoösporangia had formed within the hull of the original one. The hulls of these sporangia were still held together and attached to the main branch or filament of the fungus but were empty. A small part of the contents was left in the third one that was newly formed. The old zoösporangial cavity contained the upper parts of the new sporangia that had grown through it.

In another instance a single tube had grown up through the old sporangial cavity in the usual fashion. On the end of the tube which projected through the original apical opening of the old zoösporangium, a large, round swelling was present which resembled as to form and size the ordinary oögonia. This departure from the usual behavior of the formation of zoösporangia is shown in Figure 2. The further de-

* Pfeffer, W., Physiology of Plants, 1903, p. 39.

† Pfeffer, W., l. c., p. 116.

1 Pfeffer, W., l. c., p. 117.

2 Pfeffer, W., l. c., p. 208.

3 Klebs, Jahrb., f. Wiss. Bot., 1899, Bd. 38, p. 571.

4 De Bary, Vervil, Morph. u. Biol. des Pilze, 1884, pp. 356-370.

5 Pfeffer, W., l. c., Vol. 3, 1906, p. 348.

6 De Bary, Comp. Morph. and Biol. of the Fungi, 1887, p. 375.

7 De Bary, l. c., p. 375.

velopment of this structure was not followed out owing to the breaking down of the material under observation.

Fig. 1. Saprolegnia showing four sporangia that have grown up in the old zoosporangium x 520.

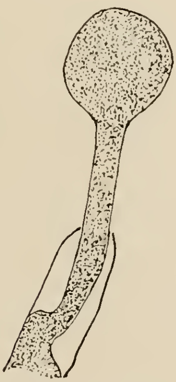

Fig. 2. Hull of the old zoosporangium occupied by a tube having a large terminal swelling x 520.

VAUCHERIA.

F. M. ANDREWS.

In Vaucheria the branches are rather long in proportion to the main part of the plant in some cases, and in other instances rather short in this respect. The plant branches at various angles. In most of the species of Vaucheria in the vegetative parts this is less than a right angle as regards the facing surfaces of the main filament and its branch. A reproductive branch generally starts off at right angles to the main filament and can be recognized as a branch that will produce reproductive organs on this account. They may become at times somewhat less or greater than a right angle, according to circumstances.

The irregular branching is conspicuous in all the different species of Vaucheria except one. This exception is seen in Vaucheria tuberosa, which branches dichotomously.[1] The single tubular cell which is often much elongated may sometimes reach a length of 30 cm.[2] The water forms are generally longer than species that are to be found growing on the soil and in many cases also of a coarser nature. Since it grows frequently in tufts, especially the forms in running water, the length and extensive branching of the mass is often not at first so evident.

In the formation of the large zoöspores the end of the filament is cut off from the rest of the plant by a transverse wall. After a time, depending on conditions, the contents of the single large cell thus formed rounds itself and later escapes through the end of the cell as a single large zoöspore. Sometimes attempts to cause these zoöspores to form by flooding the plants with water, as in the case of the land forms, is very successful, but at other times this process is not attended by very great success or none at all.

The function of the above-mentioned large cell to form the large zoöspores which will reproduce the plant asexually, even though formed in the usual way, does not always do so, owing to changed or unfavorable conditions. Instances of this kind can occasionally be seen in plants that have been submerged. One unusual instance was observed by the writer as is shown by the accompanying Figure 1. The terminal cell, which was cut off in the usual way, was of normal size and shape and apparently was vigorous in every respect as was the rest of the plant. The figure here given was drawn by the aid of a camera a short time after the specimen was observed, from fresh material which had been gathered one hour before.

The unusual feature about this cell was the production of two branches from the sides. These branches were probably of different ages, as both seemed to have had equal opportunity for growth. It will be seen, however, that the branch nearest the apex of the cell is longer than the one near the base of the cell and near the transverse

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[1] Sachs, J., Lehrbuch der Botanik. Vierte Auflage, 1874, p. 273.

[2] Sachs, J., l. c., p. 273.

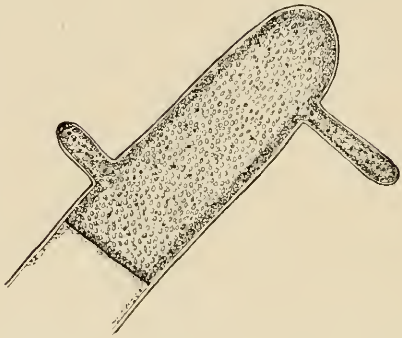

Fig. 1. Zoosporangium of Vaucheria sessilis with two branches x 300.

wall. Neither branch was separated from the supporting cell by a wall, as will be seen from the figure, nor later on, although the specimen was kept and observed under as favorable conditions as was possible. It will be noticed, furthermore, from the figure that the abovementioned branches extend at right angles from the cell. This recalls the way previously described in this paper in which the branches which are to become or to carry the sex organs in this plant arise.

Trillium Nivale.

F. M. Andrews.

In the year 1898 the writer transplanted twenty specimens of Trillium nivale from the "North Pike" road, about one mile north of Bloomington, to his yard. The purpose of this was to be able to study more conveniently certain structural features and observe as closely as possible the period of anthesis over a series of years.

A study of the habitat was made and all of the observed conditions as to soil, shade and other factors were duplicated closely. It was necessary to protect the plants at first by a low box frame, but the sides of this box stood at some distance from the plants and afforded no more shade to the plants than the rocks which originally surrounded the place from which the plants were taken. This distance between the plants and the sides of the box is evident to some extent in the

Fig. 1. Photograph of part of bed of Trillium nivale.

accompanying photograph (Figure 1). This photograph shows only one corner of the box and was taken five years after the transplanting had been done.

The box was four feet square, made of one-inch poplar lumber, was twenty-five cm. deep and had no bottom. It was found necessary later on to protect the plants at times by galvanized iron wire netting having meshes about one-half cm. square.

The transplanting was done in early spring, care being taken to remove with each plant or cluster of plants a large mass of the soil in which they were growing. The early blooming of Trillium nivale is well known. This often takes place before the snow has left the ground. The warmth generated by the plant at times melts the snow away in the form of a small well about the plant and entirely to the ground. The plants which were transplanted in the way indicated above finally grew very densely, as shown by Figure 1, and the earliest bloomers melted the snow in large areas. Being able to follow the course of development more closely and conveniently when planted in the box, it could easily be seen that sufficient warmth was generated by the young plants as soon as they had broken through the soil to melt the snow, which was often present to some extent, although this melting was not evidént at all times on the surface. On removing the top layers of snow a dome-shaped space over and about the young plant of considerable extent was usually to be found.

In the part of the box shown in the protograph (Figure 1) between fifty and sixty plants in bloom may be seen by a careful count. This photograph represents about one-fourth of the whole area of the box. The blooming plants were fully as numerous all over the interior of the box as in the part shown in Figure 1. This would amount to something over two hundred blooms which had been produced by the original plants and by new plants which had grown since the first ones were planted.

Two of the plants were observed to have advanced the growing end of the rhizome considerably during the first ten years. This amounted to a movement of fifteen cm., or an average of 1.5 cm. per year. The rhizome, however, did not increase apparently in total length from the time of transplanting, since as it advanced at the growing end it died away at the other end and thus maintained about an even length. This agrees with the mode of life of many other similar subterranean plant structures.

These plants seem, although densely crowded, to have continually and rapidly increased for the first ten years. Since then and during the last five years the average increase in number has been small. The number of individuals, although still vigorous, seems to have become so great that all the available space for more individuals to grow in the space offered by the box has been reached and a balance in this respect established. The plants are all equally illuminated and all the other conditions equally favorable for all. It will be noticed in Figure 1 that the plants of equal age show differences as to size. Especially in some individuals the photograph shows a decided difference in the size of the flowers. This difference is, however, only slightly more pronounced than the writer has observed on the average on equal counts of individuals made in the field and under the original conditions.

The density as to numbers of individuals rarely if ever equals that shown by Figure 1 over the same area in the original habitat. A few individuals may, of course, come up close together, but this is only for a very few specimens, while an equal number as that shown by Figure 1 would be scattered over a much larger area, since much more space is available in all directions. This plant in its native habitat shows a preference not only as to soil and as to illumination, but also as to drainage. This, as indicated above, was taken into consideration in arranging the plants shown in Figure 1.

The blooming of Trillium nivale is not confined to the space of a few days, but in its native habitat, and as shown by the study of the plants partly illustrated by Figure 1, this period of blooming extended often several weeks, according, in part, to the condition of the weather, etc. The period of blooming was shortened by mild weather. The plants I transplanted showed a tendency to begin blooming somewhat earlier as a rule than those in the field, but this was slight.

Pollination was effected by bees which swarmed at times about the flowers, visiting first one and then another continuously. In this way an exceptional opportunity was afforded to watch in a small space and on numerous individuals the way the large amount of pollen was transferred from one flower to another. One insect in this way often visited a half score of flowers in a few minutes, so that the distribution of the pollen was thoroughly done. The pollen is produced in large amounts in each flower and the cells of the anther which open lengthwise down the margin allow the pollen to be puffed out somewhat and made easy of attachment to the visiting insect.

In only a few instances was there any tendency toward a monstrosity in Trillium nivale. This occurred in the transplanted specimens and was evidenced by a partial transformation of the petals in one of the flowers to leaves. This instance of phyllody in Trillium nivale, however, seems to be extremely rare and is all the more surprising when it is remembered that the genus Trillium is rather inclined to monstrosities in instances of phyllody in various of its species. The writer has called attention to some of these monstrosities in a former paper[1] on three of the species of the genus Trillium, namely, Trillium sessile, Trillium recurvatum and Trillium erectum. These three species seem to be more susceptible to variation in this respect than is Trillium nivale. This one case of phyllody during the twenty-three years these plants of Trillium nivale have been under direct observation and where from twenty-five flowers at first to about the two hundred flowers which were produced in 1921 shows that this tendency is rather unusual in this species, when successive yearly observations over a long period and finally in large numbers gave ample opportunity for its detection.

The pollen grains are nearly round and in surface view show short, blunt, numerous points about evenly distributed over the surface (Plate I, Figure 1). They germinate readily in solutions consisting of 3% cane sugar to which is added 1½% of gelatine. In such a mixture germination takes place to a considerable extent after two hours. This is shown in Plate I, Figure 2, where the pollen tube has attained a length of about three times the diameter of the spore. After three hours the pollen tube has grown to about four times or more the diameter of the spore on the average, and as a rule is considerably more irregular in outline, Plate I, Figure 3.

[1] Andrews, F. M. Proceedings of the Indiana Academy of Science, 1905, pp. 187 and 188.

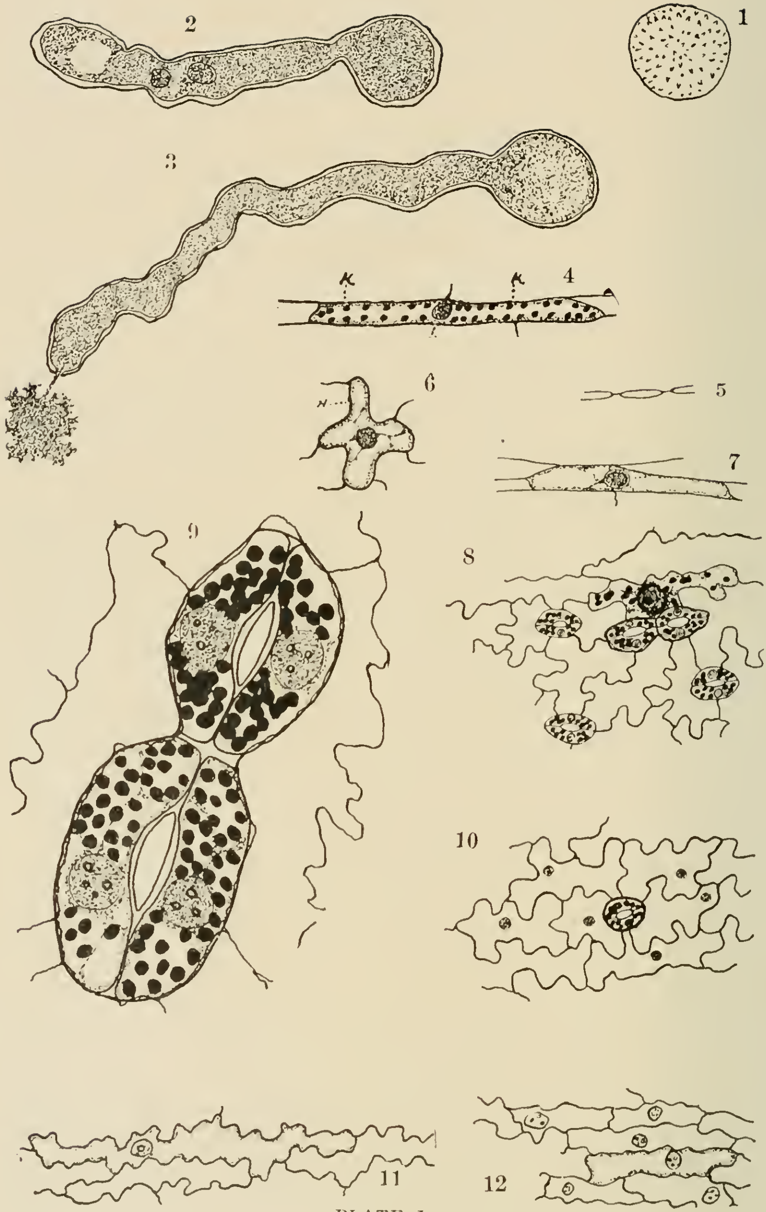

PLATE I.

At times when this length of pollen tube has been reached, it bursts, this always taking place at the end and often with considerable force so that the contents is generally forced out through a small pore and in a small stream (Plate I, Figure 3). The contents then collects as a ragged edged-mass at the end of the small stream of contents whose length is controlled by the force of expulsion, which is generally sufficient to force out the stream of contents to a length about equal to the diameter of the pollen tube (Plate I, Figure 3). When placed in distilled water the pollen grains of Trillium nivale frequently explode at once and apparently with considerable force, considering the size of the grain. This, of course, is due, as is known of some other kinds of pollen grains, to a rather sudden increase in the hydrostatic pressure of this cell. This, however, occurs in Trillium nivale as a rule in an unusually short period of time. Movement of the protoplasm of the pollen tube, as in Plate I, Figures 2 and 3, may often be seen.

The elongated epidermal cells of the stem are often filled with red colored sap and, partly due to rapid growth, have unusually thin outer walls for cells in such a position (Plate I, Figure 4). The nucleus is large in proportion to the size of the cell and several nucleoli are usually present. The red cell sap, when present, partly conceals the chlorophyll granules. The lateral walls of the epidermis even though very thin are provided with shallow pits (Plate I, Figure 4 K), which can just be observed when magnified 300 times. These pits, which are often seen in the walls of internal cells of many plants, are brought out with great definiteness when magnified 1,060 times. They are then observed to have rounded edges and are rather broad (Plate I, Figure 5 K).

The cells of the epidermis from the upper side of the leaf of Trillium nivale are wavy in outline and show no stomata. A slow movement of the protoplasm can generally be seen under favorable conditions in the various strands. The nucleus which is sometimes about central and sometimes parietal is rather large and shows in many cases several nucleoli (Plate I, Figure 6). Pits in the walls, as at H, Plate I, Figure 6, are barely discernible when magnified 200 times. The cells from the midrib on the upper side of the leaf of Trillium nivale show, as would be expected, a decided elongation and reduction in diameter. A large nucleus and rather actively moving protoplasm at times are generally much in evidence, the latter especially when magnified 450 times (Plate I, Figure 7).

The lower epidermis of the leaf of Trillium nivale shows, as usual, the presence of stomata. The chlorophyll granules are very few in number, but active movement of the protoplasm is often evident. The nuclei are rather large, often nearly equalling the diameter of some of the cells. The stomata, which are present on the lower surface of the leaves exclusively, are generally arranged so that one communicates with a respiratory cavity. Some departures from this arrangement are, however, present, as when two stomata are over one respiratory cavity as is shown in Plate I, Figure 8. The writer has shown this to be the case in a former paper.[1] In the paper referred to, the history and

[1] Andrews, F. M. Proceedings of the Indiana Academy of Science, 1914, pp. 209-211.

literature on this subject are given and the same peculiarity in some other plants is noted. As indicated in that paper, interesting questions concerning the location, development, and reactions of the supernumerary stomata await solution.

The outer epidermis of the sepal frequently shows twin stomata over one respiratory cavity[2] (Plate I, Figure 9). The strands of protoplasm often showed movement for 24 hours when magnified 450 times. The inner epidermis of the sepal, as the outer epidermis, has very wavy walls, but more pronounced than the outer epidermis in this respect (Plate I, Figure 10). Stomata are present, but few in number. In these cells the movement of the protoplasm often continued for as much as six hours during observation, as could be easily seen with moderate magnification.

The epidermis from the outside of the petal of Trillium nivale showed, as usual, much elongated and narrow cells and with very wavy thin walls (Plate I, Figure 11). The epidermis from the inner surface of the petal has smaller cells than those of the outer epidermis, its cell walls are much less wavy and more delicate (Plate I, Figure 12).

The above-mentioned facts coincide closely with similar observations made on specimens of Trillium nivale which were obtained from the native habitat. Certain other points, such as some of those above referred to, deserve further study, which can best be carried out under the conditions described in this paper.

EXPLANATION OF PLATE I.

All of the figures of this plate are of Trillium nivale.

Fig. 1. Pollen grain, surface view x 300.

Fig. 2. Pollen grain after two hours in three per cent cane sugar plus one and one-half per cent gelatine x 300.

Fig. 3. Pollen grain after three hours in the solution used for the grain shown in Fig. 2 x 300.

Fig. 4. Epidermal cell from stem x 300.

Fig. 5. Piece of cell wall of cell illustrated in Fig. 4, showing pits at K enlarged x 1060.

Fig. 6. Cell from upper epidermis of leaf showing pits at H x 300.

Fig. 7. Cell from midrib of upper epidermis of leaf x 100.

Fig. 8. Few cells from lower epidermis of leaf x 100.

Fig. 9. Twin stomata from outside of sepal x 520.

Fig. 10. Few cells from inner epidermis of sepal x 100.

Fig. 11. Epidermal cells from outside of petal x 100.

Fig. 12. Epidermal cells from inside of petal x 100.

[2] Andrews, F. M. Proceedings of the Indiana Academy of Science, 1914, pp. 209 and 210, Fig. 1.

Spirogyra.

F. M. Andrews.

A number of instances are on record where irregularities occur as to the form, conjugation or general behavior in the genus Spirogyra. Among these may be mentioned a paper by Gregory[1] which illustrates a number of specimens of Spirogyra which show branches given off. In one instance a figure is given showing a branch which has itself divided into two branches. See Fig. 2 of Gregory's paper. This, as the author states, is due probably to monads. Attention is also called to the well-known galls of Vaucheria and of Oscillatoria, the latter due to the entrance of zoöspores of Chytridiae. In the Spirogyra cells which branch, as Gregory shows, these all proceed from the convex side of the cell. This appearance of these branches on the convex or stretched side of the Spirogyra cell recalls a similar disposition in the arrangement of roots on the convex side of the main root, which, however, in the case of the roots, is a response to the mechanical factors that are operative.

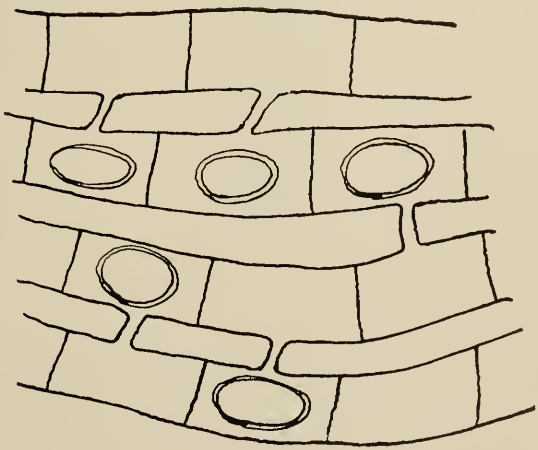

Fig. 1. Spirogyra crassa x 300.

A paper by the writer[2] in 1910 showed conjugation in two different species of Spirogyra, as Spirogyra crassa and Spirogyra communis. In another paper[3] I have called attention especially to the question of irregular cases of conjugation in Spirogyra.

In this paper also the literature is referred to in so far as it pertains to the topic under discussion. Chief among these was the paper

[1] Gregory, Emily L. Bulletin of the Torrey Botanical Club, 1892, Vol. 19, pp. 75-79.

[2] Andrews, F. M. Bulletin of the Torrey Botanical Club, 1910, Vol. 38, p. 299.

[3] Andrews, F. M. Proceedings of the Indiana Academy of Science, 1912, pp. 89-91.

of Tröndle,[1] who mentions a rather unusual case of irregular conjugation. An instance of deviation in form is shown in a paper by Pickett.[2] Another instance is given by Weatherwax of branching, etc., under the conditions there numerated. So far, however, as the branching of

Fig. 2. Spirogyra elongata x 400.

Spirogyra is concerned, this has been known for many years.

As Sachs[4] says, if one cuts up the long filaments of Spirogyra and the pieces are laid on wet peat, some of the cells put out branched colorless tubes, which behave like roots. In fact, somewhat similar results take place, as Sachs says, in highly organized plants, as in the rooting of several shoots in many vascular plants; and the stimulus of contact in the development of structures, as in Cuscuta. So that branching may be produced in Spirogyra not only from a diseased condition but also at times by injuries.

The writer has observed another case of somewhat more compli-

[1] Tröndle, A. Ueber die Kopulation und Keimung von Spirogyra, Botanische Zeitung, 1907, Bd. 65, p. 192.

[2] Pickett, F. L. Bulletin of the Torry Botanical Club, 1912, Vol. 39.

[3] Weatherwax, Paul. Proceedings of the Indiana Academy of Science, 1914, pp. 203-206.

[4] Sachs, J. Vorlesungen über Pflanzen Physiologie Zweite Auflage, 1887, p. 40.

cated conjugation in Spirogyra than the one referred to in the paper above mentioned. This material formed a sort of net on the water. When examined it showed not only some further examples of the deviations in conjugation mentioned in the paper just cited, but also a few more complicated cases of what I term net conjugation on account of several filaments being held together in the process. Being associated often in such dense masses, it is really not so surprising that such examples of conjugation would occur, but rather we should have the right to expect that it would be more frequent than has heretofore been reported. Figure 1 gives a picture of one case. This figure is a camera drawing and, as will be seen, four filaments are concerned in the process.

Another deviation from the ordinary is shown by Fig. 2. This is also a camera drawing. The material was obtained from the same place as that from which Fig. 1 was made. Most of the Spirogyra in the water where this material was obtained was Spirogyra elongata, but there was also a considerable quantity of Spirogyra communis and Spirogyra crassa. In a few instances some cells were observed where the number of chloroplasts varied. As shown in Fig. 2, a few of the cells had two chloroplasts, whereas the usual number of chloroplasts is one.

Some Aspects of Stone Mountain and Its Vegetation.

Elmer Grant Campbell.

Stone Mountain is a huge dome-shaped rock, situated sixteen miles east of Atlanta, Georgia. It measures seven miles in circumference at its base and rises 686 feet above the adjacent land surface. This mighty stone includes 663 acres of exposed granite area.[1]

The purpose of this paper is to give a panoramic view of Stone Mountain and its remarkable vegetation.* This view is prefaced by geological and botanical notes from some of the literature relative to the subject.

Geology.

Dr. Thomas L. Watson has set forth an invaluable collection of data concerning the geology of this most wonderful stone,[1] a small portion of which follows:

"Stone Mountain forms one of the few conspicuous, unreduced, residual masses found rising above the general surface-level of the Georgia Piedmont Tertiary peneplain. That this and the adjacent masses of hard contorted granite-gneiss, in the Lithonia area to the south, were not reduced to the same approximate level of the surrounding plain, can be readily accounted for, by differential rock-hardness, and remoteness from the major streams in the region. . . . .

"The chemical composition of this granite mass is shown in the two following analyses made by Mr. R. L. Packard in the laboratory of the Survey from specimens collected by Professor Yeates from the Hayne quarry:

	I	II
Silica	72.56	71.62
Alumina	14.81	16.05
Iron oxide	0.94	0.86
Lime	1.19	1.07
Magnesia	0.20	0.17
Soda	4.94	4.66
Potash	5.30	4.92
Ignition	0.70	1.00
Total	100.64	100.39

I. Analysis of the perfectly fresh rock.

II. Analysis of a spawl, which was exposed for three or four years on the dump-pile at the quarry. . . . .

"Physical tests made on the Stone Mountain granite yielded the following figures:

Specific gravity	2.686
Weight of one cubic foot of stone expressed in pounds	167.90

[1] Bulletin 9A Geological Survey of Georgia.

* The study was made in September, 1916.

Number of cubic feet of stone contained in one ton (2,000 pounds)	11.9
Percentage (ratio) of absorption	0.067

"Crushing strength tests made on the granite, in two-inch cubes, gave the following results:

	Strength in pounds	Strength in pounds per sq. in.
Stone Mountain, Ga	85,000	21,250
Stone Mountain, Ga	50,325	12,581
Stone Mountain, Ga	48,760	12,190
Stone Mountain, Ga	65,610	16,402

"A similar series of strength tests, made in 1890 at Purdue University, gave 12,438, 14,425, 12,904, 13,406 and 12,726 pounds per square inch."

Botany.

Dr. H. W. Ravenel in the Bulletin of Torrey Botanical Club, June, 1876, gave an interesting note, as follows:

Rudbeckia Porteri.—"I found this species in 1848 at Stone Mountain, Georgia, growing abundantly on the ridges and top of the mountain with Quercus Georgiana. Professor T. C. Porter had just preceded me in its discovery and the uncertain genus was dedicated to him. I have never heard of it anywhere else."

"The outlying granite peak in middle Georgia seems to have an interesting Flora. I found a well-marked variety of Hypericum prolificum and Mr. Canby has since (in 1869) found a new species of Isoetes growing in shallow pools on the summit."

Dr. John K. Small in several numbers of the Bulletin of the Torrey Botanical Club of the year 1894 made references to the plant life of Stone Mountain as follows:

January, 1894. "*Asplenium Bradleyi.*—Contrary to its usual habitat, which is perpendicular or overhanging and rather damp disintegrating cliffs. Asplenium Bradleyi was found growing on horizontal moss-covered granite rocks at the northern base of Stone Mountain, De Kalb County, Georgia, in April, 1893, altitude 1,000 feet."

"*Amorpha virgata.*—Found only on the northern and western slopes of Stone Mountain * * * Fruiting in July. It is apparently restricted to a narrow belt ranging from 1,100 to 1,200 feet above sea level and grows in a few places where the granite rocks are flat enough to hold a layer of sand."

"*Amygdalus Persica* L.—During the past season it was noticed at numerous localities in middle Georgia and was collected on the dry, rocky slopes of Stone Mountain * * * early in July at an altitude of 1,200 feet, well established and producing abundant fruit."

"*Nyssa biflora walt.*—Grows on the very summit of Stone Mountain * * * altitude 1,686 feet. It is remarkable that this tree usually confined to the seacoast or seaboard from southeastern Virginia southward should occur in the above situations. There are a number of trees on the small dome-like top of the mountain and they seem to flourish although somewhat worn and torn by heavy winds which sweep by their exposed habitat and thrive notwithstanding the fact that they grow in but a few inches of sand collected in depressions of the granite rock.

"*Lagerstroemia Indica L.*—The species is now well established about Stone Mountain * * *."

"July, 1894. *Cuscuta arvensis.*—Grows about the base of Stone Mountain, Georgia, in mats on Gymnolomia Porteri where this species forms dense patches."

Dr. Roland M. Harper, in the Bulletin of the Torrey Botanical Club, August, 1901, reported plants found on or near Stone Mountain as follows:

Antennaria calophylla Green.	Juncus Georgianus Coville Small.
Lomicera flava sims.	Scirpus sylvaticus L.
Opuntia vulgaris mill.	Asplenium angustifolium."
Polygala Curtissii Gray.	

At present it is hardly possible to view the plant distribution of this unique mountain without feeling the spirit of these botanical notes. One imagines he sees the same "dense patches" of Gymnolomia porteri, and the "Amorpha virgata" on the little shelves of accumulated sand; and the same "Nyssa biflora" in its extremely strange anchorage on the summit, growing in company with ancient and weater-beaten specimens of Juniperus virginiana, and the same assemblage of "Rudbeckia porteri" grouped with their more rugged associates "Quercus Georgiana" situated high up toward the top of the mountain; and no doubt some of the woody individuals standing here today were standing here a century ago, and to be sure the herbaceous species beheld now, have beauties and habits similar to the beauties and habits of their ancestors in generations past when botanists and nature adorers beheld them and loved them and praised them.

Physical Features and Tree Distribution.

The geological notes cited above indicate the chemical constituents and the physical durability of this granite dome of nature. It stands as a physiographic marvel, a figure unique among the geological curiosities of the world.

It may be interesting to note, that today plant life is one of the most powerful natural forces operating against the eternal existence of this mountain.

The North Side—Here almost the entire area stands like a stone wall perpendicular to the adjacent plains at the base, but this granite face bends gradually inward towards the crest, giving an oval outline to the mountain as viewed from the north. (Fig. 1.) The surface is unbroken and void of phanerogamic vegetation. The waters of all the regional rain storms that have beaten upon this mighty rock through untold ages have rushed unhalted down its sides, and yet the most marked physical features on the extreme north are numerous clean streaks, some of which are several feet in width, extending from summit to base. On close examination these streaks are found to be extremely shallow and perfectly beveled furrows in which no lichens are

Fig. 1. A view of the steep bare north side of Stone Mountain and the pure broad leaf forest on the narrow talus at the base.

Fig. 7. A mixed forest southeast of Stone Mountain.

growing. One might fancy these as the ravines on the north side of Stone Mountain that a million years or more have wrought.

In these clean, shallow grooves, or water courses, the pure, light grey granite is exposed, while the areas between them are covered with lichens of a dark grey color. This gives the north side a striated aspect.

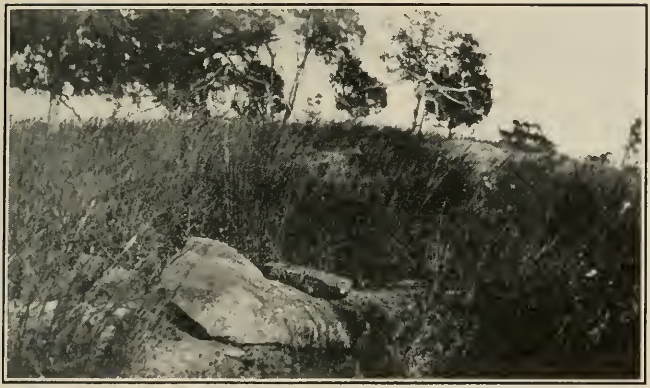

Fig. 8. A pure stand of Andropogon virginiana on the northwest side of Stone Mountain and dwarfed red cedar in the background.

The vertical north side merges westward into a graded slope the surface of which becomes progressively less steep and more broken toward the west, and thence, on around to the south. On the eastern portion of this slope no flowering plants are found, except in depressions or around weathering fragments of granite. Further west, however, there is a meager forest associated with a limited number of herbaceous species (Fig. 8). The north talus broadens as it extends westward and for a considerable distance the tree formation is dense, composed purely of broad-leaved species (Fig. 2).

Fig. 3. A south side view near the crest where the tree growth is composed largely of red cedar and loblolly pine.

The South Side—The surface of the south side is broken and irregular, having a general slope of about 45 degrees. Near the summit the tree growth is spare, red cedar and loblolly-pine being practically the only species found. About midway from top to base pine is the only

Fig. 4. A view about half way to the summit on the south side of Stone Mountain, showing the broken surface and the uneven distribution of the vegetation. Broom-sedge (Andropogon virginiana) in one of the few cracks of the mountain.

Fig. 5. A pure stand of pine at a high elevation on the south side.

woody species, all the trees being scrubby and very much dwarfed. The south talus, however, is densely covered by a pure stand of pine, each tree having a remarkably long and clear bole.

Figures 3, 4, and 5 give a progressive view of the forest on the south as it spreads from summit to base. On the south side of Stone Mountain, in fact on all parts except the extreme north side, the topography is unique, and the landscape is unsurpassed in grandeur.

Deep forested ravines (Fig. 7), cedar trees a century old or more (Fig. 3), tumbled heaps of massive granite blocks (Fig. 5), garden-like shelves of accumulated alluvium, radiant and fragrant with flowering plants (Fig. 9), cracks in the exposed granite filled with growing Andropogon virginiana (Fig. 4), a broken, scaly, cracking, wavy surface, all tell a tale of dynamics contrary to the static north side with its mere clean, light grey streaks alternating with the dark grey lichened areas.

Fig. 2. A view on the northwest side of Stone Mountain. The almost bare slope is gradual and the somewhat broad talus supports a pure stand of broad leaf trees.

Fig. 9. A pure stand of Gymnolomia Porteri in full bloom, on the south side of Stone Mountain.

The sun's rays have always struck Stone Mountain in such a way as to make the summer temperature abnormally high on the south side and abnormally low on the north. In like manner the sun's rays make the disintegrating effects of the short winters abnormally great on the south (frequent thawing and freezing) and abnormally small on the north (less frequent freezing and thawing). Thus Stone Mountain has, in close proximity, virtually two climates and two types of topography, and under these physiographic and climatic differences two remarkably diverse floral types have developed.

The East and West Sides—The east and west surfaces are strikingly similar, each having a slope which seems to be about a mean between the steep north and the gradual south, and a tree formation of near a half and half mixture of deciduous broad leaf and coniferous evergreen (Figs. 6 and 7).

Fig. 6. Mixed forest on the west side of Stone Mountain.

General Distribution of Plants.

Based on tree distribution, as an index, the general vegetation of Stone Mountain may be grouped as follows:

I. Pure Deciduous Broad-leaved on the North Side.

Here woody specimens were collected and identified as follows:

Castanea dentata.
Cornus florida.
Diospyros Virginiana (Fig. 1)
Fraxinus Americana.
Hamamelis Virginiana.
Vitis rotundifolia.
Vaccinium arboreum.
Carya glabra.
Kalmia latifolia.
Liquidamber Styraciflua.
Styraciflua.
Liriodendron Tulipifera.
Magnolia acuminata.
Nyssa sylvatica.
Oxyodendron arboreum.
Quercus alba.
Quercus Georgiana.
Quercus prinus.
Cornus stolonifera.

Associated with this group of woody species is a typical herbaceous flora, but here, as might be expected, in September the landscape presents an aspect of quiet and maturity rather than one of blossom and vigor, and the fragrance of spring time have given place to such inviting odors as the ripened fruit of the muscadine, whose drooping ladened boughs hang from many a tree and crown almost every rugged clump of granite debris. A small number of herbaceous specimens were taken and identified as follows:

Clitoria mariana.
Lespedeza frutescens.
Desmodium Dillenii.
Desmodium paniculata.
Silene stellata.
Asplenium Bradleyi.
Asplenium angustifolium.
Solidago odora.
Aspidium marginale.
Pteris aquilina.

The following mature spring blooming plants were observed in abundance:

Violets.	Legumes.
True Solomon's Seal.	Mints.
False Solomon's Seal.	Honeysuckle.
Composites of various kinds.	

II. Pure Coniferous Evergreen on the South Side.

Here the tree list is notably short. Pinus Taeda and Juniperus Virginiana. This so-called pure evergreen forest is slightly diluted by the following deciduous species: Nyssa sylvatica, Quercus prinus, Quercus Georgiana.

The talus on the south is covered by a pure stand of Pinus Taeda. This pure stand grades inland into a mixed forest with a herbaceous flora more or less like that found in any broad leaf forest of the region. The herbaceous vegetation of the exposed areas on the south

Fig. 10. Eupatorium capillifolium growing in the pure granite debris of the quarry on the southeast side of Stone Mountain.

Fig. 11. Quarry on the east side of Stone Mountain.

side, however, is composed almost wholly of three species: Andropogon virginiana (Fig. 8), Solidago odora, Gymnolmia Porteri (Fig. 9).

III. The Mixed Forests on the East and West Sides.

On these areas there is a general mingling of the north side vegetation with that of the south, but in this mingling there is a notable absence of certain of the north talus species and the occurrence of certain species not found on the north or south.

Pycnanthemum albescens.	Amorpha virgata (small).
Liatris polyphylla.	Prunus Persica.
Eupatorium capillifolium (Fig. 10).	Hypericum prolificum.

are species more or less peculiar to the east and west sides.

Summary.

In the study of plant ecology on Stone Mountain, certain rather remarkable conditions have been noted.

1. The north side is a vertical unbroken wall whose face is beveled toward the summit, and is only partially covered with lichens, its only form of vegetation.

2. The rich narrow talus on the north, which must have been formed by a very remote falling of granite fragments from the summit, bears a dense forest of broad-leaved trees with a typical herbaceous association.

3. The south side surface stands at an angle of about 45 degrees and is sparsely overgrown with conifers and flowering herbs.

4. The broad talus on the south is covered by a pure stand of pine merging into a mixed forest toward the outer margin, where are found many broad-leaved deciduous species, as oaks, hickories, tulip, sweet gum, black gum, and a herbaceous formation approaching in character that found in a pure regional deciduous forest.

5. The east and west slopes seem to be a mean between the steep north side and the gradual south side, and the east and west floras are partial blends between the north and south floras.

Conclusions.

1. A steep north side and a gradual south side have been made possible by certain conditions of the past, viz., differential exposure to the sun's rays, prevailing winds, and proximity to major streams.

2. The same conditions that have produced a physiographic distinction between the north and south sides have also made possible a floral distinction.

3. The physiographical and vegetational aspects of the east and west are but natural blends between the extremes of the north and south.

Purdue University.

PLANTS NEW TO INDIANA. X.

CHARLES C. DEAM.

Specimens of all of the plants referred to in this paper are deposited in the Deam herbarium. The grasses were determined by Agnes Chase. The Carices were determined by K. K. Mackenzie. The determinations of the remainder have been checked by specialists in the respective genera.

Muhlenbergia capillaris (Lam.) Trin.

Harrison County, October 7, 1921. No. 35257. Rocky, wooded slope about three miles east of Elizabeth. This open wooded slope borders the road in its descent over the bluff to the Ohio River. Growing in tufts in hard ground, closely associated with Quercus velutina, Viburnum rufidulum, Smilax bona-nox, Agave virginica, Liatris scariosa, Andropogon scoparius, Allium cernuum and many others.

Sporobolus clandestinus (Spreng.) Hitchc.

Fulton County, September 14, 1921. No. 34717. On a roadside sandy knoll two and a half miles northeast of Leiter's Ford. Marshall County, September 14, 1921. No. 34762. On a roadside sandy knoll just north of Yellow River, about six miles southwest of Plymouth.

Poa Wolfii Scribner.

Jay County, May 14, 1921. No. 33861. On the flood plain of a small rivulet in a white oak woods about eight miles northeast of Portland. Closely associated with Quercus macrocarpa, Ulmus americana, Fraxinus nigra, Aesculus glabra, Phlox divaricata, Claytonia virginica and others.

Carex aggregata Mackenzie.

Franklin County, May 17, 1921. No. 33972. Low alluvial bank of the west fork of White Water River two miles south of Laurel.

Carex gravida Bailey.

Fayette County, May 16, 1921. No. 33931. On the low bank of the old canal about one mile south of Connersville. Associated with Phacelia Purshii.

Smilax bona-nox Linnaeus.

This species has the base of the stem covered more or less with a dense stellate pubescence. I found the first specimens of this species in 1915 on the wooded bluff of the Ohio River in Crawford County near Leavenworth. I was not able to determine it to my satisfaction, so I set to work to find other locations for this species and collect in quantities until I had over a hundred specimens. I have found also a few specimens on the VanBuren Ridge in Perry County, about seven miles east of Cannelton. It is frequent in Harrison County on the bluff of the Ohio River east of Elizabeth.

Sisyrinchium atlanticum Bicknell.

Cass County, June 7, 1916. No. 20152. Abundant in sandy soil on the south side of Lake Cicott. Lake County, June 5, 1916. No. 20112. In a wet prairie habitat along the railroad just south of Shelby. I also have a specimen collected in the same county by L. M. Umbach, June 19, 1897, from a meadow near Miller. Stark County, June 1, 1916. No. 19913. On the low, sandy border of the southeast side of Bass Lake.

Corallorrhiza Wisteriana Conrad.

Decatur County, May 5, 1912. No. 10450. Collected by Mrs. Chas. C. Deam under a beech tree on the bluff of Flat Rock River about three-fourths of a mile above St. Paul. Dubois County, May 4, 1919. No. 27250. In a white oak woods four miles southwest of Huntingburg. Orange County, May 25, 1901, under a beech tree in a woods near Abbey Dell. Perry County, April 24, 1919. No. 27101. Rare on the wooded slope of the bluff of the Ohio River about six miles above Cannelton. Sullivan County, April 16, 1919. No. 26926. In very sandy soil in the Rose woods about one mile south of Grayville. Closely associated with Quercus velutina, Carya alba, Podophyllum and others.

Salix serissima (Bailey) Fernald.

Lagrange County, May 30, 1916. No. 19882. A tree fifteen feet high and three inches in diameter at breast high, in a pond about one mile south of Mongo. Also found along Pigeon River about one mile east of Mongo. Steuben County, July 24, 1906. No. 1251. On the low border of the west side of Silver Lake.

Polygonum neglectum Besser.

Laporte County, September 15, 1921. No. 34841. Along a woods road in a beech-sugar maple clearing about two miles north of Mill Creek.

Lychnis coronaria (L.) Desr.

Elkhart County, July 2, 1921. No. 34410. A colony of about fifty feet long and ten feet wide on the gravelly wooded bank of the St. Joseph River about one and a half miles northwest of Bristol.

Euphorbia Rafinesquii Greene.

Steuben County, August 29, 1920. No. 32533. Roadside near a crossroads about five miles northeast of Angola.

Euphorbia serpens H. B. K.

Dearborn County, September 21, 1919. No. 30122A. On a rocky bar in Wilson's Creek about one mile northeast of Aurora. Closely associated with Euphorbia maculata. Perry County, October 2, 1920. No. 33357. A large prostrate plant, rooting at the nodes, in a cornfield between the road and the Ohio River just east of Deer Creek.

Oenothera pratensis (Small) Robinson.

This is a frequent to a common plant in the southern part of the State. It is especially frequent in the "flats." I suspect that all references to Oenothera fruticosa in southern Indiana should be referred to

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[1] Bul. Torrey Club. Vol. 46:184:1919.

this species. I have it from Bartholomew, Clark, Crawford, Dubois, Gibson, Jackson, Owen, Posey, Scott, Sullivan and Tipton Counties.

Acerates hirtella Pennell.

All Indiana references to Acerates floridana[1] should be transferred to this species. I have specimens from Cass, Elkhart, Jasper, Lake, Laporte, Martin, Newton, Porter, Pulaski, Starke, Tipton, Vigo and White Counties.

Veronica glandifera Pennell.

Pennell[1] has shown that the plants of our area that have been called Veronica Anagallis-aquatica should be transferred to Veronica glandifera. I have this species from Delaware, Elkhart, Grant, Huntington, Jackson, Kosciusko, Montgomery, Noble, Porter, Shelby (Mrs. Chas. C. Deam), Steuben and Wells Counties.

Aureolaria pedicularia ambigens (Fernald) Pennell.

Recent studies of Gerardia (Aureolaria) pedicularia show that Indiana specimens belong to the glandular variety, ambigens. I have specimens from Elkhart, Kosciusko, Lagrange, Lake, Laporte, Marshall, Newton, Porter, Starke and Steuben Counties.

Artemisia ludoviciana Nutt.

Marshall County, September 14, 1921. No. 34761. Common along the railroad and adjoining roadside about one and a half miles southwest of Plymouth.

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[1] Torreya Vol. 19:170:1919.

THE TOLL OF WEEDS IN INDIANA.[1]

ALBERT A. HANSEN.

The early settlers in Indiana encountered little difficulty with the weed problem, since few of our native plants are serious weeds. As the land became more settled troublesome weeds began to appear, most of them being European plants that were introduced in impure seed. Since the earliest days of Indiana agriculture, the weed problem has increased in seriousness until at the present time the loss due to the presence of weeds is enormous. Before the weed problem can be solved in Indiana, the farmers themselves must understand and appreciate the seriousness of the situation. An understanding and appreciation of this character can perhaps be secured by a knowledge of the various ways in which weeds cause loss and the amount of damage done.

The extent of the damage caused by weeds is not ordinarily realized. The presence of weeds has been accepted as inevitable and the tendency has been to ignore them. It is hoped that the estimates here presented will not only call attention to the different ways by which weeds cause damage, but that they will also be of value in creating a realization of the importance of the problem. It is a subject that is of importance to all citizens of the state since the welfare of Indiana is largely dependent on agricultural prosperity and the control of weeds is an important factor in profitable agriculture.

The figures herein considered are based on production during the year 1920, even though 1920 can hardly be considered a normal agricultural year. The values of the various farm crops were obtained from the "Year Book of the State of Indiana, 1920."

The final estimate does not include such considerations as the damage to health caused by hay-fever weeds, etc., the losses caused by weeds harboring harmful insects and plant diseases, the esthetic loss, and the reduction in the value of property due to the presence of weeds. On the other hand, the valuable features of weeds such as the value of the organic matter they supply and the prevention of soil washing, are not considered since even approximate estimates of this character are practically impossible to obtain. In preparing the estimates, assistance was obtained from a number of specialists who have devoted many years to the study of Indiana agriculture.

Tillage Loss Due to Weeds—The figures relative to the tillage loss occasioned in cultivated crops are based on work performed in the office of Farm Management, U. S. D. A., demonstrating that cultivation costs about one-sixth of the total value of a farm crop. It is estimated conservatively that one-half of the cost of cultivation is due to the presence of weeds.

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[1] Contribution from the Botanical Department (Extension Division) of the Purdue University Agricultural Experiment Station.

Crop	*Value, 1920*
Corn	$119,647,000
Potatoes	8,448,000
Sweet Potatoes	396,000
Tobacco	2,160,000
Onions	1,456,000
Sorghum (unofficial estimate)	738,000
Cabbage	114,000
Broom corn	17,000
Dry beans	91,000
Soy beans (based on 80% of crop cultivated)	97,600
Cowpeas (based on 40% of crop cultivated)	100,800
Total value of tilled crops in Indiana (1920)	$133,265,400
One-sixth of total value (cost of cultivation)	$22,210,900
Tillage loss (one-half of cost of cultivation)	11,105,450

Loss Due to Reduced Crop Yields Caused by Weeds—The presence of weeds has been estimated to reduce the yield of corn 10 per cent; tame hay, 3 to 16 per cent; potatoes, 6 to 10 per cent; spring grain, 12 to 15 per cent; and winter grain, 5 to 9 per cent.[1] The total value of farm crops in Indiana during 1920 was $274,150,000. Assuming that the presence of weeds caused a 10 per cent reduction of crop yields, the loss would be $27,415,000.

Discount Losses—The presence of weed seeds in small grains is estimated to cause an average discount of 1 per cent. The discount may be considered as a measure of the damage due to the presence of the weed seeds. The total value of wheat, oats, barley, and rye during 1920 was $80,272,000, hence the discount loss in these crops was $802,720.

The discount loss caused by weed seeds in clover seed is estimated at 10 per cent. The value of the clover seed crop in 1920 was $1,392,000, hence the discount loss was $139,200. Figures are not available for the value of the grass seed crop during 1920.

The presence of weeds in hay is estimated to cause a discount of 5 per cent. The total value of the 1920 tame hay crop was $49,060,000, consequently the loss was $2,453,000.

The total discount loss can then be figured:

Small grains	$802,720
Clover	139,200
Hay	2,453,000
	$3,394,920

Loss Due to Land Rendered Incapable of Profitable Cultivation—The presence of the Canada thistle, wild garlic and other noxious perennial weeds has made certain areas incapable of profitable cultivation. Although the amount of land abandoned to weeds is not large in Indiana, it is a factor worthy of consideration. Land of this character occurs for the most part as small areas on a number of farms. The

[1] Cates, H. R. "The Weed Problem in American Agriculture." Separate from yearbook of the Department of Agriculture, 1917, No. 732, p. 3.

total loss from this source is estimated at $100,000. In this connection, it should be remembered that certain otherwise profitable crops cannot be grown on weedy land.

Railroad Weeds—A few years ago the writer obtained estimates of the cost of destroying weeds on the right of way of the principal railroads in the United States. The estimates ranged from $10 to $60 per mile per year. Assuming that it costs $10 per mile per year to destroy the railroad weeds in Indiana, the total annual cost for 15,000 miles of track (both steam and electric railroads) will be approximately $150,000.

Turf Weeds—The damage due to the presence of weeds in lawns is extremely difficult to estimate. Assuming the damage at $2 per lawn per year, the total will be about $200,000. To this should be added the cost of weeding golf courses and miscellaneous turfs.

Roadside Weeds—The time devoted to cutting roadside weeds can be conservatively estimated at one day of labor per farm per year. If but one-fourth of the farmers devote even this small amount of time to their roadside weeds, it will amount to 52,500 days on the 210,000 farms of Indiana. At $3 per day for a man and team, the bill for cutting roadside weeds will amount to $157,500 per year.

Pasture Weeds, Waste Place Weeds, Etc.—The estimated annual cost per farm of clipping stubble land, mowing weedy pastures and cutting waste place weeds is $5 per year. For 210,000 farms the total is $1,050,000.

Miscellaneous Losses—Among the miscellaneous losses may be included the loss from poison plants, damage to milled products caused by wild garlic and similar weeds, damage to dairy products due to wild garlic, bitterweed, etc., and the loss occasioned by mechanically injurious weeds, such as the fruits of buffalo bur, *Solanum rostratum*, the awns of grasses such as squirrel tail grass, *Hordeum jubatum*, etc. The miscellaneous losses are estimated at $500,000 per year.

Estimated Total Weed Loss in Indiana (1920).

Estimated tillage loss	$11,105,450
Estimated loss due to reduced yields	27,415,000
Estimated discount losses	3,394,920
Estimated loss due to land rendered incapable of profitable cultivation	100,000
Estimated cost of clearing weeds from railroad rights of way	150,000
Estimated damage by turf weeds	200,000
Estimated cost of cutting roadside weeds	157,000
Estimated cost of cutting pasture weeds, waste-place weeds, etc.	1,050,000
Estimated miscellaneous loss	500,000
Grand total	$44,072,870

or approximately $14 per capita per year.

What Are We Going to Do About It?

The grand total of forty million dollars' loss caused by weeds in a single year in Indiana, is probably very conservative. Cut the estimate into half, and the loss is still enormous. Although it is readily conceded that the estimates are far from accurate, nevertheless the startling figures obtained are thought to be as nearly correct as it is reasonably possible to estimate. The staggering loss attributed to weeds should cause us to pause and think more seriously of the weed problem than has been our custom.

The question naturally arises, what are we going to do about it? The following suggestions are offered as possible aids in the solution of this vast problem:

1. The use of clean, pure, viable seed is fundamental in the control of weeds. Unless pure seed is used, all other efforts to cleanse our fields will be of little avail. Good seed will solve the problem to a large extent. In this connection, the recent seed law, which will be actively enforced on and after January 1, 1922, is of great importance, since it will enable the farmer to know the viability and purity of all agricultural seed purchased from dealers. The law provides that agricultural seed offered for sale in Indiana shall be labeled, the label to state: (a) the name of the kind and variety of seed, (b) the minimum number of seeds per pound of certain weeds designated as noxious that are present in seed offered for sale, (e) the place of origin of the seed and (f) the name and address of the vendor.

2. The importance of killing weeds before they mature seeds can hardly be over-emphasized. The destruction of seedling weeds is not difficult, but when weeds are allowed to mature seeds the difficulties are multiplied manifold. Weed seeds may remain viable in the soil for a number of years, a constant menace to future crops. The mowing of pastures before the weeds mature seeds will gradually drive the weeds out and permit the pasture plants to come in. The thorough preparation of the seed bed is also very important, since thousands of weed seedlings are destroyed by this means. Again, it pays to cut a weedy hay crop early, before the weeds have had a chance to mature seeds.

3. The results of recent experiments indicate strongly that after the preparation of the seed bed, the principal, if not the only, object of cultivation is the destruction of weeds. The more general use of the sweep or knife type of cultivating implements in soils adapted to their use will aid in solving the weed problem in tilled crops. This is particularly true in corn that is planted in check rows.

4. Roadsides, fence rows and waste places generally are centers from which surrounding farm land is constantly being infested with weeds. The roadside and fence-row weeds should be mowed on June 15th and again on August 15th. The more general use of the spud and hoe against waste-place weeds is much to be desired.

5. The threshing machine is a common and efficient carrier of weeds from farm to farm. The thresher should be thoroughly cleaned after each operation.

6. Sheep are excellent weed eradicators. It is highly profitable to turn weeds into mutton and wool. A few sheep on every farm in Indiana will help materially in solving the weed problem.

7. Give the land a chance to grow profitable crops. Maintain fertility by the use of lime and the addition of organic matter and

fertilizers and drain where necessary. A luxuriant growth of pasture or turf grasses, for instance, will crowd out the weeds.

8. Many grain-field weeds can be controlled by the use of a weeder or a spike-tooth harrow in the young grain, a practice that is usually more profitable than the use of sprays and other spectacular devices.

9. Clean cultivation, crop rotation, and the use of smother crops will eradicate or control the incidental weeds. A few weeds, such as the wild garlic, Canada thistle and dodder must be dealt with by special methods.

10. Co-operation among farmers is an important factor in weed control, inasmuch as weeds are a community as well as an individual problem. Many weeds, for instance, are disseminated by wind-distributed seeds. It avails a man little to eradicate the Canada thistle on his farm if the seeds from a neighbor's land are allowed to reinfest the clean fields. Roadside weeds in particular present a problem that can be solved by concerted action only. A realization of the seriousness of the situation should arouse sentiment in favor of co-operative action.

Purdue University.

Peloria in Linaria and Other Plants.

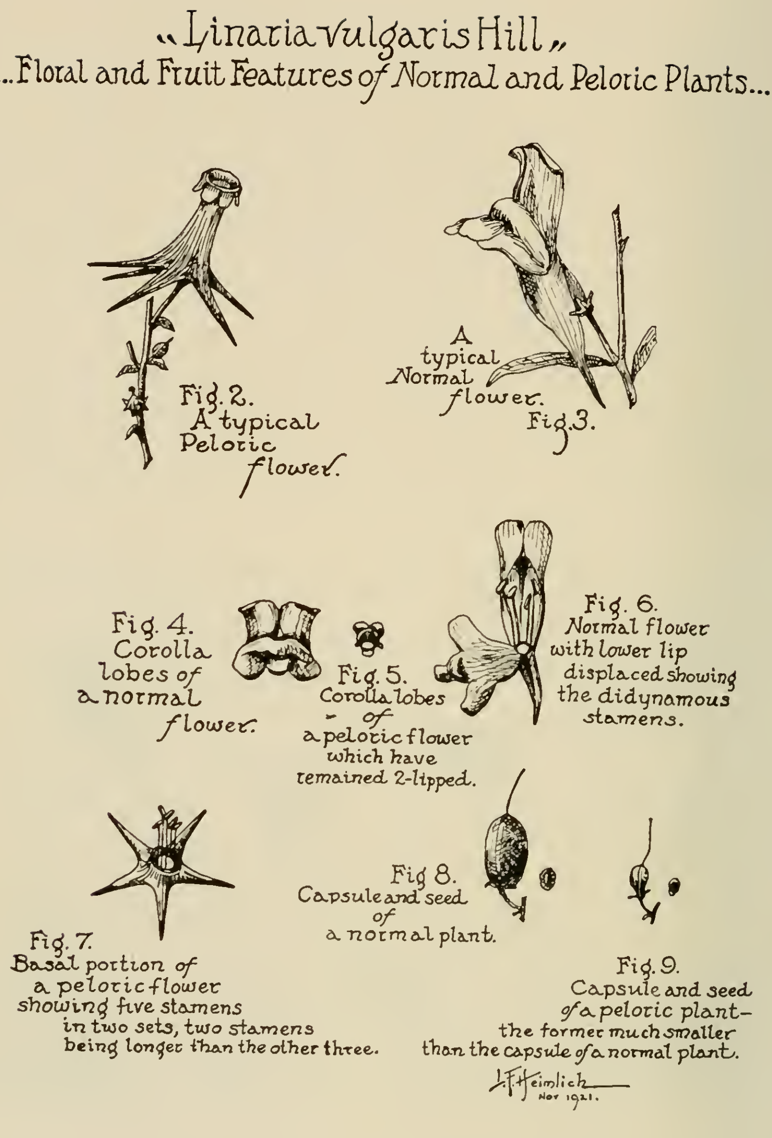
Louis F. Heimlich.

Peloria is a term derived from the Greek meaning monstrous. Applied to flowers, it is a kind of monstrosity or malformation. It is usually defined as "the phenomenon when usually irregular flowers, such as those with some of the petals or sepals spurred or saccate, develop all the parts of each set alike, thus becoming radially symmetrical." This condition was first observed and described by Linnaeus, "who found the spurred flowers of the Butter and Eggs or Toad flax (Linaria vulgaris) with five spurred petals instead of the normal one." To this condition he gave the name peloria.

Linaria is a genus belonging to the Figwort family (Scrophulariaceae). Peloric flowers of various species of this family have been reported from time to time in different countries. The species having such flowers are Linaria vulgaris Hill (4, 5, 6, 7, 8, 9, 10, 12),* Linaria dalmatica and other species of Linaria (6, 12), the snapdragon (Antirrhinum majus L.) (6, 12), and the foxglove (Digitalis purpurea L.) (4, 6, 12). Many other instances of peloric flowers of other families

Fig. 1. Linaria vulgaris Hill. Toad flax or Butter and Eggs. Normal plants to the left bearing normal flowers with one spur. Abnormal plants to the right bearing peloric flowers with five spurs.—Photograph by Mr. E. J. Kohl.

* The numbers in parenthesis refer to the same numbers opposite the references at the end of this paper.



"Linaria vulgaris Hill"
...Floral and Fruit Features of Normal and Peloric Plants...
Fig. 2. A typical Peloric flower.
A typical Normal flower. Fig. 3.
Fig. 4. Corolla lobes of a normal flower.
Fig. 5. Corolla lobes of a peloric flower which have remained 2-lipped.
Fig. 6. Normal flower with lower lip displaced showing the didynamous stamens.
Fig. 7. Basal portion of a peloric flower showing five stamens in two sets, two stamens being longer than the other three.
Fig 8. Capsule and seed of a normal plant.
Fig. 9. Capsule and seed of a peloric plant— the former much smaller than the capsule of a normal plant.
L.F. Heimlich
Nov 1921.

Some additional Abnormalities of Floral parts.

Fig. 10.
PICEA EXCELSA L.
An abnormal cone developed from a terminal bud bearing microsporophylls with large sporangia and a middle zone of sterile scales shaped like megasporophylls.
— Heterogamy.

Fig. 11.
CALENDULA OFFICINALIS L.
Floral proliferation of the inflorescence.

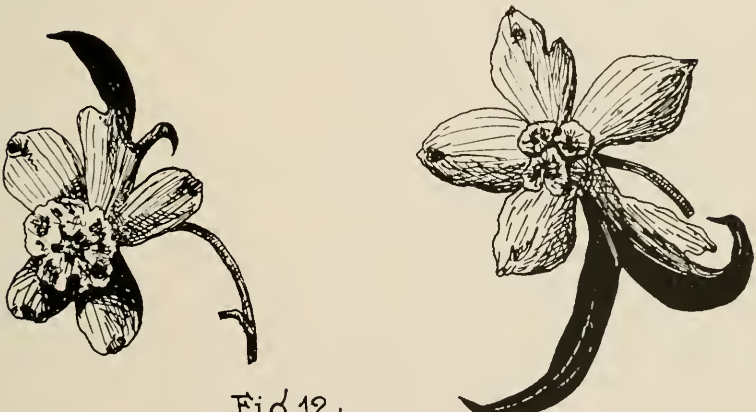


Fig. 12.
DELPHINIUM BELLADONNA.
Phyllody of the calyx. A sepal in each case has reverted partially to the leaf condition in form and color.

L. F. Heimlich
Nov. 1921.

are on record, which indicates that pelorism as a mutation is frequent (6, 12). Fig. 1.

Prior to October, 1921, the author knew nothing of peloria, although he had seen and collected various kinds of monstrous flowers. At the time above noted the author's attention was directed by Dean Stanley Coulter to a peculiar modification of the flowers of Linaria found growing along a street in the city of Lafayette. These peculiar plants were discovered by Miss Hester Meigs, a student of Jefferson high school. The writer visited the place twice and collected both normal and abnormal plants. Whole plants of each kind were pressed and dried and flowering portions of each kind were preserved in formaldehyde. Seeds of the normal plants were very plentiful, but only a few seeds were obtained from the peloric plants. Transplants were also collected and these are now sending up new shoots. After having disposed of the material in satisfactory manner for safe-keeping, the subject was investigated.

The normal plants were identified as Linaria Linaria (L) Karst. of Britton and Brown (or Linaria vulgaris Hill of Gray) and here below the genus description it is stated that the corolla, especially the terminal one of the raceme, occasionally has five spurs and is regularly five-lobed, and is then said to be in the peloria state (7). In Gray's Manual it is noted that in abnormal specimens the corolla is sometimes regularly five-spurred (8). Several large dictionaries give short definitions for the term peloria, but most of the ordinary botany books and the Encyclopaedia Britannica do not contain the term and the condition is alluded to in only two (9, 10) of the general texts examined, one of which states that regular flowers become diversely irregular and irregular kinds perfectly regular (9). This book advises the examination of Masters' Vegetable Teratology. (An old English book, London, 1868, 534 interesting pages.)

The normal flowers of Linaria have an irregular corolla with one spur at the base. The corolla is two-lipped, the upper lip erect and two-lobed, covering the lower in the bud. The lower lip is three-lobed and spreading (Fig. 3). There are four stamens which are didynamous (in two pairs of unequal length) (Fig. 6). The seeds are numerous in numerous capsules (Figs. 1, 8).

From an examination of the plants with abnormal, that is, with peloric flowers, it was found that differences existed in different peloric flowers. The corolla in all flowers examined was regularly five-spurred, the spurs alternating with the calyx lobes. The corolla tube tapered gradually to the top, where it was rolled over and divided into five small lobes which were quite regular in most cases (Fig. 2). In some instances, however, the lobes were unequal, there being a tendency to develop into two lips, the upper lip being pronounced and of two lobes, the lower lip consisting of the usual small middle lobe and two much smaller lateral lobes (Fig. 5). In all cases these more or less slight variations of lobes were found on plants with many flowers, all being pelorized, having five spurs.

All of the peloric flowers examined had five stamens instead of the normal didynamous stamens (Fig. 7). In some of the flowers there were three short stamens and two longer ones (Fig. 7), while in others all stamens were of practically the same length, i. e. regular. Balfour (Encyclopaedia Britannica IV, 1876) has stated that in some instances by pelorization it is found that tetradynamous plants become tetrandrous.

In the peloric plants collected only a very few seeds were produced. The capsules producing them were smaller than the normal capsules (Figs. 8, 9). In 1860 Darwin stated that "there is, I believe, only one case on record of a peloric flower being fertile" (1). DeVries in his experiments begun in 1886 hand pollinated peloric flowers of Linaria which produced considerable seed (6).

Before proceeding further the definition of peloria must be modified. It is a kind of abnormality (but not any kind) of the corolla. It may be slight or pronounced, complete or incomplete. It is usually understood to mean a change from irregularity to regularity—designated as a kind of reversion (as in Linaria), but it may also be just the reverse. In the latter case radial flowers become zygomorphic (4). Examples of this are seen in many Compositæ when corollas of the disk florets become strap-shaped, as in the cultivated asters, sunflowers, and chrysanthemums. In still another case the peloric condition arises from the failure of the development of regular normal parts. Normal columbine flowers have five spurs. Peloric columbine flowers with no spurs at all have been reported (4). It is also noted that the spur in Linaria species is sometimes obsolete (7). Peloria is connected with floral variation in general and it has been of specific interest in the problem of mutation (1, 6).

What is the cause of such floral malformation? The cause is not determined. Some believe that a change in relation to light is a prominent factor, especially one-sided illumination appearing favorable for the development of peloria (5). DeVries in his experiments on Linaria sought to observe the anomaly in his pedigree cultures. The experiments were begun in 1886 with normal plants. A few peloric flowers were produced, which is not uncommon in this genus. The next few generations produced nothing more than the normal number of peloric flowers. In the third generation, among many thousands of flowers, there occurred one having five spurs. This was inbred by hand and produced much seed. All other seed was discarded. The next generation contained about twenty plants having only one peloric flower among them. The peloric plant and one other were bred together, producing abundant seed. From this seed fifty plants were produced. Eleven of them bore the normal number of peloric flowers. One plant was found to bear peloric flowers only. This was, according to DeVries, a mutation, for it bred true in future generations (6).

It seems that many plants produce a few peloric flowers occasionally or more or less regularly, but that individuals which are wholly peloric are comparatively rare. In the observations of last October more than a dozen individuals were noted which were wholly peloric.

It is said that flowers far surpass all other organs in the abundance of abnormalities and monstrosities (9). Besides Linaria three other floral monstrosities have come to the author's notice. One of these is a case of phyllody of the calyx of Delphinium belladonna, grown by Mr. E. J. Kohl. The monstrosity is a reversion. One sepal is prolonged and divided and is also partly green, i. e., leaf-like in two respects (Fig. 12). Another monstrosity is a variation in the head of Calendula grown in the writer's garden. Instead of the usual head, some flowers are changed into small heads set on long pedicels. This is a floral proliferation of the inflorescence (Fig. 11). A number of such abnormalities occurred on one plant. The third monstrosity is a peculiar modification of a spruce cone (Picea excelsa L.) in which a cone bearing microspores (pollen) developed from a terminal bud, the normal place for a normal megacone. No leaves were produced from the bud. The lower part of the cone consists of very small, loose scales with rather large microsporangia full of microspores. The middle zone is made up of sterile scales similar in form to megasporophylls. This is evidently a case of heterogamy. (Fig. 10.) (Collected by author on Purdue campus.)

Peloric forms have been of little significance in horticulture (4). Peloria and other abnormalities, however, are of biological interest in discovering certain natural laws. All kinds of organic abnormalities are worth investigation, as is clearly shown by many of our cultivated plants which, like the navel orange, Fultz wheat and other kinds of wheat, the copper beech, the Shirley poppy, and cupid sweet pea, all of which arose from sudden variations or mutations.

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Plants of White County—IV.

Louis F. Heimlich.

Heretofore the author has reported two hundred species of plants as growing wild in White County. The list below includes seventy additional species. Specimens of these species were collected in the vicinity of Reynolds and at several places along the Tippecanoe river north of Monticello. The collection dates were September 4, 5, and 6, and October 30, 1921. The nomenclature, for the most part, is that of Gray's 7th edition New Manual of Botany. The authenticity of this list is vouched for by Mr. Charles C. Deam, of Bluffton, Indiana, who determined or verified every specimen. The numbers following the names refer to the specimen numbers in the author's personal collection. Brief notes are attached to a few species which seem to be of more than passing interest.

Pteridium latiusculum (Desv.) Maxon. Bracken fern. This is the Pteris aquilina L. of present manuals. Nos. 558, 583.

Polystichum acrostichoides (Michx.) Schott. Christmas-fern. No. 559.

Thelypteris palustris Schott. (*Aspidium thelypteris* (L) Sw.) Marsh shield fern. No. 629.

Osmunda regalis L. Royal fern. No. 630.

Sagittaria latifolia Willd. Broad-leaved arrowhead. No. 570.

Alisma subcordatum Raf. American water-plantain. Nos. 237, 571.

Sorghastrum nutans (L) Nash. Indian grass. No. 576.

Panicum dichotomiflorum Michx. Spreading Witchgrass. No. 620.

Echinochloa Crus-galli (L) Beauv. Barnyard-grass. No. 619.

Cyperus speciosus Vahl. Michaux's cyperus. No. 598.

Cyperus strigosus L. Straw-colored cyperus. No. 567.

Betula nigra L. Red or river birch. No. 647. In 1916 the author reported Betula lutea Michx. Yellow birch, Nos. 436, 437, as growing along the Tippecanoe about two miles south of Buffalo. (Proc. Ind. Acad. of Sci. 1917, pages 396 and 443.) It is now believed that these specimens should be referred to B. nigra L.

Urtica gracilis Ait. Tall wild nettle. No. 603.

Polygonum tenue Michx. Slender knotweed. No. 582.

Polygonum Muhlenbergii S. Wats. Swamp persicaria. No. 639.

Polygonum pennsylvanicum L. Pennsylvania persicaria. No. 600.

Polygonum Hydropiper L. Water smartweed. No. 599.

Polygonum Convolvulus L. Corn bindweed. No. 623.

Amaranthus hybridus L. Spleen amaranth. No. 612.

Berberis vulgaris L. European barberry. No. 645. The specimen is from Buffalo, collected October 30, 1921. The stems and leaves indicate that the specimens are probably the variety purpurea. The leaves were unaffected by rust.

Hydrangea arborescens L. Wild hydrangea. No. 560. This specimen was taken on the west bank of the Tippecanoe River just south of the mouth of the Hoagland ditch. Mr. C. C. Deam has a record of this species from Miami County, about three miles east of Peru. These two records represent the northern limit of the species in Indiana as known at present. It is suspected that the species may be found farther north along the Tippecanoe.

Agrimonia parviflora Ait. Many-flowered agrimony. No. 587.

Medicago lupulina L. Black-seed hop-clover. No. 638.

Amorpha canescens Pursh. Lead plant. No. 608.

Desmodium canadense DC. Canadian tick-trefoil. No. 572.

Lespedeza virginica (L.) Britton. Slender bush clover. No. 563.

Lespedeza capitata Michx. Round-headed bush clover. Nos. 564, 648. Specimens referred to this species vary considerably.

Acalypha virginica L. Narrow-leaf form. Virginia three-seeded mercury. No. 595.

Chamaesyce Preslii (Guss.) Arthur. (Euphorbia Preslii Guss.) Upright spotted spurge. No. 604.

Chamaesyce maculata (L.) Small. (Euphorbia maculata L.) Spotted spurge. No. 596.

Ceanothus americanus L. New Jersey tea. No. 557.

Hypericum prolificum L. Shrubby St. John's wort. No. 646.

Hypericum mutilum L. Dwarf, small-flowered St. John's wort. No. 594.

Hypericum gentianoides (L.) BSP. Orange weed, Pine grass. No. 609. Found only in very sterile sandy soil.

Helianthemum canadense (L.?) Michx. Frostweed. No. 584.

Lechea Leggettii Britt. & Holl. Leggett's Pin-Weed. No. 628. Reported thus far only from Allen, Newton and Starke Counties. Description in Gray is erroneous.

Apocynum cannabium L. Indian hemp. No. 618.

Asclepias incarnata L. Swamp milkweed. No. 605.

Ipomea pandurata (L.) Meyer. Wild sweet potato. No. 634.

Verbena urticaefolia L. Nettle-leaved vervain. No. 614.

Verbena bracteosa Michx. Large-bracted vervain. No. 613.

Verbena hastata L. Blue vervain or Wild Hyssop. Nos. 597, 602.

Solanum nigrum L. Black, deadly, or garden nightshade. No. 616.

Aureolaria pedicularis var. ambigens (Fernald) Farwell. Fern-leaved or Lousewort false foxglove variety. This is the Gérardia pedicularia var. ambigens Fernald of Gray. No. 556.

Aureolaria flava (L.) Farwell. Smooth false foxglove. No. 644. This is the Gerardia virginica (L.) BSP. of Gray.

Agalinis purpurea (L.) Britton. Large purple agalinis. No. 574. (Gerardia purpurea L.)

Agalinis tenuifolia (Vahl.) Raf. Slender agalinis. No. 574A.

Pedicularis lanceolata Michx. Swamp lousewort. No. 554.

Galium pilosum Ait. Hairy bedstraw. No. 643.

Lobelia syphilitica L. Great lobelia or Blue cardinal flower. No. 552.

Vernonia fasciculata Michx. Western ironweed. No. 632.

Liatris scariosa Willd. Large button snakeroot. No. 553.

Solidago nemoralis Ait. Field or dwarf golden-rod. No. 580.

Euthamia remota Greene. Slender fragrant golden-rod. No. 586. The nearest description of this species in Gray is Solidago tenuifolia Pursh.

Aster furcatus Burgess. Forking aster. No. 561. Reported thus far from only Warren and Tippecanoe Counties. According to Deam it is rare. Specimen No. 561 taken from west bank of Tippecanoe River just south of mouth of Hoagland ditch.

Aster azureus Lidl. Sky-blue aster. No. 601.

Aster umbellatus Mill. Tall flat-top white aster. No. 592.

Aster linariifolius L. Stiff or Savory-leaved aster. Nos. 555, 581. This species is now reported by Deam from Harrison, Jasper, Lake, Porter, Starke, and White Counties. It is very fond of sandy soil.

Erigeron canadensis L. Horseweed, Canada Flea-bane. No. 610.

Gnaphalium polycephalum Michx. Sweet life-everlasting. No. 627.

Silphium terebinthinaceum Jacq. Prairie dock. No. 633.

Helianthus mollis Lam. Hairy sunflower. No. 590.

Helianthus grosseseratus Martens. Saw-tooth sunflower. No. 589.

Coreopsis palmata Nutt. Stiff tickseed. No. 579.

Coreopsis tripteris L. Tall tickseed. No. 591.

Bidens frondosa L. Beggar's ticks. No. 622.

Cirsium discolor (Muhl.) Spreng. Field thistle. No. 562.

Prenanthes racemosa Michx. Glaucous white lettuce. No. 573.

Hieracium scabrum Michx. Rough hawkweed. No. 631.

Hieracium Gronovii L. Gronovius' or Hairy hawkweed. No. 585.

Purdue University.

The Growth of Tree Twigs.

C. A. Ludwig.

Methods and Results.

During the summer of 1921 the writer made a series of measurements[1] of growing tree twigs. This was with the idea of throwing what light might be possible on the nature of the plants and on the nature of growth, but more specifically of attempting to determine definitely if in the absence of irrigation reliable data can be secured in humid regions for determining the normal course of the growth rate.

There were available two thrifty young peach trees, *Prunus Persica* (L.) Stokes, and some plants of flowering dogwood, *Cornus florida* L. The first peach tree was on a slight northern slope and was rather tardy in starting growth. The other was on a southern slope but was shaded considerably by tall forest trees some distance away. It started growth sooner than the other, and as the results to be presented show, stopped growing sooner. Neither bore any peaches, as the fruit was killed by a late spring freeze. Three of the flowering dogwoods were along the south edge of a patch of woodland where they were unshaded throughout the summer. A fourth was within the forest and was shaded as soon as the forest trees had developed their leaves. The dogwood is well known as a shade enduring tree, and there was no indication that the small shaded tree used in this study was diseased or weakened by reason of the shading. None of the dogwood trees were large enough to bloom this season. The measurements were made from the base of the shoot to the base of the terminal bud and were taken to the nearest one-eighth inch. They were subject to a maximum experimental error of about $\pm$ 0.125 inch, aside from the "probable" error (error of sampling), on the individual measurements. The experimental error of the averages is considerably less, but even the greater error would produce only a negligible alteration of the growth curve.

The shoots measured on the two peach trees were divided into two classes: (1) shoots which were not so situated as to be over-topped and shaded by others; and (2) shoots which were so situated as to be shaded. The means for the shoots of class one of the first tree and the corresponding growth increments are given in Table 1. The same data are shown graphically in Fig. 1. The weekly rainfall summations are also shown at the top of the figure. I am indebted for the rainfall records to the local co-operative Weather Bureau station. The number of twigs measured was eleven for all dates except March 29th, when it was seven, the seven shoots then measured being included in the population of eleven used on all succeeding dates. The data for class two of the first tree are given in Table 2, Fig. 2. The number of twigs was 19 for March 29th, and 22 for all succeeding dates.

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[1] I am indebted to my wife, Mrs. Nelle McClurg Ludwig, for necessary aid in making and recording these measurements.

Table 1. Growth of unshaded shoots on peach tree No. 1.

Date	*Mean length*	*Mean increment*
March 29	1.49	....
April 5	2.44	0.95
April 12	4.22	1.78
April 19	5.19	0.97
April 26	7.71	2.52
May 3	11.06	3.35
May 10	15.14	4.08
May 17	19.97	4.83
May 24	25.53	5.56
May 31	32.15	6.62
June 7	38.03	5.88
June 14	43.26	5.23
June 21	48.38	5.12
June 28	52.16	3.78
July 5	55.05	2.89
July 12	56.91	1.86
July 19	58.47	1.56
July 26	59.61	1.14
August 2	60.33	0.72
August 9	60.98	0.65
August 16	61.32	0.34
August 23	61.51	0.19
August 30	61.58	0.07
September 6	61.57	—0.01
September 13	61.59	0.02

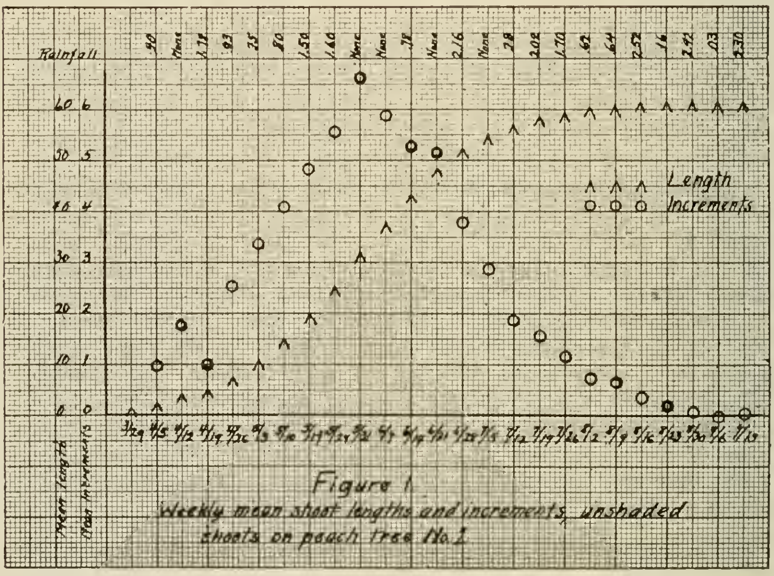

Figure 1
Weekly mean shoot lengths and increments, unshaded shoots on peach tree No. 1

Table 2. Growth of shaded shoots on peach tree No. 1.

Date	*Mean length*	*Mean increment*
March 29	1.23	....
April 5	2.11	0.88
April 12	3.58	1.47
April 19	4.59	1.01
April 26	6.59	2.00
May 3	9.23	2.64
May 10	12.34	3.11
May 17	15.53	3.19
May 24	18.89	3.36
May 31	22.85	3.96
June 7	25.89	3.04
June 14	28.34	2.45
June 21	30.15	1.81
June 28	31.41	1.26
July 5	32.23	0.82
July 12	32.72	0.49
July 19	32.95	0.23
July 26	33.11	0.16
August 2	33.13	0.02
August 9	33.14	0.01
August 16	33.08	—0.06
August 23	33.05	—0.03
August 30	33.09	0.04
September 6	33.07	—0.02
September 13	33.09	0.02

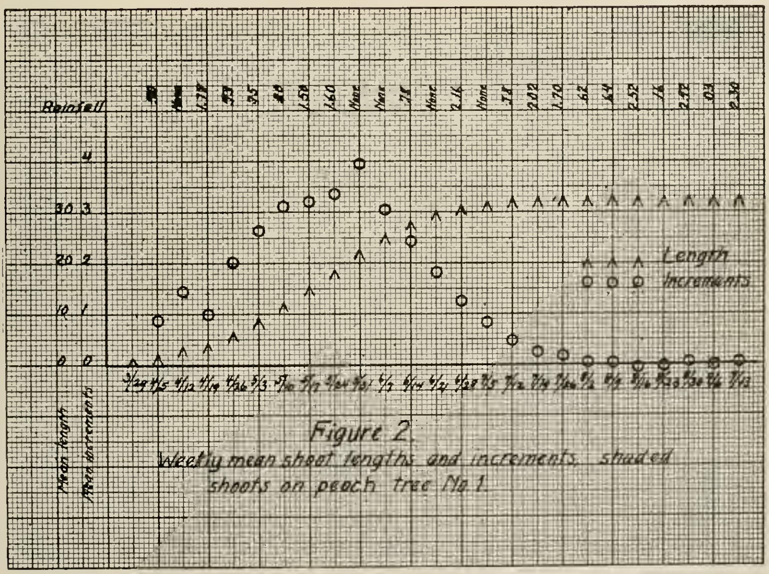

Figure 2.
Weekly mean shoot lengths and increments, shaded shoots on peach tree No 1.

The corresponding data for peach tree No. 2 are given in Tables 3 and 4 and Figs. 3 and 4. The numbers of shoots involved in these cases are 7, 18 and 9, 10, respectively.

Table 3. Growth of unshaded shoots on peach tree No. 2.

Date	*Mean length*	*Mean increment*
March 29	3.64	....
April 5	5.98	2.34
April 12	9.72	3.74
April 19	11.31	1.59
April 26	14.56	3.25
May 3	18.08	3.52
May 10	21.39	3.31
May 17	24.17	2.78
May 24	27.28	3.11
May 31	30.73	3.45
June 7	32.89	2.16
June 14	34.08	1.19
June 21	34.27	0.19
June 28	34.30	0.03
July 5	34.36	0.06
July 12	34.34	—0.02
July 19	34.34	0.00
July 26	34.44	0.10
August 2	34.42	—0.02
August 9	34.47	0.05
August 16	34.38	—0.09
August 23	34.36	—0.02

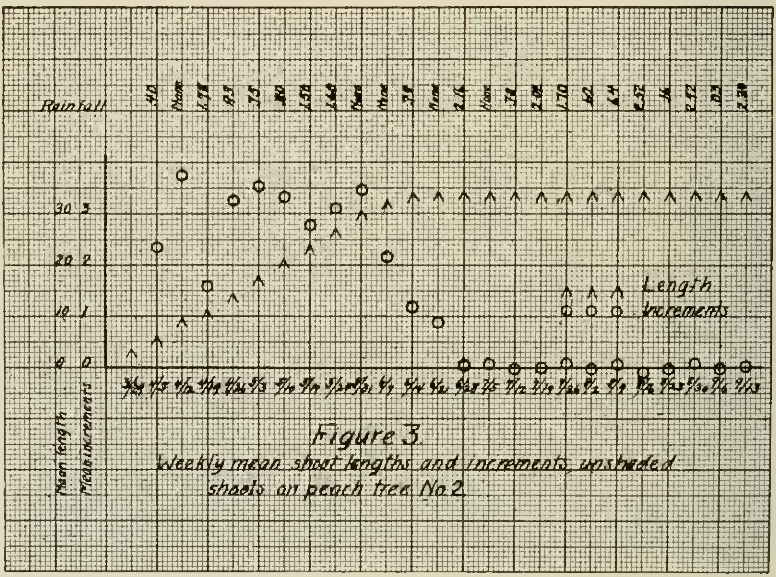

Figure 3.
Weekly mean shoot lengths and increments, unshaded shoots on peach tree No. 2

Date	*Mean length*	*Mean increment*
August 30	34.44	0.08
September 6	34.42	—0.02
September 13	34.42	0.00

Table 4. Growth of shaded shoots of peach tree No. 2.

Date	*Mean length*	*Mean increment*
March 29	2.61	....
April 5	4.54	1.93
April 12	7.53	2.99
April 19	9.08	1.55
April 26	11.56	2.48
May 3	13.56	2.00
May 10	15.00	1.44
May 17	15.91	0.91
May 24	16.74	0.83
May 31	17.36	0.62
June 7	17.68	0.32
June 14	17.86	0.18
June 21	17.91	0.05
June 28	17.89	—0.02
July 5	17.96	0.07
July 12	17.94	—0.02
July 19	17.94	0.00
July 26	17.98	0.04
August 2	17.98	0.00
August 9	17.96	—0.02
August 16	17.94	—0.02

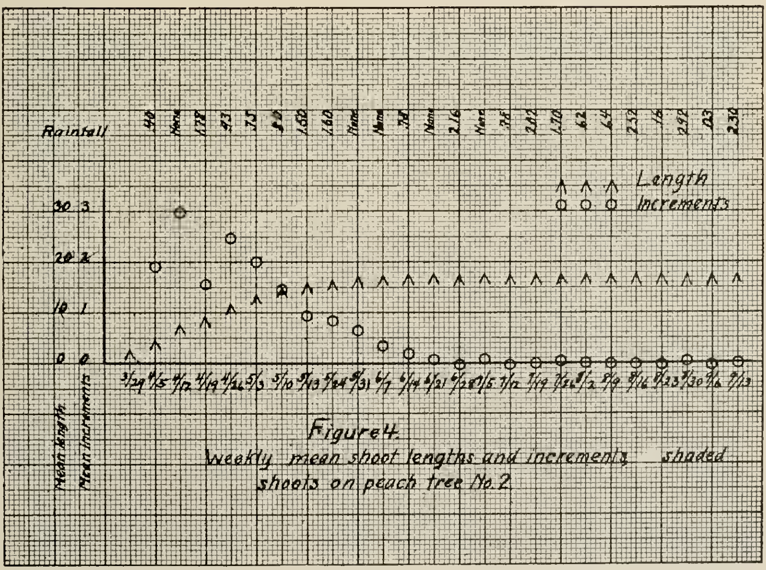

Figure 4.
Weekly mean shoot lengths and increments shaded shoots on peach tree No. 2

Date	*Mean length*	*Mean increment*
August 23	17.91	—0.03
August 30	17.94	0.03
September 6	17.91	—0.03
September 13	17.91	0.00

The data for the dogwood shoots were divided into two groups. The first included those shoots from the trees on the edge of the forest and the second those on the shaded tree. The first had 41 members and the second group had 19. The mean lengths and growth increments for these two groups are given in Tables 5 and 6 and shown graphically in Figs. 5 and 6.

Table 5. Growth of unshaded shoots of dogwood.

Date	*Mean length*	*Mean increment*
March 29	0.42	....
April 5	0.72	0.30
April 12	1.17	0.45
April 19	1.43	0.26
April 26	1.79	0.36
May 3	2.33	0.54
May 10	2.69	0.36
May 17	3.42	0.73
May 24	4.18	0.76
May 31	5.00	0.82
June 7	5.40	0.40
June 14	5.75	0.35
June 21	5.82	0.07
June 28	5.86	0.04

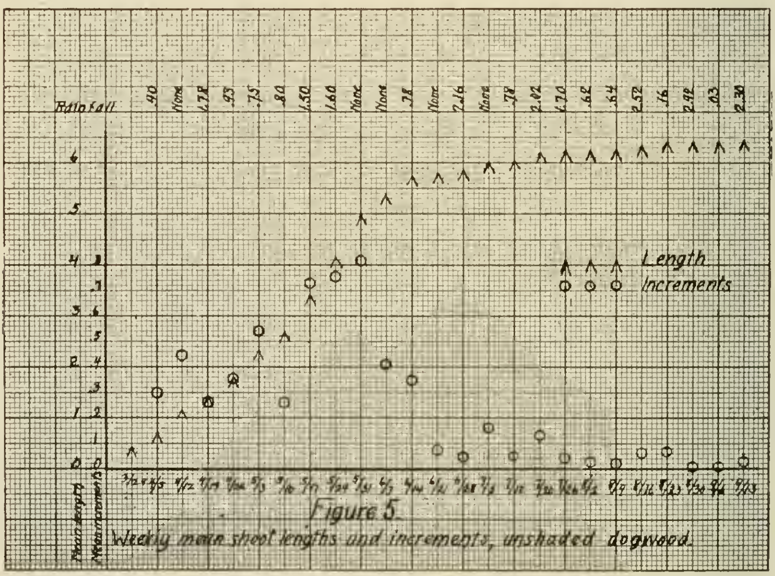

Figure 5.
Weekly mean shoot lengths and increments, unshaded dogwood.

Date	*Mean length*	*Mean increment*
July 5	6.02	0.16
July 12	6.07	0.05
July 20	6.21	0.14
July 26	6.25	0.04
August 2	6.28	0.03
August 9	6.30	0.02
August 16	6.36	0.06
August 23	6.43	0.07
August 30	6.44	0.01
September 6	6.45	0.01
September 13	6.48	0.03

Table 6. Growth of shoots of shaded dogwood bush.

Date	*Mean length*	*Mean increment*
March 29	0.42	....
April 5	0.68	0.26
April 12	1.00	0.32
April 19	1.20	0.20
April 27	1.41	0.21
May 3	1.45	0.04
May 10	1.53	0.08
May 17	1.56	0.03
May 24	1.61	0.05
May 31	1.68	0.07
June 7	1.70	0.02
June 14	1.74	0.04
June 21	1.73	—0.01

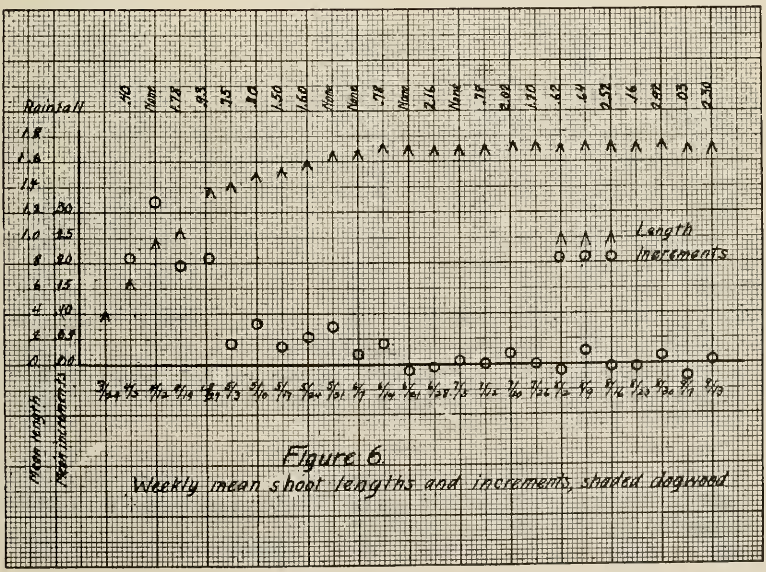

Figure 6.
Weekly mean shoot lengths and increments, shaded dogwood

Date	Mean length	Mean increment
June 28	1.72	—0.01
July 5	1.73	0.01
July 12	1.73	0.00
July 20	1.75	0.02
July 26	1.75	0.00
August 2	1.74	—0.01
August 9	1.76	0.02
August 16	1.76	0.00
August 23	1.75	—0.01
August 30	1.76	0.01
September 7	1.74	—0.02
September 13	1.74	0.00

The dogwood shoots which developed from terminal buds were further divided on the basis of whether they were true terminal branches or were lateral branches of the pseudo-whorl which develops from the terminal bud in the spring. The mean final lengths of these branches were determined for each group and for the two groups combined. The results are shown in Table 7.

Table 7. Final mean length of the true terminal branches and of lateral branches from terminal buds in dogwood.

Group	Type of shoot	Number of shoots measured	Mean length
1	True terminal	12	4.40
1	Lateral	21	7.44
2	True terminal	6	.54
2	Lateral	13	2.30
All	True terminal	18	3.11
All	Lateral	34	5.47

Discussion.

Since the data secured come from a limited number of trees and shoots under different and varying environmental conditions it will not be possible to reach conclusions concerning the normal seasonal course of the growth of tree twigs under uniform outside conditions. Furthermore, it is probably not possible to obtain such curves in humid regions without recourse to irrigation unless an exceptionally good year should happen to be found, or if the observations should be extended over a sufficiently large number of seasons to equalize variations in rainfall. Even then one season's observations under irrigated conditions ought to be more reliable. The present season's rainfall was fairly uniform, and yet the growth curve seems to have been affected rather definitely by rainfall variations. However, the variations in the conditions give certain advantages in interpretation which would not be secured were the conditions uniform.

The curves all show the same general type. The growth rate at first is slow, it increases to a maximum, and then decreases to zero as the season advances. The initial slowness of growth is not very clearly indicated by the data for the shaded dogwood bush, nor for the shaded shoots on peach tree No. 2, but it would doubtless be more evident if it had been practical to take one or two earlier sets of measurements. The type of curve is shown best of all in the unshaded shoots of peach tree No. 1.

It will be noted that peach tree No. 1 and group 1 of the dogwoods reached their maximum growth rate during the week ending on May 31st. These trees were under very similar conditions. However, peach tree No. 2 grew much more rapidly early in the season but ceased growing sooner. The shaded dogwood reached its maximum earlier than the other but because of an earlier decline in growth and not because of a more rapid early growth.

The behavior of these two peach trees seems to point toward the conclusion that the early spring rate of growth is influenced a great deal by the temperature. Tree No. 2 had a considerably warmer location than No. 1. It should also be remarked in this connection that there was freezing weather on one or two occasions after these measurements were begun. It may be possible that if optimum temperature conditions had prevailed early in the season the growth rate would quickly have approximated that found later, after making due correction for the number of working hours per day which the plant has at the two periods.

The cause of the onset and continuation of a decreased growth rate was clearly not lowered temperature, however, because growth had stopped while the temperature was still at a point at which rapid growth occurred earlier in the season. The evidence from the rainfall is that variation in the water supply was at least partially responsible. It seems reasonable to suppose that in the case of peach tree No. 1 and dogwood group No. 1 the growth rate would have continued to augment for some time longer but for the onset of drier weather. In the case of the shaded dogwood the decrease in growth was probably caused by shading. Although no record was made of the time when the forest trees had expanded their leaves sufficiently to produce full shade it was noted that growth in the shaded dogwood seemed to stop shortly after this occurred. It was also noted on the peach trees that as soon as a branch became shaded it quickly ceased growing. This was true whether the shoot came from a last season's bud or was a lateral on a shoot of this season's growth. This observation would account, at least partially, for the more rapid decrease in the growth rate of branches which became overtopped, as shown by the curves for the two peach trees.

In view of the work of Garner and Allard[2] on the effect of the relative length of day and night on the onset of the flowering stage of plants it is worthy of suggestion that this factor also may be operative in such cases as this. It is a common observation that hardy woody plants usually cease growing and harden their twigs while the weather is still warm enough for good growth, whereas in the spring they begin growing very shortly after the weather warms up sufficiently.

[2] Garner, W. W., and H. A. Allard. Effect of the relative length of day and night and other factors of the environment on growth and reproduction in plants. Jour. Agr. Res. 17:553-606. 1920.

9–20320

Owing to the lag of the seasonal curve of temperature the days of given length in spring are much cooler than days of the same length in the fall.

This study has suggested a few interesting points concerning the dogwood which do not have to do directly with the growth rate. The dogwood is well known as a shade enduring tree. The quickly declining growth rate of the shaded tree in this study suggests that this ability on the part of the dogwood is not due to an unusual power to grow in the weak light of the forest, but rather to an ability to grow for a few weeks in the spring and then spend the entire remainder of the season slowly storing up food for another few weeks' growth the next spring.

Another interesting fact, which is shown by Table 7, is that, contrary to the condition in most trees, the terminal shoot in the dogwood is shorter than the laterals of the same season's growth. Each terminal shoot, as it starts growth in the spring, produces one or more very short internodes and sends out one or two lateral branches from each of the closely spaced nodes. There are thus from one to about six laterals produced in an arrangement which simulates a whorl. The measurements mentioned above show that the average final length of these laterals exceeds the final length of the terminal. Additional observations (without measurements) show that in upright, unshaded, rapidly growing stems the terminal exceeds the laterals, but that in the case of stems growing at an angle the lowermost branch grows the longest and becomes the leader, while the rest of the branches decrease in size till the innermost (or uppermost) one is reached, and the terminal is still smaller. Thus every year a new branch becomes the leader and each successive true terminal finally assumes the role of a minor branch. The result each season is to produce a more or less eccentric umbel shaped group from each terminal bud which opened that spring.

Summary.

A number of woody shoots were measured during one season's growth period. The results showed an initial slow growth rate, which then increased to a maximum, and later decreased to zero before the temperature had dropped to the point at which growth started in the spring. The slow initial rate in this case is believed to have been due to the cool weather at the time. The onset of the decrease in growth rate is believed to be due to a decrease in available moisture for at least part of the trees, and it is therefore considered impossible to get dependable curves for the normal course of a season's growth in tree twigs without having recourse to irrigation. For one of the trees and for some shoots on others the onset of the decrease in growth rate is believed to be due to shading, and it is suggested that in all cases the variation in relative length of night and day may have influenced the course of the cycle. The ability of the dogwood to live and develop in shady situations seems not be due to an ability to grow in poor light but rather to an ability to endure shade most of the season and at the same time to store food slowly for use in a spurt of growth in the fol-

lowing spring before the forest develops full shade. In branches growing at an angle the terminal shoot of dogwood grows less than any of the closely spaced laterals which start growth at the same time. The lowermost (outermost) branch grows the most and becomes the future leader of the branch.

Clemson College.

Observations Concerning Puccinia Pattersoniana and Puccinia Moreniana.[1]

E. B. Mains.

Puccinia Pattersoniana was described by Dr. J. C. Arthur[2] from material collected by F. W. Anderson at Sandcoulee, Cascade County, Montana, in July, 1888. The host was a grass, *Agropyron spicatum* (Pursh.) Rydb., and this rust has since been found on *Elymus condensatus* Presl., *E. triticoides* Buckl., and *Sitanion jubatum* J. G. Smith in Oregon, Washington, Utah, California, and New Mexico. *Puccinia Pattersoniana* is unique among the grass rusts in that it has verrucose teliospores with the markings arranged in longitudinal lines. While studying some collections of this rust, another interesting character was found in this species. It was noticed that chloral hydrate and iodine, which was being used to bring out the pore character of the urediniospores, stained the pedicels of the teliospores a dark blue. A study of other collections in the Arthur Herbarium, including the type, showed that this character held true for all. The pedicels stained very heavily, many becoming a very dark blue, appearing almost black for a greater part of their length. Herbarium specimens of this rust when sectioned and treated with iodine, showed the stain only in the pedicels of the teliospores, the mycelium from which they arose and the pedicels of the urediniospores not staining. This reaction of iodine appears similar to that found in some of the Ascomycetes (Plicaria, etc.), where the apical portion of the ascus takes a similar stain.

Further interesting light was thrown on this fungus in the summer of 1920 by Prof. A. O. Garrett,[3] who noted that apparently the only aecia associated with *Puccinia Pattersoniana* at Gogorza, Summit County, Utah, were on *Brodiaea Douglasii*, supposedly belonging to the autoecious *Uromyces Brodiaeae* Ellis & Hark. Prof. Garrett suggests that these aecia might be in reality the aecial stage of *Puccinia Pattersoniana*, since the latter was especially abundant there, and he was not able to find any further development of the rust on Brodiaea. Unfortunately attempts to prove this connection were unsuccessful, since the teliospores from collections sent by Prof. Garrett failed to germinate the next spring. It occurred to the writer, however, that some definite evidence might be obtained as to this connection by the method so successfully used by Tranzschel in connecting several heteroecious rusts with their aecial stage. In making these connections, he made use of the observations made by Dietel[4] and Fischer,[5] who noted that a num-

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[1] Contribution from the Botanical Department, Purdue University Agricultural Experiment Station.

[2] Arthur, J. C. Bull. Torrey Club 33, p. 29, 1906.

[3] Garrett, A. O. Mycologia 13, p. 104 and 110, 1921.

[4] Dietel, P. Uredinales, In Engler & Prantl. Natürliche Pflanzenfamilien I. 1** p. 69. 1897.

[5] Fischer, Ed. Beiträge Kryptogamen Flora Schweiz 1, p. 109, 1898.

PLATE I.

ber of short cycled species of rusts possessed teliospores very similar to the teliospores of heteroecious long cycled species whose aecia were produced on the host of the short cycled species. Thus Tranzschel[6] noted the striking similarity between the teliospores of *Puccinia Pruni-spinosae* Pers. on *Amygdalus communis* and the teliospores of *Puccinia fusca* Winter on Anemone. *Aecidium punctatum* Pers., an unconnected aecial form, was known to occur upon Anemone and when aeciospores from this were sown on *Amygdalus communis, Puccinia Pruni-spinosae* was produced. In like manner several other rusts were successfully connected.

In consequence, it was thought that if *Puccinia Pattersoniana* is connected with aecia on Brodiaea, a short cycled rust having teliospores with the distinguishing characteristics of those of *P. Pattersoniana* should occur on some species of Brodiaea. In order that this search might be as complete as possible, all the species represented in the Arthur herbarium, which occur on Brodiaea, were examined, including *Puccinia Carnegiana* Arth., *P. subangulata* Holw., *P. Dichelostemmae* D. & H., *P. tumamocensis* Arth., *P. nodosa* Ell. & Hark., *P. Moreniana* Diet. & Thomp. and *Uromyces Brodiaeae* Ellis & Hark. Of these only *Puccinia Moreniana* on *Brodiaea capitata* Benth. showed teliospores with pedicels staining with iodine and these took a dark blue stain similar to those of *Puccinia Pattersoniana*. Not only does *P. Moreniana* resemble *P. Pattersoniana* in this respect but the teliospores of the two are nearly identical in size, wall thickness and in the verrucose markings in lines

In the light of the observations of Dietel and Fischer and the work of Tranzschel, the striking resemblance between the teliospores of these two rusts strongly indicates that *Puccinia Pattersoniana* has its aecial stage on Brodiaea. This also, when taken with the field association noted by Prof. Garrett, can leave but little doubt as to the connection.

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[6] Tranzchel, W. Travaux de la Soc. Imper. des Naturalistes de St. Petersbourg 25:286-297. 1904. Abstract in Botanishes Centralblatt 98:150-151. 1905.

DESCRIPTION OF PLATE

PLATE 1

A.—Teliospores of *Puccinia Pattersoniana* from the type collection on *Agropyron spicatum* with pedicels stained blue by iodine.

B.—Teliospores of *Puccinia Moreniana* from the type collection on *Brodiaea capitata* with pedicels stained blue by iodine.

Evidence of the Seed Carriage of the Euphorbia Rusts, Uromyces Proeminens and U. Dictosperma.[1]

E. B. Mains.

As part of the investigations of the life cycles of rusts being carried on by this laboratory, two species of Uromyces, *U. proëminens* (DC.) Pass. and *U. dictosperma* Ellis & Ev., have been studied. *U. proëminens* (*U. Euphorbiae* Cooke & Pk.) was studied by Carleton,[2] who showed that this rust was carried by the seed of *Euphorbia dentata* Michx. Arthur[3] showed that this species was autoecious by sowing the aeciospores from aecia on *Euphorbia Preslii* Guss. ("*E. nutans*"), obtaining uredinia and telia on the same host. The writer's attention was attracted to this rust on account of the more or less systemic aecia which persist throughout the season, the heavy production of aecia, uredinia and telia on the fruit, and the evident strains which exist in this rust in the vicinity of Lafayette, Ind. *U. dictosperma* is a species found on *Euphorbia Arkansana* Eng. & Gr. and other species farther west in Nebraska, Kansas, Texas and westward. The life history of this species has been in question, first as to whether the systemic aecia on these hosts belong to this species or to some heteroecious species, and second as to whether uredinia are produced in the life cycle.

Uromyces proëminens.

In the fall of 1920, seed was collected from plants of *Euphorbia dentata* which were heavily rusted with telia of this rust. In the field this species does not appear until midsummer, so that by starting the plants in the greenhouse there is no chance for infection from without. The seed was planted the 22d of January and about the time the first leaves were well developed, sixty of the plants were transplanted to a flat. Infection first showed up March 1st, when pycnia appeared upon one capsule of one plant. Following this, other plants showed pycnia or aecia or both. Since there was some variation in the manner of development on the various infected plants, each will be discussed separately.

Plant 3-4.

The rust showed on this plant as pycnia upon one of the terminal capsules of the main shoot March 1st. March 27th, two more capsules showed pycnia and both pycnia and aecia appeared on the leaves of the secondary branches arising from the axils of the cotyledons. May 4th, aecia also had appeared on the terminal fruits. No further de-

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[1] Contribution from the Botanical Department Purdue University Agricultural Experiment Station.

[2] Carleton, M. A. U. S. Dept. Agri. Bureau Plant Ind. Bull. 63 p. 9-11. 1904.

[3] Arthur, J. C. Bot. Gaz. 29 p. 271. 1900.

velopment of the rust on this plant was noted, the new branches being rust free.

Plant 3-2.

This plant showed pycnia April 7th on the secondary branches arising from the axils of the cotyledons. Upon April 19th, pycnia and aecia showed on the secondary branches. Following this throughout the summer up until September 3d, the plant continued to send out new branches most of which were covered with pycnia and aecia. No other stages developed.

Plant 5-4.

This plant first showed rust on April 19th, when pycnia appeared covering the capsules and leaves of the two secondary branches. On April 27th, pycnia also appeared upon one capsule of the central shoot and aecia appeared intermixed with the pycnia on the secondary branches. Part of the new branches, as they developed during the summer, showed pycnia and aecia covering the leaves and capsules.

Plant 6-5.

On April 19th, pycnia and aecia appeared on the leaves and capsules of the secondary branches, and on May 4th, pycnia showed on the terminal capsules of the main shoot. On May 5th, uredinia appeared scattered over the plant. Shortly afterward, the plant died.

Plant 9-4.

On April 19th, pycnia and aecia appeared on the capsules and the leaves of the secondary branches. On April 27th, two of the capsules of the main shoot showed pycnia, followed by aecia May 4th. On May 4th, aecia apparently without pycnia appeared upon the leaves of two new branches. On May 11th, uredinia appeared scattered over the plant. About June 3d, the plant died without showing any further development of the rust.

Plant 4-4.

On April 19th, aecia apparently unaccompanied by pycnia appeared on the capsules of the secondary branches. No further development of the rust occurred.

Plant 4-3.

On May 11th, this plant showed pycnia on the capsules of the main shoot. On July 3d, several new branches also had pycnia. No further development of the rust occurred.

In all, seven of the sixty plants showed infection either with pycnia or aecia or with both. As indicated above, there was some variation as to the manner in which infection showed and developed. In some cases it appeared first on the terminal capsules of the main shoot, following later on the secondary branches. In some cases the plant outgrew the infection and became rust-free with the dying of the infected branches.

In other cases the infection developed with the plant throughout the season, invading the new branches as they were formed. In general pycnia appeared first, followed shortly by aecia. Occasionally pycnia only appeared and in a few instances apparently only aecia developed.

Aeciospores from the above material were sown on five uninfected plants and uredinia and telia of *U. proëminens* were produced upon the leaves and capsules. Later ten other plants became infected, showing uredinia and telia apparently from the aeciospores and urediniospores of infected plants.

Uromyces dictosperma.

Seed from plants of *Euphorbia Arkansana* heavily infested with telia of *U. dictosperma* was collected by Mr. E. Bartholomew at Stockton, Kansas, July 2, 1920, and sent to Dr. J. C. Arthur, who kindly turned the material over to me for this work. This seed was planted August 20, 1920, forty-two plants being obtained. These were transplanted to a flat September 2d, and upon November 12th one plant showed infection, one branch being covered with aecia. This infected branch soon died and all the plants appeared free from rust until the last of March, when a number showed infection. The plant showing aecia in November again showed aecia upon one of its branches. Out of the forty-two plants, eleven showed infection, aecia or pycnia and aecia developing upon one or two branches. Later uredinia and telia appeared on most of the plants apparently from aeciospore infection. The branches infected with aecia soon died without setting seed and the plants finally showed only telia.

Aeciospores from the above described material were sown on uninfected plants and uredinia were produced. The urediniospores in these sori were, however, soon replaced by the characteristic teliospores of *Uromyces dictosperma*. From these cultures it is evident, therefore, that the more or less systemic aecia found on *Euphorbia Arkansana* associated with the teliospores of *U. dictosperma* represent the aecial stage of this rust. Aeciospores from these aecia give rise to uredinia, which, however, as such, exist for only a short time, the urediniospores being replaced by teliospores. *Uromyces dictosperma* in consequence is a full-cycled, autoecious species.

It is considered that the above evidence is sufficient to prove that these two rusts are seed carried. The press of other work has not allowed the question to be investigated as to how this takes place. The investigations of Carleton would indicate that in the case of *Uromyces proëminens* the rust was carried on the surface of the seed since plants from seed treated with corrosive sublimate showed no infection. To explain the production of aecia, it would be necessary to assume, however, that teliospores were carried on the seed and germinated while the plant was still young. In the above experiments the teliospores would have to germinate in the fall without overwintering, while in the field they would germinate in the spring after overwintering. Carleton was not able to obtain germination from the teliospores which were present on the seed at the time of planting. In consequence the manner in which this rust is seed carried will have to be left for future investigations.

Treatment of Rhus Poisoning.

O. P. Terry.

It seems there are almost as many "cures" for rhus poisoning as there are people susceptible to it. These cures vary from an ounce dose of epsom salt (taken internally, of course) to applications of Tr. Iodine and solutions of sugar of lead externally.

Those who know themselves to be susceptible to the poison should investigate the possibility of immunizing themselves by taking Tr. rhus toxicodendron. This paper outlines a successful method of treating the dermatitis after it has appeared. No claim of originality is made in the selection of the drugs used, but, it is believed, something new will be found in the manner of their application.

The following paragraphs give in order the steps in the treatment and if begun within a few hours after exposure to the poison will prevent the inflammation.

(1) Thoroughly wash the exposed skin with a heavy lather of laundry (strongly alkaline) soap in warm water, using a soft brush.

(2) Immediately mop off the skin with cotton saturated with ethyl alcohol (denatured with phenol is preferable).

(3) Then apply Tr. grindelia, using a pledget of cotton or soft cloth. Continue the application of this at four-hour intervals until all itching has ceased or until practically all swelling has disappeared. The skin now will feel dry and drawn. (The length of time required for this part of the treatment will vary from two to five days, depending upon the susceptibility of the patient to the poison and also upon the length of time elapsing between exposure and the beginning of the treatment. An average is about three days.)

(4) For the purpose of restoring the surface of the skin to a normal condition, now may be applied a mixture of 1/3 ounce each of ethyl alcohol, glycerine, and rose water, to which is added ten grains of phenol. This softens and aids in the exfoliation of the dead epidermis.

Purdue University.

INDIANA FUNGI—VI.

J. M. VAN HOOK.

The first paper of this series on the subject of Indiana Fungi,* which was undertaken in 1910, was a mere list of those fungi which appeared to be, for the most part, new to our State. In the five papers previously published, we have recorded 724 species. In the later papers we have gradually added more data concerning each species, in many cases now entirely rewriting descriptions. Where only fragments of descriptions are given, it is to be understood that such fragments are additions to, or differences from, the original.

Investigators, particularly in the field of the so-called Imperfect group, are amazed at the many meager descriptions by which one is expected to identify his specimen. If the host were unknown, it might easily be placed under any one of a dozen species. *Spots* are often described as "epiphyllous" or "hypophyllous" when it is very evident that the writer had in mind "pycnidia," "acervuli" or "conidiophores." It is very evident that spots on living leaves are practically always *amphigenous*, but differing sometimes only in color. The characteristics of spots both on the upper and lower sides of leaves should be described.

Much new, rare or extraordinary interesting material has been made available by Mr. H. M. Hudelson, who is collecting particularly the fleshy and woody forms.

Where the name of the collector is omitted, it is understood to be that of the writer; when the locality of its occurrence is not given, it is to be presumed that it was collected in Monroe County.

ASCOMYCETES.

Hysteriographium gloniopsis (Ger.) E. & E.

On decorticated *Ulmus americana*, Monroe County, 1907. Indiana University number 3809. The spores of this fungus remain hyaline for a long time.

Podosphaera biuncinata Cke. & Pk.

On leaves of *Hamamelis Virginiana*, Stephens Creek, October 17, 1920. 3846.

BASIDIOMYCETES.

USTILAGINALES.

Entyloma compositarum Farl.

On living leaves of *Ambrosia trifida*, Stone Springs, June 30, 1920. 3830.

* Indiana Fungi-I, 1910, 459 species.
Indiana Fungi-II, 1911, 71 species.
Indiana Fungi-III, 1912, 27 species.
Indiana Fungi-IV, 1915, 99 species.
Indiana Fungi-V, 1920, 68 species.

Entyloma serotinum Schroet.

On living leaves of *Mertensia Virginica*, Harrodsburg, May 7, 1921. 3865. At this early date, this fungus had already killed the lower leaves of its host. The similarity of leaf spotting by certain species of Entyloma to those caused by Imperfect Fungi is strikingly noticeable here.

UREDINALES.

Gymnosporangium germinale (Schw.) Kern.

On branches of *Juniperus Virginiana*, Weimar Lake, April 24, 1921. 3863. Collected also at Harrodsburg. Found on twigs and branches of all sizes up to an inch or more. Our specimens agree well with the description given by Arthur except that spores are usually constricted and many much longer than given. The average length is fully the extreme recorded by him. We find spores more than 80 microns long.

HYMENOMYCETALES.

Clavariaceae.

Clavaria inequalis Fr.

In large palm pot, greenhouse, May 17, 1921. Also in September. Plants white, upper half somewhat yellow. Some enlarged slightly on top; others rounded.

HYDNACEAE.

Hydnum caput-ursi Fr.

On decayed log (*Nyssa sylvatica*), Bean Blossom Valley, November 12, 1921. Hudelson. 3909.

POLYPORACEAE.

Boletus chrysenteron Fr.

Ground, open woods, July 6, 1921. 3877.

Polyporus fragrans Pk.

On bark of log (*Ulmus americana*), Bean Blossom, November 12, 1921. Hudelson. Has odor of sweet anise and licorice. 3908.

Poria undata (Pers.) Bres.

City Water Works, October 27, 1908. 2192. (See Mycologia, *12*, 89, 1921.)

Trametes sepium Berk.

On stake of deciduous wood, Campus of I. U., October 14, 1921. 3384. Common on structural timber.

AGARICACEAE.

Clitopilus prunulus Fr.

On ground, Griffey Creek, June 23, 1921. Hudelson. 3873.

Cortinarius distans Pk.

On ground, Bean Blossom, June 27, 1921. Hudelson. 3874.

Lepiota cristata Fr.

Ground, I. U. Campus, July 6, 1921. Paul E. Harris. 3876.

Pleurotus spathulatus (Fr.) Pk.

On ground, Bean Blossom, September 27, 1921. Hudelson. 3882. This species is very similar to P. petaloides but has spores 7½ by 4 to 5 microns, whereas the latter has globose spores, 3 to 4 microns.

Russula foetentula Pk.
Griffey Creek, June 20, 1921. Hudelson. 3782. Distinguished by the cinnabar red color at the base of stem.

PHALLINALES.

Mutinus elegans (Mont.) E. Fisher.
On ground in woods, Monroe County, June 10, 1921. 3885.

LYCOPERDINALES.

Bovistella Ohiensis Ell. & Morg.
On ground, Bean Blossom, June 15, 1921. Hudelson. 3870.

PLECTOBASIDINALES.

Scleroderma Geaster Fr.
On a clay bank, Bean Blossom Valley, September 27, 1921. Hudelson. This is an interesting fungus, seeming to prefer a rather raw clay situation. They are easily overlooked, as only the top is visible, this being split sometimes into star-like segments but often in a very irregular manner. They ordinarily split one-fourth to one-third of the distance from the top. They are from two to four inches in diameter. 3596 and 2883. (Bovistella Ohiensis Morg. number 3596 in Indiana Fungi IV, for 1915, should be referred here.)

FUNGI IMPERFECTI.

SPHAEROPSIDALES.

Phyllosticta circumvallata Wint.
On somewhat languishing leaves of *Liriodendron tulipifera*. Also on circular spots due to the common catalpa midge. July 22, 1921. 3879. Harris.

Phyllosticta Podophylli Wint.
On living leaves of *Podophyllum peltatum*, Cedar Cliff, May 6, 1921. 3867. Huckleberry ravine, May 24, 1921. Anderson. 3868. This fungus is common in Monroe County and varies from the description as follows: Pycnidia, almost wholly epiphyllous, 100 to 150 microns in diameter with a definite pore about 20 microns in diameter. Spores irregularly globose or ovoid, granular, 9 to 12½ by 7 to 10 microns. The arrangement of the pycnidia along the veins is very noticeable.

Septoria verbascicola B. & C.
Common in Monroe County, on *Verbascum blattaria*. I. U. Campus, August 7, 1908. 2386.

Spots, 1 to 6 mm. in diameter, white center with broad purplish border, circular, amphigenous; pycnidia mostly epiphyllous, prominent, rupturing the epidermis, dark, pore small, wall thin and easily rupturing about the pore; spores hyaline, long bacilla-like, curved, flexuous or straight, as much as 50 microns long and .5 to 1 micron thick. (The ease with which the pycnidia rupture above may cause it to be placed under the Melanconiales in hasty study.) Since no description of this plant is given in Saccardo, it is herein described as shown in our local fungi. Professor C. H. Kauffman, of the University of Michigan, has kindly compared specimen number 749 of the exsicatti of Ellis' N. A. F. with the above description and says that it agrees well with it.

MELANCONIALES.

Cylindrosporium Capsellae E. & E.

On living leaves of *Lepidium Virginicum*, six miles west of Bloomington, July 25, 1920. 3861.

The measurements of the spores on this new host agree well with those in the description, except that they are only 12 to 30 by 2 to 2½ microns, while in Ellis and Everhart's original description they are given as 35 to 45 by 3. We have two specimens collected on Capsella Bursa-pastoris. The spores in these are slightly longer, measuring 15 to 37 by 2 to 2½. They are variously curved and are 1 or 3-septate, not uniform in thickness and occasionally pointed at one end. Though differing somewhat from the original description, it seems proper to refer this specimen to C. Capsellae E. & E. In addition to the spore difference noted above, the acervuli are hypophyllous as well as epiphyllous.

Marsonia Thomasiana Sacc.

On living leaves of *Evonymus atropurpureus*, Showers' Farm, August 26, 1920. 3811.

Spots 1 to 6 mm. broad, usually 1 to 3 mm., amphigenous, subcircular or angular, with reddish margin; acervuli amphigenous, erumpent through the cuticle, 25 to 50 microns and later often extending so as to cover most of the spot and leaving a white, flaky appearance due to the adbundance of spores drying in masses; spores 17 to 30 by 8 to 12 microns, mostly about 20 to 25 by 10, pyriform, usually constricted at the septum; the upper cell twice the width of the lower one, subspherical and occasionally not exactly above it but tilted slightly to one side by the lower cell being bent; conidiophore very short cylindric, about 4 to 7 by 4 to 5 microns.

HYPHOMYCETES.

Cercospora avicularis Wint.

Common on living leaves of *Polygonum* species throughout Monroe County. 2805. Collected on the Showers' Farm, August 20, 1920. Spots scattered, amphigenous, 1 to 6 mm., brown in dried specimens, bounded by a narrow elevated reddish-brown line, yellowish outside this line; tufts of conidiophores chiefly epiphyllous; conidiophores short, about 25 by 4 microns, colored at the base; conidia pale yellow (almost hyaline), 3 to 7-septate, curved or straight, 40 to 90 by 3 to 4 microns. Distinguished from C. polygonacea E. & E. by its short conidiophores.

Cercospora depazeoides (Desm.) Sacc.

On living leaves of *Sambucus Canadensis*, Showers' Farm, August, 1920. 3810. Our specimen agrees with the European type rather than with C. sambucina E. & K. collected in New York and Kansas. The spots agree with those described for C. depazeoides except that they are 2 to 6 mm. This covers both the sizes described for C. depazeoides and for C. sambucina (4 to 6 and 2 to 4 respectively). The conidiophores agree also with the European form except that we have a minimum length of 50 microns. While the spores are for the most part 75 by 5 microns, they range from 50 to 115 by 5 to 5½. It seems rather remarkable that our Indiana specimens should agree so well with the European form as compared with those from New York and Kansas situated as we are between the two States. In our judgment C. sambucina E. & K. is not sufficiently different from C. depazeoides to constitute a separate species. The "shot hole" effect of the fungus upon the leaves is very noticeable in our specimens.

Cercospora granuliformis Ell. & Mart.

On *Viola cucullata* (V. sororia), Kerr Creek, June 22, 1920. 3821. Varies from the description as follows: conidiophores 3 to 4 microns in thickness; conidia 20 to 62 long, straight or sometimes bent, cylindrical or enlarged near the base, 1 to 5-septate (mostly about 3), hyaline and not brown. Our specimens have many things in common with C. Violae Sacc., C. murina Ell. & Kell. and C. granuliformis Ell. & Holw. These common characters suggest a too close relationship of these species.

Cercospora Nasturtii Pass.

On leaves of *Radicula Nasturtium-aquaticum* at a spring one mile southeast of Bloomington, July 24, 1921. 3880. Large areas of this cress were killed by this fungus at this date. It appeared as follows: spots circular, 1 to 10 mm. (eventually spreading over and killing the entire leaf), pallid, with ochraceous border; conidiophores amphigenous, fuscous, light colored at the tips; conidia 40 to 112 by 4 to 6 microns, 3 to 7-septate (many are 4-septate), cylindrical to long tapering, some cells thicker than others, hyaline. Our specimens bear great resemblance to several species and varieties of Cercospora described on various Cruciferae, some of which seem too closely related.

Cercospora murina Ell. & Kell.

On *Viola cucullata*, I. U. Campus, July 13, 1916. 3700.

Cercospora Rubi Sacc.

On leaves of blackberry, Weimar Lake, October 21, 1920. 3851. Further study of specimen number 3655 reported in 1915 (Indiana Fungi IV) as C. septorioides E. & E. seems to assign it here. As stated there, C Rubi Sacc., C. rubicola Thuem. and C. septorioides E. & E. have many common characteristics, while our specimens differ somewhat from all of them as follows: spots amphigenous, one-third to one cm., orbicular, at times somewhat limited by veins, wood-brown to avellaneous, becoming paler with age, bounded by a purplish-fuscous border; conidiophores densely aggregated, short, 15 to 30 by 3 to 4 microns, wavy above; spores 30 to 100 by 2 to 4 microns, continuous to 7-septate, most of the larger ones slightly curved and 5 or 6-septate.

Isariopsis laxa (Ell.) Sacc.

On leaves and pods of beans (*Phaseolus vulgaris*), Clark County, Indiana, August, 1920. 3816.

So far as the writer is able to learn, this is the first time this fungus has been recorded as injuring or growing upon bean bods. During the month of August, 1920, and to some extent during the same month of 1921, a number of gardens were completely ruined by this disease. It appeared first upon the leaves, then attacking the pods, spotting and rotting them. The appearance of the spots upon the pods is entirely unlike that caused by anthracnose. They are usually larger, more superficial at the beginning, and present a blotched appearance around the edge. Further work is being done to determine more definitely the exact nature of and the conditions necessary to cause bean pods to be severely injured by this fungus. This fungus was first noted in America by Ellis under the name of *Graphium laxum Ell.* Bull. Torr. Club, 1881, p. 65.

Ramularia Plantaginis Pk.

On living leaves of *Plantago Rugelii*, six miles west of Bloomington, July 25, 1920. 3833 and 3858.

Our specimens have spots 1 mm. to 2 cm. in diameter, brown, with small light colored center. Specimen number 3633 has much smaller spots than 3858. Conidiophores amphigenous, and especially abundant near the outer edges of the spots, wavy in outline, and bearing spores laterally as well as terminally, about 25 microns long. Spores cylindrical, rounded at the upper end, somewhat truncate below, 12 to 45 by 4 to 5 microns, continuous, becoming 1 or even 2 or 3-septate. This fungus corresponds well with the too brief description by Peck in Report 32, 1879. Ramularia Plantaginis Ell. & Mart. is said to have minute spots. The descriptions of these two species, however, seem, in the light of our material, to be near if not identical. From the fact that conidiophores are found in the outer brown part of the spots, it seems better to describe spots as brown with pale center rather than, spots small, pale with broad border. Since Peck's description antedates that of Ell. & Mart., it seems preferable to refer our specimens to R. Plantaginis Pk.

Sterigmatocystis nigra V. Tiegh.

On bread, July 14, 1921. 3878.

Myxomycetes.

Tubifera ferruginosa (Batsch.) Gmelin.

On pieces of rotten wood, I. U. Campus, June 26, 1921. O'Neal. 3875. Tops of sporangia even more pointed than figured by MacBride, and the figure shows them more pointed than warranted by the descriptions.

Indiana University.

The Popping of Corn.

Paul Weatherwax.

The ability of the grains of some varieties of Indian corn to "pop" when heated lends a unique interest to this otherwise unusually interesting plant, and a number of popular notions and more or less scientific theories have attempted complete or partial explanations of the phenomenon.

Kraemer's detailed histological studies lead him to the belief that the popping of corn is due to peculiarities in the minute structure of the starch grain.

Wilbert showed, in 1903, that the "pop" was due to the expansion of moisture in the grain, and that corn too dry to pop well could be improved by soaking in water and then partially drying. He also found that the hull of the grain plays no essential part, and that the pop starts in the densest pheripheral portion of the grain.

Attacking some old ideas as to the popping process, Storer found, in 1904, that the expansive medium responsible for popping was not a volatile oil. He also found that the hull of the grain was not necessary, since pieces of grains would pop the same as whole grains.

A year ago at the meeting of this Academy, Carr and Ripley revived the problem by inquiring into "What puts pop in popcorn?" Disposing of the history of the question with the statement that it is often "joked about but seems never to have been considered seriously enough to lead to any investigation", they discuss certain observations and experiments on a number of varieties of popcorn. They state that the expansive medium causing the pop is steam generated within the starch grain, and that between a wide range of extremes the moisture content is immaterial. In explaining how the pressure is confined for a time and then suddenly released, they state (p. 264): "The cellular starch wall is very elastic, permitting of wide distention, and a loss of some cell granules, without breaking. Other corn grains split open without much cell elasticity being shown." Although this terminology cannot readily be translated into standard terms as applied to cell structure, it is taken to mean that the cell wall is the structure responsible for the peculiarity, and that popcorns differ from other varieties with respect to this structure. They emphasize the important point that successful popping requires the dextrinization of most of the starch, and this requires that the heat be applied at an optimum rate.

In the light of significant results coming from recent investigations, this seems an appropriate time to collect and evaluate the data afforded from all sources and to generalize on the subject.

Nature of the Process.—The popping process is in reality a miniature explosion caused by the slow application of heat, and resulting in a disruption in which the endosperm increases greatly in volume, often turning the grain inside out. Physical examination shows a profound change in the texture of the endosperm, the cell walls being destroyed, the starch grains exploded, and other characteristics of organic structure obliterated; and chemical analysis indicates hydrolysis of most of the starch and a considerable loss of moisture.

Two factors here present themselves for explanation: (1) the expansive medium acted upon by the heat; and (2) the structure which gives force to the explosion by confining the accumulating pressure until a limit is reached.

Most of the investigators of the subject up to the present have been physicists and chemists, and they have satisfactorily solved the problem involved in the first of these factors, the expansive medium. But they have failed to locate the confining structure, because here the clue is afforded by the difference between popcorn and kinds of corn that do not pop; and this falls within the field of plant morphology.

The Expansive Medium.—An old idea, that the expansive medium, acting as a vehicle for the disruptive force, was a small volume of air imprisoned in the middle of the grain, seems long ago to have been abandoned for want of evidence. And the more recent one, attributing the explosion to a volatile oil, has gone by the same route. The significant changes that occur in popping indicate that the disruptive force is distributed throughout the endosperm, while analysis shows that the oil content is limited to the embryo of the grain.

The occurrence of maximum and minimum moisture contents for good popping—although the range is wide—and the visible escape of steam during popping, indicate that water contained in the very hygroscopic starch grains themselves is the substance that expands and causes the explosion. At least a partial hydrolysis of the starch is necessary for best results, and this necessitates slow enough application of the heat to permit dextrinization before the explosion occurs. Experience has shown that best results are obtained when the popping temperature, which is 175° to 200° C., is reached in two to three minutes from the initial application of heat.

The Confining Structure.—The confinement of the increasing pressure until the instant of explosion was long attributed to the pericarp of the grain, but experiments do not bear out this idea. Pieces of grains will pop, as will also grains with holes drilled in them, and grains with the pericarp removed.

A microscopic examination of the endosperm of maize shows the contents of each cell to consist of numerous starch grains embedded in a mass of desiccated colloidal material, the protoplasm of the cell. This colloidal material is the seat of all the protein of the endosperm except that in the aleurone layer. The flinty or soft texture of the endosperm depends upon how completely the colloidal material fills the interstices between the starch grains. The moisture in the starch grain is changed to steam during the heating process, but the starch is held intact by the colloidal matrix until the limit of its capacity is reached. Then the explosion of the starch grains of a few cells at the surface, where the tissue is flintiest, releases the external pressure on underlying units, and the whole ten million grains let go simultaneously. The cell wall is a comparatively fragile structure, incapable of holding any great pressure, and playing no significant part in the process. In the softer varieties of corn the steam generated during the application of the heat tends to leak out through the more porous matrix of colloidal material so that the explosion, when it finally occurs, is much less violent; and it comes at a lower pressure than in good popping varieties because the confining structure is not strong enough to hold a greater pressure.

All kinds of corn pop more or less, and the process is also characteristic of the seeds of many other species of grasses. But it is only in the small-seeded flint varieties known as popcorns, and in some of the sorghums, that the grain undergoes so great a change as is generally indicated in the popular term *popping*. The necessary structure for successful popping is a flinty endosperm. The range of moisture permissible is much wider than is generally supposed.

Popping and Protein Content.—Since the hardness of the endosperm is determined by the degree to which the interstices between the starch grains are filled with the colloid rich in protein, a close correlation might be expected between the popping quality and the protein content of the grain. A general correlation does occur, but analyses such as those given by Carr and Ripley (p. 262) show that it is not so close as might be expected.

It may be remarked in passing that the ordinary analysis of the whole grain of corn is scarcely more than useless in the solution of a problem like the one here at hand. A grain of corn consists of three separate and distinct parts—pericarp, endosperm, and embryo—members of three different morphological generations of the plant, and possessed of three distinct genetic possibilities, and capable of having three uncorrelated chemical compositions.

The protein concerned in the popping process is located in the interstices between the starch grains of the endosperm, that in other parts of the grain playing only a passive part. An analysis of the whole grain will indicate feeding qualities and many other things, but to take such an analysis as an index to popping qualities, or, as some have done, to the hereditary constitution of the embryo, is exactly as scientific as carrying out a nitrogen determination after spilling an unknown quantity of a substance of unknown composition into the digestion flask.

Analyses of endosperms carefully separated from the rest of the grains show a much closer correlation between protein content and popping qualities. But even here too much must not be expected. Protein content is only a matter of relativity after all. Starch grains vary much in size and in shape, and there is consequent variation in the amount of protein-bearing colloid necessary to fill all the spaces sufficiently to produce flinty translucency. The endosperm of the flintiest type the author has ever analyzed had only a little more than 6% protein, while that of a relatively soft, floury variety had more than 12%. Although the former had large enough a grain to be classified among the flints, it popped well; the latter merely split open when heated. But microscopic examination showed the one to have large, hexagonal, closely-arranged starch grains, only a small amount of colloid being necessary to fill the interstices completely; the latter had small, rounded, loosely-arranged starch grains, and the relatively large amount of protein-bearing material was not sufficient to fill the spaces and produce a flinty texture. The difference between the two conditions is not wholly one of heredity, the weather conditions attendant upon maturity, and doubtless the chemical constitution of the soil, being determining factors.

Structure of the Starch Grain.—Kraemer's theory that the ability to pop is dependent upon the minute structure of the starch grain, is not readily substantiated. The extremes that he notes between popping and non-popping varieties in this respect can all be found in good popping varieties if enough samples are examined.

The "Puffed" Cereals.—Contrary to the opinion expressed by Carr and Ripley (p. 261), there is good evidence that in the manufacture of the "puffed" cereals exactly the same principle is involved as in the popping of corn, man having provided what nature omitted. The grain, containing a proper amount of moisture, is enclosed in an air-tight metal drum and heated until the optimum temperature and pressure have been reached. Then, by suddenly opening the drum, the pressure outside each grain of the cereal is released, and each starch grain explodes because of the internal pressure of the steam.

Summary.

The popping of a grain of corn is an explosion due to the expansion, under pressure, of moisture contained in the starch grains. Until the instant of the explosion, this force is confined by the colloidal matrix in which the starch grains are embedded. Neither air nor any volatile oil is in any way concerned with the process as the expansive medium.

As a result of popping, there is hydrolysis of much of the starch, a loss of moisture, and the obliteration of all cellular structure in the endosperm.

Except to aid slightly in confining the pressure, neither the embryo nor the hull (pericarp) of the grain plays any part in the process.

Maximum, minimum, and optimum moisture contents are indicated, but the range is wide.

The flinty texture of the endosperm is an accurate index to popping qualities. Hardness of the endosperm is due to nitrogenous material filling the interstices between the starch grains; but, because of variation in the size, shape, and proximity of the starch grains,—and consequent variation in the relative amount of material necessary to fill the interstices,—popping quality is not in direct proportion to protein content.

The difference between popping and non-popping varieties is wholly one of hardness of endosperm. Popping is not in any way dependent upon the minute structure of the starch grain. Non-popping varieties may be made to pop if they are heated to the proper temperature under pressure and the pressure suddenly released.

For successful popping, the heat must be applied rapidly enough to generate steam faster than it escapes, but slowly enough to permit hydrolysis of most of the starch before the explosion occurs. Best results are obtained when the heat is so applied that a temperature of 175° to 200° C. is reached in 2.5 to 3 minutes.

Indiana University.

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Additions and Corrections to the List of Indiana Mosses.

T. G. Yuncker.

In the list of mosses of Indiana submitted to the Academy last year there were omitted, it has been discovered, several mosses that are reported as occurring in the State. These additional species were included in a list of mosses of Monroe County made by Professor F. L. Pickett and published in *The Bryologist* for May, 1915. There were, also, in this list several species not reported by me as occurring in Monroe County. In order that the list of last year may be made as complete as possible, I list below the species that were not previously included.

Species not included as occurring in Indiana.

Brachythecium rivulare B. & S.

Dicranella heteromalla var. *orthocarpa* (Hedw.) E. G. B.

Forsstroemia trichomitria var. *immersa* (Sulliv.) Lindb.

Hypnum molluscum Hedw.

Orthotrichum Lescurii Aust.

Orthotrichum Schimperi Hamm.

Rhytidium rugosum (L.) Kindb.

Species not reported as occurring in Monroe County:

Aphanorhegma serratum Sulliv.

Brachythecium campestre B. & S.

Bryhnia graminicolor (Brid.) Grout.

Bryum caespiticium L.

Buxbaumia aphylla L.

Campylium hispidulum (Brid.) Mitt.

Ceratadon purpureus (L.) Brid.

Cratoneuron filicinum (L.) Roth.

Dicranum fulvum Hook.

Eurynchium hians (Hedw.) J. & S.

Hedwigia albicans (Web.) Lindb.

Leptobryum pyriforme (L.) Wils.

Leucodon brachypus Brid.

Mniobryum albicans (Wahlenb.) Limpr.

Mnium affine Bland.

Philonotis fontana (L.) Brid.

Thuidium microphyllum (Sw.) Best.

Tortella caespitosa (Schwaeger.) Limpr.

The following errors in synonymy have also been observed in my previous list:

Polytrichum formosum Hedw. as reported is probably *P. ohioense* R. & C.

Bryum Wahlenbergii Schwaegr. is *Mniobryum albicans* (Wahlenb.) Limpr.

Thuidium tamariscinum B. & S. is probably *T. delicatulum* (L.) Mitt.

Anomodon fragilis is *A. tristis* (Cesat.) Sulliv.

Hypnum serpens radicle (?) is possibly *Amblystegium serpens* (L.) B. & S.

Hypnum riparium cariosum (?) is possibly *Amblystegium riparium* B. & S.

DePauw University.

A Chemical Study of the High Frequency Corona Discharge.

F. O. Anderegg.

All commercial methods of making ozone take advantage of the chemical properties of a corona or silent discharge. In order to prevent the undesirable spark discharge from forming it is necessary to use some device such as a dielectric. Glass, micanite or similar insulating material interposed between two electrodes is a great aid in the formation of a discharge suitable for ozone production. Dielectrics have several disadvantages; they cannot be used at high temperatures; they are apt to be easily broken mechanically and finally they are subject to annoyingly frequent punctures. Moreover, a dielectric undergoes progressive changes which are apt to have considerable effect on the yield of ozone.

The high frequency discharge has certain advantages which have made desirable some investigations of its availability for ozone production. Because of the time necessary to build up a spark discharge from small electrodes it is possible in a suitably designed tube to have brilliant corona discharges without the use of dielectrics.

In 1896 Nikola Tesla,[1] observing the production of ozone in air subjected to the discharge from certain forms of his high-tension high-frequency coils, applied for a patent. The electrodes were parallel plates; these do not produce a form of discharge very suitable for ozone production, so that this apparatus has not achieved any commercial success. The use of a high-frequency corona discharge in reducing the molecular weight of hydrocarbons so as to render them suitable for use as gasolene has been described by Cherry.[2] By this means, he has eliminated the dielectric, which, at the temperatures used (up to 480°), would give considerable trouble. Other investigators[3] working with frequencies as high as 1,200 cycles apparently have found optimum frequencies for certain conditions.

[1] N. Tesla. U. S. Patent 568, 177 Sept. 22, 1896.

[2] L. B. Cherry *Trans. Am. Electrochem. Soc.* 32. 345 (1917). U. S. Patent 1229, 886 July 12, 1917. Doubtless a certain amount of cracking occurs under the given conditions. Indeed the use of a corona discharge primarily for cracking has been more recently patented. Schmidt and Wolcott. U. S. Patent. 1307, 931, June 21, 1919. The use of high frequency for polymerization of acetylene has been described by Kaufman, *Ann.* 417, 34 (1918).

[3] Shenstone and Priest, *J. Chem. Soc.* 63, 938 (1898) concluded that the maximum efficiency is to be obtained with a 16 cycle discharge. Further discussion of the effect of frequency has been given by Rideal, Ozone, Van Nostrand, 1920, pp. 105-107, but it must be remembered that uncertainties as to meter readings and as to the effect of other uncontrolled variables render the conclusions drawn there of doubtful value. A comparison of a number of ammeters placed in the primary circuit of an induction coil operated on direct current showed that none of them registered the same value or even the true value as obtained from oscillographs. The maximum deviation was about 25 per cent. However, the tendency to use 500 cycles whenever available for commercial production of ozone must have some significance.

Experimental: Preliminary experiments were made with a small Tesla coil. One side of both the secondary and primary was grounded, the other end of the terminal ending in a platinum wire supported on the inside of a bell, similar to the method proposed by H. Guilleminot,[4] so that the corona discharge, which is produced under suitable electrical conditions, may ozonize the air. The Tesla coil was supplied with energy from a small induction coil. The concentrations of ozone were very small and the power yield was only 2-5 g. per killowatt hour on a basis of gross input into the induction coil. A more suitable arrangement for securing a corona discharge is a wire passing through the axis of a tube,[5] as previously used for the study of the direct current corona. At first a No. 29 platinum wire was placed in a five-inch aluminum tube. The results obtained were quite variable and it was thought that the variability of the direct current which excited the induction coil was responsible; but on applying storage battery current, the improvement was not great. An oscillographic study of the secondary current and of the voltage from a tertiary coil wound on the induction coil showed a very inconsistent wave form. Various make-and-breaks were tried without success. A 5,000 v. Thordarson type H-1 transformer was substituted and with a fairly constant source of alternating current gave results which were very much more consistent.

Description of Electrical Set-up. A very steady source of alternating current at 110 v. was applied through variable resistance to a Thordarson transformer of type H-1 whose ratio was 1:50. A condenser made of three concentric aluminum tubes, having a capacity of 0.0007 microfared, was placed in parallel with the high voltage terminals. A zinc spark gap with variable adjustment was used in an atmosphere of ether vapor. The Tesla coil was composed of four turns of wire in the primary and 200 in the secondary with an air core. The frequency was measured with a Kolster decremeter calibrated by the Bureau of Standards. The wave length varied according to the size of the wire in the tube and according to whether the measuring apparatus was connected to the tube or to the wire. With No. 29 wire, the wave length was 185 m. for the tube and 2000 m. for the wire, while with No. 16 wire, these values had increased to 260 and 300 m. respectively. The frequency, then, was in the range between 1 and 1.6 million cycles per second. Variations in the width of the spark gap and in the power-input had no effect on the wave length. Attempts to change the frequency by changing the capacity of the primary or secondary circuit of the Tesla coil or by changing the inductance of the secondary had no effect on the frequency but resulted in reducing seriously the secondary current as well as the corona discharge. Evidently an optimum set of dimensions of the circuit can be obtained for each tube according to its capacity. No attempt was made to work out the relationships involved. The electrical circuits used in this work were such as to give optimum discharge in the tube used. In other

[4] H. Guilleminot, *Compt. rend.* 136, 1653 (1903) describes an apparatus but gives no data as to its chemical possibilities.

[5] F. O. Anderegg, *J. Am. Chem. Soc.* 39, 2581 (1917).

words, the circuit must be "tuned" according to the dimensions of each discharge tube used.

Air dried by passing through sulphuric acid wash bottles and over freshly cracked potassium hydroxide was passed into one end of the corona tube at constant pressure. The flow rate was measured with the usual type of flowmeter. The corona tube was 193 cm. long and had an internal diameter of 4.65 cm. The volume with side arms was 3,402 cc. The wire was passed through small holes in glass plates which were cemented to the aluminum tube by a special wax[7] which has shown itself to be very resistant to the action of ozone. Inlet and outlet tubes were made by screwing short lengths of aluminum tubing into holes in the side of the tube near the end, and inside of these, glass tubes were sealed tight with the special wax. The first part of the absorption apparatus was made entirely of glass and the absorbing liquid was standard alkali by means of which nitrogen pentoxide, formed in the discharge, could be absorbed. The amount of ozone absorbed by the small volume of solution used was found to be well within the experimental error. To absorb the ozone two Erlenmeyer flasks were used. The rubber stopper in the first Erlenmeyer flask was protected by a very thin coating of beeswax, which was unaffected by the ozone during experiments lasting more than a year.

The procedure was to pass a corona discharge through still air enclosed within the tube or through air which was flowing through the tube at a definite rate. The pressure in the tube was maintained constant at 750 mm. The temperature was that of the room, 22-30°. Changes in temperature of 10° were shown to produce only very slight variations in yields. Results are given for different wires under various conditions of flow rate of air and under varying electrical conditions. The amperes, volts and watts of the primary circuit of the Thorardson transformer were recorded as well as the voltage across the spark gap. The current in the secondary of the Tesla coil was measured with a hot wire ammeter and reached values as high as half an ampere at 6,000-8,000 v. when the gross input into the system was less than 150 watts. A very poor power factor in this part of the circuit is thus indicated. The power factor of the circuit which excites the transformer ranged from a very low value for the feeblest coronas to 50-70% for the most intense discharges.

The material as well as the size of the wire produced changes in the discharge with corresponding changes in the chemical reactions. A platinum wire was at first used because of its supposed chemical inertness, but platinum is a material which has been found to be one of the most active catalytic substances known. Its catalytic properties seem to depend upon surface absorption and it has been noted that with continued use, as in the oxidation of ammonia, it becomes, apparently, badly corroded. This is, of course, not a true corrosion but a very large

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[7] A wax that will withstand the action of ozone and oxides of nitrogen and yet possesses desirable mechanical properties, is made by melting 5 parts of rosin, adding 3 parts of red sealing wax and then stirring in 2 parts of beeswax. Harding and McEachron, J. Am. Inst. Elec. Eng., April, 1920.

increase in the surface.[6] A platinum wire that had been used as an electrode for corona work was found to have suffered similarly. And with the increase in the surface there was a notable increase in a "lag

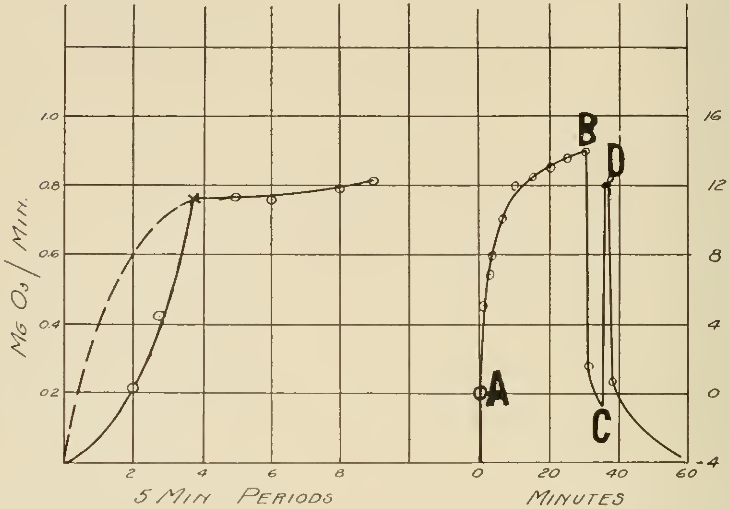

FIG. I. FIG. II.

Fig. I. The "lag effect" due to a platinum wire. A continuous discharge was passed through air flowing at the rate of 190 cc. per min. so that the air in the tube would be renewed in 18 min. The continuous line indicates the actual results for successive five min. periods. The break in this curve occurs with the elimination of the lag effect. The dotted curve shows the normal course of ozone production without any complicating lag effect.

Fig. II. Evidence of an "ionization pressure". The discharge was passed through enclosed air and the pressure was followed by a manometer containing a pure paraffin oil. At A and C the current was turned on and at B and D it was turned off. The jumps are too great to be caused by the rise in temperature.

effect". In Fig. 1 the continuous line follows the actual results obtained in a typical run. Air was passed through the apparatus continuously at a rate of 190 cc. per minute, so that the air in the tube was replaced every 18 minutes. After five minutes of discharge the outcoming air was analyzed for ozone during the second five-minute period in one analysis apparatus and during the third five-minute period in another apparatus. Average yields of ozone per minute during each five-minute period are given. The air that comes out of the tube at first contains less ozone than after it has had a chance to come in contact with the discharge during its whole passage through the tube. Because of the very marked electric wind the effect of any slower rate of flow along the walls than in the middle was largely eliminated.

[6] *Ibil,* p. 2593. A considerable amount of material is accumulating in this laboratory as to the properties and nature of this lag. It will be assembled in a separate publication. For the illustration of the charge on the surface of platinum see Rideal and Taylor, Catalysis in Theory and Practice, Longmans Green & Co., 1919.

The longer the time spent in the discharge the greater the concentration of the ozone, but, owing to the reverse decomposition of the ozone, which occurs simultaneously, the increase in ozone concentration with time should be logarithmic as indicated by the dotted curve. The lag effect has operated against ozone production at first.

An iron wire was also found to be unsuitable because of the large magnetic losses with high-frequency currents. A copper wire was found to be much more suitable, although it became gradually oxidized and covered with more or less nitrate with some "lag effect", although much less than with platinum wires. Aluminum was found to be the best material for ozone production.

An interesting "ionization pressure" has been noted at the University of Illinois by Kunz and his students.[7a] The same effect was observed with the high-frequency corona. In Fig II are plotted some results. The discharge was passed through enclosed air and the pressure changes were followed by means of a manometer filled with the purified paraffin oil called "stanolax". At A the discharge was started and stopped at B; after three minutes it was started again at C and at the end of one more minute of discharge was again discontinued. The sharp breaks are mostly due to the ionization pressure. They are much too sharp and extended to be caused simply by the heating of the gas. At the end the pressure drops below that of the atmosphere, indicating some kind of condensation reaction such as ozone formation.

Typical results are given in Figs. III, IV and V. In Fig. III a No. 33 copper wire was used and the data for one spark gap width

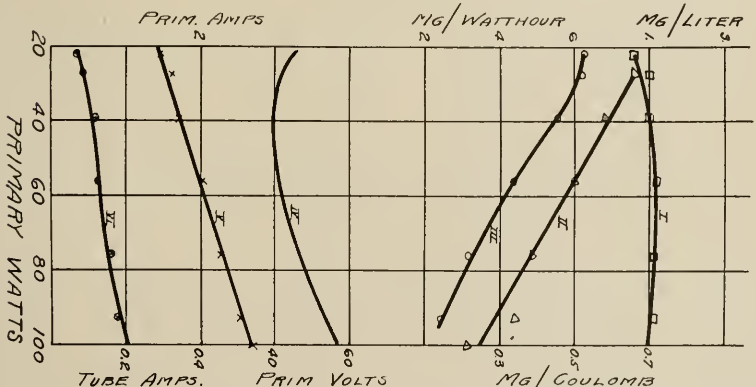

Fig. III. A No. 33 copper wire was placed co-axially in an aluminum tube. The air flow rate was 280 cc. per min. The spark gap-width was 1.2 mm. Six variables are plotted against the gross primary watts as abscissa. I. gives the concentration curve in mg. per liter (g. per cu. M.). II. expresses the yield of ozone in mg. per coulomb of current flowing into the discharge tube. The efficiency of ozone production is plotted in curve III. in terms of mg. per watt hour (g. per kilowatt hour). The other three curves give the electrical readings; IV. for the primary volts; V., the primary amperes and finally VI. gives the amperes of the discharge current as measured by a hot-wire ammeter.

[7a] *Phys. Rev.* 8, 285 (1916); 10, 483 (1917).

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are given. Results with other spacing of the spark gap with this wire and with other sizes of copper wire are essentially similar. With a No. 18 wire of copper or, better, aluminum, the efficiencies are increased two or three times, while the concentrations are often doubled. In this figure the points of interest are the similarity of the curves for primary amperes and for tube amperes, a direct proportionality usually existing. The voltage, on the other hand, as a rule requires a high value in order to start the spark gap and then falls to a minimum. In most cases, the efficiency of the process as expressed in g. per kilowatt-hour (mg. per watt-hour) runs closely parallel to the curve for the yield of ozone per coulomb as calculated from the hot-wire milliammeter in the tube circuit. Usually, also, the concentration is increased at the expense of efficiency, although there are certain conditions where this generalization does not hold. In Fig. III the efficiency is constantly decreasing because in the short distance of the spark gap the tendency of the spark is to change over in characteristics toward a power arc,

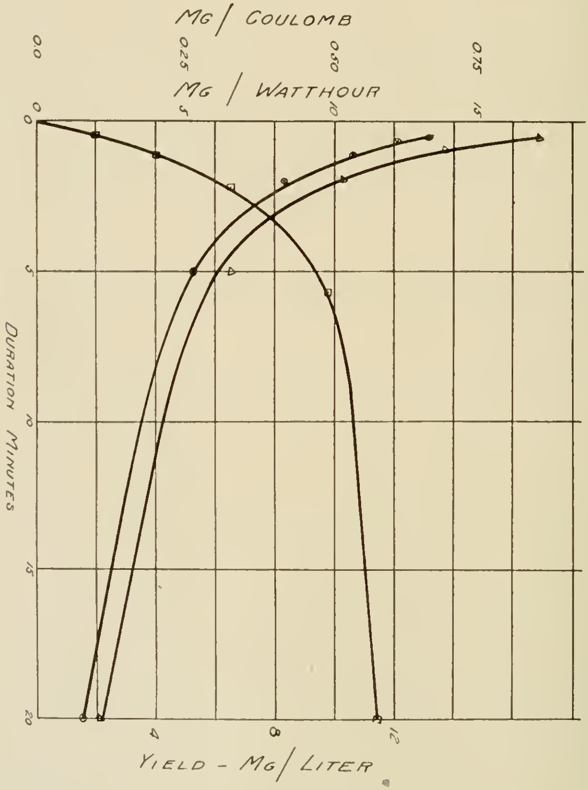

Fig. IV. Enclosed air was subjected to discharge in the same tube provided with a No. 12 wire. The gross power input into the tube was 65 ± 2 watts. The spark-gap was set at 2.0 mm. Note the reciprocal relation of the concentration and efficiency curves, characteristic of *nearly* all chemical reactions in corona discharges.

so that the energy expended in the tube is not proportional to the primary energy. In Fig. IV, where air enclosed within the tube is subjected to discharge for different periods of time, the concentrations are increased with time but at a loss of efficiency owing to the simultaneous decompositions of ozone, such as occurs also with very low frequencies or direct current.[8] In this way, concentrations up to 15 g.

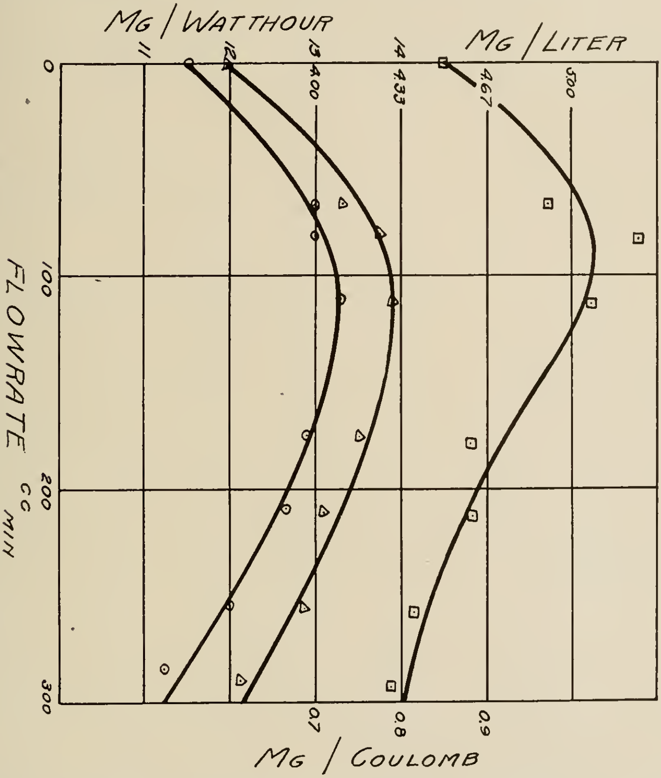

Fig. V. The rate of flow of air through the tube was varied. The length of discharge was 1 min., after which the tube was swept out completely. A No. 18 wire was used and the primary power was 75 2 watts. The spark-gap was set at 2.00 mm.

per cubic meter (mg. per liter) were obtained. In Fig. V an optimum flow rate is indicated for the given conditions. Similar optima have been previously obtained with different types of 60-cycle ozonizers.[9]

The size of wire has a marked effect on the optical and chemical properties of the discharge. Around a fine (No. 33) wire there is a

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[8] Chassy, *Compt. rend.* **133**, 789 (1901) with a Berthelot ozonizer and 60 cycle current. Anderegg, *loc. cit.*, gives curves for a direct current discharge in oxygen. The shapes of these curves have been checked by A. C. Grubb and J. K. Stewart working independently in this laboratory with current rectified by a kenotron.

[9] Ray and Anderegg, *J. Am. Chem. Soc.* **43**, 967-78 (1921), observed an optimum flow rate with the 60 cycle discharge in apparatus A. It was also noted with the very large apparatus E for both ozone and nitric acid production.

weak, nearly uniform glow extending only 4 or 5 mm. from the wire before it tends to break into a spark. With No. 24 wire, fine streamers or brushes are noticeable which become the chief characteristic of the discharge around a No. 18 wire. A No. 12 wire was tried, but the effect was to reduce the radius of curvature so much that sparks were the only form of discharge which could be produced.[10] A No. 16 wire gave the same effect, but, remembering Vosmaer's experiments on space distribution,[11] a number of small points were filed on this wire from which magnificent brushes would be thrown out sometimes to distances estimated as half of the radius. The resonance range under these conditions is narrow and easily overstepped, so that while the discharges most brilliant optically and most effective chemically occurred around a No. 16 wire with points, yet very small surges of power tended to throw them over into sparks with greatly diminished yields. Better total yields are obtained with smaller wires, thus sacrificing erratic for more reliable, although less intense, effects.

Under the best conditions ozone was produced at an efficiency of from 15 to 17 g. per kilowatt hour calculated on a basis of gross power input. No attempt was made to determine the efficiency of the process on a basis of the power delivered from the secondary of the transformer because of the uncertainty in obtaining the tare of the transformer. However, certain considerations indicate that it had a rather large tare, so that with a properly designed transformer the efficiency would have been doubled, or possibly trebled. The loss of energy in the spark gap varied, of course, with conditions. To determine the value the spark gap was enclosed within a water-tight container and immersed in a large calorimeter which had been calibrated with electrical energy. The results at 80 and 110 watts gross input indicated a loss of the total energy supplied to the transformer of 12 and 15%.

The concentration of oxides of nitrogen produced in the corona discharge was 0.005-7% by volume. For every molecule of nitric oxide formed there were produced from 70 to 90 molecules of ozone. When, however (as around a No. 16 wire), a spark played more or less intermittently, the concentration of oxides of nitrogen as well as their ratio to ozone was materially increased. Two runs were made with a discharge in which almost continuous sparking predominated, accompanied by some corona. With a gross input of 120 watts, 41 mg. of nitric acid was obtained in 20 minutes at a flow rate of 95 cc. per minute, so that the concentration was about 0.8% by volume (21 mg. per liter). A 40-minute run at a flow rate of 200 cc. per minute produced 90 mg., reducing the concentration nearly half. The efficiency in each case was a little more than 1 g. nitric acid per kilowatt hour. This method offers little promise as a means of nitrogen fixation under these conditions but might be effective at high temperatures.

[10] The larger wire increases the capacity and tends to throw the circuit out of resonance. With the reduction in radius of curvature of the smaller electrode, the condition of parallel plates is approached.

[11] Vosmaer, Ozone, Van Nostrand, 1916, pp. 56-64. Incidentally, this question of space distribution has resulted in a very larger variety of possible modifications, many of which have been patented.

It has been thought[12] that one of the benefits of a high-frequency discharge might be in setting up so great a vibration with the molecules as to loosen the bonds so that new combinations might take place. A simple calculation would show that the intensity factor of this form of energy is much too small to have appreciable effect in any way except, possibly, upon the loosest of secondary valence combinations. This resonance result must not be confused with the results produced by ionic bombardment of molecules in the large voltage gradients of the corona discharge; nor should it be confused with the very real chemical action of the ultra-violet radiation accompanying any corona discharge.

Summary.

1. This study of the production of ozone in a high-frequency corona discharge indicates that it is governed by the same laws that control its production in either low-frequency or direct-current corona discharges.
2. With the use of high frequency, the discharge apparatus itself is simplified through elimination of any dielectric. This point is of especial value for high temperature work.
3. On the other hand, the apparatus for supplying the electrical energy is much more complicated than for low frequency. This results in greater first cost and in increased energy losses, with consequent decreased efficiency.
4. The conditions which give the most intense discharge with greatest ozone production narrow the resonance range so that small surges of power tend to shift the discharge from corona to spark.
5. The high-frequency discharge is unsuitable for the oxidation of nitrogen. Where ozone is desired, the rather low concentration of oxides of nitrogen is an advantage, but even in the spark discharge the amount of nitrogen oxidized indicates a very low efficiency.
6. In order to use additional discharge units, it would be necessary to "retune" the high-frequency circuits.
7. Even a frequency of a million and a half cycles per second would have little, if any, effect in loosening the chemical bonds.
8. Some evidence is given of a "lag effect" when platinum wires are used.
9. The existence of an "ionization pressure" is indicated in a high-frequency corona discharge.

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[12] L. B. Cherry, *loc. cit.*, offers this explanation. But consideration of the energy of the radiation needed to activate carbon compounds indicates that it requires a frequency of 10^{14}-10^{15}, an order of magnitude quite different from the value of 10^{5}-10^{6} cycles per second of the wireless waves set up in his discharge apparatus.

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Ozone in Ventilation: Revivification of Mice.

F. O. Anderegg and R. H. Carr.

There has been a considerable amount of discussion as to the value of ozone for ventilation. A summary of the situation was presented before this academy a year ago.[1] The work to be described here is a direct outgrowth of that report and describes some experiments to obtain direct evidence as to the value of ozone physiologically. In view of the success of Dr. Cunningham,[2] of Kansas City, in treating a great variety of diseases by the use of a tank in which the patient spends several hours each day at a pressure of some 15 pounds, it seems desirable to secure evidence as to whether the use of an activated form of oxygen might be beneficial. Some experiments of James Todd,[3] of Pittsburgh, in this connection are of interest.

In the work here described advantage has been taken of the fact that a mouse will die when left in contact with its own exhalations for a sufficient time. This period will vary with the weight, vigor, etc., of the mouse. By placing mice of equal liveliness in filter flasks and then drawing a slow stream of air through the bottles in series, the mouse in the last bottle would be expected to succumb first. In an actual experiment, some divergence is, of course, noted, caused by variations in individual mice. The procedure was to draw air at the rate of 25-50 cc. per minute through 8 or 10 bottles, each containing a mouse, until the mice in a larger number of the bottles exhibited marked lethargy. Then ozonized air was drawn through the bottles in the opposite direction and the revivifying effect noted. Different concentrations of ozone were used. The results obtained so far are rather of a qualitative than of a quantitative nature. To make them quantitative will require a large number of mice so as to largely eliminate individual variations. Sufficient mice for this purpose are being accumulated.

Certain preliminary conclusions may be drawn at this time. Mice which have become rather sick as a result of breathing their own exhalations can be revived by the use of ozone. The greater the concentration of ozone, or the greater the flow rate of ozonized air, the shorter the period of convalescence. On occasion, certain mice have succumbed completely to the poison, and these, of course, could not be revived. The revivifying effect of ozonized air was much greater than that of air free from ozone. The action of ozone seems to be to eliminate the poisonous exhalations by oxidation. Also, when drawn into the lungs, it tends to be selectively absorbed by the blood so that the oxidation of waste material throughout the system is accelerated. With

[1] These Proc. 1920. pp. 271-3.

[2] Floyd L. Parsons. Everybody's Business. Saturday Evening Post, April, 1921.

[3] Experiments with Oxygen on Disease. James L. Todd, New Era Printing Co., Lancaster, Pa., 1916.

the increased removal of waste and poisonous substances from the body, the animal begins to recover. When the ozonized air is started, it passes first into a bottle which contains a rather large amount of foul gases. Then, unless the flow rate is considerable, very little ozone will reach the second bottle. To make a fair test, ozonized air should be drawn directly into each bottle and the time required for recovery noted.

Summary.

Mice which have been poisoned more or less badly by their own exhalations may be brought back to their usual activity by ozone in concentrations estimated as from 1 to 10 parts per million.

Purdue University.

Ozone as a Bleaching Agent in Steam Laundries.

F. O. Anderegg.

In Europe the application of ozone to various commercial uses has been much more successful than in this country. Thus we see great ozone installations for the purification of the city water at Paris and many other cities. Notable application of ozone to the ventilation of the London Subway is being made, while the French use considerable amounts of ozone in the synthesis of various perfumes and other high-grade organic chemicals.

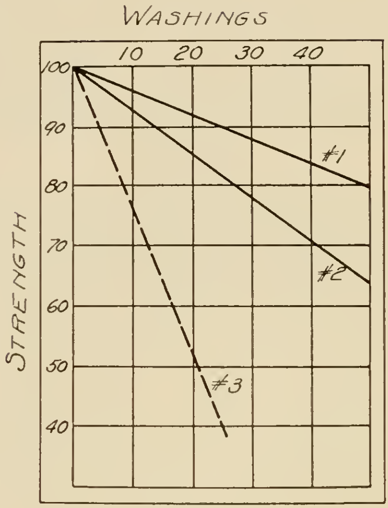
In Germany there are two firms which produce ozonizers suitable for use in steam laundries. One, the Ozongesellschaft m. b. H., is a branch of the Siemens-Halske firm, which is connected with the famous A. E. G., the great electrical trust. This concern uses the most modern modification of the Siemens tube, which has been used extensively for ozone production for a great many years. Another company has concentrated on the application of ozone to laundries. This firm goes by the name, Aktiengesellschaft fuer Ozon-industrie.

Both of these companies advertise in the most glowing terms as to the wonderful merits of ozone as a bleaching agent. Claims are made of great saving in soap, water, overhead, labor, in addition to considerable improvement in quality through the use of ozone as a

Tests made on cotton goods by the Staatlichen Materialpruefung-samtes of Berlin-Dahlen. No. 1 is for ozone bleaching in cold water. No. 2 gives similar data for ozone in hot water, while No. 3 shows the harmful effect of typical peroxide bleaches which has reduced the strength (festigkeit) of the goods to 40% in 25 washings.

bleaching agent. It is stated that the most delicate material is unharmed by their ozone bleaching. Shirts are supposed to have the white part bleached purer white while the colored pattern is brightened by this treatment. Now ozone acts on most organic material with which it comes in contact so that it is surprising that the colored part should not be bleached also! On the other hand, tests made at Berlin-Dahlem by the Staatliches Materialpruefungsamt, using the Goedicke apparatus of the Aktiengesellschaft fuer Ozon-industrie showed that with ozone the goods lasted very much longer than with chlorine bleach material. Samples of cotton cloth were treated and observed after every ten bleachings. A decrease in strength was observed while the weight and stretching were both increased. The cotton goods still maintained 80% of their strength after 50 treatments in cold water, 64% in hot water, while 25 bleachings with chlorine water reduced the strength to a very small value.

As to cost, there is considerable doubt also as to their claims. The use of Javelle water as practised today in up-to-date laundries is a very small item. The interest on the cost of an ozone installation in addition to the power consumption, although it amounts to but a few



watts, bring the cost of ozone just about to a level with that of Javelle water. There remains only the question of quality. At present, it is frequently remarked that home-washed clothes outlast laundry-washed clothes often two to one. Part of this is due to the stronger soaps, soda, etc., used in the laundry, part to the greater mechanical agitation perhaps, and part to bleaching methods. The housewife does not usually use a chemical bleach, but gets the natural effect of the sunlight and moisture in producing sufficient active oxygen in one form or another to give a very beautiful bleaching action. If ozone has the property of emulating sunlight bleaching its use would certainly be desirable.

Heinz & Co. of Berlin are treating newly-woven linen in two revolving drums with ozone to remove the yellowish tinge very successfully. These drums were built by the Aktiengesellschaft to order and their successful operation resulted in the application of ozone to laundry bleaching in several laundries. This is a development of but the last two or three years and ozone may well have found a real use in this field.

Deut. Waescherei Ztg. 22, No. 6, pp. 594-595 (1920); 23, No. 9, p. 328 (1921); 23, No. 15, p. 587 (1921).

Purdue University.

Some Characteristics of a Siemens Ozonizer.

Karl B. McEachron.

For a number of years the Engineering Experiment Station at Purdue University has been conducting an investigation entitled, "The Fixation of Atmospheric Nitrogen by the Silent Discharge Process." In the course of this work a study has been made of certain types of discharge tubes, and very brief discussion will be given here of some of the results of the tests on the Siemens tube.

Discharge Tube and Absorption Apparatus.

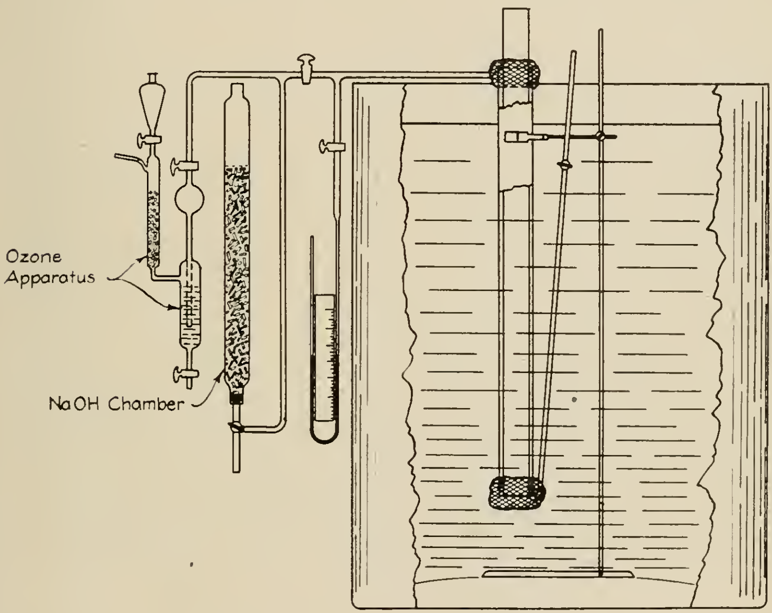


Fig. 1.

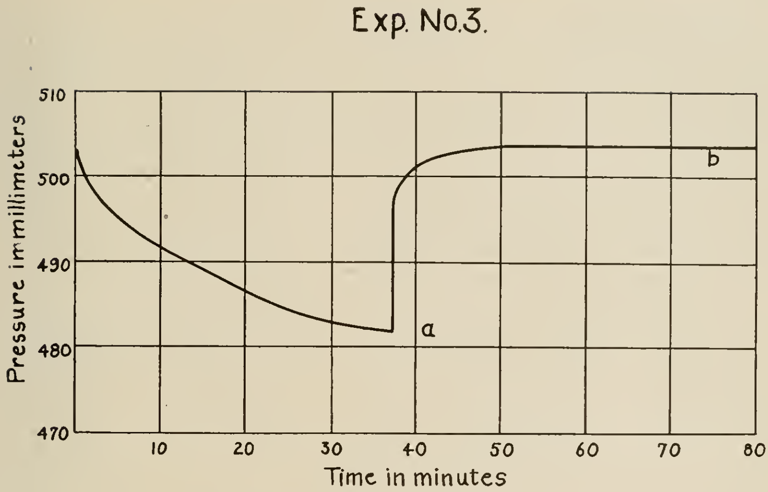
An idea of the construction of this tube may be gained by reference to Fig. 1, which shows the tube supported by a ring stand in a tank of cooling water. The tube was constructed of two glass tubes arranged concentrically, the inside one being sealed at the bottom. The space between the two tubes was closed at either end with paraffine, and small tubes so placed that air could enter at one end of the annular space between the tubes and leave at the other end. The radial length of the annular discharge space was approximately 3 mm., the outside diameter of the inner glass tube being 33.5 mm., and the length of the discharge space, 50 cm. The volume of the discharge space was found by actual measurement to be 166 cc. The inside tube was filled with acidulated water, and this together with a spiral of No. 18 copper wire placed inside the tube acted as the high tension electrode. The water surrounding the tube, which was made conducting by the use of NaCL, was grounded through the medium of the metal containing tank connected to the ground. A spiral of wire was wound around the outside of the discharge tube and connected to ground to insure even distribution of voltage over the entire length of the tube.

Absorption apparatus consisting of broken glass tubing placed inside a tower was connected as shown in Fig. 1. Sodium hydroxide was used in most cases as the absorbing liquid. In some cases the gases were passed through a KI solution from which the ozone yield could be determined by titration with sodium thiosulphate. The inlet and outlet tubes were provided with stop cocks so that the tube could be completely closed and the pressure of the gas in the discharge tube measured by the mercury manometer. Alcohol thermometers were placed in the liquid inside the inner tube of the discharge tube and in the cooling water surrounding the tube. Means were provided whereby dry air could be passed through the discharge space, the air having been dried by the use of sulphuric acid, after which it passed through a chamber containing soda lime.

Two sources of power were provided for producing the required electric potential to break down the air in the space between the two tubes, one of these being a large induction coil and the other a high voltage transformer. The induction coil was operated from a 110-volt direct current source and was provided with a rheostat in series for varying the high tension voltage. This coil is capable of delivering a spark between needles of more than 30 cm. in length. The high tension transformer, rated at 50 kva. 200,000 volts, was connected to an alternator giving practically a sine wave. This transformer has been arranged so that the current in the secondary winding may be read directly. The high tension voltage was determined by calibrating the tertiary coil, with which the transformer was provided, against the sphere gap standard of the A. I. E. E.

Tests on Enclosed Volumes of Dry Air.

All of the tests which will be reported in this paper were made upon enclosed volumes of dry air, using either the induction coil or the high tension transformer. Only tests which are more or less typical will be given here, and represent but a small part of the total number of tests made. Correction for pressure change due to increase of temperature as the run progressed was not made, although in many cases the temperature rise curve is shown, this temperature being invariably that of the inner electrode. The temperature of the outside of the tube did not change materially on account of the large body of cooling water which was agitated frequently.



a - 5.6 vol. % NO b - .6 vol. % NO

FIG. 2.

The curve in Fig. 2, taken from Spiel,* who made tests on a Siemens tube with induction coil supply, shows a decrease in pressure with time, until a reversal point is reached, after which the pressure rises rapidly, coming back to nearly if not quite the original pressure.

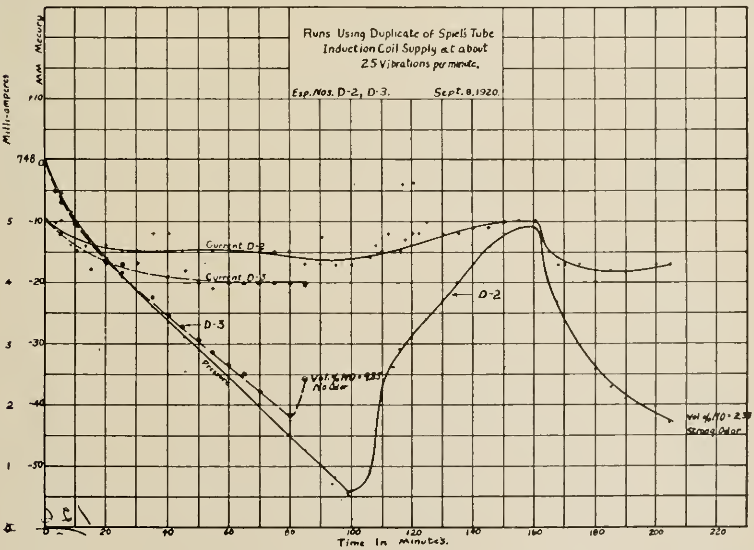


Fig.-3.

* The Formation of Nitric Oxides by the Silent Electric Discharge in a Siemens' Tube, by Hugo Spiel, Doctor's Thesis, The Technical High School; Vienna, 1909.

At the reversal point a concentration of 5.6 per cent calculated as NO was obtained, while at the point b after the pressure had become constant concentration of only 0.6 per cent NO was found. Spiel concludes that no lower oxides of nitrogen are formed, only N_2O_5. Spiel determined the concentration at the reversal point by making a second run holding all the conditions as near like the first run as possible. It has been found, however, by plotting the data which Spiel gives, that the pressure time characteristic was not the same for both runs, and this condition is one which the author of this paper has found to exist in all the work done at Purdue with enclosed volumes of air.

Characteristics, different from anything reported by Spiel, appeared when the first run was made on the discharge tube, after being set up, using the induction coil for power supply. The changes in current and pressure with time may be seen by reference to Fig. 3. The current shown is the actual current and was measured in the ground connection of the cooling tank. The full line curve marked D-2 represents the first run, which was continued for 205 minutes. The pressure seemed to go through a cyclic change which also appeared in the current to some extent. A second run (D-3) was made, giving quite different current with a reversal at a higher pressure coming 20 min-

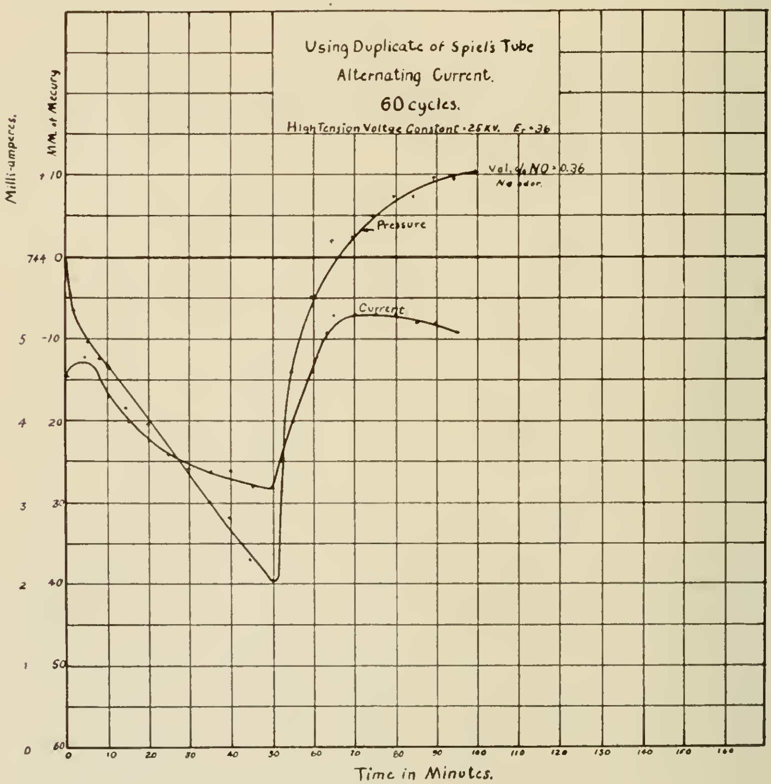


Fig.- 4.

utes sooner than in the first run. The concentration of NO at the end of the first run, at a pressure of —42.5 mm. was 2.3 compared with a concentration of 9.35 per cent NO at —42.0 mm. Here the pressures are practically the same and yet the products are quite different. Several runs were made later in the attempt to check the cyclic change in this run, but without success.

Another run under the same conditions was made and stopped at the reversal point, which occurred at 130 minutes with an NO concentration of 9.9 per cent, the tube current being 3 milliamperes compared with 4 and 4.5 milliamperes for the first two runs. Although 34 runs were made, following these first two runs, yet in every case the concentrations were much lower than in these first two runs.

Using the transformer supply, the curves shown in Fig. 4 were taken, the high tension voltage being held constant. The same reversal occurred here as before, but the pressure increased very rapidly after reversing and at the end of the run a concentration of 0.363 per cent NO was obtained. The second test with alternating current (D-8), reversed at a pressure about 7 mm. higher than did D-7, but the reversal in both came at 50 minutes. The concentration at reversal with alternating current was 2.48 per cent NO, which is considerably less than was obtained with the induction coil. The variation of the tube current should be noted since the current curve follows the pressure curve more or less in shape. Another run with the transformer was made at 31 cycles, which was as near the 25 vibrations per second of the induction coil as could be obtained. The pressure in this run reversed at 53 mm. below the initial pressure of 740 mm. after an exposure to the discharge for 110 minutes. The concentration at this point was 3.21 per cent NO.

From these results it is clear that the yield of nitric oxides, which may be discovered by the titration of NaOH for the determination of acid formed, is not proportional to the pressure decrease as might be expected. To get some idea of the concentration for different times of exposure to the discharge with both the induction coil and the alternating current, a series of runs were made which are tabulated in Table I.

TABLE I.

No. D—	Length of Run (min.)	Pressure Decrease at end of run (mm.)	Percent NO. at end of run	Concentration per mm.	Concentration per min.
		Induction coil runs—Frequency—25			
13	10	—12.5	0.073	0.0058	0.0073
14	20	—16.5	1.00	0.062	0.05
14.5	40	—25.5	1.88	0.074	0.047
15	60	—34.0	2.12	0.082	0.035
		Alternating Current Runs—Frequency—31			
10	10	—12.0	1.52	0.127	0.152
11	20	—17.5	1.91	0.109	0.09
12	40	—26.0	2.11	0.081	0.07

Although the average current for the alternating current runs listed in Table I was less than for the induction coil runs, yet the concentration per millimeter, and per minute, are higher, indicating that under the conditions examined, the use of alternating current increases the speed with which the nitric oxides are formed. It should also be noticed that the concentration per millimeter pressure change increases with the length of run using the induction coil, but decreases with alternating current, indicating that short alternating current runs are advantageous.

Several runs were made to discover, if possible, the reason for the lack of consistent results, but the results were erratic, the pressure reversal varying both as to time and pressure decrease. The yields of nitric acid were different with each run and seemed to vary erratically also.

The usual practice before beginning a run was to sweep out the tube with dry fresh air. On one occasion this sweeping out process was omitted and the results were quite surprising. The tube had stood over night, the products of the last run having been blown out the night before. Instead of decreasing, the pressure increased 17 mm. in 50 minutes, the titration at the end of the run showing only a trace of nitric oxides and no odor of ozone could be detected. Two

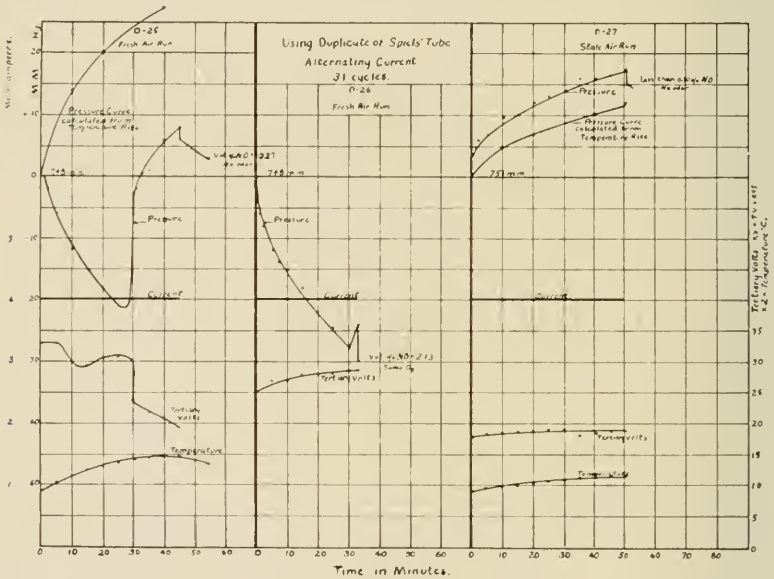


Fig-5.

other runs, D-25 and D-26, were made under all the same conditions, except that the tube was swept out with fresh dry air just before applying the voltage. The curves showing the characteristics of these three runs are found in Fig. 5.

The pressure time characteristic with fresh air (run D-25) shows three distinct parts, viz., the pressure decrease, the pressure increase to initial pressure and the pressure rise after reaching the initial pressure. A very small yield of NO was obtained from this run, while more than eight times the concentration of NO was obtained at the reversal point on run D-26, which was made under the same conditions as D-25.

Several runs were made to determine whether or not the pressure rise could be duplicated, and it was found that it could be reproduced as desired, using either the induction coil or the alternating current. Whether or not the same result would have taken place in a new tube of different construction is not known.

The experiments made on fresh air compared with those made with air which has stood in the tube for a considerable period show a very marked change. When the air is not fresh in the tube, but has stood for some time in the tube following the last application of the high voltage discharge, the pressure rises when voltage is applied, and no appreciable quantity of ozone or nitric oxides are to be found. The corona discharge is more noisy and appears to consist of many sparks and points. This condition is much like that after reversal when fresh air is used, for immediately upon reversing the discharge changes from a quiet blue glow to noisy streamers and condensed discharges, which condition increases as long as the pressure increases. Although the shape of the pressure rise curve differs somewhat when using stale air compared to the rise above the initial pressure when using fresh air, yet, all the evidence obtained goes to suggest that in some manner the air standing in the tube is carried through the equivalent of a reversal and subsequent pressure rise. The air standing in the tube may well be affected by some traces of the products of the previous run, this action being catalytic in its nature. Such traces may remain occluded in the glass or in a very dilute state in some air pocket.

Run No. D-28 was made in an effort to secure more information concerning the way in which the contamination took place. This run followed D-27 with an interval of 23 hours. The air was swept out of the tube following D-27 in the usual manner, allowing about 15 minutes for absorption. The tube was then closed up for 3 hours, after which fresh dry air was blown through at a rapid rate for 3 hours. The tube was again closed up, and the next day, after an interval of 17 hours, run D-28 was made. Reversal took place at 30 minutes after the pressure had decreased 28 mm. Titration at this point gave a concentration of 0.4 per cent NO, while but a trace of ozone was observed.

From this experiment it appears that the effect of contamination is reduced by sweeping out the products after a run, using a large quantity of air. In case the tube stands for a considerable length of time, even though the tube has been carefully swept out, the yield is materially affected as in D-28, where the yield was about one-eighth of what it was in D-29, which was a check run with fresh air. Thus, even small traces of the previous runs serve to greatly reduce the yield. Curves showing the pressure changes for D-28 and D-29 will be found in Fig. 6.

The results from the use of a discharge tube not only vary with the design but also vary greatly with tubes of the same design. A second tube built of pieces of the same tubing and having practically all the same dimensions as the tube described in the first part of this

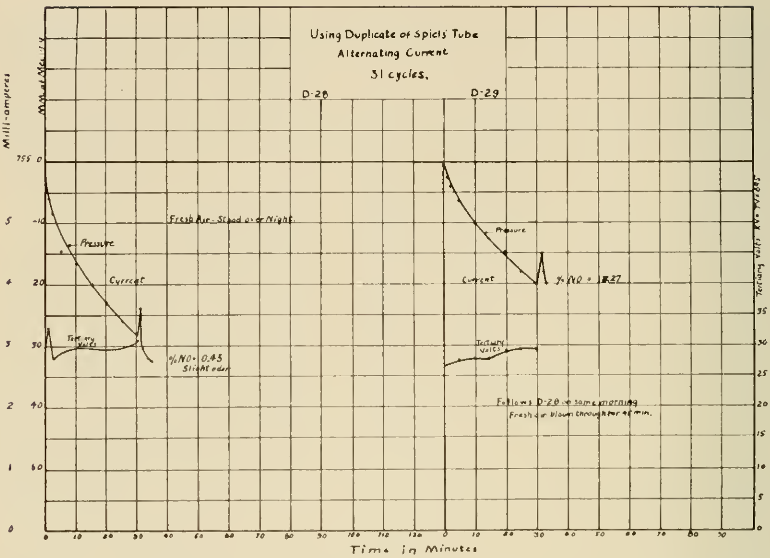


Fig.- 6.

paper was constructed. The first test on this tube was made with alternating current and the results may be seen by reference to Fig. 7. The pressure characteristic is very different than any obtained with the first tube. Instead of decreasing rapidly as before, the pressure remained constant for 10 minutes and then began to fall rapidly. For the most part, the points fall on a straight line, which again is very different from any result obtained before. The pressure decreased 114 mm. in 190 minutes, which when corrected for temperature gives a pressure decrease of 143 mm. below the atmosphere. This represents a contraction in volume of nearly one-fifth and yet the NO concentration was only 1.2 per cent, and only a slight odor of ozone. It appears likely that some heavier molecule than we know of at present is being formed. That this must be true will be clear when it is stated that in order to secure such a pressure decrease an NO concentration of 15 per cent would be required if the decrease was due to the formation of N_2O_5 calculated as NO. Such a contraction is not of the same order of magnitude as the one observed in this run.

Several runs were made on this tube in an effort to again secure the great pressure decrease observed in D-37, but although most of the runs showed the same initial characteristic as did D-37, yet reversal came in every case before the pressure had decreased more than 60 mm. The difficulty of duplication of results is one which has been met with continually in the work done on these discharge tubes.

Conclusions Drawn from the Tests.

1. Holding conditions as constant as possible, the pressure reversal points do not check at all closely, and concentration values obtained at the reversal point by stopping a check run can give but approximate values for this reversal point.

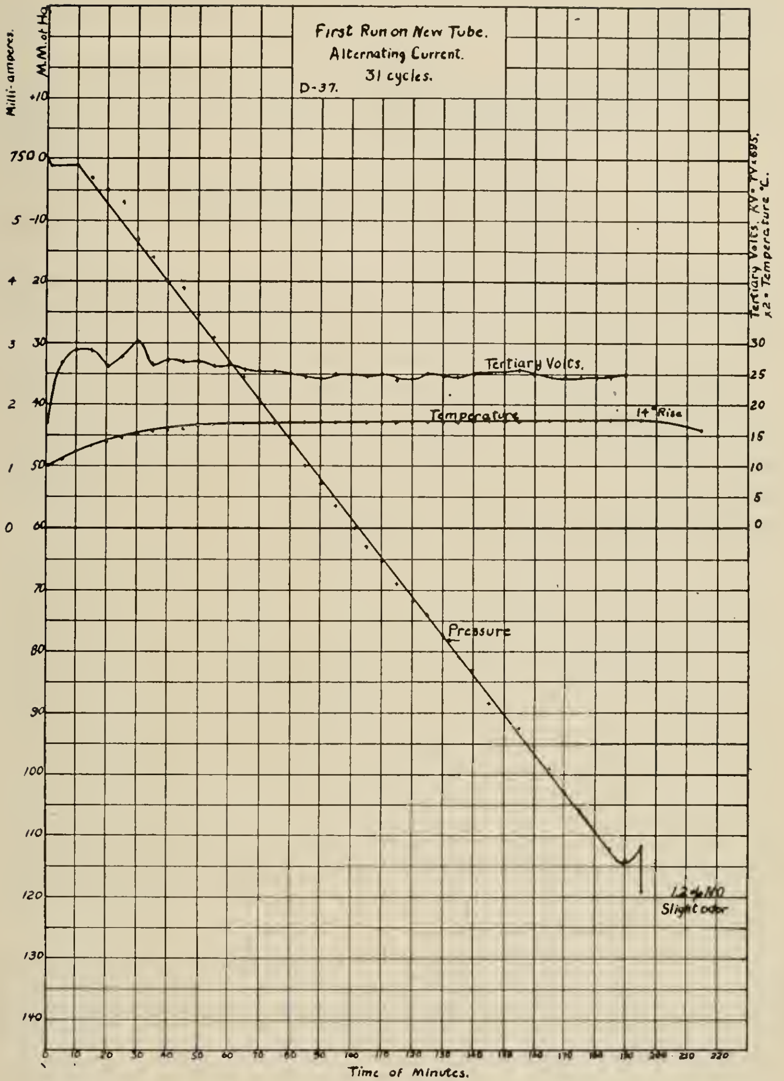


Fig.- 7.

2. When air in the tube has been in contact for a considerable period with other air which has been previously subjected to electrical discharge, the usual pressure decrease is modified, the yields diminished, and in case sufficient contamination has taken place the characteristics of the tube changed altogether, the pressure increasing instead of decreasing and the yield greatly reduced or eliminated altogether.

3. While it is true that the discharge is more or less erratic in a given tube, yet there seems to be some foundation for the statement

that different tubes of the same design and of similar materials will yield different results.

4. The usual pressure characteristic consists of four parts:
   1. The pressure decrease.
   2. The pressure increase (usually quite rapid) up to atmospheric pressure.
   3. The pressure increase (having the shape of a temperature rise curve) above atmosphere.
   4. The abrupt pressure decrease when the power supply is disconnected.

Part 4 always occurs; parts 1, 2 and 3 are to be found together when working with fresh air only, while part 3 only will be found when the air has been sufficiently contaminated.

When the pressure is decreasing the discharge is more quiet and, as a rule, the temperature rise less than when the pressure is increasing. The character of the discharge is also quite different after reversal than before, thus indicating a very definite change in the structure of the air. This statement is also borne out by the fact that changes in pressure are accompanied by corresponding changes in current flow when the voltage is held constant.

5. The pressure decrease is not proportional to the nitric oxides absorbed. The pressure decrease is always greater than can be accounted for by the products absorbed, thus indicating the presence of some heavier molecule. It is true that some of the pressure decrease may be due to some of the gas being driven into the glass, but that this would account for the discrepancy observed seems doubtful. Whether this heavy molecule is a combination of O and N or a heavy molecule of O or N it is not possible to state. It is likely, however, that more than one such combination will be found in the effluent gases.

6. Although not conclusive, the data does show that in most cases the pressure decrease with alternating current is more rapid than with the induction coil. The 10, 20, and 30 minute runs indicate that alternating current may also be expected to produce a higher concentration of nitric oxides in a given time, and especially is this true for the shorter periods of discharge.

Complete data showing the results of tests not only on the Siemens tube but tubes of other design, together with much other material of interest relating to the corona discharge, will be found in a bulletin of the Engineering Experiment Station of Purdue University, to be published in the near future.

The author wishes to express his appreciation for the assistance given him in the prosecution of this work by various members of the staff of Purdue University and particularly to Dr. Anderegg.

Engineering Experiment Station, Purdue University.

The Simultaneous Electro-Deposition of Lead and Lead Peroxide.

M. G. Mellon and H. F. Reinhard.

Part I—Introduction.

General. For many years it has been known that one may obtain the deposition of either metallic lead upon the cathode or lead peroxide upon the anode by the electrolysis of an aqueous solution of lead nitrate, depending upon the conditions maintained during the electrolysis. Many experiments under varied conditions have shown that lead may be quantitatively deposited on the anode as the peroxide from a solution of the nitrate containing 10 to 20 per cent nitric acid of Sp. G. 1.35-1.40.[1] A quantitative deposition of the lead in the metallic state has not been accomplished from aqueous solutions of the nitrate except through the addition of other compounds, such as those recommended by Stähler and Alders.[2] They accomplished this by separating the lead as amalgam from a solution of the nitrate (0.0997 g. lead) and of mercuric chloride (0.0855 g. mercury) together with 1 cc. of concentrated nitric acid and 1.5 cc. of phosphoric acid. Also Vortmann[3] states that lead can be quantitatively separated as an amalgam from a solution containing 1.4 g. of the lead salt, 1.2 g. mercuric chloride, 3-5 g. sodium acetate, 1 cc. of a concentrated solution of potassium nitrite, and enough acetic acid to dissolve any white precipitate formed.

In connection with two other investigations[4] lead amalgams were used which were made by electrolyzing a 10 per cent solution of the nitrate with a weighed amount of mercury for the cathode and a platinum foil electrode for the anode. After electrolyzing for 2 to 3 hours with a current of approximately 20 milliamperes, sufficient lead was deposited in the mercury to show a considerable amount of solid along with the liquid amalgam. This solid was taken to be the compound Pb_2Hg, described by Fay and North.[5] A comparatively thick, adherent deposit of lead peroxide was always obtained on the anode. In this previous work a coulometer was included in the electrical circuit, the assumption being that a quantity of lead would be deposited in the mercury cathode equivalent in amount to the metal deposited in the coulometer. Then, knowing the weight of the lead deposited and the weight of the mercury, one could readily calculate the percentage composition of the amalgam. Such a procedure, with a silver coulometer, has been used by Henderson[6] for zinc amalgams, and by Richards and Wilson[7] for

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[1] Smith—Electro-Analysis, p. 109 (1918).

[2] Ber. 42, 2685 (1909).

[3] Ibid. 22, 2756 (1891).

[4] Henderson and Stegeman—J. Am. Chem. Soc. 40, 84 (1918). Mellon and Henderson—Ibid. 42, 676 (1920).

[5] Am. Chem. J. 25, 216 (1901).

[6] Phys. Rev. 29, 507 (1909).

[7] Carnegie Inst. Pub. 118, 1 (1909).

amalgams of thallium, indium and tin. Meyer[1] has used a hydrogen coulometer for similar work.

The validity of the above assumption regarding lead has seemed questionable, and the purpose of the present work has been to ascertain, first, the relative amounts of the two deposits; and, second, the relation between each of these amounts and the amount of silver deposited in a silver coulometer placed in the circuit in series with the cells containing the solution of lead nitrate. The latter quantities should enable one to answer the question as to whether there is deposited in the mercury a weight of lead equivalent to the weight of silver deposited in the coulometer, and, therefore, whether one can calculate the per cent of lead in the amalgam from the amount of silver deposited.

Previous Work. Although "Lead most readily of all the elements forms oxide on the anode during electrolysis,[2] there is a considerable tendency for this element to separate from an aqueous solution of the nitrate partly as metallic lead on the cathode and partly as lead peroxide on the anode. Various individuals[3] have noted this division of the lead between the two electrodes and have studied the factors influencing the formation of the two deposits. Electrolysis from a neutral solution gives both the metal and the peroxide. An addition of nitric acid seems to improve the conditions for obtaining the peroxide; for with 15-20 per cent of the acid present, all the lead deposits in this form. Even with these higher concentrations of acid, however, a small amount of metallic lead may deposit, but it gradually dissolves as the decomposition proceeds. Easily oxidizable substances, such as lactose, glycerine, etc., hinder or prevent the formation of the peroxide. Oxalic acid, for example, is said to be very efficient for this purpose.

In this earlier work there is included no mention of quantitative results on the relative amounts of the deposits of metallic lead on the cathode and lead peroxide on the anode, under the different conditions of electrolysis. Any of the quantitative determinations have been made with the aim of separating all the lead, either as peroxide or as the metal.

Present Problem. The object of the present investigation has been the determination of the quantity of lead deposited at each electrode, under varying conditions of electrolysis, together with a determination of the quantity of silver deposited in a coulometer placed in the electrical circuit. This has involved, first, the arrangement of apparatus suitable for the electrolysis; and, second, the selection of satisfactory analytical

[1] Z. Phys. Ch. 7, 481 (1891).

[2] Mathers—Trans. Am. Electrochem. Soc. 23, 178 (1913).

[3] Luckow—Z. anal. Ch. 19, 15 (1876); Ibid. 22, 485 (1883).
Schucht—Ann. Chim. Phys. (5) 13, 508 ().
Frechland—D. R. P. 140, 317; J. Ber. 9, 660 (1903).
Thomälsen—Chem. Ztg. 18, 1355 (1894).
Vortmann—Ann. 351, 238 (1907).
Gooch and Beyer—Am. Jr. Sci. (4) 25, 249 (1908); 27, 59 (1909).
Fairchild—J. Ind. Eng. Chem. 3, 902 (1911).
Smith—J. Am. Chem. Soc. 27, 1287 (1905).
Tenney—Am. Jr. Sci. (4) 5, 413 (1883).

methods for the determination of the lead peroxide on the anode, the metallic lead in the mercury of the cathode, and the metallic silver in the coulometer.

PART II—EXPERIMENTAL PROCEDURE AND DATA.

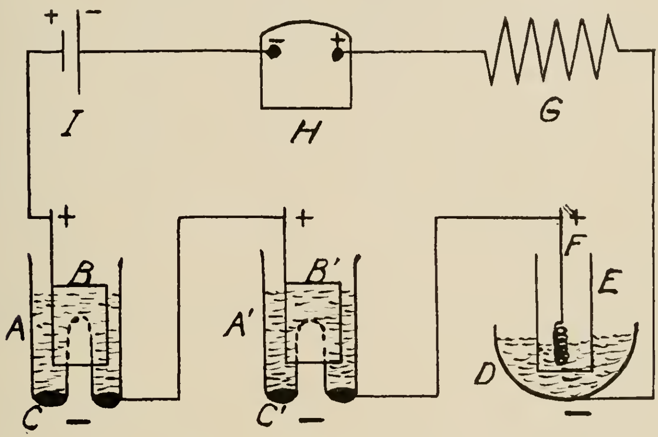

Fig. 1

Apparatus. The arrangement of apparatus used is illustrated by Fig. 1, in which A, A′ represent special glass cells containing the solution of lead nitrate—these were about 6 cm. in diameter and of such a form that 40 g. of mercury easily covered the platinum points in the bottom; B, B′ are anodes of platinum foil 2.5 cm. in diameter and 5 cm. in length; C, C′ are the mercury cathodes, the electrical contact being made with them by means of three short pieces of platinum wire sealed through the glass; D is a platinum dish 7 cm. in diameter serving as the cathode in the silver coulometer; E is the porous cup, 3.5 cm. in diameter, and F the anode of 15 gauge coiled silver wire; G is an adjustable rheostat; H a milliammeter and I a storage cell.

Analytical Methods. The weight of silver deposited was determined by weighing the platinum dish after drying to constant weight at 105° C.

In order to determine the lead in the deposit of peroxide, the original intention was to follow the volumetric method suggested by Scott.[1] This consists in dissolving the peroxide from the electrodes with a hot mixture of 15 cc. of fifth normal oxalic acid and 10 cc. of nitric acid (Sp. G. 1.2) and titrating the excess of oxalic acid with tenth normal potassium permanganate. The end point in the titration with the potassium permanganate proved to be so indefinite that the method was abandoned for a procedure essentially that recommended by Smith.[2]

[1] Standard Methods of Chemical Analysis, p. 240 (1917).
Chwala and Colle—Z. anal. Chem. 50, 209 (1911).

[2] Loc. cit.

This consisted in washing the deposits with water, placing the electrode in a platinum dish, and drying both in an electric furnace in which the temperature was maintained at approximately 250° C. by means of a pyrometer. While wet, the peroxide did not show any tendency to scale off during handling; but as soon as dried, it often did not adhere well. By drying in the platinum dish, any particles falling off were saved, since the dish and electrodes were weighed together.

It was planned to determine the weight of lead deposited at the cathode according to the method of Stähler and Alders,[1] that is, by obtaining the increase in weight of the mercury cathode after having decanted the electrolyte and washed the amalgam with water, alcohol and ether. Although it is stated that this procedure gives very good results, it was not found possible to handle the amalgams in this way without having marked evidence of oxidation on the surface of the amalgam, even with only a few hundredths of a gram of lead present. Sometimes a black scum formed on the surface, which was easily lost in the washing by decantation. Some of the preliminary results were obtained in this way, but the method was changed for one proving more satisfactory.

The procedure adopted consisted essentially in the replacement of the lead in the amalgam by another element, thus bringing the lead into aqueous solution from which it could be precipitated.[2] This was accomplished by washing the amalgam with water by decantation and then adding 25 cc. of a 10 per cent solution of copper nitrate. The solution remained on the amalgam from 15 to 24 hours, after which it was decanted and the resulting amalgam washed with water. Copper is less soluble in mercury than lead, and most of the determinations showed considerable brownish-red material in the beaker containing the amalgam, after standing in contact with the copper nitrate for several hours. This was found to be largely copper, along with some mercury, and the solution was always filtered from this precipitated matter. To the filtrate two or three drops of acetic acid were added, the solution heated to somewhat less than boiling, and the lead precipitated with potassium dichromate. The precipitate was handled and weighed according to the directions of Scott.[3]

General Procedure. The arrangement and manipulation of the silver coulometer followed rather closely the suggestions of Richards and Anderegg,[4] a porous porcelain cup and recrystallized silver nitrate being used. All the precautions noted in their papers were not followed, such as corrections for the amount of electrolyte included in the cathode deposit and protection from dust during electrolysis, since the nature of the present work did not seem to warrant it.

Each determination was made by placing 30 to 50 g. of mercury in each of the glass cells and adding 100 cc. of the solution of lead nitrate to be electrolyzed. The platinum foil anodes were suspended in the electrolyte about 1.5 cm. above the surface of the mercury. In-

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[1] Loc. cit.

[2] Mellon and Reinhard -See following paper.

[3] Standard Methods of Chemical Analysis, p. 236 (1917).

[4] J. Am. Chem. Soc. 37, 7 675 (1915).

side the platinum dish serving as cathode for the coulometer, and about 0.5 cm. above the bottom, the porcelain cup was suspended. The silver wire in the form of a spiral was lowered close to the bottom of the cup. After filling the dish nearly full, and the cup slightly below this level, with a 5 per cent solution of silver nitrate, the current was allowed to pass from 1 to 3 hours. At the end of this time, the solutions in the three cells were siphoned off simultaneously, being replaced with distilled water until the ammeter in the electrical circuit indicated practically no current passing. The weights of silver and lead deposited were then determined according to the methods already outlined.

The solution of lead nitrate used as electrolyte for the determinations reported in Table II was made by dissolving an amount of the salt in water to produce an approximately 10 per cent solution. For the second series, the solution was made by diluting 40 cc. of concentrated nitric acid to 1 liter with the previous solution; and the third solution was made in the same way, using 80 cc. of the nitric acid.

The value for the lead equivalent of the silver deposited was obtained by multiplying the weight of the silver for each determination by the ratio obtained in dividing one-half of the atomic weight of lead (207.20) by the atomic weight of silver (107.88), this ratio being 0.9603. The factor used for lead in lead peroxide was 0.866.

The quantities reported for lead as lead peroxide and for lead as lead amalgam are the average of the two cells run in each experiment. The values reported as variations from the average indicate the amount by which each determination varied from the average of the two. The amperage showed some variation during the electrolysis, and the values recorded are taken as the average. Table I includes some preliminary results, and Table II those obtained in the later work.

TABLE I.
Deposition of Lead from Aqueous Solutions of Lead Nitrate.

No.	Time in Hours	Milliamperes	Lead as Peroxide	Lead as Amalgam	Ratio of Anode Lead to Cathode Lead
1	3.0	20	0.2383	0.2329	1.0232
2	3.0	20	0.2489	0.2294	1.0850
3	3.0	20	0.2505	0.2384	1.0508
4	3.0	24	0.3098	0.2979	1.0399
5	5.5	10	0.1993	0.1870	1.0657
6	4.0	14	0.2099	0.1932	1.0864
7	4.0	19	0.3229	0.3040	1.0621

The investigation reported in this paper was begun at The Ohio State University in 1919 by C. C. Curran under the direction of the senior author. The results in Table I, obtained at that time, when compared with those in Table II, show the effect of employing more refined methods of analysis.

In this earlier work a copper coulometer was used, but the results obtained with it indicated inaccurate manipulation. The lead peroxide was weighed after drying at 105° C.; and the metallic lead was obtained from the increase in weight of the mercury cathode, after being washed with water, alcohol and ether. These determinations include

TABLE II.
Deposition of Lead from Aqueous Solutions of Lead Nitrate

No.	Time (Min)	Amperage	Pb Equiv. of Silver	Lead as Peroxide	Variation from Ave. of 2 Cells	Lead as Amalgam	Variation from Ave. of 2 Cell	Ratio of Anode Pb to Pb Equiv. of Silver	Ratio of Cathode Pb to Pb Equiv. of Silver	Ratio of Anode Pb to Cathode Pb
					(Series I—No. HNO_3)					
				0.2031				0.9936		1.0026
1	70	44	0.2044	0.2062	±0.0001	0.2025	±0.0000	1.0088	0.9907	1.0187
				0.2963				0.9858		1.0018
2	107	44	0.3006	0.3008	0.0004	0.2958	0.0002	1.0008	0.9840	1.0171
				0.1567				0.9831		1.0021
3	51	44	0.1594	0.1591	0.0003	0.1564	0.0003	0.9981	0.9810	1.0172
				0.4193				0.9893		1.0030
4	130	46	0.4238	0.4257	0.0005	0.4178	0.0004	1.0044	0.9860	1.0189
				0.3667				0.9942		1.0120
5	240	22	0.3688	0.3723	0.0003	0.3624	0.0003	1.0094	0.9826	1.0273
				0.2290				0.9914		1.0144
6	250	20	0.2310	0.2325	0.0001	0.2258	0.0003	1.0065	0.9773	1.0297
				0.3911				0.9974		1.0091
7	200	30	0.3922	0.3971	0.0000	0.3876	0.0002	1.0126	0.9884	1.0245
				0.3919				0.9872		1.0061
8	75	70	0.3970	0.3979	0.0003	0.3896	....	1.0023	0.9813	1.0214
					(Series II—40cc HNO_3 per L)					
9	140	46	0.4473	0.4490	0.0005	0.4367	0.0000	1.0038	0.9763	1.0282
10	145	30	0.2879	0.2776	0.0000	0.2764	0.0013	0.9642	0.9600	1.0043
11	130	40	0.2445	0.2408	0.0003	0.2382	0.0012	0.9849	0.9742	1.0105
12	85	40	0.2308	0.2347	0.0013	0.2291	0.0012	1.0169	0.9928	1.0244
					(Series III—80cc HNO_3 per L)					
13	105	60	0.4346	0.4287	0.0001	0.4244	0.0020	0.9864	0.9719	1.0101
14	....	....	0.5377	....	....	0.5202	0.0030	....	0.9674	....
15	130	65	0.5385	0.5257	0.0050	0.5142	0.0045	0.9762	0.9349	1.0223
16	75	60	0.3232	0.3171	0.0025	0.3232	....	0.9811	1.0000	0.9811

the errors resulting from drying the peroxide at a temperature too low to expel all the water, and from the oxidation of the amalgam during washing and drying. The former values are then too high and the latter too low, thus increasing the ratio of the former to the latter. No nitric acid was used in these determinations.

Table I does not include the deposits of copper in the coulometer. It will be noted in these earlier results that the ratios of the deposit of lead at the anode to that at the cathode are distinctly higher and more variable than is the case with the new results for Series I shown in Table II.

Discussion of Results. As shown in Table II, the results for solutions containing free nitric acid are so variable for the different experiments and so inconsistent for the two cells in each experiment, that one seems justified only to conclude the action of some variable and uncontrolled factor. However, even from these acid solutions, the deposits of lead at both the anode and cathode are approximately equivalent to the corresponding deposit of silver, and also, for a distinct change in concentration of nitric acid, there is not any marked change in the ratio of the amount of lead deposited at the anode to that deposited at the cathode.

For the experiments in which no nitric acid was added to the solution of lead nitrate, the results are distinctly less variable, both for the separate experiments and for the two cells in each experiment. Using some variation in the amperage for the different experiments, and with a considerable difference in the time each ran, there is a fair constancy in the ratios for each of the two deposits of lead to the silver in the coulometer, and, consequently, for the one deposit to the other; and also there is a fairly satisfactory agreement in the amount of the deposits in the two cells. It will be noted that, with one exception, the amount of lead found in the anodic deposit was always more than the lead equivalent of the silver, and that in the cathodic deposit was always less.

Apparently, then, for the solutions made up by dissolving lead nitrate in water, one must conclude either that there is not deposited (under the conditions maintained in this work) at the cathode or at the anode an amount of lead equivalent to the amount of silver, the former being less and the latter greater; or that some error in the manipulation of the apparatus or in the methods of analysis has prevented the recognition of the deposit of an electrochemical equivalent of lead at either of the electrodes.

The average of the ratios of the lead deposited at the anode to the lead equivalent of the silver is 1.0053 for the eight experiments; and for the cathodic ratio the average is 0.9864. These averages indicate the deposition at the anode of an amount of lead 0.5 per cent more, and at the cathode 1.4 per cent less, than the electrochemical equivalent of the silver. The variation of the individual ratios from these averages is approximately 0.5 per cent.

In considering the explanation of the cause of these variable results, one comes first to the question of the accuracy of the coulometer. Many careful researches have resulted in the adoption of the porous cup type of silver coulometer as the standard for the measurement of electrical current. As already mentioned, the manipulation of the coulometer in the present work would not give the high degree of accuracy attained by Richards and Anderegg, but it seems probable that the error involved in these measurements is small.

The second source of error to be considered is in the analytical methods used for the determination of the lead. In the handling of the peroxide the chief difficulty has been in drying the deposit under conditions that will remove all the water and yet not convert any of the peroxide to monoxide. This determination has been worked over many times and Smith finally recommends drying at a temperature of at least 200° C., when the error involved is stated to be small. The drying in this work was made from 230° to 300° C. No appearance of the yellow monoxide was noted; if there had been some undetected, the results calculated would be lower than otherwise, owing to the fact that the deposit would weigh less than if there were no such conversion. In one set the values for the peroxide were checked by conversion to the monoxide and weighing as such. Although it may be possible that the combined errors of the coulometer and the general manipulation could account for the difference between the lead at the anode and the lead equivalent of the silver, it does not seem probable.

If one uses the empirical factor 0.853 of Hollard[1] for lead in lead peroxide instead of the theoretical value of 0.866 in calculating the results for Table II, a considerable difference is noted in the relationships involved. These values have been inserted in the table in the parentheses. It will be noted that the ratio of the lead deposited at the anode to the lead equivalent of the silver falls in all the cases considered to values much closer those for the ratio of the lead deposited at the cathode to the lead equivalent of the silver. In some cases they are very close together. The average of these anodic ratios becomes 0.990 as compared with 0.986 for the cathodic ratios. These values indicate the deposition of an amount of lead at each electrode slightly less than the electrochemical equivalent of the silver deposit.

For the determination of the lead in the amalgam the data presented by the authors in the preceding paper indicates that the method employed is accurate. These results showed that the weight of lead not recovered by this procedure was less than 0.1 per cent of that originally added to the mercury. The error in this determination would not seem to account for the variation of 1.4 per cent between the lead found and the lead equivalent of the silver.

Part III—Summary.

In this work involving the electro-deposition of lead from aqueous solutions of the nitrate, there has been presented:

1. A review of the investigations bearing upon the division of lead between the two electrodes during the electrolysis.
2. Data associated with the quantitative relationship between the anodic and cathodic deposits of lead, and the relationship between these and the deposit of silver in a coulometer.

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[1] Ibbotson and Aitchison—Analysis of Non-Ferrous Alloys, p. 60 (1915).

Some Experiments on the Determination of Lead in Lead Amalgam.

M. G. Mellon and H. F. Reinhard.

In working with lead amalgams several types of procedure have been employed by various individuals for obtaining the concentration of the lead in the amalgams. These methods may be conveniently classified as electrolytic, gravimetric, and physico-chemical. There follows a brief outline of the principles involved in the three types of procedure.

Electrolytic Methods. One electrolytic method takes advantage of the scheme used for preparing the amalgam. Under certain conditions Stähler and Alders[1] found that lead deposits in a mercury cathode. They maintain that the amalgam formed may be washed with water, alcohol, and ether, and weighed. Knowing the original weight of the mercury serving as the cathode, the increase in weight represents the amount of lead deposited. From these two weights the concentration of the lead may be calculated. In using this procedure Vortmann[2] encountered difficulties from the oxidation of the amalgam when the electrolyte was alkaline. The authors have had similar trouble when working with lead amalgams in which the lead was deposited from aqueous solutions of lead nitrate. The above procedure is ultimately a method of preparing an amalgam in which the concentration of the element deposited in the mercury is known, rather than a method of analysis.

A somewhat similar method has been employed by Richards and Wilson[3] for amalgams of thallium, indium and tin. As in the above method, the amalgams were prepared by depositing the different elements electrolytically in a mercury cathode. The concentration of the metal deposited was obtained by means of a silver coulometer included in the electrical circuit during the electrolysis, the assumption being that the element deposited in the mercury was equivalent in amount to the silver deposited in the coulometer. The percentage composition of the amalgam could then be calculated from the weights of silver and of the mercury serving as cathode.

A third electrolytic method is that suggested by Smith.[4] It involves the solution of the amalgam in nitric acid and the deposition of both elements. With properly arranged apparatus, and under suitable conditions, the lead deposits at the anode as the peroxide and the mercury at the cathode.

Gravimetric Methods. The methods outlined here for the gravimetric estimation of the concentration of lead in lead amalgams involve

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1 Ber. 42, 2685 (1909).

2 Ibid. 22, 2756 (1891).

3 Carnegie Inst. Pub. 118, 1 (1909).

4 Electro-Analysis, p. 229 (1918).
Smith and Moyer—J. Anal. Ch. 7, 252 (1893); Z. anorg. Ch. 4, 267 (1893).
Smith and Heidenreich—Ber. 29, 1585 (1896); Z. Elektrochem, 3, 151 (1897).

the solution of the amalgam and the subsequent separation of the two elements by the precipitation of one of them. The first of these is based upon the fact that mercuric sulfide is insoluble in dilute, boiling nitric acid (Sp. G. 1.2-1.3), while lead sulfide is soluble. For this determination Treadwell,[1] and also Scott,[2] recommended the precipitation of the elements from their solution (the mercury being present entirely in the mercuric form) by hydrogen sulfide. The precipitate is filtered off, washed with hydrogen sulfide water, transferred to a dish and boiled for a considerable time with the dilute nitric acid. The solution is then diluted, the mercuric sulfide filtered off and washed with water containing nitric acid. Certain precautions are necessary in the final determination of the two elements.

As a second gravimetric method Crookes[3] suggests the addition of sulfuric acid to the solution containing the lead and mercury, followed with alcohol to form about one-sixth the volume of the solution. The precipitated lead sulfate requires washing with dilute alcohol containing a little sulfuric acid. The separation of the lead by this means is based upon the insolubility of its sulfate and the solubility of the mercuric sulfate. Horsford used this method.[4]

Physico-Chemical Methods. Richards and Wilson[5] have measured the densities of lead amalgams as a means for obtaining the concentration of the lead. From these results they were then able to obtain this concentration by reference to a curve showing the variation in density of the amalgam with change in the amount of lead present. Such a method is based upon the fact that the physical property being measured varies with, or is a function of, the concentration of the constituent being determined.

Meyer[6] and Richards and Forbes[7] have investigated a second, interesting physico-chemical method. Their work included the elements zinc, cadmium, lead, tin, copper, and sodium. The principle of the method has as its basis the familiar equation for electrode potentials as developed by Nernst. When applied to concentration cells in which the two electrodes are amalgams or alloys it has the form—

$$E = \frac{RT}{nF} \ln \frac{c_1}{c_2}$$

in which the various terms all have their usual significance. In such a combination as

$$\text{Zn. Hg } (C_1)\text{—}ZnSO_4 \text{ (Sat. Sol.)—Zn.Hg } (C_2)$$

one will find a given potential whose magnitude will depend upon the concentrations of the two amalgams and the temperature, as the chief factors. To apply the above equation in calculating the concentration of a given element in an amalgam, one would set up a combination such as that mentioned for zinc amalgams, using an amalgam of accurately

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1 Treadwell-Hall—Analytical Chemistry II, p. 194 (1915).

2 Standard Methods of Chemical Analysis, p. 271 (1917).

3 Select Methods in Analytical Chemistry, p. 321 (1894).

4 Am. J. Sci. [2] 13, 305 (1852).

5 Carnegie Inst. Pub. 118, 1 (1909).

6 Z. phys. Ch. 7, 477 (1891).

7 Carnegie Inst. Pub. 56, 1 (1906).

known concentration for one of the electrodes and the one of unknown concentration for the other. The potential E could then be measured for the combination. This leaves as the one unknown quantity in the equation the concentration of the amalgam being measured, and its value may readily be calculated.

Hulett and Minchin[1] have made use of this scheme in their study on the distillation of amalgams and the purification of mercury. They state that one part of zinc can be detected with certainty in ten billion parts of mercury, and that the method is probably the most delicate analytical procedure known.

Criticism of Methods. None of the preceding methods seemed to meet the requirements, as to ease and accuracy, for certain work that is being conducted in this laboratory. As already noted, the first electrolytic method was unsuitable because of oxidation of the amalgam during washing and drying.

For the method involving the electrolytic separation of the lead and mercury, or the gravimetric separation, either of the mercury as mercuric sulfide, or of the lead as lead sulfate, the amalgams under investigation contained entirely too much mercury. There was generally present from 30 to 50 grams of this element and only about 0.5 gram as the maximum amount of lead. For an electrolytic separation this amount of mercury would require altogether too much time, even if there were involved no other undesirable features. Likewise, in the gravimetric methods which involve a separation by precipitating one of the constituents, the mechanical difficulties of handling a solution containing such a large proportion of mercury would be too great to insure a high degree of accuracy in the determinations.

Two distinct difficulties are evident in the method involving the determination of the density of the amalgams. In the first place, it is not easy to handle lead amalgams without oxidation of the surface. The difficulty is increased if the amalgam is wet and must be dried during the procedure. In the second place, the densities of lead and mercury are so near each other that a considerable change in density of the amalgam does not result from a small change in the concentration of the lead in the amalgam. This means that the accuracy in determining the concentration of the lead by this method would not be so great as in the case of such elements as cadmium and zinc, whose densities are much less than that of lead.

Although the method based upon the measurement of the potentials of amalgams apparently may be very accurate, distinct precautions must be observed in making such determinations. Rather elaborate electrical apparatus is required along with an accurately controlled thermostat for holding the temperature factor constant. No attempt was made to use the method in the present work, although it is hoped a later study may be made on concentration cells with lead amalgams. Previous[2] work has indicated that, under certain conditions, a very constant and reproducible potential is obtained for a saturated lead amalgam.

[1] Phys. Rev. 21, 388 (1905).

[2] Mellon and Henderson—J. Am. Chem. Soc. 42, 676 (1920).

Present Work.

Oxidation of Lead Amalgams. As already stated, in the course of some work in this laboratory with lead amalgams, it was not found possible to handle them according to the method of Stähler and Alders without having marked evidence of oxidation, even with only a few hundredths of a gram of lead present. Amalgams prepared electrolytically were always bright, and remained so during washing with water and alcohol. When washed with ether, however, there often formed on the surface of the amalgam a dark film which was easily lost on further washing. If washed immediately and quickly with the ether, not much of the film formed; but the longer the time of washing, the more film there was present. It was difficult to avoid losing it when washing by decantation; and if much was present, some was always lost. On standing any length of time following the washings with just water and alcohol, there was always considerable oxidation.

To show this oxidation of the amalgam on standing, and the resulting loss in weight with washing, the following determinations are typical, except that the errors are considerably exaggerated due to the length of time the amalgams stood before washing. These amalgams were made up by dissolving a known weight of lead in a known weight of mercury and allowed to stand in a beaker 48 hours. After washing with the liquids mentioned, the amalgams were dried in a desiccator and reweighed, with the results shown in Table I. Numbers 1 and 2 were washed once with 10 cc. of water and twice with 10 cc. portions of alcohol, while numbers 3 and 4 had, in addition to this, two washings with ether.

Table I.

Loss in Weight of Amalgams During Washing.

No.	Weight of Mercury	Weight of Lead	Loss
1	43 0182	0 8496	0 0138
2	40.8870	1 0832	0.0076
3	57 2745	1.0357	0.0162
4	39.2819	0.8600	0 0227

Development of Method of Analysis. On account of the defects inherent in the methods already outlined for the analysis of lead amalgams, it seemed desirable to have available a method for determining the concentration of the lead involving some procedure by which the element could be brought easily from the amalgam into aqueous solution, and then determined gravimetrically in this solution. A solution of copper nitrate was selected as a promising possibility for obtaining the replacement of the lead in the amalgam by another element, thus bringing it into aqueous solution from which it could be precipitated. Copper sulfate was rejected because it brought about the formation of lead sulfate very shortly, which seemed to retard the replacement process. The procedure adopted consisted in covering the amalgam in a beaker with 25 cc. of a 10 per cent solution of copper nitrate for a period of 15 to 24 hours, decanting the solution, and washing the remaining amalgam. Copper is less soluble in mercury than lead, and many of the determinations showed considerable brownish-red material on the surface of the amalgam, after standing in contact with the solution of copper nitrate for several hours. This was found to be largely copper, along with some mercury, and the solution was always filtered from this precipitated material.

Determination of Lead in the Amalgam as Lead Sulfate. In trying out the method for displacing the lead from the amalgam by means of a solution of copper nitrate, the first attempt to precipitate the lead was with sulfuric acid. Amalgams containing known weights of lead stood four days in contact with 40 cc. of a 10 per cent solution of the copper nitrate. After decanting the resulting solution, an additional 10 cc. portion of the copper nitrate stood on the amalgams for 30 minutes. From the total, warm solution the lead was precipitated with dilute sulfuric acid. The weight of lead sulfate was determined by filtering it on a Gooch crucible, the ignition being accomplished by supporting the crucible in an asbestos ring placed in a larger crucible and heating the latter to dull redness for 15 minutes. The weight of lead was found to be uniformly low, as shown in Table II.

TABLE II.

Determination of Lead in Lead Amalgam as Lead Sulfate.

No.	Lead Taken	Lead Found	Percent Loss
1	0.5650	0.5606	0.78
2	0.4748	0.4704	0.92
3	0.5108	0.5058	0.98
4	0.5024	0.4977	0.93

Solubility of Lead Sulfate in a Solution of Copper Nitrate. Assuming that the low values for the lead found resulted from the solubility of the lead sulfate in the solution of copper nitrate, definite weights of prepared lead sulfate were allowed to stand four days in a 10 per cent solution of the copper nitrate. The precipitate was then filtered off and weighed as before. The results shown in Table III are only preliminary and more accurate determinations will be made under varying conditions, but the increase in solubility with increase in concentration of copper nitrate is evident.

TABLE III.

Solubility of Lead Sulfate in a Solution of Copper Nitrate

No.	Vol. of Sol. of $Cu(NO_3)_2$	$PbSO_4$ Taken	$PbSO_4$ Found	Percent Loss
1	25cc	0.7000	0.6764	3.39
2	50	0.7000	0.6556	6.33
3	50	0.7000	0.6533	6.61

Solubility of Lead Chromate in a Solution of Copper Nitrate. The foregoing work on the determination of the lead as lead sulfate and on its solubility in solutions of copper nitrate indicated that the results might be due to a failure of the lead to change entirely from a metallic solution as amalgam to aqueous solution as lead nitrate, that is, a state of equilibrium was established, leaving part of the lead still in the amalgam from which it did not precipitate as the sulfate; or it might be due to the solubility of the lead sulfate in the excess of copper nitrate, or to a combination of the two. The method seemed to be useless for quantitative determinations and no further work was attempted with it.

With the idea that lead might be precipitated quantitatively as the chromate in the presence of copper nitrate, the solution of lead nitrate being used as electrolyte was analyzed for its concentration of lead by precipitating the metal, in the presence of a few drops of acetic acid, with potassium dichromate.[1] The precipitate was dried at 120° C. in a Gooch crucible. Then the same volume of solution of lead nitrate was treated as before except for the addition of 20 cc. of the solution of copper nitrate before the precipitation of the lead chromate. The results shown in Table IV indicate either that the solubility of lead chromate in a solution of copper nitrate is very small, or that errors are inherent in the procedure which serve to compensate such solubility.

TABLE IV.

Solubility of Lead Chromate in a Solution of Copper Nitrate

No.	Volume of Solution of Copper Nitrate	Volume of Solution of Lead Nitrate	Weight of $PbCrO_4$
1	None	50cc	0.3316
2	"	"	0.3313
3	20cc	"	0.3312
4	"	"	0.3309
5	"	"	0.3308

Determination of Lead in Lead Amalgam as Lead Chromate. Since there seemed to be only a small amount of lead lost when precipitated as the chromate, in the presence of 20 cc. of a 10 per cent solution of copper nitrate, the next step was to ascertain whether the lead in a lead amalgam could be quantitatively determined as the chromate. Following the procedure used in the attempt to determine the lead as sulfate up to the point of precipitating the lead, a few drops of acetic acid was then added, followed by a solution of potassium dichromate sufficient to complete the precipitation. The amalgam had been made

TABLE V.

Determination of Lead in Lead Amalgam as Lead Chromate

No.	Lead Taken	Lead Found	Difference	Percent Variation
1	0.3153	0.3149	—0.0004	—0.12
2	0.2616	0.2615	—0.0001	—0.04
3	0.2763	0.2761	—0.0002	—0.07
4	0.3013	0.3014	+0.0001	+0.03
5	0.2751	0.2754	+0.0003	+0.11

[1] Scott—Standard Methods of Chemical Analysis, p. 236 (1917).

by adding a known weight of lead to 40 to 50 grams of mercury and allowing it to dissolve in the mercury before the addition of the solution of copper nitrate. The results shown in Table V indicate that the method is satisfactory for a quantitative determination of the lead in a lead amalgam.

Summary.

The material presented in this paper includes:

1. A brief review of some of the methods that have been proposed for determining the concentration of lead in lead amalgams, together with a consideration of the possibility of applying them to the analysis of such amalgams containing a large amount of mercury and a relatively small amount of lead.

2. An account of some experiments made with the object of developing a more desirable procedure for the above determination. This work has involved the following determinations:

   a. The loss in weight of lead amalgams during washing.

   b. The amount of lead in lead amalgams by weighing the metal as the sulfate and as the chromate.

   c. The solubility of lead sulfate and of lead chromate in an aqueous solution of copper nitrate.

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Chlorination of Mixed Silver Halides in Gooch Crucibles.

M. G. Mellon and J. C. Siegesmund.

Any two of the three halogens, chlorine, bromine, and iodine, in the form of their salts, may be determined in a mixture of these salts by the familiar indirect, gravimetric method. This procedure consists of the following steps: precipitating the two halogens together in the form of their silver salts; drying and weighing as such in a Gooch crucible; chlorinating the weighed residue in order to replace the bromine or iodine, or both, and thus converting this residue to silver chloride; and the weighing of the latter salt. Then from the weights of sample, mixed silver halides, and the resulting silver chloride, it is possible to calculate the percentage of the halogens in the sample.

As an example of an indirect analysis, the determination of one pair of the three halogens is included in the course on general quantitative chemical analysis as given in this laboratory. The scheme employed[1] for the chlorination of the mixed silver halides has been to transfer the weighed residue, along with the asbestos in the Gooch crucible, to a boat. The boat was then placed in a hard glass tube, where it could be heated with a burner when necessary, and chlorine passed through the tube until a constant weight was obtained, indicating a complete conversion to silver chloride. This procedure necessitates at least four weighings: the sample, the mixed silver halides, the boat and contents before chlorination, and the same after chlorination.

One distinct liability for error in the process just described lies in the transfer of the asbestos and mixed silver halides from the Gooch crucible to the boat. It is often a difficult matter to obtain a quantitative transfer of the halides, especially when a film clings to the inside surface of the crucible. Small pieces of asbestos in the holes in the crucible may be neglected, since it is necessary to transfer only those portions upon which are liable to be found the particles of silver halide.

With the aim of avoiding the troublesome transfer of the contents of the crucible to the boat, the above procedure has been modified so as to chlorinate the mixed halides directly in the crucible. The scheme adopted for class work consists in placing the Gooch crucible inside a larger crucible, covering the latter with a watch glass having a hole in the center and with the convex side up, and bringing chlorine in contact with the residue by means of a glass tube extending down through the hole in the watch glass to within about 1 cm. of the bottom of the crucible. To hasten the chlorination the outer crucible may be heated. The bromine or iodine replaced are easily driven out of the inside crucible. They often condense at first on the under side of the watch glass but soon disappear with later heating of the crucibles. It is sometimes well to break up a hard residue by means of a glass rod before chlorination, since it is not as well exposed to the action of the chlorine as when spread out in a boat. The weighings neces-

[1] Mahin—Quantitative Analysis, p. 115 (1919).

sary with this procedure include the sample, the mixed halides, and the remaining silver chloride, one less than with the other procedure.

The modified method is essentially similar to that employed by Treadwell[1] who filters the mixed halides into a weighed Fresenius asbestos filter tube of difficulty fusible glass. The tube and contents are weighed, the halides chlorinated in it, and the tube again weighed.

The results shown in the accompanying table illustrate typical determinations as made using the two schemes of chlorination.

Sample Number	Chlorination in Boat		Chlorination in Crucible	
	%Cl	%Br	%Cl	%Br
1	35.30	27 80	35.58	27.51
	35.29	27.81	35.44	27.57
	35.27	27.56	35.53	27.45
	35.13	27.92	35.42	27.60
2	38.10	24.90	37.90	25.10
	37.82	25.18	38.07	24.80
	37.74	25.14	38.17	24.76
	38 03	25.01	38.10	24.74
	.....	.....	38.10	24.78
	.....	.....	37.96	25.20
	%Cl	%I	%Cl	%I
3	45.63	18.75	45 59	18.91
	45.50	19 07	45.44	18.79
	45.62	18 97	45.50	18.88
	45.70	18.90	.....	.....
4	50.41	12 46	50.20	12.92
	50.33	12.55	50.35	12.72
	50.30	12 63	50.26	12.60
5	52.95	9.71	53.15	9.35
	53.05	9.70	53.17	9.45
	53.08	9.50	53.10	9.50
	52 99	9 60	.....	.....
	%Br	%I	%Br	%I
6	17.01	19.78	17.02	19.74
	16.91	19.36	16.97	19.68
	.....	.....	17.19	19.39

The analyses for sample No. 1 were made by the junior author. The other results have been taken from the reports submitted during 1919 and 1920 by the students in general quantitative chemical analysis. While these analyses do not check as well as might be desired, most indirect, gravimetric methods are subject to rather large errors unless approximately equal amounts of the two constituents are present and the multiplying factors used for the calculation is small. Ashley[2] cites an example where an error of 1 mg in a weighing results in a percentage error of 26.20 for one of the constituents.

Conclusion.

A modification of the method for chlorinating mixed silver halides has been proposed. Its advantage over the method previously employed

[1] Treadwell-Hall—Analytical Chemistry, Vol. II, p. 334 (1915).

[2] Chemical Calculations, p. 190 (1913).

lies in the saving of one weighing, and in avoiding the liability of loss in transferring the asbestos and mixed halides from a Gooch crucible to a boat.

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Acyl Derivatives of o-Aminophenol.

R. E. Nelson and H. L. Davis.

When o-aminophenol, ($HOC_6H_4NH_2$), is acylated with two different acyl groups, one group attaches itself to the nitrogen and the other to the oxygen, forming a stable diacyl compound. In attempting to prepare the isomer of the above compound, the isomer rearranges spontaneously forming the same diacyl compound. A molecular rearrangement takes place and the group finally found attached to the nitrogen depends on the two acyl groups used.

Saponification of the diacyl compound removes the acyl group attached to the oxygen first.

If the remaining hydrogen of the acylated amino group be replaced by an alkyl group no rearrangement takes place.

A typical example of this rearrangement is found in Ransom's[1] work. He acylated oxyphenylurethane, ($HOC_6H_4NHCO_2C_2H_5$), with benzoyl chloride in alkaline solution. The attempt to prepare the isomer of benzoyloxyphenylurethane, ($C_6H_5CO.OC_6H_4NHCO_2C_2H_5$), by acylating benzoyl-o-aminophenol, ($HOC_6H_4NHCOC_6H_5$), with ethyl chlorformate in alkaline solution, resulted in the formation of benzoyloxyphenylurethane, the carbethoxy group,—$CO_2C_2H_5$, occupying the position formerly held by the benzoyl group.

Ransom and Nelson[2] observed similar rearrangement in attempting to prepare the isomer of carbamyl o-oxyphenylethylurethane, ($C_5H_{11}CO_2.OC_6H_4NHCO_2C_2H_5$).

If an acyl group is attached to the oxygen of o-nitrophenol and the acylated nitrophenol is reduced the resulting free base rearranges. The acyl group exchanges position with one hydrogen of the amino group.

Stieglitz and Upson[3] investigated the time of arrangement of a number of substituted monoacyl derivatives of o-aminophenol, substituting chlorine, bromine and the methyl group about the ring, and concluded that, "the more or less positive character of the amino group, as shown by the affinity constants, does not seem to have any paramount influence in determining the tendency of the base to undergo rearrangement, as measured by the rate of rearrangement", but that, "the velocity constant depends more on changes affecting the neighboring carbalkoxyl groups".

Raiford[4] did not find the rearrangement of diacyl derivatives affected by the substitution of negative groups about the ring.

From the previous work done it seems that the diacyl derivatives of o-aminophenol tend to undergo rearrangement regardless of the

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[1] Amer. Chem. Journ. Vol. 23, No. 1, 1.

[2] Jour. Amer. Chem. Soc. Vol. 36, N 2, 390.

[3] Amer. Chem. Journ. Vol. 31, No. 1, 497.

[4] Journ. Amer. Chem. Soc. Vol. 41, No. 12, 2068.

weight of the two acyl groups concerned, or whether the latter possess carbonyl or carboxyl groups. Neither does the substitution of negative groups about the benzene nucleus affect the tendency to rearrange.

The purpose of this investigation has been principally (1), to determine whether closely related alkyl radicals in the aliphatic acyl groups affected the rearrangement, and (2) to determine whether the same alkyl radical in the different acyl groups affected the rearrangement.

Experimental Part.

Acetyloxyphenylurethane, ($CH_3CO.OC_5H_4NHCO_2C_2H_5$), was prepared from oxyphenylurethane and acetic anhydride in alkaline solution. White needle-like crystals melting at 72.9° to 73.4° were obtained from ligroin. On saponification oxyphenylurethane was obtained, showing the carbethoxy group to be attached to the nitrogen in acetyloxyphenylurethane.

Action of Ethylchloformate on o-Acetylaminophenol.

When o-acetylaminophenol, ($HOC_6H_4NHCOCH_3$), is treated with ethylchlorformate in alkaline solution acetyloxyphenylurethane, and not its isomer, is obtained. The product of saponification is oxyphenylurethane, showing the carbethoxy group attached to the nitrogen where the acetyl group had been.

In connection with the behavior of the acetyl group, Raiford's work with unsubstituted o-aminophenol was repeated and the exchange of position between the acetyl and benzoyl groups observed.

Propionyloxyphenylurethane, ($C_2H_5CO.OC_6H_4NHCO_2C_2H_5$), was prepared from oxyphenylurethane and propionic anhydride in alkaline solution. Crystals of long, white, silken needles melting at 41.7° to 42.4° were obtained from dilute alcohol. Saponification showed the carbethoxy group to be attached to the nitrogen.

Propionl-o-aminophenol, ($HOC_6H_4NHCOC_2H_5$), was prepared from o-aminophenol and propionyl chloride in ether solution. Small white, cubical crystals melting at 76.2° to 77.2° were obtained from ligroin slightly diluted with ether.

Action of Ethylchlorformate on Propionyl-o-aminophenol.

On treating propionyl-o-aminophenol, in alkaline solution, with ethylchlorformate a diacyl compound is formed identical with, and in fact is, propionyloxyphenylurethane. Saponification yields oxyphenylurethane, showing that the carbethoxy and the propionyl groups had exchanged places.

When two closely related alkyl radicals, one being attached to the carbonyl group and the other to a carboxy group, are used in the preparation of a diacyl derivative of o-aminophenol, the acyl group containing the carboxy group is always found attached to the nitrogen. When necessary a molecular rearrangement takes place to effect this.

When the same alkyl radical is used, in one case attached to a carbonyl group and in the other to a carboxy group, the acyl group containing the carboxy group, again, is found attached to the nitrogen.

Purdue University.

A Subterranean Cut-Off and Other Subterranean Phenomena Along Indian Creek, Lawrence County, Indiana.

Clyde A. Malott.

The drainage basin of Indian Creek in Monroe, Greene, Lawrence, and Martin counties, Indiana, offers a number of interesting physiographic phenomena. Indian Creek from its source in western Monroe County southwest of Bloomington to its entrance into East White River a few miles above Shoals in Martin County, traverses a sinuous route some 50 to 75 miles in length, though the direct distance is but little more than 25 miles. The valley in the upper portion is rather broad and lies on a limestone plain which is perched from 100 to 150 feet above the more deeply intrenched streams on either side of the basin. This condition of its upper portion has resulted in wholesale subterranean piracy, and some 15 square miles in area have been diverted from the surface route through Indian Creek to the more deeply intrenched streams on either side.[1] In the middle and lower portions of Indian Creek basin the valley is very tortuous and narrow. It is deeply set in a dissected plain, the narrow valley floor lying from 200 to 300 feet below the preserved portions of the dissected plain. The upper parts of the valley sides are composed of clastic rocks belonging to the Chester series. These rocks often form benches with abrupt sides of massive sandstone facing the valley. The lower parts of the valley sides are composed of the so-called Mitchell limestone which is exposed in the steep, wall-like sides of the meander curves. Within the meander curves of the valley occur local sinkhole plains far below the dissected surface of the plain in which the valley is cut. Springs of considerable size enter the stream and furnish a large part of the perennial waters. Some of these springs are mineral springs, such as at Trinity Springs in Martin County. At one place a complex meander curve more than 3 miles in length is in the process of being cut off through the development of subterranean drainage beneath the spur of upland across the narrow neck of the meander loop. It is with this feature that the present paper chiefly deals.

The accompanying topographic sketch, Fig. 1, shows a small area of 4 square miles in western Lawrence County through which Indian Creek passes in a very sinuous route. The area lies in T. 5 N., R. 2 W. The village of Silverville lies a mile south of the area, and Armstrong station on the Bedford-Switz City Branch of the Monon Railway is about 1 mile north of the area. The area is about 9 miles west of Bedford. This locality has been mapped in particular to show the developing subterranean cut-off in Indian Creek. The locality also is

[1] See the Bloomington, Indiana, Quadrangle. Also see, Beede, J. W., "The Cycle of Subterranean Drainage as Illustrated in the Bloomington, Indiana, Quadrangle," Proc. Ind. Acad. Sci. for 1910, pp. 107-111.

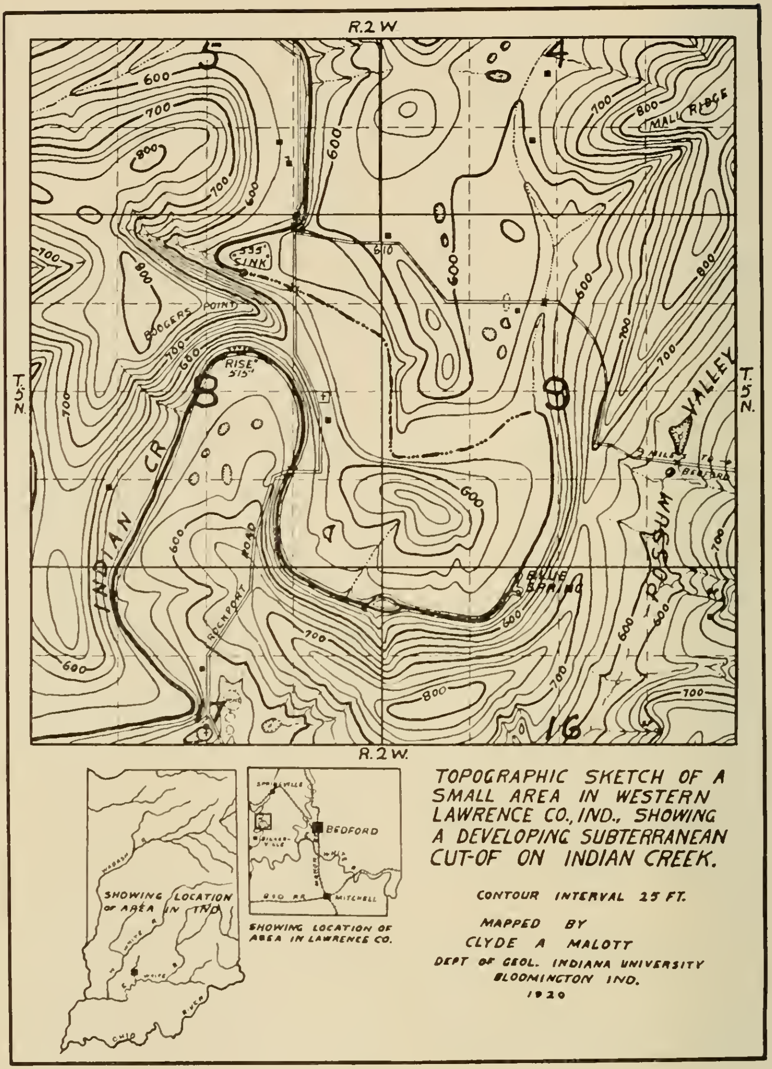


FIG. 1.

interesting from the standpoint of other features present, and these will be briefly discussed.

Indian Creek in this locality lies in a very sinuous valley and is deeply sunk below the higher upland divides. The length of the stream across the two miles of the mapped area is 5¾ miles, or nearly three times the direct distance. The stream both above and below the mapped area is but slightly less sinuous. It occupies a narrow valley which is rarely more than 200 yards in width at the bottom. It is usually at one side or the other of the narrow valley floor and at the foot of a bluff or steep rocky slope, varying from 30 to 275 feet in height. (See Fig. 5.) The most striking feature of the stream and its valley is the complex eastwardly turned meander. This meander is more than 3 miles in circuit and returns to within one-fourth mile of the place where it begins. (See Fig. 1.)

The topographic condition of the area is that of an irregularly dissected plain somewhat beyond the stage of maturity. The land forms present are far from being uniform in kind and size. Diversity rather than uniformity of land forms persist throughout the region. Prominent ridges are present, but their crests are individually uneven and rough. Rock benches frequently occur on the higher flanks of the valley sides, but are not always present there. Great sags and prominent eminences occur. The ravines are sharp and rocky, and their upper parts possess very steep descents. Local isolated sinkhole plains are present midway between the streams and the rough ridge crests. These local sinkhole plains are chiefly associated with the valleys of tributary streams in their approach to the main valley. Some of the sinkholes have become plugged and have become small lake basins. The larger topographic features and their relationships are shown on the accompanying topographic sketch, Fig. 1.

The altitudes within the area of the sketch map range between 510 and 875 feet above sea level. The maximum relief is 365 feet. The immediate relief is as much as 275 or 300 feet. The chief relief forms are the great bluffs on the outside of the meander turns, the sharp uneven sandstone ridges, and the isolated hill within the big meander loop. The curved bluffs on the outside of the meander turns are dis-

FIG. 2.

Fig. 2. View of Blue Spring, a large artesian spring which comes from a cavernous opening at the foot of the hillside adjacent to Indian Creek. The waters which have their exit here have been drained from Possum Valley which lies east of Indian Creek, and have been diverted from their former surface course through the development of subterranean channels. The region furnishes an excellent example of subterranean stream piracy.

continuous and alternate from side to side of the valley. These relief forms are in great contrast to the local sinkhole plains developed some 50 to 100 feet above the valley floor of Indian Creek.

The ridges of the area are composed chiefly of massive sandstones, though their lower and more gentle slopes are composed of the upper part of the Mitchell limestone. The sinkhole plains are developed approximately 100 feet below the top of the Mitchell limestone, or near the top of the St. Louis geologic unit. The local sinkhole areas as shown in sections 8 and 17 are somewhat lower than those in sections 4 and 9. This is in harmony with the dip of the strata to the southwest.

Features accompanying subterranean drainage are very much in evidence. Possum Valley, a small portion of which is shown on the topographic sketch, is a streamless valley which lies east of Indian Creek valley. This valley offers some interesting physiographic phenomena. As a valley basin it is some 3 or 4 miles in length. It is rimmed by sandstone ridges with the exception of the opening on the south. Its floor is occupied by numerous sinkholes and swallow-holes. Small streams descend from the sandstone ridges and hills and enter the swallow-holes in the bottom of the valley. Some of the ravines or small streams are headed by springs which commonly issue from the foot of steep sandstone bluffs near the tops of the ridges. Two such springs are shown on the topographic sketch. South of the area covered by the topographic sketch the valley is open and is occupied by a normal surface stream, Hackley Creek, which enters Indian Creek a mile or so below. Little or none of the waters which drain into the swallow-holes enter Hackley Creek. These waters apparently enter Indian Creek

FIG. 3.

Fig. 3. View showing the pool in Indian Creek channel in which the waters sink. During low water condition all the water enters the subterranean channels here and passes southward beneath "Boogers Point", re-entering the surface channel of Indian Creek after passing through a subterranean channel or channels one-fourth mile in length. The fall of the subterranean route is approximately twenty feet. The route taken by the surface stream during higher water stages is 3.1 miles in length. (See Fig. 1.)

through an underground system which has its terminus at Blue Spring. (See Fig. 2.) Blue Spring is a spring of great volume which rises out of a cavernous opening at the foot of the rocky meander curve in section 16, and enters Indian Creek channel. Little of the cavernous opening is visible, as the spring is artesian. After heavy rains the muddy waters rise vigorously and in greatly increased volume. During dry weather the pool at the opening is a deep blue color, and the water rises quietly and flows away at one side practically at the level of Indian Creek.

Possum Valley is characteristic of many valleys of its kind developed in the Mitchell limestone along the western margin of its outcrop. Such valleys are almost invariably tributaries to a larger and more deeply intrenched main stream. They have originated as valley basins through normal surface erosion in the clastic rocks of the Chester series. As the main streams were intrenched through downward erosion, the tribuary valleys were also cut down, but less rapidly than the main streams. When the tributary streams had cut through the clastic rocks to the Mitchell limestone, the main streams were already well intrenched within the Mitchell limestone. The tributary streams were thus somewhat perched above the main streams, and possessed a valley floor of limestone. Subterranean drainage gradually developed in the tributary valleys, especially at some distance from their junction with the main streams. In many cases the waters which enter the subterranean channels through the swallow-holes in the middle and upper portions of the near streamless valleys re-enter the valley at the surface and continue to the main stream as a surface stream. But more frequently the waters have been diverted through subterranean channels directly to the main stream, the waters passing beneath the divide between the main stream and the tributary. Beaver Valley west of Mitchell in southern Lawrence County is an example of semi-streamless in its upper portion, the subterranean waters of which in part come to the surface lower down in the valley basin. Possum Valley illustrates the sort in which the water has been diverted by subterranean piracy.

It should be noted that there is a distinct difference in the manner of stream diversion in subterranean stream diversion as compared to surface stream diversion. In the latter kinds of stream diversion the diverting or pirate stream is the sole aggressor, while the diverted or captured stream is wholly passive. In the case of stream diversion through the development of subterranean drainage, the diverted stream is the chief aggressor and brings about its own diversion. Because of such a fundamental difference in the manner of stream diversion, some question arises in the mind of the writer as to the propriety of calling subterranean stream diversion stream piracy, though the expression stream diversion conveys the full meaning of the action.

Subterranean drainage takes place as a matter of economy of distance. The subterranean routes are always shorter and more direct than the abandoned surface routes. In the case of Possum Valley the economy of distance is obvious. The subterranean route under the dividing ridge is very short as compared to the old surface route below.

Streamless valleys of this sort may have one or more than one underground system, but the old surface stream is broken up into a large number of small surface systems. Each tributary of the former surface stream may become a small surface system to itself, possessing its own particular swallow-hole marking the terminus of the individual surface system.

The topographical sketch, Fig. 1, has been prepared especially to show the conditions attending the development of a subterranean cut-off, wherein a great meander loop is being abandoned on account of the development of a sub-surface route across the neck of the meander. The waters of Indian Creek in low water condition disappear at the foot of the steep slope forming the north side of "Boogers Point" spur. (See Fig. 3.) The waters reappear one-fourth mile south in a series of springs at the side of the surface channel where it has returned from

FIG. 4.

Fig. 4. View showing the place where some of the waters from the subterranean cut-off re-enter Indian Creek channel. The series of springs coming out at and slightly above water level indicate that the subterranean route beneath "Boogers Point" spur is not well concentrated.

the complex eastwardly extending meander loop. (See Figures 4 and 5.) Here again is illustrated economy of distance in subterranean drainage over the surface route. The subterranean route beneath "Boogers Point" spur is approximately one-fourth mile in length, whereas the surface route is more than 3 miles in length. The fall is approximately 20 feet, and is sufficiently great to give rise to considerable mechanical erosion along the subterranean route. Such erosion, however, is greatly lessened through the lack of concentration in the subterranean route, as it appears that the route is a diffuse one. The waters at the "sink" disappear chiefly in one pool, though other pools below the main one show indications of water loss. The waters re-enter the channel as broad streams through the accumulated talus at the foot of the meander bluff. The issuing waters extend along the stream, coming out practically at stream level, for a distance of 100 yards or more. There is nothing spectacular about either the "sink" or "rise". In high water the surplus passes through the surface channel around the great meander curve.

One may speculate on the drainage conditions here in the future. It does not appear that the subterranean route is likely to become clogged and the route shut off. The St. Louis limestone is notable throughout its outcrop in Indiana and Kentucky for its perfection of

FIG. 5.

Fig. 5. View of the meander curve against which Indian Creek channel snugly fits just northeast of the center of section 8. (See Fig. 1.) The view shows the main part of the spur forming the neck between the two limbs of the great meander curve. It is locally known as "Boogers Point". The arrow indicates the place of the re-entrance of Indian Creek waters into the surface channel. (See Fig. 1.)

development of subterranean channels. Lost River in Orange County, Indiana, has a subterranean route 8 miles in length, having practically abandoned a surface route approximately 19 miles in length. It is possible and even probable that the subterranean route will be enlarged in the future. One may consider it as developing to the stage of an open tunnel and the formation of a natural bridge. The rock of the ridge over the subterranean route is at least 200 feet thick and is competent. The lower 150 feet of it is limestone and the remainder is sandstone. If it should ever reach the open tunnel stage, it is only a step further to the open drainage stage. Such a condition is a high probability in the course of time. Each end of the subterranean route is situated on the outside of a meander curve. These curves may be expected in time to develop, and the subterranean route thus become shorter. Such will only hasten the development of the passage way to the open tunnel stage and eventually to the open drainage stage. When it has advanced to either one of these stages the present circuitous meander channel may be abandoned. If this condition is ever attained the meander route would no longer be considered a part of Indian Creek or Indian Creek valley. But it is more likely that the circuitous meander route will be retained through the continued action of the flood waters, as it is to be kept in mind that erosion is chiefly accomplished during high water stages in areas of topographic youth and maturity. Still another possibility is suggested by the wash on the west side of the road in the northwest quarter of the northeast quarter of section 8. Should this wash develop sufficiently the "sink" would be abandoned through the development of a surface cut-off, thus causing the abandonment of the present developing subterranean cut-off.

This drainage adjustment which is taking place through the development of an underground route across the neck of a meander loop is here called a subterranean cut-off. When once completed the result is the same as in a surface cut-off of a meander loop, whether it is in the case of a meandering stream or a meandering valley. This drainage adjustment does not well classify under stream piracy, as may be suggested and which may possibly be referred to as "self-capture". The term "self-capture" may be inferred to have a definite meaning, but in itself it is a rather impossible term. The term "subterranean cut-off" is expressive of the condition of drainage and gives a direct inference to the process, and is therefore preferable.

Indiana University.

THE HEWITT OIL FIELD, CARTER COUNTY, OKLAHOMA.

LOUIS ROARK.

Introduction.

The Hewitt Oil Field which is one of the most important fields in Oklahoma is located in the western part of Carter County, Oklahoma. The field was discovered June 1, 1919, by the Texas Company, when their well No. 1, on the A. E. Denny lease, was drilled in with an initial production of 410 barrels flowing. This well is located in the northeast corner of the NW. ¼ of the NW. ¼ of the NW. ¼ of section 27, Township 4 South, Range 2 West. This discovery well of the field is located on the south edge of the field and is now an edge well.

Since the bringing in of this well development has been very rapid until at the present time there are about 550 producing wells with an average daily production of about 45,000 barrels of oil. As yet the field has not reached its maximum production.

The writer commenced studying the geological conditions of this field for the Roxana Petroleum Corporation in January, 1920, and spent about five months' time on the work. A report was submitted the latter part of June, 1920.

At the present time the Carter Oil Company, the Wolverine Oil Company, the Westheimer and Daube interests and the Humble Oil and Refining Company are the largest producers in the field. The Carter Oil Company is leading in production with a daily average of about 9,000 barrels. The specific gravity of the oil varies from 34 degrees to 38 degrees Baume.

The writer is greatly indebted to the Roxana Petroleum Corporation for giving permission to publish this article and to Mr. R. A. Conkling, head geologist of the Roxana Petroleum Corporation, under whose supervision this work was done, for his advice and suggestions.

Location and Area of the Field.

The Hewitt field is located in Township 4 South, Range 2 West. This township is in the western part of Carter County, Oklahoma, about 25 miles north of Red River, the southern boundary of Oklahoma, and about 20 miles west of Ardmore, Oklahoma.

The field is 3 miles east of the southeast extension of the Healdton field and about 12 miles southwest of the western part of the Arbuckle mountains. The field covers an area of 6 to 7 square miles. There are 13 sections in the township with producing wells as follows: Sections 9, 15, 16, 21, 22, 10, 23, 25, 26, 27, 28, 35 and 36, of which the first five are the principal producing sections.

Topography and Drainage.

The relief of the Hewitt field proper is about 100 feet. The highest point is near the southwest side of the field in the southwest corner of section 22, Township 4 South, Range 2 West. This point has an elevation of 929 feet above sea level and the lowest point is along the bottom of Bayou Creek which passes thru the northern and eastern portion of the field. The elevation of this flood plain is 837 feet above sea level. There are no steep escarpments along the sides of the valley. The topography may be classed as late maturity in age since the area is well drained and the larger streams have developed flood plains to some extent.

The field is drained by Bayou Creek and its tributary streams. Bayou Creek flows southeast and empties into Red River and thence into the Mississippi River.

The production in Hewitt is not confined to a major divide as in Healdton. Wells are found on the highland and also in the bottom along Bayou Creek and its tributaries.

The Hewitt field was covered for the most part with scrub oak timber, commonly known as black jack, at the time the discovery well was drilled. This timber has been greatly removed and thinned during the progress of development of the field.

Stratigraphy.

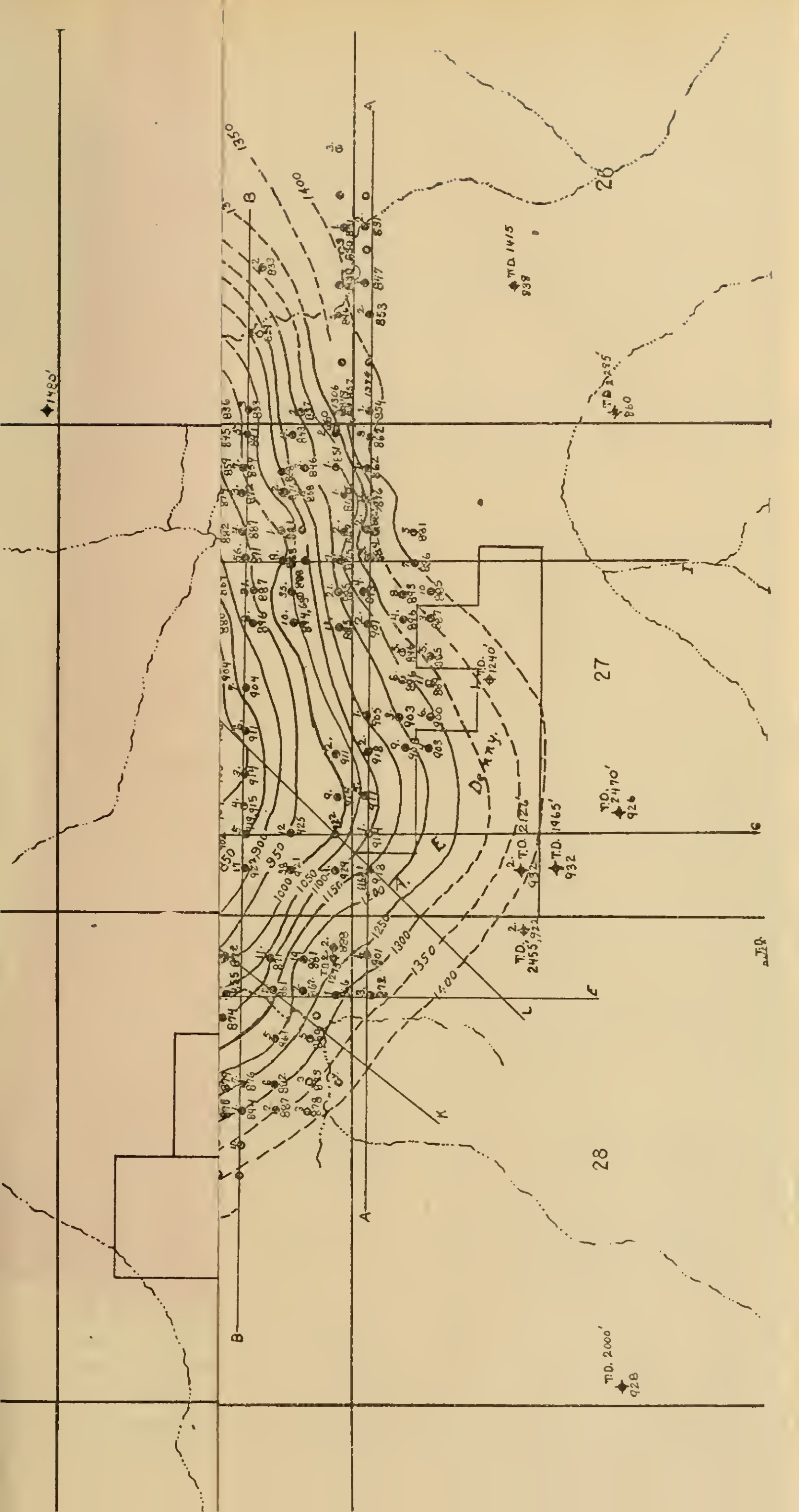
The generalized geologic section of Southern Oklahoma as given by J. A. Taff in his report on the Geology of the Arbuckle and Wichita Mountains, U. S. G. S. Prof. Paper No. 31, is shown below, and a brief description is also given of those principal formations that occur in the Hewitt field.

GEOLOGIC SECTION SOUTHERN OKLAHOMA (After J. A. Taff.)

Cretaceous	Cambrian
Permian	Pre-Cambrain
Pennsylvanian	Franks Conglomerate
Undifferentiated	Caney shale
Undifferentiated Red Beds	Sycamore limestone
Sandstones, shales, limestones and coals	Woodford chert
Wapanucka limestone	Hunton limestone
Pennsylvanian	Sylvan shale
Mississippian	Viola limestone
Devonian	Simpson formation
Siluro-Devonian	Arbuckle limestone
Silurian	Reagan sandstone
Ordovician	Igneous rocks
Cambro-Ordovician	

Cretaceous.—The Cretaceous occurs in the Hewitt field only as a capping for a few of the highest hills and consists of undifferentiated sand and gravel and is of little or no importance.

Permian.—The undifferentiated red beds of the Permian which covers the Hewitt field to a depth of 50 to 400 feet, consist of alternating beds of red, gray and white shale, and brown, white and red sandstones. The Permian is thinnest near the center of the subsurface structural high as mapped, this high being about the center of the field as now outlined. The Red Beds, as the Permian is commonly called,



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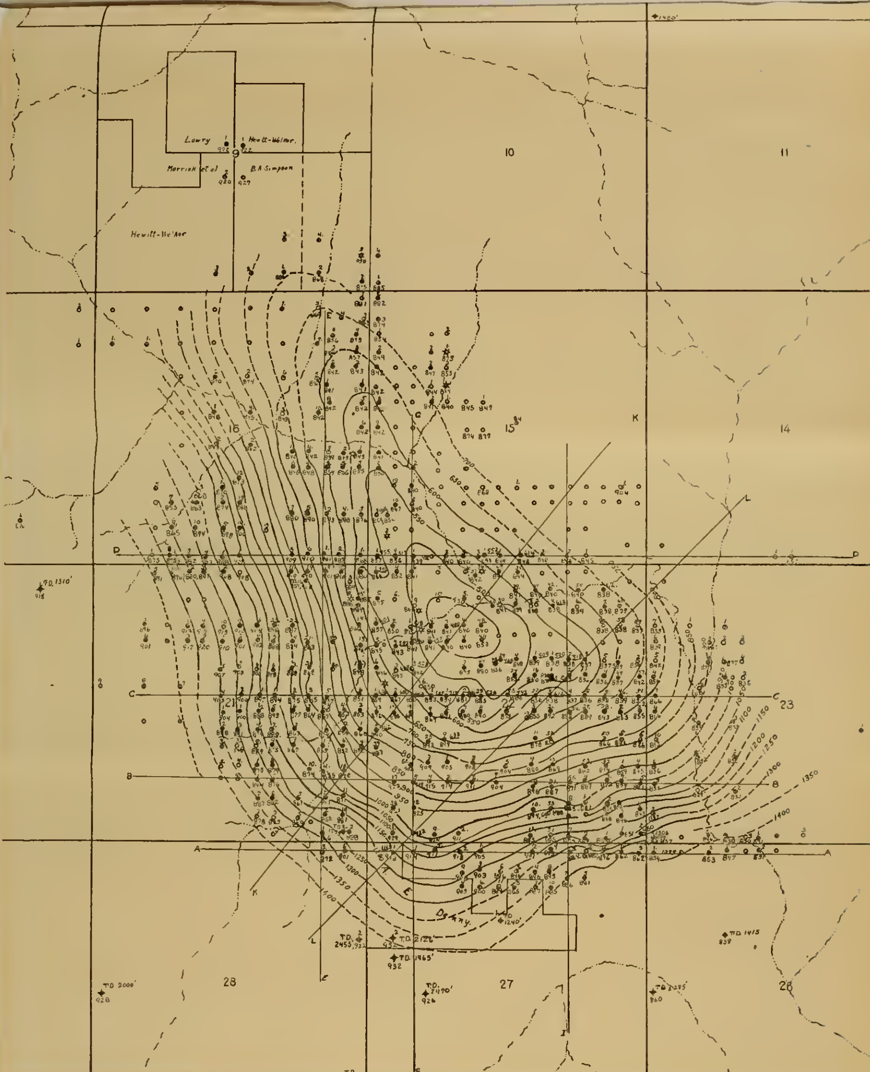
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thicken rapidly toward the edges of the field and as the lower part of the anticlinal structure is reached. In the producing wells along the edge of the field, especially the south and west side, the Red Beds attain a thickness of 400 feet. The Permian thickens tremendously away from the field where the angular unconformity between the Permian and Pennsylvanian decreases. Many of the sandstones found in the Permian carry fresh water in considerable quantities. There is not a well defined basal water sand of the Permian in the Hewitt field as, in the Healdton field. (The Healdton Field, Oklahoma, by J. G. Bartram and Louis Roark. Bull. Am. Assoc. of Petroleum Geologists. Vol. 5.)

Unconformity Below the Permain.—The Permain rests upon the underlying Pennsylvanian in the Hewitt field with an angular conformity. Beneath the Permian is a thick blue shale interval with occasional sandstone and thin limestone lenses, the former carrying gas, oil and water . This blue shale is of Pennsylvanian age and steeply dipping while the Permian on the surface shows only slight dips, therefore resting upon the Pennsylvanian with an angular unconformity. The Permian on the surface dips about 30 to 40 feet to the mile while the underlying Pennsylvanian shows dips of about 1,000 to 1,200 feet to the southwest.

Pennsylvanian.—The Permian is underlain by a thick series of blue shale, sandy shale, sandstones and limestones of Pennsylvanian age, it is from these formations that the oil of the Hewitt field is produced. So far as known from present drilling records the Pennsylvanian varies in thickness from 1,200 to 2,200 feet in the Hewitt field and nowhere has the Pennsylvanian been drilled thru and older rocks penetrated. It is therefore impossible at the present writing to determine the thickness of the Pennsylvanian because of this lack of information, which can be obtained from deep wells penetrating the older rocks. The Pennsylvanian outcrops about 12 miles east of the Hewitt field where dips of 65 to 85 degrees can be observed. It is also impossible to project these formations and estimate the thickness of the Pennsylvanian in the Hewitt field because of the angular unconformity between the Pennsylvanian and the older formations below and the unconformity of the Pennsylvanian with the Permian above. In addition to these unconformities the Pennsylvanian formations have flattened out until they are dipping only about 10 to 12 degrees on the sides of the Hewitt field.

The writer has not been able to accurately determine to which part of the Pennsylvanian these shales, sandstones and limestones belong, but believes they belong to the lower Pennsylvanian or Glenn formation.

Beneath the Permian Red Beds there is a thickness of 1,000 to 1,800 feet of blue shale with sandstone and limestone lenses. These irregular sandstone lentils carry water, oil and gas and occasionally make small gas and oil wells. Immediately under this shale interval is the main body of oil and gas sands called the Hewitt Sand Zone. The thickness of this zone has not been fully determined but is about 600 to 700 feet thick, carrying one to seven sandstones interbedded with shale, sandy shale and limestone.

The lower Pennsylvanian has not been definitely identified in the Hewitt field due to either its absence or the fact that the wells have not been drilled to sufficient depth to reach the lower member, unless the producing zone is Glenn, which is now believed to be the case.

Unconformity Below the Pennsylvanian.—So far as known the unconformity below the Pennsylvanian has not been reached by any wells drilled in the Hewitt field. The writer believes that old buried hills of rocks older than the Pennsylvanian exist beneath the Hewitt field as in the Healdton field (Unpublished data on Healdton Oil Field by J. G. Bartram and Louis Roark). Old limestone hills similar to the Criner Hills, twelve miles southeast of the Hewitt field, exist beneath the Healdton field and it is believed that a similar condition exists in the Hewitt field except that such hills are more deeply buried than in the Healdton field, where the older formations are found as shallow as 800 feet in some parts of the field. Deep drilling in the heart of the Hewitt field will eventually penetrate these old limestones making up the buried Hewitt hills. The rocks in these buried hills are believed to be sharply folded with the Pennsylvanian resting unconformably on the steeply dipping eroded edges of the earlier rocks. This is the condition in the Criner Hills southeast of Hewitt where the Pennsylvanian overlaps the earlier formations and in the Healdton field northwest of Hewitt.

Older Formations.—The formations older than the Pennsylvanian have not been identified in the Hewitt field and therefore will not be discussed here. These older formations have been fully described from a study of exposures at their outcrop in the Arbuckle Mountains, about 12 miles northeast of the Hewitt field, by J. A. Taff in U. S. G. S. Prof. Paper No. 31. (Geology of the Arbuckle and Wichita Mountains.)

Structure of the Permian.

There is a slight folding of the Permian in this area, giving a small anticlinal doming of the surface formations. The highest portion of this dome is near the section corner of sections 21, 22, 27 and 28, Township 4 South, Range 2 West. The Permian structure is probably due to a slight deformative movement after the deposition of the Permian. A small part of the Permian structure may be due to sagging and settling of the Permian.

This surface structure is a flat dome-like fold with dips of 30 to 40 feet to the mile. The discovery well of the field was drilled by the Texas Company on their A. E. Denny lease, known as Denny No. 1 well, and is located in the northeast corner of the northwest quarter of the northwest quarter of section 27, Township 4 South, Range 2 West and was well located on the surface structure for a favorable test. Due to the unconformity between the Permian and Pennsylvanian formations the discovery well was near the south edge of the field as well No. 2 on the same lease drilled by the Texas Company 1,600 feet south of No. 1 was a dry hole 2,126 feet. The writer believes that this No. 2 well should have been drilled to 2,250 or 2,300 feet before being condemned as a dry hole.

Structure of Pennsylvanian.

In studying the Pennsylvanian structure of the Hewitt field nine cross-sections were plotted on tracing linen. The oil sands were used as a datum plane on which to draw subsurface contours. Four east-west cross-sections, three north-south sections and two northeast-southwest sections were drawn. In addition to these cross-sections the logs of all producing wells were plotted on individual graphic log forms, thus making sections in any direction available for purpose of correlation and study.

From these cross-sections and plotted logs the accompanying subsurface map was made (Fig. 1). Correlation lines were drawn on the top of the producing sands and also on the water sands above the oil sands and thru sands carrying only slight shows of oil and gas. These correlation lines on the water sands help to check the correlation of the sands, although the water sands cannot be depended upon entirely because of their lenticular nature.

These correlation lines show that the oil sands have a considerable degree of regularity, although there are some irregularities due to local thickening and thinning of the sands and also to inaccurate logs. The sands in the Hewitt field are much more regular than in the Healdton field but not as regular as in the fields of the northern part of Oklahoma.

The structure of the Hewitt field as shown by the accompanying subsurface map (Fig. 1) is an elongated dome with the long axis extending north and south, about 10 degrees west of north. The top of the dome is flat, covering about one-quarter section and dipping off steeply to the west, southwest and south. Since the completion of the accompanying map further drilling, extending the field north, shows that the Hewitt anticline has as minor structural features two domes connected by a slight saddle.

The crest of the main Hewitt dome, or the dome further south, is in the northwest quarter of section 22, Township 4 South, Range 2 West. From the apex the Hewitt sands dip steeply to the west, southwest and south. The dips to the east and north are not nearly so steep as in the other directions. However, the east and north sides of the field have not been fully limited by dry holes so the amount of dip has not been determined. The sands dip north to about the west quarter of section 15, Township 4 South, Range 2 West, where they commence to rise to the second dome located probably in the northwest quarter of section 15, Township 4 South, Range 2 West.

The principal differences between the two domes of the anticline is that the north dome is higher structurally and yields strong gas wells whereas the south dome is lower and has never produced any dry gas from the Hewitt sand.

In addition to the two minor domes on the main anticline there are indications of the presence of two faults. Along the north line of section 22-4S-2W wells are producing at considerably different depths. Either the sands dip steeply to the north forming a very sharp syncline between the two domes or else the Hewitt sand zone is faulted. The failure to find sands at depths where the Hewitt sand should occur in offset wells strongly suggests a fault with the upthrow side to the south. On the north side of the north line of section 22 in section 15 the Hewitt sand not only is found about 300 feet deeper than in offset wells to the south, but the sand is not as productive as in the wells where found at a higher elevation. If present this fault would extend almost parallel with the north line of section 22 dying out to the west before the northwest corner of section 22 is reached. This fault may be the cause of the two structural highs with a saddle between. The presence of this fault and its extent to the east has not been verified but is strongly suggested by the records of the wells in this area.

Indications also point to a fault limiting the field on the north thru the center of section 9-4S-2W with an east-west trend. The upthrow side of this fault would be to the south. This fault is strongly suggested by wells near the center of section 9. The Humble Oil and Refining Company found a typical Hewitt section in their Hewitt-Walker No. 2, which is producing from sands found at 1,390 feet and below while just across the line to the north Merrick, et al, in their Lowery No. 1 and the Hewitt-Walker No. 1 of the Humble Oil and Refining Company drilled to depths greater than 1,800 feet, and found nothing but red beds and water sands. The fact that the Hewitt sands were not found in these two north wells makes it almost certain that a fault with an east-west trend exists.

Future drilling will be necessary to prove the presence and extent of these two faults. However the writer believes that they exist and will have an important bearing on the limits of the field to the north and northeast.

The Hewitt anticline is very steeply folded. The formations dip west, southwest and south from the crest of the anticline at the rate of 1,200 to the mile. As mentioned above the east and north dips have not been fully established. The producing formations are more steeply folded in the Hewitt field than in any other producing field in Oklahoma with the possible exception of the southeast extension of the Healdton field where dips equally as steep in the producing sand have been observed by J. G. Bartram and the writer (Fig. 1, p. 472, Bull. Am. Assoc. of Petroleum Geologists. Vol. 5).

The Hewitt sands are of Pennsylvanian age, probably the Glenn formation, and are believed to have been deposited over and around a core of older rocks as is the case with the Healdton sands and were folded with the older rocks before the Permian was laid down and possibly again slightly folded after the deposition of the Permian. To date the Pennsylvanian has not been penetrated and the older formations discovered or at least they have not been identified. The Pennsylvanian is at least 2,000 to 2,100 feet thick at Hewitt.

A small part of the dip on the structure may possibly be due to settling and sagging of the Pennsylvanian sediments about a core of older rocks. The structure is due primarily to deformative movements after the deposition of the Pennsylvanian. This is shown by the steep dips of the Pennsylvanian producing sands and the angular unconformity beneath the Permian.

Source of the Oil.

The oil of the Hewitt field and also of the Healdton field has come from either the Pennsylvanian shales and limestones and the asphaltic sands near the base of the Pennsylvanian, or from the Caney shales of

Upper Mississippian age, or from the Simpson formation of Ordovician age.

No doubt much of the oil, and possibly most of it originated in the Pennsylvanian shales and limestones and the Caney shale of Mississippian age where present. These shales are dark and appear organic which, with the presence of limestone, indicates plenty of organic life at the time of deposition for the formation of a considerable quantity of oil and gas.

The Simpson formation may have been a very important source of oil in the Hewitt and Healdton fields. This formation is known to carry oil in the Healdton field as there are two wells producing oil from sands of Simpson age at a depth of about 2,700 to 2,775 feet. The Simpson formation has much asphalt and other evidences of oil at its outcrop in the Arbuckle Mountains. This formation seems to have carried oil in great quantities and may have given up large amounts to the overlying Pennsylvanian sands thru faults, fissures and unconformable contact with the Pennsylvanian sands.

The regional movements which occurred in Pre-Pennsylvanian times before the deposition of the Pennsylvanian caused very extensive folding and faulting. These movements were followed by erosion over a long period which exposed the earlier rocks along the crests of the anticlines. The Pennsylvanian was then deposited upon these eroded upturned edges of older rocks and no doubt in direct contact with the Simpson and other oil forming formations. This made conditions ideal for the migration of oil from the older eroded beds into the overlying Pennsylvanian reservoirs from which the oil is now produced. This migration took place across the unconformity from the older oil bearing formations and also thru the faults which no doubt existed.

Oil Sands.

In addition to the main Hewitt sand which has produced most of the oil to date there are other oil and gas bearing sands. These sands will be discussed in order from the top down.

Shallow Gas Sand.—The shallow gas sand has produced considerable gas from wells drilled to it. This shallow sand is found on top of the structure at depths varying from 250 to 400 feet and lies about 1,000 to 1,050 feet above the Hewitt sand. These shallow wells produce from 100,000 to 3,000,000 cubic feet of gas per day. This gas was of considerable importance on account of the shortage of gas in the field and was used for operating purposes. Many of the gas wells in this shallow gas sand were short-lived and soon became exhausted. The sand varies considerably in thickness but has an average thickness of about 20 feet. Further down on the flanks of the structure this sand either produced water or was cut off entirely by the unconformity between the Permian and Pennsylvanian.

The 600 to 700 Foot Gas Sand.—A second shallow gas sand has been found 600 to 700 feet, which has produced some good gas wells. The wells which produce gas from this sand have an initial production from 3,000,000 to 10,000,000 cubic feet of gas per day. For the most part the wells in which this gas is encountered are bradenheaded and the gas produced between the ten and twelve inch casing. The gas is then used for operating purposes while the well was then drilled to the oil sand. This sand is lenticular in character and varies considerably in thickness. The depth at which this sand is found varies with the position of the well on the structure and with the elevation of the well. If the well is on top of the structure the sand is found at a much shallower depth than when located off the top of the structure. The sand lies almost uniformly 625 to 650 feet above the Hewitt Sand Zone.

Stray Oil Sands.—There are several stray oil sands found above the Hewitt sand and below the 600 foot gas sand. These sands vary from 70 to 300 feet above the Hewitt sands. These sands are not regular and are of but small extent. Wells drilled to these stray sands vary greatly in initial production, and do not hold up in the amount of oil produced for very long. The initial production of wells drilled to these sands is from 25 to 200 barrels per day.

Hewitt Sand Zone.—The Hewitt Sand Zone includes a zone 600 to 700 feet in thickness made up of oil bearing sands, shales, sandy shales and dry sands but no water sands occur in this zone.

The first or main sand in the Hewitt Sand Zone has been the main producing sand in the Hewitt field. This sand is surprisingly continuous and is the datum used in making the subsurface structure map of this area. This first or main sand was the principal producing sand until November, 1920, when deeper drilling showed that some of the deeper sands were of more importance. This main sand is found in wells on top of the structure as shallow as 1,200 feet in the north central part of section 22-4S-2W and as deep as 2,100 to 2,300 feet along the north line of section 27-4S-2W. This sand dips at the rate of 1,200 feet to the mile to the west and 1,000 feet per mile toward the south.

The Hewitt Sand Zone is capped by a blue shale interval of about 400 feet with hardly a break. This shale separates the oil sands and the higher water bearing sands and also prevents the migration upward of the oil thus leaving the sands of the Hewitt Zone barren of oil.

The sands of the Hewitt Zone are soft, porous, and usually white and gray in color. The sand varies in porosity and size of grains. This variation in porosity and in the size of grains accounts for the difference in production of the various wells. The heaviest production comes from wells where the sand is fine grained and loose. The lighter production comes from sands with coarser grains and more firmly cemented but still comparatively soft.

Deeper sands in the Hewitt Sand Zone have been found to be of considerable importance. The intervals to these deeper sands are not constant due to the lenticular character of the sands. A few sands of importance have been found which persist with fair regularity in most parts of the field.

A second sand of importance about 75 to 100 feet below the main or top sand has been found in most parts of the field. In all cases this sand, when drilled into, increases the production of the wells. Occasionally in some parts of the field this sand is more prolific than the main sand. This sand when wells are deepened to it increases the production 20 to 100 barrels per day.

The next sand of any importance and regularity lies about 150 to 200 feet below the top or main sand of the Hewitt Sand Zone. This third sand in nearly all cases increases the production of wells when penetrated. This increase in production is from 25 to 200 barrels per day.

A fourth sand occurs about 275 to 325 feet below the top or main sand, which also increases production considerably in the wells which have penetrated it. This sand probably increases production around 100 to 200 barrels per day.

Another sand is found at about 400 feet below the top sand which increases production about 200 to 300 barrels. This sand may be called the fifth oil sand of the Hewitt Sand Zone.

The sixth oil sand probably will prove to be one of the most prolific sands of the zone and is found at about 600 to 650 feet below the top sand of the Hewitt Sand Zone. This sand has produced as much as 400 barrels per day in some of the few wells drilled to it.

The deepest producing sand stratigraphically in the Hewitt field is the seventh sand of the Hewitt Sand Zone and is found about 700 feet below the top or main sand. This sand will probably increase the production in the wells which have penetrated it 100 to 200 barrels.

Further exploiting of the sixth and seventh sands may prove them to be the most prolific sands of the Hewitt field.

There is no data available with which to predict whether there are deeper sands in the Hewitt field than this seventh sand. If there are deeper sands we are not able to predict whether they will carry oil or water.

No sands in the Hewitt Sand Zone have been found which carry water in the field and this factor will make it easy to produce from all sands without endangering the upper sands by permitting water to enter the sands. It will be a very easy matter to deepen the wells and produce from two or more sands in the same well.

Water Conditions in the Hewitt Field.

There are three sources of water with which the oil man has to contend, namely: (1) upper water, (2) edge water or water in the base of the sand and, (3) bottom water or water in a separate sand below the oil sand.

To date the first or upper water is the only source of water with which the Hewitt operator will have to deal. This upper water is easily taken care of by casing off the water before the oil sand is penetrated.

At the present writing there are only three or four wells in the Hewitt field making water along with the oil and these are known to be due to casing leak, that is, the casing failed to shut off the water or a leak has developed in the casing from some cause and permitted this upper water to enter the well.

Eventually edge water will make its appearance in the field and will have to be taken care of. This will first make its appearance in the wells along the edge of the field and migrate in on the field as the sands are drained of their oil.

Bottom water may make its appearance as deeper drilling continues and then will have to be shut off by one of the various methods of plugging or shutting off bottom water commonly used in the oil fields. The methods used in plugging and shutting off water will not be discussed in this article.

Oil Production.

There are about 550 wells producing in the Hewitt field with an average daily production of 45,000 barrels of oil. The average daily production per well in the Hewitt field is about 80 barrels. This average exceeds the average per well of any other field in the state. No doubt the average daily production of the wells could be greatly increased by the deepening of a great many of the wells in the field. The wells range in initial production from 50 to 2,000 barrels per day.

A Zone of Large Concretions in the Knobstone.

W. M. Tucker.

My attention was recently called to a peculiar and interesting bed of concretions in the Knobstone of Monroe County. The deposit is very local in its distribution. It occurs in two ravines in sections 1 and 2, T. 10 N., R. 3 W., in the northwest corner of Monroe County. The two ravines head on the Harrodsburg limestone near the middle of sections 1 and 2 and extend northward, immediately entering the Knobstone with the characteristic rapids and small waterfalls. The main ravine (west) has a depth of seventy feet one-fourth of a mile from its source, and the smaller one (east) attains that depth in a shorter distance. The larger ravine enters the concretionary zone thirty-five feet below the contact of the Harrodsburg and Knobstone. The zone is

FIG. 1.

Fig. 1. A concretion five feet in diameter which has been dislodged from the ravine wall in the background.

fifteen feet thick. The concretions can be seen in the ravine walls for about one-fourth of a mile, just south of the Monroe County line (Figs. 1 and 2). The bottom of the ravine is strewn with concretions and fragments for this distance. Only four were found in the smaller ravine which at this point is about one-quarter of a mile east. None were found in the other ravines of the neighborhood.

The concretions vary in size from a fraction of an inch to five feet in diameter. They show none of the concentric structure which is displayed in some concretions. No distinct nucleus was discovered in any of them. The composition of the concretions is highly silicious, especially those in the upper part of the zone. Those in the lower

FIG. 2.

Fig. 2. Three concretions, each about two feet in diameter, in place in the ravine wall.

part of the zone contain considerable calcium, iron and aluminum. An examination of a specimen from the extreme top of the zone under the petrographic microscope resulted in the following estimate of contents: quartz, 8/9; calcite, 1/9; traces of limonite, pyrite and kaolinite. A chemical analysis of a specimen from the lower part of the zone gave the following results:

$Si\,O_2$	46.48 %
$Ca\,O$	17.92
Fe_2O_3 / Al_2O_3	19.87
$Mg\,O$	.395%
$C\,O_2$	14.69
$S\,O_2$	.08
Total	99.435%

The concretions of this zone resemble those of the Olentangy shale of Ohio in size, mode of occurrence and general appearance but those of the Olentangy shale are of very wide distribution. Beds of limestone occur in the Knobstone south and east of this zone at about the same horizon. Small concretions are found at many horizons in the Knobstone. So far as known there is no relation between this bed of concretions and the concretions of other parts of the Knobstone nor do they seem to be related to the limestone beds. So far as known there is no similar zone of concretions in the Knobstone or elsewhere in Indiana.

Acknowledgement is made to Prof. W. N. Logan who made the petrographic estimate, Mr. Luther S. Ferguson, who made the chemical analysis, and Mr. Arch R. Addington, who developed and mounted the pictures. *Indiana University.*

DECREMENT MEASUREMENTS.

R. R. RAMSEY

In wireless work one of the important measurements is the logarithmic decrement of the aerial or decrement, as it is called in wireless. Decrement is an indication of the sharpness of the radiating wave. To liken radiation from a wireless station to the radiation from a light source: a station with a low decrement gives a line spectrum of a definite wave length while a large decrement means a band spectrum covering a large range of wave lengths. It is hard, or next to impossible to tune out a station with a large decrement. On this account the U. S. Government has outlawed stations with decrement greater than .2. Another advantage of small decrement is that all the radiated energy of the sending station is concentrated on one wave length, while the energy is scattered over a broad band when the decrement is large.

The solution of the differential equation of an oscillating circuit containing resistance, inductance, and capacity may be put into the form $I = I_0 e^{-\alpha t} \sin wt$ where I_0 is the initial or maximum value of the current, I is the value of the current at any time, t; w, is the angular velocity or $2\pi n$, n being the frequency and, $\alpha = R/2L$, R being the resistance and L the inductance of the circuit.

The equation can be represented by the curve of figure 1.

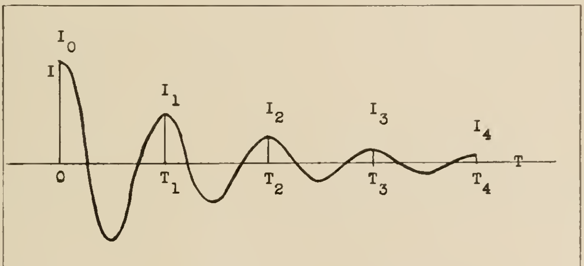

Fig. 1 .

The amplitudes are:

$$I_0 = I_0 e^{-\alpha o T}$$

$$I_1 = I_0 e^{-\alpha T} \qquad \text{and} \qquad \frac{I_1}{I_2} = \frac{I_0 e^{-\alpha T}}{I_0 e - \alpha 2T} = e^{\alpha T}$$

$$I_2 = I_0 e^{-2\alpha T} \qquad \frac{I_2}{I_3} = \frac{I_0 e^{-\alpha 2T}}{I_0 e^{-\alpha 3T}} = e^{\alpha T}$$

etc.

$$\frac{In}{In+1} = e^{\alpha T}$$

From this $\alpha T = \log.\frac{I_1}{I_2} = \log.\frac{I_2}{I_3} = \log.\frac{I_n}{I_{n+1}}$. This is the same as the usual logarithmic decrement used in ballistic galvanometer work, except in ballistic galvanometer work we follow the English fashion of taking the ratio of the two successive swings in the opposite direction instead of the two successive in the same direction. Or the decrement in U. S. wireless is two times the value determined by the English method. The determination of I_1, I_2, etc., or successive amplitudes of the current is impossible where the frequency is in the order of 1 million, as it is in wireless work.

In the above equation the frequency $n = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$.

If R is small or zero, this becomes $n = \frac{1}{2\pi\sqrt{LC}}$. This is the same value for n obtained from the equation of alternating current in a circuit containing resistance, inductance and capacity, with an alternating e.m.f.

$I = \frac{E}{\sqrt{R^2+(1/Cw-Lw)^2}}$ The value of I is a maximum when $1/Cw - Lw = 0$, i.e. $I = E/R$. If $Lw = 1/Cw$, then $(2\pi n)^2 = 1/CL$ or $n = \frac{1}{2\pi\sqrt{LC}}$.

The above equation for I can be written $I^2 = \frac{E^2}{R^2+(1/Cw-Lw)^2}$.

When the reactance term $1/Cw - Lw = 0$ the circuit is in resonance with the e.m.f. Then $I^2_r = \frac{E^2}{R^2+(1/C_r w - Lw)^2} = \frac{E^2}{R^2}$ where C_r is the value of the capacity which makes the circuit in resonance with the e.m.f. Then $Lw = 1/C_r w$.

If the capacity is changed until $I^2 = 1/2\, I^2_r$, I^2_r being the resonance value, then $1/2 I_r = \frac{E^2}{R^2+(1/Cw - 1/C_r w)^2}$ and $2R^2 = R^2+(1/Cw - 1/C_r w)^2$ since doubling the denominator will halve the value of I^2. Then

$R^2 = 1/w^2([C_r - C]/CC_r)^2$ or $R = 1/w(C_r - C/CC_r)$

$T = 1/n = 2\pi/w$ and decrement $d = \alpha T = R/2L\ T$.

$$d = \frac{R}{2L}t = \frac{1}{w}\left(\frac{C_r - C}{CC_n}\right)\frac{2}{w2L} = \pi\left(\frac{C_r - C}{C_r}\right)\frac{1}{w^2}\frac{2}{2CL}.$$

$d = \pi\frac{C_r - C}{C_r}$ where C_r is the value of the capacity at resonance and C is the value of capacity which reduces the mean square of the current to 1/2 its value. In this manner the decrement is measured by determining the resistance in terms of a capacity.

The decremeter consists of a coil, a variable condenser, and a radio frequency milliammeter or galvanometer connected in series and placed near the radiating source. The capacity is varied until the current is a maximum or the circuit is in resonance with the source. The capacity of the variable condenser is varied until the mean square of the current is reduced to 1/2 the first value. Then the decrement is calculated. This gives the sum of decrement of the source, ærial, and the decrement of the decremeter. This is exactly the same as in measuring the resistance of a 1 to 1 transformer circuit by introducing resistance in the circuit until the current is made 1/2. The value of R introduced is equal to the sum of the resistances in the two circuits. This holds if the mutual inductance is large as in a transformer.

Since $d=\alpha T=(R/2L)T$, doubling the resistance in either circuit will double the decrement of either circuit.

Thus the introduction of resistance in the decremeter circuit until the current in the decremeter is made 1/2 half, the circuit being kept in resonance all the time, will double the decrement of the decremeter. Then if $D_1=d_1+d=$ first decrement measurement and $D_2=2d_1+d=$ second decrement measurement with resistance inserted in decremeter circuit. Then $d_1=D_2-D_1$.

The decremeter is assumed to be loosely coupled to the aerial so as not to affect the aerial circuit. The method is much more simple than that usually given, as in formulae 63 and 64, page 94, Radio Instruments and and Measurements, Circular of the Bureau of Standards No. 74. This formula is:

$$\delta^1=\frac{2\delta\delta_1+\delta_1^2-\delta^2}{\delta-\delta_1}$$

Where δ^1 is the decrement of the aerial, δ the decrement of the wave meter and δ_1 the increase of δ due to the resistance added which reduces I_1^2 to $1/2\ I^2$.

δ^1 the decrement of the aerial seems to be given in terms of two unknown quantities. The remark is made, "It should not be forgotten that these formulae apply only when the coupling is very loose and both decrements are small". This is the condition assumed in the derivation of my formulae.

The most accurate method of getting the decrement of a decremeter is to use a continuous wave current such as is generated in the modern tube circuits or wireless telephone circuits. In these circuits the wave is continuous or the decrement is zero and the decrement measured is that of the decremeter alone.

This method can be used to determine the decrement of the decremeter and thus check the above method.

The decremeter used contained a 250 milliampere milliammeter whose D. C. resistance was 6 ohms.

When the current in the decremeter was large there was a tendency to spark over in the condenser. This brush discharge introduced a resistance in the circuit which was more or less variable. This tends to make the decrement of the decremeter greater at 200 milliamperes than at 100 milliamperes.

Due to the fact that the current is intermittant in a damped wave station. This sparking over effect is greater with damped waves than in the case of continuous waves.

The following table gives results with CW and damped waves. Decrement of wave meter at wave length indicated.

15–20320

	100 mil. amp.	200 mil. amp.	
390 meters	.11	.14	
375 meters	.10	.15	
375 meters	...	.15	
348 meters	.10	.14	
310 meters	.12	.14	Average $\delta_1 = .126$

Decrement of decremeter with resistance introduced to reduce the current from 200 to 100 milliamperes.

100 milliamperes	375 meters
$2\delta_1$	.24
.26	.27

Average $\delta_1 = .127$

Decrement of decremeter with damped wave 375 meters.

$$D_2 = 2d_1 + d = .36$$
$$D_1 = d_1 + d = .23$$
$$D_2 - D_1 = d_1 = .13$$

Second:

$$D_2 = 2d_1 + d = .38$$
$$D_1 = d_1 + d = .24$$
$$D_2 - D_1 = d_1 = .14$$

Thus it is shown that the above method of determining the decremnet of a decremeter checks fairly well with the CW. method.

Indiana University.

Studies of the Biology of Freshwater Mussels.

III. Distribution and Movements of Winona Lake Mussels.[1]

William Ray Allen.

Introduction.

Many summers have been more or less devoted to the study of lake Unionidae by the writer. An account of the feeding mechanism and survey of the food materials was published in 1914. A further study of ingestion, food selection and digestion by experimental methods appeared in 1921. While attempting to account for the assortment of food material, further study was made of the distribution and effectiveness of the organs of special sense. A paper on reactions to chemical and physical stimuli is now ready for the press. Some of the statements which are made in the following pages, e. g. reactions to light and pressure sense, are based upon data fully discussed in the above paper and may here seem arbitrary. To what extent the animals assume a definite place in the lake in response to these physical and chemical stimuli, it is the province of the present paper to show.

Previous Survey. Headlee and Simonton's careful exploration of the mussels of Winona Lake ('03) revealed eight species—*Lampsilis luteolus, L. subrostratus, L. glans, Micromya fabalis, Quadrula rubiginosa, Anodonta grandis, A. edentula* and *Margaritana marginata.* I have translated from the synonymy of Call ('99) to that of Simpson ('99). In many summers' collecting I have added but one species and only a single specimen—*Quadrula plicata,* 175 mm. in length, taken off Yarnell's Point. It is a river form, and having no direct access from the outlet on account of the dam, it probably owes its introduction to an accidental fish host or to human agency.

Headlee and Simonton state that *Lampsilis luteolus* and *Anodonta grandis* greatly outnumber the other species. They show that the mussel zone lies upon or near sandy and gravelly banks; that distribution toward the shore is limited by waves and muskrats, and outward by the soft character of the bottom. Furthermore, they believe that the "black marl" of the deeper water destroys any mussels which go too far out by stopping up the gills.

The *Anodontae* were found by Headlee and Simonton in the edge of banks where sand and mud intergrade, *edentula* being more of a mud-dweller than *grandis. Lampsilis luteolus* was found to be the most cosmopolitan, found principally upon sand and gravel. *Fabalis* and *glans* occurred in deeper water, on relatively firm bottom. *Subrostratus* inhabited the outer portion of the range of *luteolus.*

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[1] Contribution from the Zoölogical Laboratory of Indiana University No. 188.

These authors discuss the possible factors governing distribution, and reject all except three—enemies, wave action and bottom. I shall refer again to this portion of their paper, and discuss these factors in order.

The Hydrography of Winona Lake.

Winona Lake is one of the many kettle hole lakes of the region. It lies in the center of Kosciusko County, in the mid-northern portion of Indiana. It has a maximum length of two miles, and averages three-fourths mile in width. Gently undulating moraines in alternation with flat peaty, or mucky, areas which represent in large measure extinct marsh or lake, prevail in the surrounding terrain.

The northern and eastern shores of Winona Lake lie close to gravelly moraines, and the middle of the western side even more closely. The southern and northwestern shores are separated from high ground by more extensive flat areas, which are but little above lake-level, and have gone through the lake-marsh succession. In the case of this lake the process of degradation through the erosion of the outlet has been arrested by a dam. Just prior to the mussel survey by Headlee and Simonton much dredging had been done at the east, south, and northwestern portions of the lake. (Fig. 1.) This resulted in a rather profound alteration of the bottom in some parts, and the elimination of some mussel beds.

Sugar Creek, Cherry Creek, and Pocahontas Creek, springs, and artesian wells are the principal sources of the incoming water. The outlet is a creek two miles in length which enters the Tippecanoe River below Warsaw. Since the tributaries are small, though steady, mussels have not gone above the lake. The latter is purely lacustrine in form and marks the upper limit in its drainage system for all bivalves except Sphaeriidae. Such has not always been the case, for I have found shells at least two miles up Pocahontas Creek. We should expect a rather small number of species so near the headwaters of Walnut Creek. Nor should we expect to find river mussels so far up.

Since the lake level has been held nearly constant for many years, the shore line has been well stabilized. Also the wave cut terrace is now well established, and in most parts of the lake its margin is sharply set off from the abysmal portion of the lake in accordance with the angle of rest of its component materials. Thus the ten and twenty foot contours parallel the shore most closely of all. (Fig. 1.) Wave action is still at work reducing the sharp points of the shore line, and the most sandy and gravelly parts of the terrace are these exposed points; while in the coves the bottom merges into mud at a much slighter depth. The prevailing storms are northwest. This is correlated with the fact that the wave cut terrace of the east shore is everywhere wider than others, and that the contours of the west shore lie closer together. Except for the sheltered situations the east terrace is swept freer of mud, which is distributed farther out in the lake. The southern corners of the lake have not yet recovered from the dredging of twenty years ago. The south shore receives the wind and waves obliquely from the northwest,

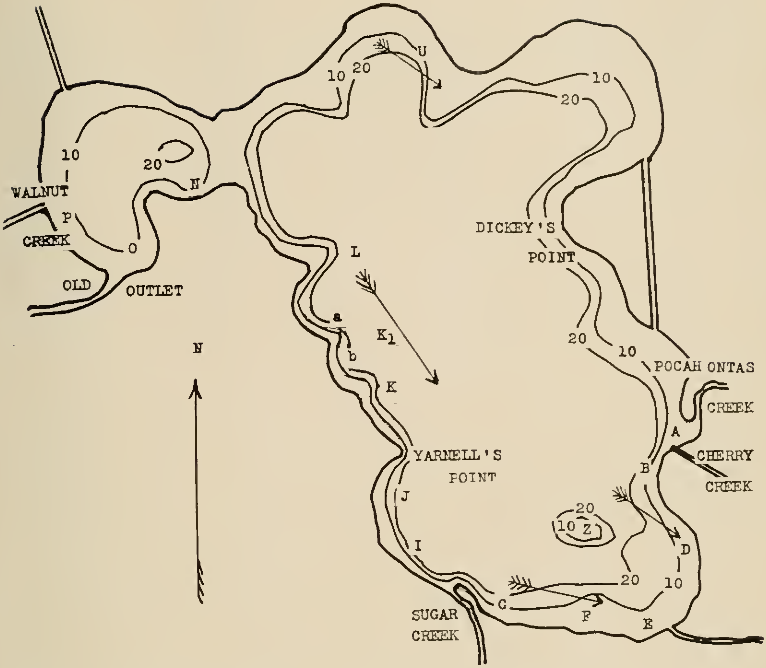

Fig. 1. Winona Lake, Indiana. Ten and twenty-foot contours shown. Letters represent stations referred to in text. Arrows are shore currents.

hence a slow distribution of its mud toward Boys' City Bay (Scott, '16, p. 14, map) and a rather firm bottom results.

The terrace constitutes a shelf of rather moderate depth surrounding the lake. This is the principal habitat of the mussel population. Baker ('16) and others have recorded the occurrence of the maximum population on the most exposed points of the shores of lakes. This generalization holds for Winona Lake except at its extreme leeward corner—Boys' City Bay—where the drift, marl, and mud from all parts of the lake accumulate and are graded out within a short distance from the shore. Kosciusko beach (Map, B) is the most exposed part of the shore line. Here in spite of much intensive collecting it continues to be one of the most populous areas of the lake bottom.

Factors Governing Distribution in Winona Lake.

Having in mind the character of the lake it will now be pertinent to examine the facts of distribution and the possible factors limiting the same. We will first consider the three accepted by Headlee and Simonton.

(1) *Muskrats.* These animals are known to depopulate small areas of mussel beds. Where occurring in sufficient number it is possible that they very definitely limit the shoreward extension of the same. However at the present time there are too few muskrats here to have a significant effect, except locally, about the mouths of creeks in particular.

(2) *Wave action.* Despite the lack of predatory enemies, mussels are uncommon on wave-swept beaches or elsewhere at two feet depth or less. Headlee and Simonton found numerous individuals thrown up on the beach following storms, and concluded that this is the manner in which their shoreward distribution is limited. The writer has seen very few such cases except those thrown up by human agency. Recently dead *Anodontae* sometimes float to the surface and are swept ashore, thus entitling them to the vernacular name of "floater."

The writer placed mussels experimentally in water of a few inches depth near the shore at various points about the lake. Sooner or later they were sure to turn and seek greater depths, oriented by a pressure sense. This movement is expedited in times of storm and high waves. The explanation is a matter of stimulation or annoyance by the moving water and sand in suspension. In protected areas the return to deep water is more leisurely.

(3) *Bottom.* The above authors have very clearly shown how the several species are limited to the respective types of bottom in the lake. The matter of preference of certain types of bottom is a function of shell weight, at least in part. The *Anodontae* alone are found sometimes on muddy substrata, while the other species are sand dwellers, all having also moderate shell weight and erect posture. In the paper referred to in the introduction experiments along these lines will be described.

During recent years no *Margaritana marginata* have been obtained from the lake. Almost no *glans* and *fabalis* have been seen. Rather few *subrostratus* and *rubiginosa* have been taken, and in both cases have been confined to small groups of individuals in a few localities. *Subrostratus* has been collected always in rather deep water off exposed points. Since so few localities of the favored type occur, we may thus account in part for their small numbers.

The western shore is so inclined to the prevailing northwesterlies that southward shore currents are set up. (Fig. 1, arrows.) Thereby even the wind has a share in determining mussel distribution, locally. (Scott, '16, map opp. p. 14.) On every point of land this shore current picks up the mud from the northern margin and deposits it on the southern fringe of the same point, in the quieter water of the lee slope. Thus the beach has an alternation of sand and mud bottom on the west shore, arranged in serrate outline. The effect on mussel distribution may be seen with the help of the map (Fig. 1) and the table. A census of the two dominant species at various points demonstrates that not only general distribution, as shown by Headlee and Simonton, but also the minute local distribution is largely a matter of the character of the bottom.

In the following table the records represent all the mussels found at a depth of from three to four feet, for a distance of a few rods, and on bottom areas selected at random. In all cases where sand is abundant *luteolus* predominated, and was nearly wanting on soft bottoms. *Anodonta* occurs often on sand, but oftener on mud or marly sand. Headlee and Simonton's zones are thus shown not to correspond at all to contour lines, for the physiographic agencies which assort the bottom materials are complicated on the west shore by the action of the shore currents.

This is also observable at one point on the east shore—the north side of Boys' City Bay—(Map, D) and at one point on the north shore, (Map, U) which lie somewhat parallel to the prevailing winds.

TABLE I.

Correspondence of Species to Type of Bottom.

Section	Anodonta grandis present	Lampsilis luteolus present	Bottom character	Remarks
D	18	23	Marly sand	....
			Marly mud	
O	31	2	Very soft	....
I—K	14	39	Sandy	....
E	10	6	Soft marl	All small
K_1	a 9	12	Marly sand	
	b 31	16	Marly mud	See Figure 1
L	42	52	Marl, mud	....
Z	3	33	Firm, marly sand	"Sunken Island"

Section K_1 will illustrate very well how the gradation in bottom is followed in the distribution of the two species. (Table I and Fig. 1.) The sandy portion has fewer *Anodonta* than *Lampsilis*, while the adjacent muddier part has twice as many *Anodonta* as *Lampsilis*. Section L is subject to similar comparison. Such comparisons can be made between areas in the above table, except Section E.

Headlee and Simonton relate that mussel beds at Stations E to I were covered twenty years ago with mud from dredging operations. To this day many dead shells are found in those areas, and few living mussels. I was long at a loss to explain the occurrence of so many dead shells where there were almost no live ones. Even today they have secured a new foothold only in the more or less exposed places (e.g. Section G.)

The extremely soft bottoms of the canals and Section N of the lake are inhabited by Sphaeriids, but not by Unionids. In the latter some dead shells are found.

Evermann and Clark's observations of the distribution in Lake Maxinkuckee ('17) show that there the greater part of the bivalve population lies within the shoreward contours, and that deeper dredgings bring up more *Anodonta* than *Lampsilis*. Baker ('18) finds by far the greater part of the invertebrate life of Oneida Lake within the six foot contour, the bivalves lying more deeply than the other invertebrates. My collecting in Winona Lake shows that the mussel zone of Winona Lake is in somewhat shallower water. We might expect this in a small kettle hole lake, whose littoral is chiefly a wave cut terrace, going off sharply into deeper water at its outer margin, and itself averaging less in depth than in such a lake as Oneida. Being formed by waves and currents, it tends to be shallower and narrower in lakes too small for large waves. Headlee and Simonton's map indicates that the mussel life belongs predominantly within the ten-foot contour. While they found live mussels out to a depth of twenty-two feet, the deeper ones were all narrowly limited to exposed points, which the undertow keeps swept clean, and on the lee shore, where the thermocline may sometimes be depressed. Aeration and food must be better at such points than at others of equal depth.

Needham and Lloyd's Figure 191 is likely to mislead one to regard the 10-20 foot zone as the most productive in Winona Lake.

River mussels, as well as lake forms, have preferred types of bottom, hence "shoals."

Having in the main corroborated Headlee and Simonton's analysis, with respect to the three factors given above, and compared the present situation with that of fifteen years ago, let us consider some of the factors ignored or rejected by them.

(4) *Sex* can be eliminated. Both males and females seem to occur over the entire range.

(5) *Age* is probably pertinent. First because juveniles are rarely collected on the grounds where adults are most abundant. In the second place, while adults are prevalent on certain types of bottom, some of them must have migrated thither, for the host fishes of course do not drop the young mussels upon selected bottom. It will be interesting to learn the evolution of the parasitic habit of the bivalves, the origin of specific infection, and the correspondence in preferred habitat between given mussels and their respective hosts. The matter of age is very uncertain due to the rare finding of juveniles.

(6) *Pressure* has been shown (in paper No. II of this series) to initiate and to govern the movements of mussels. Their distribution is partly due to this factor. It is probably of greater importance inshore than in deep water. The pressure difference within a few inches of the surface must be greater than differences of several feet in deep water, at the outer limit of the range. Physiologically the change from twelve inches to six inches should be the equivalent to a change from twelve feet to six feet. The most active movements of mussels actually take place in water of slight depth.

(7) *Light* has a directive influence upon the movements which may sometimes affect distribution. The experimental demonstration is discussed in the above named paper.

(8) *Relation to the Epilimnion.* The above factors without further additions are sufficient to account for the adjustment to favorable environment. Yet it is at least a happy coincidence that the most suitable bottom, depth, etc., occur in the epilimnion. Otherwise mussel life would have been impossible. Food supply, temperature, and oxygen are at the optimum where the bottom is also most favorable. Furthermore these conditions are best fulfilled during the summer months, the time of highest metabolic activity of the animals.

The thermocline of Winona Lake begins at a depth of fifteen to twenty feet. Therefore the contours which represent its contact with the lake bottom are quite near the boundary of the wave-cut terrace. The terrace is thus washed by the epilimnion only, and the hypolimnion lies wholly outside the terrace. Conversely, the greater part of the lake bottom lies beneath the hypolimnion. These facts are of importance to the mussels in the ways mentioned above.

(a) *Temperature.* The development of a thermocline due to the thermal resistance of water to mixture results in the maintenance throughout summer of low temperatures below its level. Instead of a distribution of the heat of summer throughout the water, the epilimnion receives most of it. Its temperature is therefore much higher than if the heat became distributed vertically, and higher than when the lake becomes holothermous in autumn. This results in a heightened metabolic rate on the part of the inhabitants of the epilimnion, while the abysmal bottom on the contrary is rendered unfit for the production of many living things.

(b) *Oxygen, Carbon Dioxide, and Carbonates.* The water of the epilimnion receives most of the sun's energy that is not reflected from the surface. Only here is photosynthesis effective, and here the phytoplankton has evolved methods of flotation which keep the lake's minute inhabitants mostly near the surface. For these reasons oxygen production is virtually limited to the epilimnion. Currents due to wind are set up which distribute the epilimnetic water from one part of a lake to another. The return currents pass underneath, next to the thermocline. For mussels the situation is perfectly adapted to secure well oxygenated water so long as they remain above the level of the thermocline. Yet even more striking than the oxygen curve of Winona Lake is the increase of the carbon dioxide. (Scott '16, p. 34.)

Were a lake bottom in the hypolimnion entirely suited in other particulars to support mussel life, the conditions of temperature and oxygen would make it virtually uninhabitable. *Sphaerium* has been collected from bottom of various depths down to eighty feet, where, during summer, it exists under almost anaerobic conditions.

The increase in acidity as we read downward in a lake means a corresponding reduction of the available carbonates, which is of importance in shell formation. Most of the marl deposition occurs in shallow water. The lime cycle is a function of the epilimnion almost wholly.

In all respects we may say that the stratification of a lake tends toward increasing the habitability of the epilimnion at the expense of the hypolimnion. The turnover in autumn is rendered harmless to mussels through the thorough mixing, and through the temperature reduction.

(c) *Food Supply, etc.* The currents of the epilimnion are no less important to the Unionidae in that a constant renewal of the food supply is effected. That it is entirely sufficient is shown by the fact that freshly collected mussels are never without plankton in the intestine, or without a crystalline style. (Allen, '14, and '21.)

Evermann and Clark ('17) have stated as a foregone conclusion that rivers are the abode of mussels *par excellence.* And it is true that there are more species and larger individuals. But I cannot wholly agree with their explanation. They say it is due to the changing water of the current, abundance of food and dissolved oxygen. Yet it is not explained why lake beaches are inferior in these respects to river shoals. In the former we have a slower, though no less steady, movement of water. The dissolved oxygen exists in great concentration, even to supersaturation. The plankton content of a lake surface is far in excess of that of most rivers. The average temperature of the lake habitats through the year is probably higher than in rivers, due to temperature discontinuity. Since these things are true, the metabolic rate should be higher. Then, with higher metabolism, more food, and more oxygen, lake mussels should be the larger, if these were the determining factors. In the upper reaches of lake-fed rivers the mussels may profit to a certain extent by the water flowing from the lakes above.

It is likely that the Najades originally populated the fresh waters through the rivers rather than originating in the lakes. The lakes are younger, more transient, less extensive, at greater altitudes, and at the extremes of the drainage systems, and mussels have had less time in which to grow adjusted to them than to rivers.

Feeding Conditions upon Stream Deltas. Northwesterly winds have diverted the mouth of Pocahontas Creek southward into a shallow bay. The bivalve population of this bay were observed at times to have an almost complete change of diet. Ordinarily the food is lake plankton. After heavy rainfall the increased volume of creek water usually spreads out in a sheet of a few inches depth over the entire bottom of the bay. On such occasions the food of the mussels is greatly altered. The same phenomenon was sometimes observed to take place when there had been no rainfall, and at first it was puzzling to explain the sudden changes of diet from lake to stream plankton. The explanation turned out to be simple, when it was found to correspond to the diurnal or cyclonic temperature changes. The creek is shallow and its temperature changes more rapidly than that of the lake. After a cold period, its cooler water sinks into the water of the lake and spreads out in a thin layer at the bottom of the embayment. Its planktonts become the food of the mussels there, and they are excluded from their normal food supply. When the creek water is turbid and cold at the same time, it may easily be seen to underlie the warmer clearer lake water. It follows the bottom closely until the edge of the terrace is reached, where it spreads out horizontally in the region of the thermocline, in water of virtually equal temperature.

This alternation in temperature and food does not show evidence of inciting movement. But, during freshets, when the lake level is greatly changed upon the littoral, movements shoreward begin, due to pressure change.

In streams one may often see the siphonal regions of living shells used as holdfasts by such filamentous stream algae as Cladophora. This does not ordinarily occur in the lake. Yet it is a common observation in the above-mentioned bay where the water of the creek lies next to the substratum, even well out from the mouth of the creek.

Evermann and Clark acknowledge the greater food content of lakes. They suggest that fertilization is favored in the current of rivers and take no cognizance of the movements of lake water which accomplish the same purpose. Their explanation of the distribution of mussels upon riffles and other parts of a river bed lays emphasis upon the current as the distributional factor. Since lake species tend also to seek out gravelly or sandy beds and few choose soft bottom, the correspondence to river forms is exact. In lakes it is certainly the character of the bottom which is of most importance, and this factor can as readily explain distribution on river bottom. The current has of course produced the form of the bottom, and is thus an indirect factor.

These authors point to the possible reduction of vitality in small lakes through inbreeding—hence less size. They also show that a given lake species reaches its maximum growth only in the more fluviatile lakes. The writer has often noted this inequality between the mussels of the isolated, headwater lakes such as Winona and those of the elongated, fluviatile Oswego and Tippecanoe lakes.

Mussels are by no means unique in the occurrence of the smaller members of a family in smaller bodies of water, the larger members grading in size with the size of the stream or lake. Fishes are notable in this regard.

Movements and Migrations.

Isely ('13) through the checking up of marked mussels arrived at the conclusion that well-grown river forms are virtually sedentary. Evermann and Clark ('17) have often observed the tracks of mussels moving in shallow water. They state that the fixed habit increases with the increase in age and with increased depth. These observations are doubtless true in spite of the seemingly anomalous fact that younger individuals burrow more deeply than the older. The limey crust on the former rarely covers more than the siphon region of the shell, indicating the extent of submergence.

As told above, the writer has checked the movements of Winona Lake species, and finds an inshore or offshore movement corresponding to the stage of the lake water.

Observations on White River in late spring, and after summer freshets, show that sand bars newly exposed after having been submerged for a time, are more or less populated. Furthermore, mussels are stranded sometimes by receding water, and often tracks are seen which show that an effort has been made to reach deeper water.

Mussels upon rather permanent gravelly bars bounded by rock or mud bottom, are much limited in their movements. Shifting channels and shifting sand bars imply a corresponding movement of their population.

During the summer of 1915 the writer marked sixty or more *Lampsilis luteolus*, somewhat after Isely's method, and planted them at several points in the lake. Still others were planted during the following summer. Forty were put in water of three and one-half feet depth in Boys' City Bay, on bottom of marly sand. In the summers of 1916, 1917, 1919, and 1921 systematic efforts to recover these mussels were made. Many others of similar size were found, and many empty shells, but no marked mussels or shells were ever picked up. Others were put out in front of the Biological Station. Only two of these were found subsequently. Three years later one was found that had moved fifty feet from the starting point and had shifted from water of two feet depth to four. The other record was about the same in distance without change in depth, in six years. In six years the latter had increased in length scarcely one-fourth inch.

From the above it is clear that movements do take place. In some cases they are more or less seasonal, and of considerable magnitude deserving to be called migrations.

"Sunken Island" (Fig. 1) consists of several acres at 4-10 feet below the surface, having a sand-marl bottom, and only small areas not covered with Potamogeton. Little evidence of movement of its abundant mussel population is ever seen.

Mussels changed from one habitat to another usually exhibited greater unrest than undisturbed ones. A number were first accustomed to stream conditions, then subjected to the following experiment. They were placed, ten together in a rectangle, two siphoning upstream, two down, and the remaining six transversely to the current, in the mouths of Sugar and Pocahontas creeks. On succeeding days their positions were checked, with especial reference to tropic movements in response to current, depth, obstacles, distance moved, etc. The experiment was repeated many times.

There were 101 identifiable reactions considered, as follows, in those cases in which some movement had occurred:

(1) Remained transverse to current	25 out of 72 possible
(2) Turned transversely to current	5 out of 48 possible
(3) Remained faced downstream, siphoning up	23 out of 24 possible
(4) Turned downstream, to siphon up	23 out of 96 possible
(5) Remained facing upstream, siphoning down	13 out of 24 possible
(6) Turned upstream to siphon down	12 out of 96 possible

There was some tendency to remain transverse to the stream when placed that way originally, but much less tendency to assume a new position in opposition to current. There was a greater tendency to remain siphoning downstream than to turn that way. Of those set to siphon upstream nearly all retained that orientation, and one-fourth of the others assumed it, a much higher proportion than of those which chose to siphon in any other direction. This seems to bear out the tradition that mussels prefer to siphon upstream. Yet I am encouraged to believe that the orientation is as much a reaction to the pressure sense and a desire to reach deeper water, as it is a rheotropic reaction. Almost all the cases under item six took place after rains when the creeks rose; the depth of the water was doubled and the velocity increased. The reaction was more probably due to increased depth than to current. These cases are few but selected, and there were many rejected cases that seemed to point the same way. Yet an *Anodonta* placed in an eddy pool three feet deep did not move until a freshet raised the creek. Then it moved round and round the pool at the same depth, against the current of the eddy, not attempting to get out, and doubtless oriented by the eddy.

The bottom of Sugar Creek consists of much finer sand, gravel, and mud than Pocahontas. Hence the movements of *Lampsilis* were much more frequent and pronounced in the former. This despite the fact that Sugar Creek is cleaner and colder.

Movements were observed also in the outlet of the lake—Walnut Creek. When the dam was raised and the creek lowered most of its mussels sought deeper water, and more or less downstream movement took place. After periods of higher water the direction of movement was more random. Here again the amount of movement was coextensive with the favored bottom.

Obstacles on the bottom divert a mussel from its course. In the lake or in slight current the original course is often not resumed; but in a brisk current the mussel tends to fall back into the same angle with the flow of water regardless of what that angle may have been. Obstacles may include an alternation of sand, gravel, and mud. Driftwood, plant roots, rubble, or stones are the more obvious ones. The concave walls of an aquarium may be followed a little way, but will soon bring the mussel to a halt. Ripple marks upon sandy bottom may be seen to have diverted a mussel more or less shoreward.

The prevalence of mussels upon favored type of bottom is in itself an argument for greater or less migration. Juveniles do not remain where left by their fish hosts at random, but find their way to suitable substratum.

Besides the common lake species there occurred in the outlet not far below the dam the following additional: *Symphynota costata, Quadrula undulata,* and *Lampsilis anodontoides. Quadrula plicata* doubtless occurs; it has been mentioned that one individual has been taken in the lake.

Miscellaneous Observations.

In addition to the production of a shell the Unionidae may constitute a geological agent of a sort not usually recognized. The total amount of water siphoned and the amount of material taken out of suspension are surprising. Both mud and organic matter are separated out and precipitated in mucous clots. An aquarium jar filled with muddy water is cleared entirely in the course of a few hours by a single mussel.

Beneath the posterior end of a mussel which is actively siphoning in a lake the ground may be seen to be carpeted with a conspicuous amber-green slimy coating.

Due to the considerable deposition of marl on the plant grown terrace, through the reduction of the bicarbonates to carbonates in photosynthesis, there is much less lime present in the water of the outlet of Winona Lake. Prof. Scott has determined the carbonate ratio to be about thus: Springs : upper lake : outlet :: 3 : 2 : 1.

The writer compared the total weights and shell weights of 16 *Lampsilis luteolus* from Dickey's Point in the lake with an equal number from Walnut Creek. The results follow:

	From lake	From outlet
Average length	90.8 mm.	87.4 mm.
Average weight	127.0 gm.	107.0 gm.
Average shell weight	69.0 gm.	51.0 gm.
Ratio shell to total weight	54.0%	48.0%

The lake specimens were heavily encrusted with the usual marl deposit, and were cleaned for comparison. The total weights were then taken with the mantle chambers full of water. The number used was small, hence subject to error. The matter will be followed further. So far as the present data go we have a significant difference due to either the lime content of the lake, or to some other factor. This difference in shell weight amounts to six per cent of the total weight of the body, or about twelve per cent of the shell weight itself. Comparative data are not yet available from lakes of greater or less hardness.

Summary.

Headlee and Simonton's survey of Winona Lake, Evermann and Clark's of Maxinkuckee, and Baker's of Oneida show great similarity in the mussel distribution. The first named authors ascribe the limitation of mussel beds in their narrow shore zone to the encroachment of enemies, to wave action, and to the character of the bottom. The writer finds that enemies are of less importance in Winona Lake than formerly, yet the shoreward distribution continues to be held within bounds, that wave action is pertinent chiefly as a stimulus to movement, and that the character of the bottom is probably the most important of all distributional factors.

The present writer agrees with Headlee and Simonton in disregarding sex as a distributional factor, and to some extent age. Pressure incited certain more or less seasonal movements, and light is a stimulus to movement.

Since the time of the foregoing paper on Winona Lake, much has been learned concerning the physical and chemical conditions of that body, the work chiefly of Scott. While the stimuli mentioned are largely responsible for confining the lake mussels to their narrow zone, yet the deeper parts of the lake are much less habitable to freshwater mussels for reasons which were necessarily disregarded in 1903. Due to the thermocline the conditions of temperature and dissolved gases are both unfavorable to mussel life. Furthermore the food supply is principally confined to the epilimnion, which bathes the lake bottom only along the shore.

A set of experiments show that the movements in creeks of mussels transplanted from the lake are due both to pressure and to current, the latter chiefly directive.

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A Study of the Life History and Productivity of Hyalella Knickerbokeri Bate.[1]

Dona Gaylor.

Introduction.

My first work with the arthrostracan crustacean, Hyalella knickerbokeri Bate was in the summer of 1920 at the Indiana University Biological Station at Winona Lake, Indiana, and its study was continued throughout the winter of 1920-1921.

The first problem was to determine, if possible, the contribution made by Hyalella knickerbokeri Bate to the food of higher animals. I soon found I could not get very far in my studies until I had worked out the life cycle of the amphipod in some detail.

Hyalella knickerbokeri is widely distributed. It is found in every state but at widely scattered localities. It is especially abundant in southern Canada, southern Minnesota, northern Iowa, Illinois, and Indiana. Miss Weckel ('11) extends its range to Lake Titicaca, Peru, South America. Its distribution is also discussed by Jackson ('12), Weckel ('07), and Della Valle ('93).

Methods.

Hyalella can be collected easily by washing Chara or other water plants in water contained in a small basin. They were then transferred to other vessels. The moving of individuals was done entirely with a small pipette and when the young were extruded they were transferred to a separate dish from that in which the mother was located, one at a time. It was next to impossible to count them when all together in one dish with the mother, due to the continual movement of all of them. Paired individuals were kept in separate dishes where they could be examined at will. The dishes were numbered and the data for each

[1] Contribution from the Zoölogical Laboratory of Indiana University No. 187.

pair entered under the same number in my notes as was written upon the dish.

I found that Hyalella would feed upon almost any water plant, but seemed to show a preference for certain ones such as Ceratophyllum, Elodea, and Chara. I also observed amphipods of the species feeding upon certain animal tissue, e.g. a dead dragon-fly nymph, a dead isopod, a dead amphipod, etc. Foods of other species of amphipods are discussed in some detail, by Sexton and Mathews ('13), M. Armand Virè ('03), and Della Valle ('93).

Relation of Reproduction to Season.

All the evidence that I have collected points to the fact that Hyalella has a distinct breeding period, limited to the warmer months. For example, when a hundred or so animals were examined during the first of February, not a single female was found with eggs in the brood pouch nor were there any young, present. The same was true when several hundred adults were examined the first of April. At neither time were any individuals observed mating when they were brought to the laboratory, but the second day after they were collected and in a warm room some fifty-odd pairs were isolated, the male carrying the female in the usual manner when preparing for copulation. These animals were collected on April 6, and on April 8 were noticed pairing. This sudden change in so many animals shows conclusively that both sexes were ripe and ready for mating as soon as conditions (which I believe to be temperature) were suitable, but the time for mating was put off as long as conditions were not favorable. All the females, whether mated or not, could be easily distinguished from the males, because the ova could be distinctly seen and approximately counted as they lay in the ovary which is located in the dorsal thoracic region. The testes appeared as a lighter green than the ovaries and are located approximately in the same position in the male as the ovaries are located in the female. The testes, however, were much more elongated, tapering at each end while the ovaries appeared as a cylindrical green patch ending abruptly at each end. The male ducts according to Kunkel ('18) open by papillae on the ventral side of the last thoracic segment. The oviducts each open at the base of the fifth coxal plate so that when the eggs are deposited they are caught in the marsupium which is formed by certain hair-like projections on the ventral side known as oostegites.

Fifty pairs were isolated the day the male began to carry the female. Of these I succeeded in carrying only three pairs through to the second oviposition. These were pairs 6, 9, and IV, Table 1. In two cases there were twenty-four days and in one case twenty-six days between two successive ovipositions. The dates are found in Table 1.

The young (Table 2) hatch about the twenty-first or twenty-second day after oviposition and remain in the brood pouch from 0-3 days when they are extruded at the time the moult of the female occurs in preparation for the next oviposition. The male may begin to carry the female as early as the seventh day before she moults, three or four days before the young are even hatched. The eggs become easily visible about a week before they are laid. Jackson ('12) succeeded in carrying one individual through until the young were hatched. From the twentieth day until the twenty-fifth after ovipositoin he was compelled to be absent. On the twenty-fifth day the young were swimming about in the dish. Then, he says "From these observations we see that the eggs were in the pouch twenty-five days, at least, before they

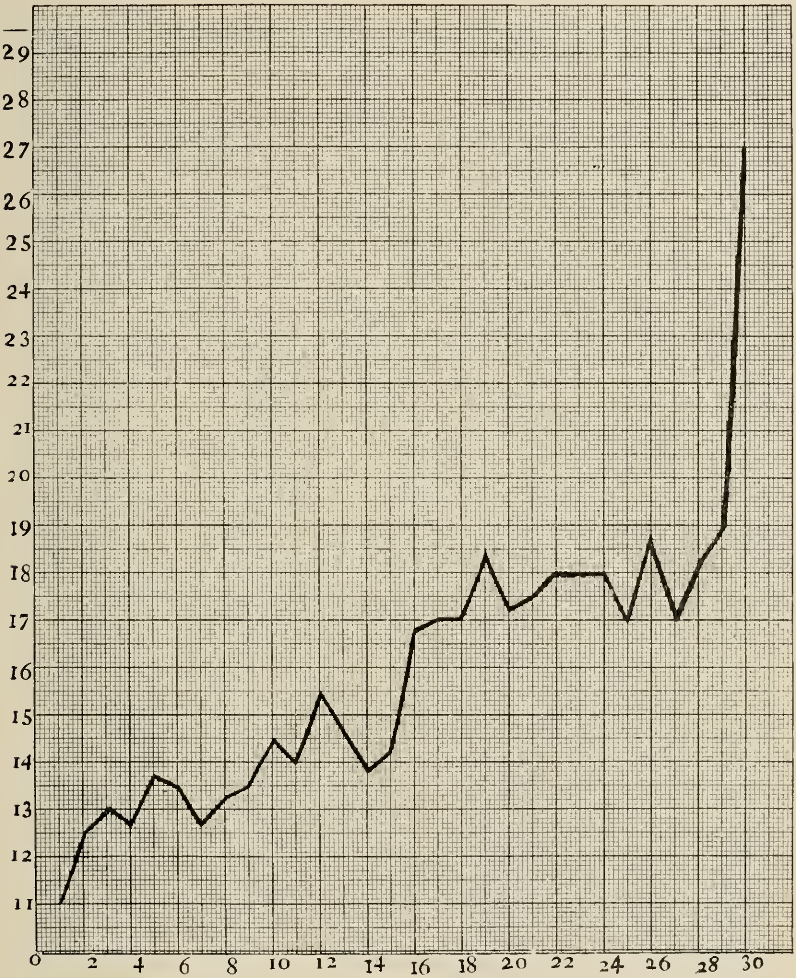

FIGURE 1

Figure 1. The ordinate represents the length of the third joint of the second antenna of the amphipod Hyalella knickerbokeri. The abscissa represents the number in a brood of the amphipods. There is shown a distinct correlation therefore between the age (since any part of an amphipod increases directly with age, the length of any part would represent the age) of an amphipod and the number in a brood.

hatched." I believe my observations and data show clearly that there is an incubation period of about twenty-one days with a brooding period of one to three days after hatching. The twenty-fourth day after the first moult the second oviposition takes place. Therefore, the young cannot be carried more than three days after they hatch for the female moults at that time.

The sequence of events in mating and oviposition is briefly stated as follows: The male carries the female about with him from one to seven days, leaving her when she moults and returning to carry her until

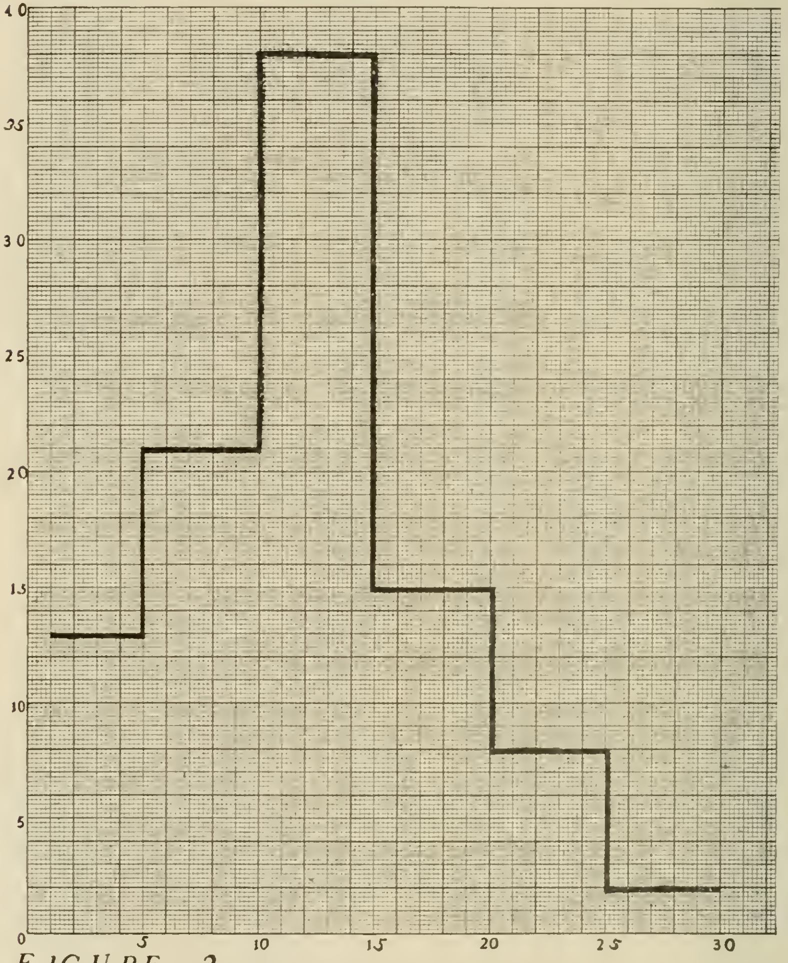

FIGURE 2.

Figure 2. The ordinate represents number of broods. The abscissa represents the number in a brood. This figure represents broods extruded between June 27 and August 14, 1920. Very few animals were breeding at the beginning of the observations recorded here.

copulation takes place which usually occurs during the next twenty-four hours after the female moults. Oviposition then follows copulation directly and the female breaks away from the male's grasp either before or during oviposition.

Seasonal Distribution of Number in Brood.

Preliminary measurements indicated that the third joint of the peduncle of the second antenna is in direct proportion to the length, which in turn has a direct correlation with the age of the animal. I

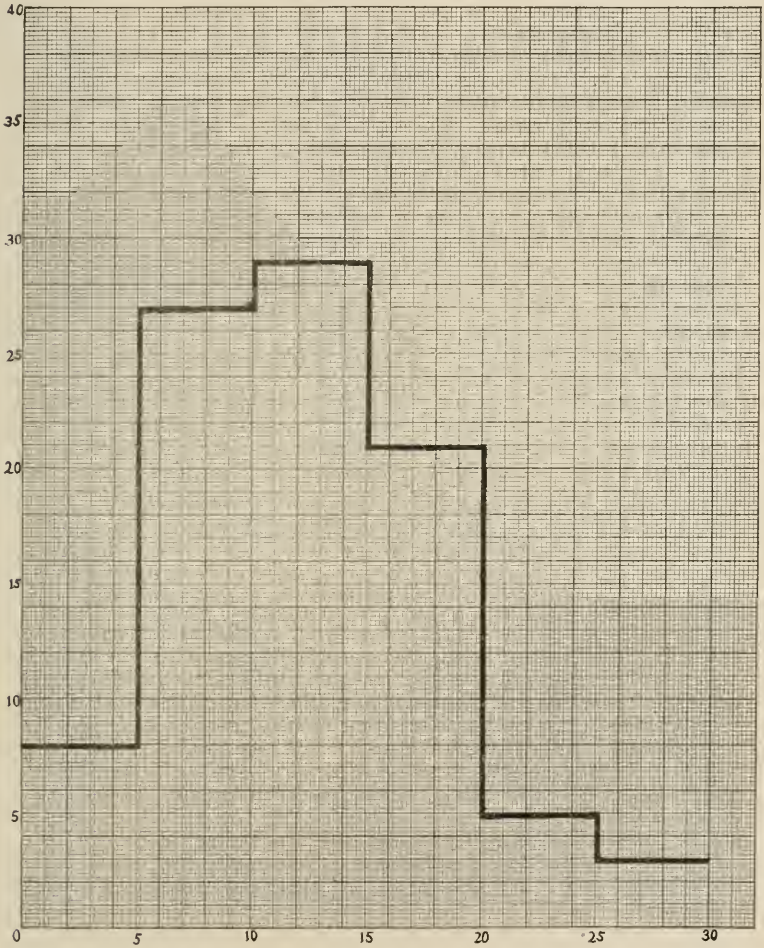

FIGURE 3.

Figure 3. Shows the transition period between time represented in Figure 1 and Figure 4. The time broods were extruded was August 7-14.

measured the aforesaid joints, taking the average length of the joint as the ordinate and the number in a brood as the abscissa, and constructed Figure 1. The figure showed that the number in a brood did increase with the length of the third joint of the peduncle of the second antenna. Therefore, I feel safe in concluding that the number in a brood increases with the age of an animal.

I have not had the good fortune to observe the number of young in two successive broods of the same female. However, Sexton and Mathews ('13) state that in Gammarus chevreuxi, the number of eggs seemed to increase with age, e.g., in the case of one individual the

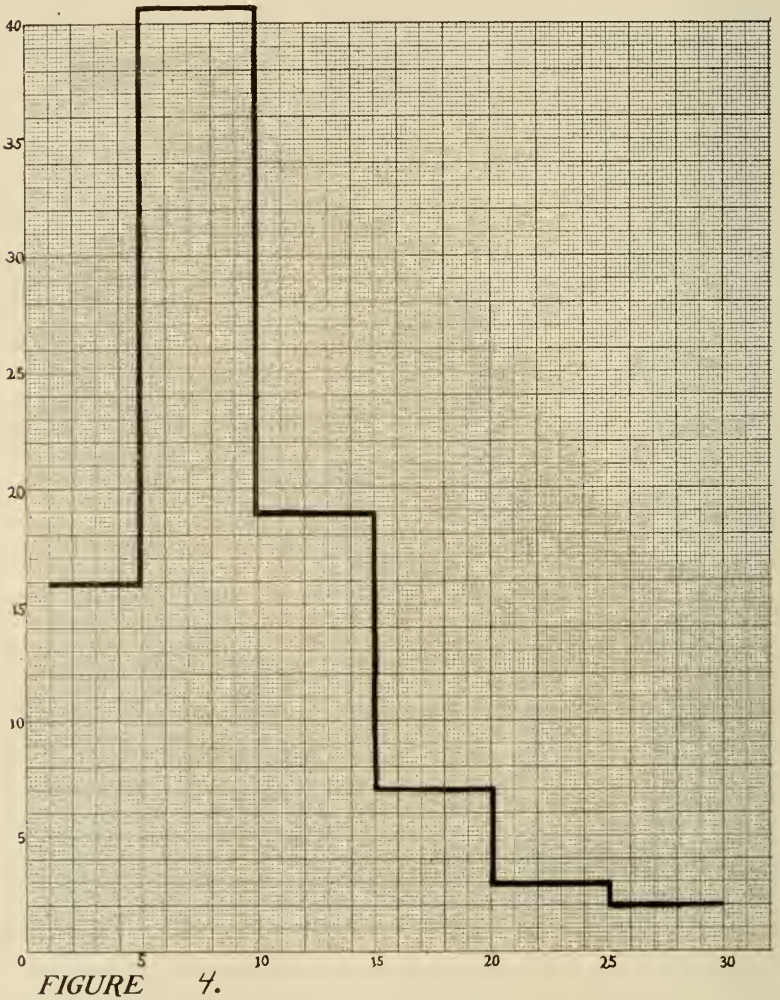

Figure 4. Ordinate and abscissa same as in Figures 2 and 3. Broods extruded between August 16 and September 26.

number of eggs increased from eighteen to forty-four as the age of the animal increased.

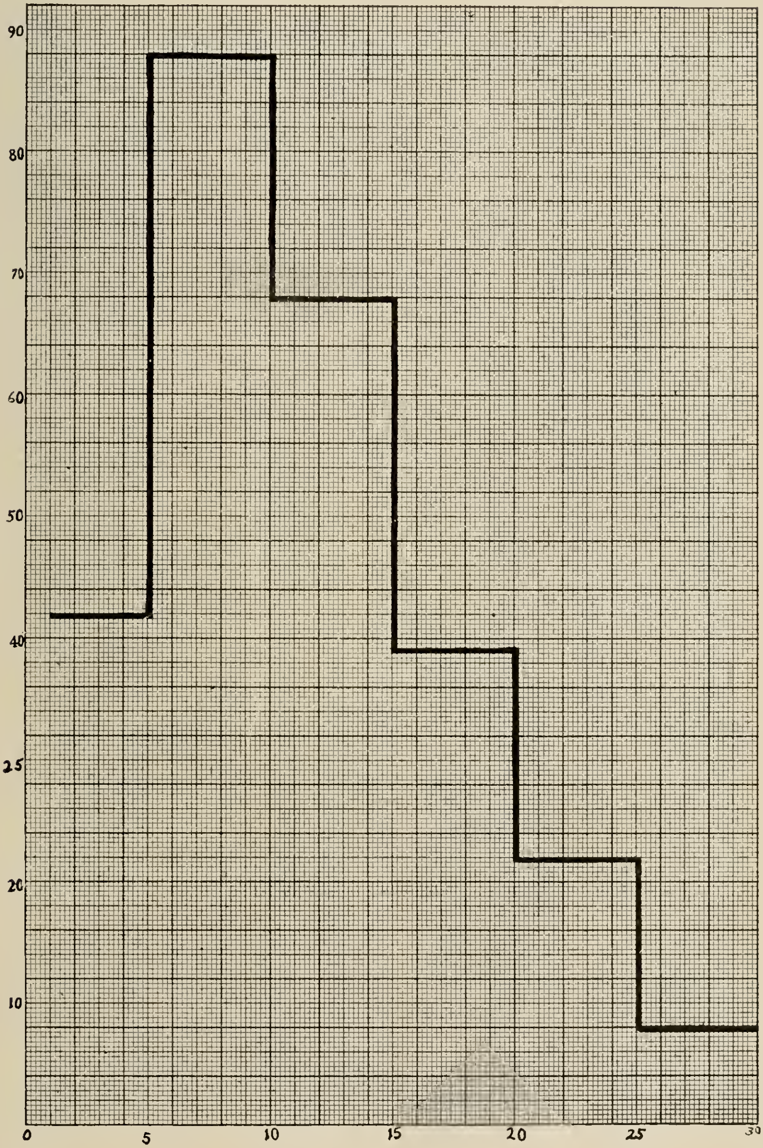

FIGURE 5.

Figure 5. Ordinate and abscissa same as in Figures 2, 3, and 4. Includes all broods extruded between June 27 and September 26, 1920, a total of 293 broods.

The largest number of broods with ten to twelve in a brood occurs early in the season during the last of June to the middle of August (Figure 2), but in the latter part of the season the largest number of broods with five to ten in them are found. (Figure 4.)

Let me suggest that probably the high point of (Figure 2), which represents all those females producing from ten to fifteen in a brood, represents those individuals breeding which were themselves produced the year before. As the season progresses the highest point is changed and the number of individuals producing five to ten reaches the largest number. There is a smaller number in a brood because younger animals are breeding and evidently they themselves were produced early that same season. Summing up then we might say that

1. In the early part of the season there are larger broods, produced as a rule, than during the latter part of the season, therefore

(a) Individuals reproducing in the first part of the season were themselves produced during the previous season and are older than,

(b) Individuals reproducing toward the last of the season which were themselves produced early that same season.

(c) Figure 3 shows the transition stage as occurring during the middle of August. That is, the largest number of broods produced with ten to fifteen in a brood is being reduced both in number and its relative position to the number of broods of five to ten in a brood.

After the females produce from ten to fifteen young in a brood the females seem to gradually die off. (Figure 5.) There could be very few reasons for this.

(a) The females might become barren after reaching a certain age but this is unusual in crustacea and I myself never found it to be true in the hundreds of individuals examined.

(b) Died when a certain age was reached, which is not true as there would be a sudden drop some place in Figure 5 but it is a gradual drop.

(c) The animals might meet with accidents such as being seized and eaten by other animals. This seems to me is the true explanation so that an animal increases in age it has fewer companions its own size and age. Thus an individual seldom, if ever, reaches a size, which in reality represents its age, to produce a brood above the thirty mark.

Additional Observations.

Holmes ('03) in his discussion of sex recognition among amphipods states that the instinct of the males for carrying the females is very strong, and that they cling to them by the first gnathopods even when injured. His point is that the lack of resistance on the part of the female when carried by the male, determines whether she shall be carried by him or not, and not merely her sex. In corroboration of this view I saw a male tugging away at a male who in turn was carrying a female. He pulled and tugged while the two ventral amphipods remained comparatively quiet. If the male carrying the female had not been carrying her, he would not have permitted the other male to carry him, but he clung to his mate in spite of his unusual position.

I had the good fortune to observe the process of copulation several times which was in detail as follows:

On April 15, 1921, I observed a male swimming about with a female which he held in the usual way, but every once in a while, when swimming he braced his pereopods against the dorsal side of the female and then by forcing them backward quickly, produced a short quick jerk of himself but did not seem to effect the female. This he did three or four times, which actions seemed to be a signal for copulation or at least a procedure gone through with before copulation which immediately followed and lasted a period of twenty-five or thirty seconds.

Without changing or releasing his hold of the female with his first gnathopods by which he held her on the dorsal side, he extended the posterior part of his body around the female to her ventral side until his uropods touched the marsupium of the female at its mid-ventral part. He pressed the marsupium with a succession of quick movements with the tips of his uropods, lasting as stated about some twenty-five or thirty seconds. His last thoracic somite just turned past the coxal plates of the female so that the ejected sperm could be quickly swept into the marsupium by the fast moving pereopods of the female. Meanwhile the male did not perceptibly move his pereopods. He next straightened himself into the dorsal position and swam off with the female, but modified the swimming by extending his first gnathopods with which he still clung to the female, pulled the female back as if he were shaking her. He did this several times and the whole process as described above was repeated as many as eleven times. The next morning, April 16, the eggs were deposited in the brood pouch and he no longer swam about with the female. One time I observed a pair copulating while the eggs were passing down the oviduct but usually, as far as I can observe, copulation occurs before the eggs even start down the oviduct.

On April 12, 1921, I observed a male carrying a female which had laid her first egg in the brood pouch. When the second one had passed down she struggled free and from that time 11:12 to 11:52 a. m., a total of forty minutes exactly, she had laid all the eggs. My observations for Hyalella knickerbokeri is the same as Sexton and Mathews ('13) for Gammarus chevreauxi as to the laying of the eggs, for the last one laid was the most posterior and also as they stated an oviduct was clearly seen. I could distinguish it only when the eggs were passing down it.

The ova are of a dark green color and as they left the ovary by means of this small tube, smaller in diameter then the ova, they were pressed out of their usual spherical shape. The eggs passed down both oviducts at the same time. The oviducts were seen to open at the base of the fifth coxal plate.

The incubation period for Hyalella knickerbokeri is, as stated above, about twenty-one days. The eggs remain green for a week or ten days, then turn black. When examined under the binoculars one can see the elongated embryos. About the eighteenth to the twentieth day they become a reddish brown or pinkish and on the twentieth day the red eyes of the embryo can be distinguished very well. Miss Langenbeck ('98) says that the colors of the embryos of Microdentopus gryllotalpa Costa changed color in a similar manner.

The young after hatching may be extruded that same day or any time up to three days later when the mother moults in preparation for the next oviposition.

Hyalella knickerbokeri swims about restlessly until it comes in contact with any object and then crawls into the crevices and between the branches of plants until as much of it is in contact as possible. There it comes to rest. H. T. Jackson ('12) says of this species that, "They may come to rest curled up in the surface film, the surface tension then producing the contact stimulus." This may be easily observed at any time.

Phototropism.

The influence that light has upon Hyalella is quite noticeable. If a number are placed in a glass dish, they collect almost immediately on the side of the dish away from the windows. There are always some leaving the light and swimming to the other parts of the dish but they eventually get back to the side farthest from the light. C. H. Phipps ('15) says, the stimulus of the direction of rays to which the Amphipods react negatively has a stronger effect than the stimulus of light intensity." Thus we see Hyalellae are positively thigmotropic and negatively phototropic.

The average number of Amphipods in a brood is 11.27 out of a total of 3,103 young in 275 broods counted. The maximum number in any brood was thirty young and the largest number of broods occurred with seven in a brood.

Summary and Conclusions.

1. Data collected seems to point to the fact that Hyalellae of northern Indiana have a distinct breeding season during the warmer months of the year.
2. The breeding habits of Hyalella knickerbokeri are similar to other amphipods.
3. The female is carried by the male from one to seven days before copulation occurs.
4. The female moults before oviposition and the period between moults is twenty-four to twenty-six days.
5. Copulation lasts about twenty-five to thirty seconds but is repeated ten to twelve different times at intervals of a few minutes.
6. Oviposition follows copulation in the following twelve to twenty-four hours. There are twenty-four to twenty-six days between ovipositions, therefore there are twenty-four to twenty-six days between broods.
7. The incubation period is about twenty-one days.
8. The young are carried in the brood-pouch from one to three days. Then the female moults in preparation for her next oviposition.
9. Preliminary measurements indicated that the length of the third joint of the peduncle of the second antenna is in direct proportion to the life length.
10. The age of an amphipod is correlated directly with the number of young in a brood.
11. The number in a brood increases as the length of the third joint of the peduncle of the second antenna. (Figure 1.)

12. The number in a brood must increase each successive brood or as the animal increases in age.

13. Hyalellae probably live a second summer, for the largest number of broods occurring with ten to fifteen in a brood was toward the beginning of the season. (Figure 2.)

14. Hyalella knickerbokeri is positively thigmotropic and negatively phototropic.

15. The average number of young in a brood was 11.27 individuals.

16. The largest number of broods produced were produced with seven in a brood.

17. The maximum number in any brood counted was thirty young.

18. The total number of young counted was 3,103.

19. The total number of broods observed was 275.

Acknowledgment.

I undertook the studies recorded in this paper at the suggestion of Dr. Will Scott. It is due to his help that it is now completed.

State Normal School, Terre Haute, Indiana.

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TABLE I.

Number of Pair	Date ♂ began to carry ♀	Date ♀ moulted	Date ♂ carried after moult of ♀	Date eggs were deposited	Date young were hatched	Date young were extruded	Date ♀ was again carried by ♂	Date of second moult	Date of 2nd time carried after moult	Date of second oviposition
Pair 1	April 8	April 9	?	April 10	May 1	May 1	April 24			
Pair 2	April 8	April 11	April 11	April 12	May 2 or 3	May 5				
Pair 3	April 8	April 9	April 9	April 10	May 2	May 4–7				
Pair 4	April 8	April 13	?	April 13	May ?	May 6				
Pair 5	April 8	April 10	?	April 11	April 3?	May 4 & 5				
Pair 6	April 8	April 10	?	April 10	May 1	May 4	April 29	May 5		May 6
Pair 7	Aptil 8	April 10	?	April 10	May 3 6	May 6				
Pair 8	April 8	April 9	?	April 9	April 30	May 1				
Pair 9	April 8	April 12	?	April 13	May 1	May 6	April 29	May 6	May 6	May 7
Pair 10	April 8	April 12	?	April 13	May 3					
Pair 11	April 8	April 13	?	April 13	?	May 4 & 5				
Pair 12	April 8	April 9	?	April 10						
Pair 13	April 8	April 12	April 12	April 13						
Pair 14	April 8	April 10	April 10	April 11						
Pair 15	April 8	April 13	?	April 13		May 6	April			
Pair I	April 7	April 8		April 9	April 29	April 29				
Pair II.	April 7	April 11		April 12	May 2					
Pair III.	April 7	April 10		April 11	May 2-3					
Pair IV.	April 7	April 8		April 9		April 30	April 27	May 2	May 2	May 3
Pair V.	April 7									
Pair VI.	April 7	April 9		April 10						
Pair VII.	April 7	April 10		April 11						
Pair VIII.	April 7	April 9								
Pair IX.	April 7	April 10		April 12						
Pair X.	April 7	April 13		April 13						
Pair XI.	April 7									
Pair XII.	April 7	April 9		April 9						
Pair XIII.	April 7	April 11		April 12	May 2					
Pair XIV.	April 7	April 10								
Pair XV.	April 7	April 11		April 11	May 2	May 4				

An Indiana Insect Survey.

John J. Davis.

The scientific and economic value of a survey of the insect fauna of Indiana and the need of such a survey has been emphasized to the writer for several years, so much so, in fact, that plans were drawn up three or four years ago, the initial steps being taken before I became connected with Purdue University. These plans, made before learning of the Biological Survey Committee of this Academy, seem to be appropriate at the present time and will, I believe, fit in conveniently with the plans of this committee.

Briefly, the object of such a survey would be to explore, exploit, record, map, collect and study the insect fauna of Indiana; to determine the occurrence and range of all insects of the state and to study their relation to plants, animals, human welfare, etc. Such a survey would include a study of the relation of insects to changing conditions, that is, swamp areas being reclaimed by drainage, peat bogs, sand areas, and the like, being put under cultivation for the first time, etc. It would also include studies of the small lake areas, caves, and similar places. In this connection it is planned to build up a working collection of insects representative of the state and of surrounding states and in time it is hoped that collections of insects, illustrating systematic, economic, biologic and ecologic groups, can be prepared for distribution to high schools and other public institutions.

No very definite method of procedure has been formulated. Indiana is very fortunate in having had a number of the country's best entomologists. Thomas Say, the father of American entomology, described and studied many species from Indiana during his residence at New Harmony, 1826 to 1834. One of the country's best known economic entomologists, Francis Marian Webster, carried on his early work in Indiana. The lasting influence of Webster's work on the agriculture of the state has been impressed upon the writer and more than one farmer of the older group has told me of the work which Webster did on his particular farm. More recent is the work of W. S. Blatchley and E. B. Williamson, both systematists without a peer. Blatchley's monumental works on the Classification of Coleoptera and Orthoptera are recognized standards as are also Williamson's equally classical Odonata studies. Besides Blatchley and Williamson, Indiana has other entomologists, nationally recognized as authorities in their groups, including H. F. Dietz and H. C. Kinsey, authorities on the Coccidae and Cynipidae, respectively, H. E. Enders and E. J. Kohl who have specialized on the biting lice (Mallophaga), W. H. Larrimer on the Jassidae, H. J. Painter on the Orthoptera, and the writer has studied the Scarabaeidae and Aphididae.

Necessarily an insect survey of this nature requires a division of work and it was planned to appoint honorary curators for the different groups or orders, to serve without pay, who would co-operate in collecting, determining, monographing and in other ways assist in the plans. Where possible, residents of Indiana would be responsible for the work, but in some groups it would be necessary to look to others for co-operation in the systematic studies. Probably the Myriopoda and Arachnida should be included in the insect survey plans since they are usually treated with the insects and by entomologists.

Probably three card indexes should be maintained, as follows:

I. Index of the previous references in literature, arranged systematically.

II. Index of the collection records, (a) the insect index arranged systematically and (b) a host index referring to the species in the insect index (a); arranged alphabetically.

III. Index based on the economic, biologic, and ecologic records and arranged systematically.

All three indexes are in use by the writer at the present time and many records have been accumulated.

The uses and values of an insect survey for Indiana are innumerable but a few might be noted at this time.

Aside from the purely scientific value of such a survey and collection, this work will be of direct use in handling economic problems and in this connection we will enumerate as follows:

1. Prevents errors and facilitates accurate identification. We will not be safe from serious errors in our work with economic insects until we know far more of our insect fauna than we know now.

2. We will be able to define with considerable accuracy the "Life Zones". Thus the Insect Survey work will show the regions where watch must be kept or measures applied and will avoid waste of attention and effort in regions where the problem is not of importance.

3. In the case of sudden outbreaks of insects not previously known to be destructive, our Insect Survey will furnish data to enable immediate action and will furnish a basis upon which to proceed with our studies and for information to the public.

4. Insects are continually changing habits and where a previous knowledge of the insect has been available it has proven of greatest value in such cases. A few examples are: The strawberry root worm attacking strawberry plants but doing very little damage has, in the past few years, become one of the worst pests of roses in greenhouses; certain snout beetles of the genus *Lixus* which have heretofore been known to attack only wild dock are becoming a pest of corn in the swamp areas now being drained in Greene County; the greenhouse leaf roller was once only known to attack weeds but now is a common pest of celery and other garden vegetables as well as numerous greenhouse crops; the rose leaf-roller was little known when it attacked wild cherry but now it is a pest of rose; the quince curculio attacked only haws before the advant of the quince; a common tree hopper until recently was to be found only on wild plants but now it is generally common on several important ornamentals; and a host of other examples could be cited and additional ones are certain to come to us every year.

5. Biology teachers draw on the insects as an inexhaustible source for their classwork and the survey will undoubtedly become a valuable asset to the teaching of biology in the state. The educational value of a survey, such as planned, is beyond estimation.

A survey as planned is a gradual development but a start has been made and it is hoped this paper will stimulate the organization of an insect survey for Indiana. The insect collection at Purdue University is essentially a collection purchased from T. B. Ashton of Kansas some thirty years ago and is especially rich in Coleoptera, containing many rare and new species. The collection is being transferred from old wooden boxes to up-to-date Schmitt boxes and the various groups are being submitted to specialists for correct classification as rapidly as possible. The card indexes previously mentioned have already been started. The entomologists of the state have co-operated in furnishing specimens and data. An exceptionally fine set of Odonata has been placed in the collection by E. B. Williamson, many specimens of Coleoptera and Hemiptera have been furnished by Doctor Blatchley, a series of Crambidae have been donated by Geo. G. Ainslie of the U. S. Entomological Laboratory, Knoxville, Tenn., specimens of Jassidae by W. H. Larrimer, a valuable collection of Coccidae by Harry F. Dietz and the writer has included his own collection of Scarabaeidae and several thousand slides of Aphididae.

Thus a start at least has been made towards studying the insect fauna of Indiana and we wish to take this opportunity to urge all members of the Academy interested in the work to offer suggestions and to co-operate in making the Indiana Insect Survey the best in the United States.

Purdue University.

A National Insect Pest Survey and Its Relation to Indiana.

John J. Davis.

At the last annual meeting of the American Association of Economic Entomologists, it was recommended that a National Insect Pest Survey be organized under the direction of the Bureau of Entomology, U. S. Department of Agriculture, in co-operation with the official entomologists of the various states. Such a survey was intended to ascertain the extent of injuries caused by various insects, and their distribution, and to keep the entomologists throughout the country apprized of developments during the growing season, since such information would undoubtedly prove of greatest value in forecasting probable insect troubles, and would aid in the early recognition of recent insect introductions and newly established pests.

In response to the suggestion of the American Association of Economic Entomologists, Dr. L. O. Howard, Chief of the Federal Bureau of Entomology, organized an Insect Pest Survey under the direction of Mr. J. A. Hyslop. The objects of this survey as outlined by Dr. Howard include collecting and disseminating information on the status of insect pests throughout the country including both native and foreign pests; to give information on the first appearance of migratory pests so that possible precautionary methods can be taken; to accumulate information on fall and winter stages of such pests as a basis for forecasts; and to prepare reports and careful estimates of damage occasioned by insect pests.

The plan of organization involves for the Federal Bureau the general supervision of the work and issuing information in the form of monthly and special reports, as well as annual reports which will include a summary of seasonal geographic ecologic maps correlated with weather and abundance, tables of damage estimates, etc. A state collaborator or insect pest reporter has been designated for each state and he in turn works in co-operation with other entomological agencies of the state. The state collaborators are expected to submit reports to the Bureau of Entomology regularly each month so that the data are received at the Washingon office no later than the 20th of the month. The information received from all the states is then compiled and published the first of each month under the title of "The Insect Pest Survey Bulletin." The information needed for these reports includes name of insect, the crop or crops attacked, the seriousness of the infestation, whether or not it is wide spread or local, the per cent of damage, other pertinent facts regarding the situation, the success or value of controls which may have been put into practice and name of observer. The importance of this survey to the people of the State of Indiana cannot be overestimated. The entomologist by carefully studying these reports from month to month, is soon able to determine in a general way the factor causing this or that insect outbreak; he is able to generalize and secure information which oftentimes is of greatest assistance in future years and above all he is able to follow the northern march of such serious migratory pests as the army worm and frequently to forecast the possibility of troubles which by timeliness and foresight may be easily overcome. The success of this pest survey is not with the Federal Bureau of Entomology nor is it dependent on the individual co-operation of the various state insect pest reporters, but upon the thorough co-operation of all entomological forces and others interested within the state. The speaker has been appointed state insect pest reporter for Indiana and takes this opportunity of requesting the co-operation of every member of this Academy in submitting information on all insect troubles.

During the past season we have had the earnest support of Mr. Harry F. Dietz of the State Conservation Commission. Any others in the state who care to co-operate in this work are requested to advise us. They will be furnished with data sheets and franked envelopes so that no expense in collecting or sending in the information will be involved.

Purdue University.

Reactions to Light and Photo-Receptors of Annelida.

Walter N. Hess.

As one surveys the more important groups of Annelida, he at once discovers that these groups differ considerably from one another in their possession of eyes or other cells which function as photo-receptors. Although this paper will refer briefly to *Nereis virens* as representative of the Polychaeta, and to *Glossiphonia parasitica*, one of the Hirudinea, it will be chiefly confined to a discussion of our common member of the Oligochaeta, *Lumbricus terrestris*.

Nereis virens, as is well known, possesses two pairs of eyes on its prostomium. If the worms of this species are exposed to lateral illumination, from either the right or left side, they react negatively and orientate readily in a negative direction. If the eyes of a normal specimen are removed from one side with a sharp scalpel it no longer reacts as before, but produces "circus movements" in that it turns chiefly away from the side possessing the functional eyes. With all four eyes removed no reactions to light are apparent. From these experiments we feel warranted in stating that the cells which function in photo-reception in *Nereis virens* are definitely localized, and are probably found nowhere else except in its four eyes.

Our common leeches, such as *Glossiphonia parasitica*, possess several paired segmental eyes which function as photo-receptors in a similar manner as the eyes of *Nereis*. Here the eyes are more numerous and are more widely distributed, however, than in *Nereis*.

Our common earthworm, *Lumbricus terrestris*, possesses no perceptible eyes, yet it responds readily to the effects of light stimulation. Normal worms of this species, when exposed to light of ordinary intensities readily move away from the source of illumination, and orientate very definitely in a negative direction. These same worms, which are negative to light of ordinary intensities, become positive, in keeping with their nocturnal habits, when the light is greatly diminished. If the brain of a normal earthworm is removed by a dorsal incision, or by the removal of the first three anterior segments, the worm no longer reacts negatively to ordinary illumination, but it becomes strongly positive, and if six, or even more of the anterior segments are removed, they are still positive. There is a brief period, however, of only a few seconds' duration when first exposed to light that these worms give negative reactions. In each case they quickly adapt themselves to the light and become positive. Similar results were obtained with *Allolobophora foetida* with as many as forty anterior segments removed. These results show that the brain of the earthworm is not necessary for reaction to light and orientation. They, however, indicate that earthworms are more sensitive to light when the brain and the photo-receptors at the anterior end are functional, than they are when these are not functional. This accounts for the fact that, while normal worms are photo positive only in very weak light, specimens with the brain removed are positive in strong light.

The experiments referred to above also prove conclusively that the earthworm possesses cells which react to light, and that these cells are not limited in their distribution to the anterior end. In fact, experiments show that the worm is sensitive to light over its entire body, the anterior end being most sensitive, the posterior end next in sensitiveness and the middle region of the body least sensitive of all.

These, and other experiments which were performed, seem to indicate that the Annelids as a group are negative in their reactions and orientations to ordinary light; that those forms which possess definite eyes seem to have the cells which function as photo-receptors localized in these eyes, while those worms that do not have perceptible eyes possess cells which function as photo-receptors that may be distributed more or less over the entire body. Some of the annelids, at least, which are negative to ordinary illumination are positive to very weak light, and if the brain and the anterior photo-receptors are destroyed these worms also become positive to strong light.

DePauw University.

A High Fecundity Record for Drosophila Melanogaster.

Roscoe R. Hyde.

Three females of the species Drosophila melanogaster have been encountered in my experiments with this fly that have made exceptionally high egg laying records. This fly as I have previously shown lives on an average of about forty days and during this period the average female deposits about 500 eggs. The fecundity record by days of the three flies in question is given in table I. The females were mated and kept in separate bottles to which a small amount of well fermented banana was added. Each day the banana was removed and a new lot added. The banana served for food and also as a trap for the collection of eggs. The eggs were counted with the aid of a small hand lens and dissecting scope. In this way I have observed the egg laying capacities of hundreds of these flies and the three listed are so exceptional that their performance is here recorded.

Number 8, the most productive fly laid 2,184 eggs. She emerged from the puparium on November 28, 1912, and was mated on the following day. Her egg laying record begins December 1 and continues until

TABLE I.

Fecundity record of three exceptional females of Drosophila melanogaster.

Number of ♀	Dec. 1912			Jan. 1913			Feb. 1913		
	8	9	13	8	9	13	8	9	13
1	25	25	30	23	33	38	32	30	15
2	30	26	21	25	22	37	15	9	10
3	27	17	51	35	48	43	16	22	15
4	23	18	6	32	8	22	22	20	14
5	25	35	23	17	22	12	21	6	13
6	25	33	25	25	30	30	17	3	10
7	21	17	7	29	10	19	26	20	10
8	12	30	42	31	18	31	21	2	7
9	26	28	20	8	10	6	29	9	15
10	20	34	40	18	23	20	24	8	4
11	31	26	21	19	0	0	23	D	5
12	43	45	40	43	35	25	28		10
13	27	39	31	40	25	23	17		4
14	24	29	31	29	35	30	19		7
15	34	28	27	19	13	16	19		6
16	50	2	39	21	18	7	17		6
17	46	28	45	47	37	30	12		3
18	30	29	40	21	13	10	6		2
19	53	50	43	31	21	32	9		1
20	58	53	42	28	22	28	5		2
21	22	1	53	40	36	21	8		4
22	5	30	20	23	36	23	5		2
23	36	25	24	30	30	26	0		2
24	45	17	30	14	19	24	0		
25	25	35	35	27	8	9	0		
26	28	22	35	32	19	20	D		
27	30	10	28	41	21	24			
28	35	15	25	35	33	15			
29	27	18	36	24	16	18			
30	30	18	31	13	10	16			
31	60	30	39						
Total number of eggs laid							2,184	1,613	1,807

February 26, 1913, when she became very feeble and was accidentally killed.

Attention is called to the fact that this fly often produced her weight in eggs during the course of 24 hours, and throughout her life she averaged her own weight in eggs every two days. The calculations are based on the following data:

(1) Determination of the weight of the egg of Drosophila before and after drying. A number of eggs were carefully picked with a needle from a mass culture and weighed. They were dried at 37° C for four days and again weighed. The weights are recorded in table 2. The average weight of the egg before drying is 0.0180 milligrams and after drying 0.0111 milligrams.

TABLE II.

This table gives the weight in milligrams of eggs of Drosophila melanogaster, before and after drying.

1919	No. of eggs	Weight before drying	Weight after drying at 37° C for 4 days.
Dec.			
5	100	2.0	....
6	100	2.3	1.5
18	112	2.5	1.7
19	100	1.3	0.6
21	110	1.3	0.9
Total ...	522	9.4	4.7
Average weight		0.0180	0.0111

(2) Determinations made for 204 newly emerged females gave an average weight before drying of 1.2436 milligrams, after drying at 37° C for five days the average weight per fly was 0.305 milligrams. The average weight of 128 newly emerged males, 1.0601 milligrams; after etherization and drying for five days at 37° C, their average weight was 0.300 milligrams. The flies of this species vary greatly in size, depending upon cultural conditions. The determinations are here made for animals of average size.

When one computes the total weight of the 2,184 eggs laid by female number 8 in terms of the average weights of eggs and females here found it is demonstrated that this fly laid 32 times her weight in eggs. If account is taken of the dry weight of the fly and the dry weight of the egg then she laid approximately 80 times her weight in eggs. This is a striking physiological performance.

The fecundity record is apparently not modified as a result of fertilization for the unfertilized female lays eggs regularly and in large numbers. However, when the flies are kept in large numbers in the same bottle the females do not lay as many eggs on the average as when kept separately, despite the fact that on the average a larger egg laying surface may be exposed for each fly in the crowded culture.

Johns Hopkins University.

Army Worm Control Through County Organization.*

W. H. Larrimer.

A very general outbreak of the true army worm, *Cirphis Unipuncta*, Haw., occurred throughout the Central United States during the late spring and early summer of 1919. Since the distribution and general facts concerning this outbreak have already been recorded, it is intended to select a typical county where the infestation was most severe and cite it as an example of complete control of this pest through the co-operation of county farm organization.

As a matter of convenience, Henry County, Indiana, will be taken as an example, though any one of a dozen or more equally infested sections might be selected. Here the army worms appeared suddenly, as is their custom, in the timothy, rye, and wheat fields throughout the whole northern portion of the county. Many farmers were immediately in trouble and as is their custom in such a case, they began to make life miserable for the County Agent who, in turn, sent out an S. O. S. to every possible source for information and assistance in combating the pest. In response thereto the writer arrived at Newcastle, the county seat, at 10 a. m., June 18. Very few welcomes can equal that accorded to a Bug Man by a county agent who is besieged by farmers, who in turn, are besieged by army worms.

A very hurried survey of the situation was made. Owing to many of the reports and superstitions regarding the habits of the pest, the whole population, both of county and towns was verging on a panic. The idea prevailed that the worms were traveling south from the north end of the county and were eating every green thing and that nothing could stop them until frost had put an end to their depredations. Many infested fields of grain had been burned on the supposition that this was the only way the worms could be destroyed. Many barrels of gasoline had been wasted in not only useless but destructive fires of this nature. Furrows had been plowed through the center of grain and hay fields as well as around them, for no particular reason other than to stop the supposed general southward march of the worms.

One farmer said that he singled out a worm and followed it while it traveled three miles in one night. A poor woman, with tears running down her cheeks, anxiously inquired if something could not be done to prevent the worms from entering her house and eating up her carpets. The mayor of one town, was reported to have prepared a proclamation, declaring stores and factories closed and requested that the entire population be released to join forces with the farmers in combating the pest.

A short trip through the infested section revealed the fact that there was nothing unusual about this outbreak. The most heavily infested fields were plainly indicated by a group of farmers engaged in

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digging trenches. Several groups of from fifty to one hundred of these men were assembled, and the facts regarding the habits of the pest were imparted and control measures recommended. The most remarkable and outstanding feature of the situation was the near-panic caused by the absolute lack of any reliable knowledge whatever concerning a pest with which practically every entomologist is familiar. After a hurried conference with the county agent, a definite plan of action was formulated. Obviously the first thing to be done was to allay the popular fear due to the exaggeration of the threatened danger, and next, to organize the community for a definite plan of control, based on methods known to be effective. The mayor was advised that his proclamation need not be published. When it came to organization, the county agent was in his element. Through the Secretary of the Farm Bureau, a general call was sent out asking for representatives from every township in the county. The line call was sounded on the country telephones and a whole line was given the information at once. Each township chairman designated the representatives for his township to report at the Court House immediately. As soon as they arrived, a mass meeting of several hundred farmers was held. Any available hall being too small to accommodate half the crowd, the writer stood on a large boulder in the Court House yard and looked down on a most painfully attentive audience. A few brief facts concerning the life history and habits of the pest were given, emphasis being put upon the fact that practically all of the worms would disappear into the ground in less than a week and that an army worm never traveled any great distance as a worm. Assurance was given that the control measures recommended, namely, the combination of dust furrows and poison bran mash, had been frequently demonstrated and found to be thoroughly effective. Instructions for the construction of the dust furrow barriers and the preparation and application of the bran mash were given in detail. The recommended dust furrow barrier is made as follows: Throw a furrow with a plow toward the oncoming worms. Dress up with a shovel the straight side, which is toward the protected crop, so that a small bank of loose soil or dust comes flush with the top of this straight side. At frequent intervals, say 12 to 15 feet, dig shallow post holes in the bottom of the furrows. The worms coming into the furrow, try again and again to climb out over the straight side. They can easily climb the hard straight side until they reach the loose soil or dust which gives way under them and back they fall. After several vain attempts they crawl along the furrows until they drop into the holes where they can be killed by oil, burning, or merely mashed with a suitable chunk of wood. If left to themselves, very few caterpillars either in the furrows or the post holes, survive the hot sunshine of the next day. The standard bran mash was recommended to be applied wherever the worms were present and the crop was such that they were capable of causing further injury.

As to organization, under the leadershp of their chairman, the farmers of each township were to work as a unit, concentrating their efforts on the worst infested farms first. In case a township in the more heavily infested portion of the county needed help, the chairman was to report his needs to the county agent, who could then furnish assistance from a township where the infestation was light. The farmers went to work on this simple plan.

Very few additional furrows needed to be made since by connecting those that had already been made at random and shaping them into an effective barrier was all that was necessary. The crop most seriously endangered was corn and where a portion of the field was infested, it was separated from the uninfested portion by a furrow and the poison mash used in preventing further injury.

A trip through the infested sections about sundown showed groups of farmers busily at work on a definite plan. Confidence in their method of protection had now almost entirely replaced the excitement of the forenoon. Now and then a group could be observed very much interested in watching the worms in vain efforts to cross the dust furrow. They would breathlessly watch a poor worm laboriously climb the straight edge of the furrow and as it reached the loose soil at the top and fell sprawling back again, a whoop of glee would burst forth from the watchers. Late that night many a farmer went home to his first sleep in three days.

The next day each farmer repaired his furrows and eagerly examined the results of poison bran mash put out the night before. Favorable reports came in from everywhere. On one particular farm where the farmer made and applied the mash as directed, absolutely no further injury to his corn occurred, while a small area which his slightly skeptical mind caused him to leave as a check, was totally destroyed.

The county agent now had the situation well in hand and professional assistance was in demand elsewhere. His final report came a week later, and being quite typical, is quoted as follows: "All you said has come true."

U. S. Bureau of Entomology, West Lafayette, Indiana.

A Preliminary Report on Hog Lung-Worms.

George Zebrowski.

The work covered in this report comprised a series of experiments on the habits and life history of the common hog lung-worms, Metastrongylus apri and Metastrongylus brevivaginatus. This work is still being continued, and its object is three-fold: first, to determine the morphology and habits of these parasites; second, the life history; third, to discover if possible, some practical means of control. The first two points are mainly covered in this report. The third point, and parts of the life cycle are yet to be completed. These experiments are submitted at this time with the hope, that being largely original, they may prove of value to other workers in this field.

The above parasites are of common occurrence in the lungs of Indiana hogs. By different investigators, these same species have been reported from every country where hogs are kept, hence, there is little doubt as to their world-wide distribution. Until recently little work has been done with these worms, especially as regards their habits and life history. Belief is still current that they are of minor economic importance, due no doubt, to their small size and general prevalance. However, it was observed, in the examination of several hundred lungs, that the number and extent of pathogenic lesions varied directly with the number of these parasites present. The very consistent results in this respect, led to the inevitable conclusion that these parasites must be considered of much greater importance in swine economy, than has hitherto been the case.

In the literature on this subject many conflicting terms are used to designate these parasites. Thus Strongylus paradoxus, and Strongylus apri, are two of a number of synonyms for Metastrongylus apri. This form is also confused with another species of common occurrence, namely, Metastrongylus brevivaginatus. In Indiana hogs these species occur in approximately equal number. The chief characteristics by which they can be distinguished are the bursa and spicules of the males. In M. apri, the bursa is bilobate and each lobe is sustained by five costae. The two spicules are very long and slender, and each terminates in a single barb. In M. brevivaginatus, the bursa is less campanulate, and each spicule terminates in two hooks. These spicules are much shorter, averaging only 1.25 mm. in length. The body of this species is also longer and stouter than is the case in M. apri. In these experiments M. apri is chiefly considered, although, in general, such conclusions as are drawn can apply to both species.

The most recent classification ascribed to these parasites is the following:

1. Phylum; Nemathelminthes.
2. Class; Nematoda.
3. Family; Strongylidae.

4. Sub-family; Metastrongylidae.
5. Genus; Metastrongylus.
6. Species; M. apri.
7. M. brevivaginatus.

Description.

M. apri: Cylindrical, unsegmented worms; body long and slender; buccal capsule absent or slightly developed; mouth with six lips; dorsal and externodorsal rays slender, the other thick; postero-lateral ray reduced or absent; females often show a dark hair line throughout their length; cuticle transversely striate. Male: 12 to 17 mm., average length, 16 mm.; spicules very long (about 4 mm.), and each terminates in a single barb; bursa deeply bilobate, opens laterally; five costae in each lobe; spicules segmented, cylindrical, capable of being coiled up within the bursa or of being withdrawn into the body cavity; dark brown, reticular tubes of chitin; fleshy portion consists of a membrane which is attached by a bulb like expansion to the seminal vesicle. Female: 2 to 4 cm.; vagina about 2 mm. in length; vulva close to anus, and on a slight eminence in front of it. Eggs contain living embryos coiled within them, and range in length from .05 mm. to .08 mm. The width averages .02 mm. less than the length; tail of female terminates in a short horn-like process; embryos when liberated measure .22 to .25 mm. in length, and .01 to .012 mm. in thickness.

M. brevivaginatus: The same general description applies to this species as to M. apri. Male: 15 to 20 mm. long; spicules 1 to 1.5 mm. long; body and bursa larger, stouter and more conspicuous, than in preceding. Females: 3 to 5 cm. long; eggs .07 to .10 mm. long and .05 to .08 mm. wide; larvae somewhat larger than those of M. apri.

Morphology.

When viewed under a low power objective, the structure of these parasites is found to be relatively simple. In both sexes there is a dark, well defined, digestive tract traversing the entire length of the individual. This tract communicates with the mouth by means of a muscular, conoid esophagus, and terminates in a ventral anus near the posterior end of the body. Worms that are full grown show the body cavity to be almost completely filled with enlarged and convoluted reproductive organs. These, together with the alimentary tract, so completely fill the body cavity that there remain only here and there small irregular spaces. In the female the oviduct becomes continuous with the uterus, a short distance behind the esophagus. It then pursues a course parallel to the intestine, until it terminates in the vulva on a slight prominence in front of the anus. The reproductive organs of the male consist likewise of a single tube. However, this tube is not bent upon itself, as is the case in the female, but is single and tapering, and constricts to form the testicles and the seminal vesicle. To the terminus of this last are attached the two spicules, which function in copulation. The body of the female terminates in a blunt horn-like projection, that of the male in a rather complicated, membranous, clasping apparatus. During copulation the male grasps the female with this structure, and impregnates her by inserting the spicules already mentioned, into any region of her body, so that they penetrate to the uterus. Here the sperms are discharged and fertilization takes place.

The females are viviparous and produce hundreds of young. Within the uterus the eggs may be found in all stages of development. This development becomes more and more complete as the eggs approach the oviduct, till finally, when this last is reached, full grown, active larvae may be seen coiled within the egg capsules. The eggs are oval in shape and possessed of at least two membranes. On the outside there is a thick envelope of a gelatinous nature, which is very sticky, and which adheres readily to whatever surface it touches. Around the body of the embryo there is another thin, protective membrane, within which the embryo may often be found intact, even after the removal of the outer gelatinous coat. The thin, transparent, membranes which surround these eggs, together with their ease of procurement, should make them ideal for the study of karyokineses, and kindred biological investigations.

The body wall of these parasites shows many peculiarities. Enclosing the body contents is a transversely striated, muscular layer, somewhat thickened at the two extremities. In the male, well defined, oblique striations occur in the region of the bursa. The costae which support the bursal membrane are projections of this same muscle layer. On the outside there are several layers of very thin cornein, which are transparent and easily permeable to gases and liquids. When an adult specimen is placed in distilled water, the following changes may be observed: In a few minutes the outer layer of cornein separates from the muscle layer in blister-like swellings all over the body. These blisters are very transparent and easily overlooked. When touched with a needle, they at once collapsed, showing that they are formed of a membrane which encloses a fluid of high osmotic pressure. As this interchange of liquids continues, the specimen grows tense and turgid, until it finally bursts open along the median ventral line. The body contents are then forcibly ejected by the contraction of the longitudinal muscle fibres in the body wall. The rupture thus begun continues throughout the whole length until the worm is entirely everted. In this condition the body wall looks like an undulated band or ribbon, and is shrunk to about one-fifth of its original length. Specimens prepared in this manner are easy to study as the internal organs suffer little injury. By this means the eggs are discharged in great abundance wherever suitable conditions are found.

The characteristics shown by these worms suggests at once that very exact environmental conditions are necessary for their development. In this phylum of parasitic roundworms, respiration is seemingly effected through the dermal surface, for the adults, at least, show very quick responses to density changes in surrounding liquids. Indeed, so delicate is this adjustment, that a specimen of Trichinella spiralis (which had been kept in strong formaldehyde solution for three years) exhibited very life-like movements, when placed into a drop of water. Other specimens, known to be dead, acted in like manner when the solution in which they were kept, was placed upon a slide, and allowed to evaporate. These experiments would tend to prove that the body wall plays an important part in the metabolic functions of these parasites. This fact is important, because it may offer ultimately a means of control. For example, Kroening reports very favorable results in the treatment of sheep lung-worms, by injecting a 1 per cent solution of carbolic acid into the trachea. The ready absorption of volatile liquids or gases by these parasites, would offer a ready explanation for his results. Further experiments are, however, needed along this line, especially as regards administering, and the standardization of lethal doses of the antiseptics used.

Distribution.

Believing that a knowledge of the approximate frequency and distribution of these parasites would shed some light upon their life history, a systematic count was kept to determine these facts. Table 1 shows the range and distribution for an entire year. The degrees of infestation of the different lots of hogs examined, have been reduced to percentages, and from these last the accompanying chart was constructed. Turning now to the chart we see two points of rather light infestation. These are due to the fact that the hogs were all over a year old. These instances tend to uphold the results of other investi-

TABLE 1.

Prevalence of M. apri in Local Hogs.

Date Examined	Hogs Examined	Hogs Infected	% of Infestation
1920			
March 15	11	4	.363
March 16	31	12	.387
April 3	19	3	.157
April 10	37	17	.450
April 24	52	23	.442
May 4	28	4	.142
Sept. 13	62	48	.774
Sept. 20	47	34	.723
Sept. 27	45	35	.777
Oct. 4	32	24	.750
Oct. 18	39	28	.718
Oct. 25	29	21	.724
Nov. 1	25	17	.680
Nov. 8	62	44	.709
Nov. 22	53	38	.716
Nov. 29	45	32	.711
Dec. 6	42	29	.690
Dec. 13	28	18	.642
Dec. 20	35	21	.600
1921			
Jan. 3	43	27	.627
Jan. 10	19	10	.526
Jan. 17	30	17	.566
Jan. 31	27	15	.555
Feb. 14	42	17	.404
Feb. 21	57	26	.456
Feb. 28	74	28	.378
March 7	62	27	.435
March 14	83	32	.385
March 21	28	9	.350
March 28	35	10	.314
April 11	62	29	.467
April 18	60	24	.400
May 2	74	35	.472
May 16	50	22	.440

Total number of hogs examined: 1458.
Number of affected hogs: 780.
Average percent of affected hogs: .534.

gators, namely, that older hogs or pigs are more resistant to these worms. If we omit these digressions, our curve will then show a decided symmetry. March was found to be the month of least infection, and this is doubtless due to their getting rid of parasites during the winter months, and not acquiring subsequent infection. The dotted line represents a period during which no observations were made. Again, the maximum infestation is found to occur during the summer and fall months. The percent of affected hogs diminishes gradually during the winter months, until it again reaches the lowest level in March. In the succeeding months of April and May, a rather sharp rise may be noted, and this in a measure corresponds to the warm rainy weather of these two months. It would seem therefore, that

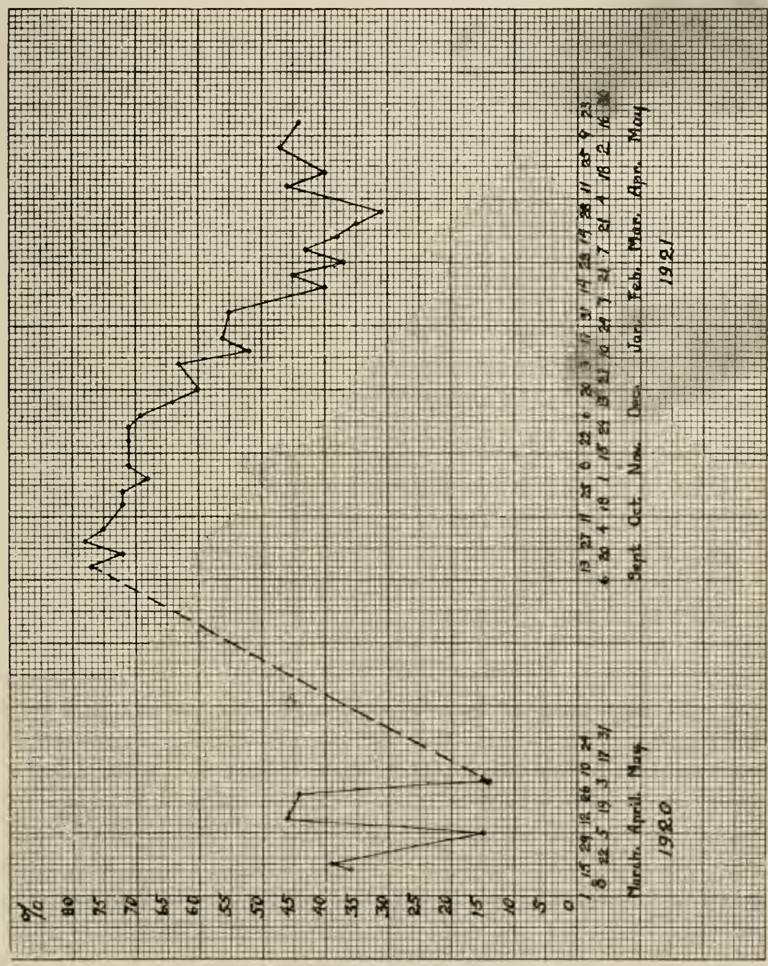

CHART FOR TABLE I.

warmth and moisture are essential environmental conditions for the development of these worms. The total number of hogs examined was 1,458. Of these 780 were found affected with lung-worms, which gives an average of 53 per cent for the entire year.

Frequency.

In this experiment, the lungs of four hogs were examined, which showed average infestation. These hogs are indicated respectively as A, B, C and D in table 2. In the lungs of hog A, three lesions were found; two in the right and one in the left lung. These lesions were carefully excised and dissected in physiological salt solution, in which the worms were counted. Like procedure was followed in the case of the other lesions, and the numerical results obtained are shown in the table. Certain facts that are thus brought out might be emphasized: first, the size of the lesion is but a rough index of the number of worms it contains; second, the right lungs are more often affected than are the corresponding left lungs; third, the ratio of males to females is approximately one-half.

TABLE 2.

Lung Worm Count in Affected Hogs.

Hog	Lung	Lesion	Size of Affected Area	Females	Males	% of Males
A	Right	1	31 X 17 mm.	18	10	.55
	"	2	35 X 18 mm.	62	22	.34
	Left	3	37 X 20 mm.	47	27	.57
B	"	4	40 X 35 mm.	32	18	.56
	Right	5	30 X 15 mm.	57	33	.56
C	"	6	35 X 22 mm.	28	17	.75
	Left	7	34 X 20 mm.	42	24	.56
D	"	8	27 X 15 mm.	51	20	.39
	Right	9	36 X 19 mm.	54	25	.46
	"	10	18 X 12 mm.	12	5	.41

Hog A contained 186 worms.
Hog B contained 140 worms.
Hog C contained 111 worms.
Hog D D contained 167 worms.
Average of males 51%.
In this count no attempt was made to separate the species of lung-worms.

Diagnostic Symptoms.

Unless they occur in very large number, lung-worms give little indication of their presence. The first symptom is a dry, husky cough, accompanied with an arching of the back. Frequently, there is a profuse discharge from the nostrils and eyes, and the membranes of these are pale. Young pigs that harbor this parasite show a general unthriftiness, anaemia, and looseness of the skin. In extreme cases, vomiting and diarrhoea may also occur. It should be borne in mind however, that all these symptoms are obscure and of too general application to be of much value. For example, a post-mortem examination of several pigs, that had evinced typical lung-worm symptoms, brought to light a heavy infestation of Ascaris suilla. These worms were present in such numbers that they practically filled up the stomachs and intestines of all affected individuals. Superficial diagnosis should therefore be always followed by a post-mortem or microscopic examination.

The typical appearance of a lung affected with these parasites will show the initial lesions occurring at the very posterior tip. These lesions are gray in color, and have a solid appearance and feeling. A sharp demarkation also exists between the healthy and affected portions. These last rise prominently against the general surface, and are due to the clogging up of air tubes by the bodies of the worms and the debris they produce. Adult worms feed on blood and lymph by puncturing the walls of blood vessels, thus causing an acute inflammation. The eggs and larvae produce a diffuse pneumonia characterized by a dry puffiness of lung tissue. In old hogs, extensive, watery tumors occur, in which remnants of dead worms can be found. Small nodules, very characteristic of true tubercles, are also present.

One noticeable feature of these examinations was the common occurrence of bacterial lesions associated with the presence of these parasites. Probably these worms do not carry infection themselves, but the watery tumors which they produce undoubtedly make excellent culture media for any bacteria that chance to find their way into the lungs. In the hundreds of cases that were examined, secondary infections of this nature were of frequent occurrence. Lung-worms may thus be an important factor in causing disease.

Life History.

The general paucity of exact information in the field of parasitology is made very apparent when we attempt to find some concrete statements regarding the parasite in question. Until quite recently, nothing was known of its life history. The following report, copied from California Experiment Station circular 148, presents our most authentic knowledge of this subject.

"Early in our investigations we observed that the embryos found in the lungs were of two kinds. Our first thought was that these might be embryos of two different species of lung-worms, but this was discounted by the fact that we could find but one species of adults in the lungs. That the difference might be due to sex was rejected owing to the fact that the types differed not only in shape and structure, but also in their movements, location and habits. Thus the theory gained belief that these two types were designed to maintain a free-living and a parasitic generation. This belief was confirmed by Doctor von Linden of the University of Bonn, who found that in the mucus of the trachea and of the space behind the nose there were slim, strong-moving embryos that were capable of living outside the body. In the lungs the embryos were short, thick, slow moving and unable to live outside the body. Dr. von Linden found that if slim, strongly moving larvae are placed on moistened earth they continue their development, and she has been able to raise eleven successive free-living generations in this way.

"Dr. von Linden believes that the embryos destined to reproduce the free-living generations, work their way up to the trachea and are swallowed and excreted from the body with the faeces. The embryos then moult and withdraw within their skins, which form a sort of cyst, protecting the larvae from extremes of heat or cold and dryness until conditions are suitable to their growth. Under favorable conditions the second generation of worms appears in from four to six weeks and further generations continue to appear at this interval for about four months. This period of increase is generally followed by a standstill of about three months when the increase again starts. The thick, slow moving embryos die almost immediately when placed outside the body."

In addition to repeating the above experiments two other alternatives were tried, namely, to determine the possibility of some intermediate host, and to see to what extent these parasites develop within the soil.

Theory of Free-living Generations.

The common occurrence and wide distribution of these worms suggests a comparatively simple life history. Before proceeding further, it might be well to emphasize the fact that much confusion still exists between these species of lung-worms. This difficulty is, however, more nominal than real, because even with the unaided eye both species of the males at least, can be readily distinguished. By plunging a mass of these worms into a 30 per cent solution of alcohol in a watch glass, and inspecting them against a black background, there is little difficulty in separating the two species. The males of M. apri are more transparent, more tightly coiled and slender, than is the case with M. brevivaginatus. The females of the former species are also more slender and average about 4 cm. in length. The following averages (obtained by measuring one hundred males of each species) give first the body length, and second, the length of spicules.

	M. apri.	M. brevivaginatus
Length of body........................	14.16 mm.	18.50 mm.
Lengths of spicules....................	3.80 mm.	1.25 mm.

An examination of twenty lesions from as many different hogs, showed the presence of both species of lung-worms in thirteen cases. Of the remaining seven lesions, five contained M. apri, and three contained only M. brevivaginatus. These results would indicate that this last species is much more common than is generally supposed. Experimental evidence seems to indicate that most females over 4 cm. in length, and the larger eggs (mentioned under description) belong to this species.

Attempts to duplicate the work of Dr. von Linden were in the main unsuccessful. Most of the points she mentioned were repeated, but the conclusions did not always coincide. The following tabulation gives the results obtained, together with their probable interpretation.

Structural differences were invariably found due to sex, especially if the larvae were well advanced in their development. This differentiation began to appear in the second week of growth when the larvae were grown in soil cultures. Besides this anatomical difference, a difference in size was commonly observed. These two distinct types could always be traced to the presence of two species of lung-worms. If, for example, females over 4 cm. were placed in sterile soil, the resulting larvae were always of two kinds. The first was a slim, active form, and the other a rather stout, sluggish form. In this last, ovaries were clearly distinguished in the second week of growth. The larvae within each group were consistently alike, hence their structural differences could only be due to sex. In soil cultures where no effort was made to separate the females on the basis of length, two kinds of larvae were also found; namely, the slim, and the active forms. However, each of these types could be further divided into two groups, which were identical in every respect except size. The presence of these larger larvae could be best explained on the basis that they were the young of M. brevivaginatus.

Active larvae were found in scrapings from the sinuses of the head, the trachea, and in the mucous discharges from the nose. These more active forms were found to be due simply to differences in the stage of development. Experiments have shown that the larvae of lung-worms remain sluggish for several days after they are hatched, during which time important morphological changes occur.

Attempts to raise the free-living generations were unsuccessful. However, when the proper environmental conditions were provided, there was little difficulty in growing larvae taken directly from the lungs. Such larvae grew actively for a period of four weeks, after which time no growth took place but they continued to live indefinitely. These results do not agree with the statement made by Dr. von Linden and others, that the embryos taken from the lung die almost immediately when placed outside the body. It was found that young larvae are very susceptible to moisture and temperature changes, to bacteria and decomposition products, and to proper aerobic conditions. No difficulty was experienced in keeping lung-worm larvae for several days in physiological salt solution, provided this solution was changed daily, and thoroughly aerated.

Theory of Intermediate Hosts.

In conducting this series of experiments, such animals were used as are commonly found in hog runs and wallows, and which might readily be a source of infection to the hog. Table 3 shows in tabular form the animals with which experiments were conducted and their attendant results.

Most of the flies and lice were caught upon the bodies of dead hogs. A count was kept of each species, to find if possible, the per cent of infected individuals. Specimens were examined by tearing them to pieces in salt solution, and dissecting the contents under a binocular microscope. No affected individuals were found.

Attempts to infect the Ostracoda and Cyclops were made by placing them in a beaker of water, into which were also put a large number of lung-worm larvae. These were left in contact for ten days, during which time daily examinations were made to determine any occurrence of parasitism. The results were consistently negative. Examination of these crustacea was facilitated by first dissolving out the

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calcareous skeletons with HCL, and then compressing them between two slides.

Earthworms, from which most of the intestinal contents had been squeezed out, were placed into soil cultures containing larvae in different stages of development. These were examined at varying intervals, ranging from one to five weeks. The method of doing this was to place a cleaned individual into salt solution, in which it was cut open and the intestinal contents examined. Small pieces of the worm itself were next compressed between two slides and observed under the microscope. Among the contents of the intestine, many lung larvae and larval skins were found. However, the larvae were all dead and seemingly had undergone digestion. Parasitism of thé worms themselves was found in two individuals. These showed, imbedded in the tissues, roundworms very similar to the lung-worm larvae in question. Remembering, however, that all were equally exposed to infection and that only these two specimens were found parasitized, any conclusions derived from this experiment must necessarily be unreliable. Such parasites as were found could have been acquired before the worms were placed into the soil cultures.

In conducting the experiments with rats, four individuals were used. Two of these were fed lesions containing lung-worms at intervals of one week apart for a period of four weeks. The other two rats were fed larvae in advanced stages of development, and at approximately the same intervals, for a period of ten weeks. After one month the first two rats were killed and found free from infection. The other pair of rats was killed three months after the first, and two weeks after the last feeding. These had very typical verminiferous lesions in both posterior lobes of the lungs. When these lesions were examined, numerous dead larvae and cast skins were found within them. No living larvae were found.

An examination of the rat faeces showed that most larvae were excreted within the first 24 hours. In faeces of the first pair of rats no larvae could be found after the second day of feeding. In the case of the other two rats, the larvae persisted for four days. A large portion of these last seemed to have escaped digestion, but no living larvae were found.

Blood samples of these rats were taken at different times, but gave negative results.

TABLE 3.

Experiments with Intermediate Hosts.

Species	Number Examined	Results	Completed
Colliphora erythrocephala (Blue-bottle Fly)	35	Negative	1920 Sept. 22
Musca domestica (Common House Fly)	67	"	Sept. 27
Haematopinus suis (Hog Louse)	47	"	Sept. 28
Cypris candida	19	"	Oct. 9
Cyclops	22	"	Oct. 11
Earthworms	17	?	Oct. 27
White Rats	4	Positive	May 9

It would appear from these experiments that M. apri and M. brevivaginatus have no intermediate hosts, but that active, growing larvae may occasionally invade the lungs of another animal than the hog. In such a case, however, they are unable to continue their development. An exception might be cited in the case of the human host; for several cases are on record where worms, seemingly identical with those of the hog, have been found in human lungs.

Theory of Partial Development in the Soil.

Analyzing the facts thus far considered, it would appear that these parasites spend a part of their development within the soil. To grow these worms, small wooden boxes were used parafined on both surfaces. Different kinds of soils were found to give different results. The optimum soil types were, first, a humus to which some sand had been added, and second, soil scrapings from the bottom of an old manure pile. Neutral or slightly alkaline soils gave the best results. It appears that young larvae feed within the soil, for they made no appreciable growth in the sterile plots until such time as seeds were planted and had begun to sprout. In this regard oats and beans gave satisfactory results, and they served moreover, as excellent indices in the control of moisture. Check experiments were in all cases conducted with soil sterilized under a pressure of fifteen pounds of steam for one hour.

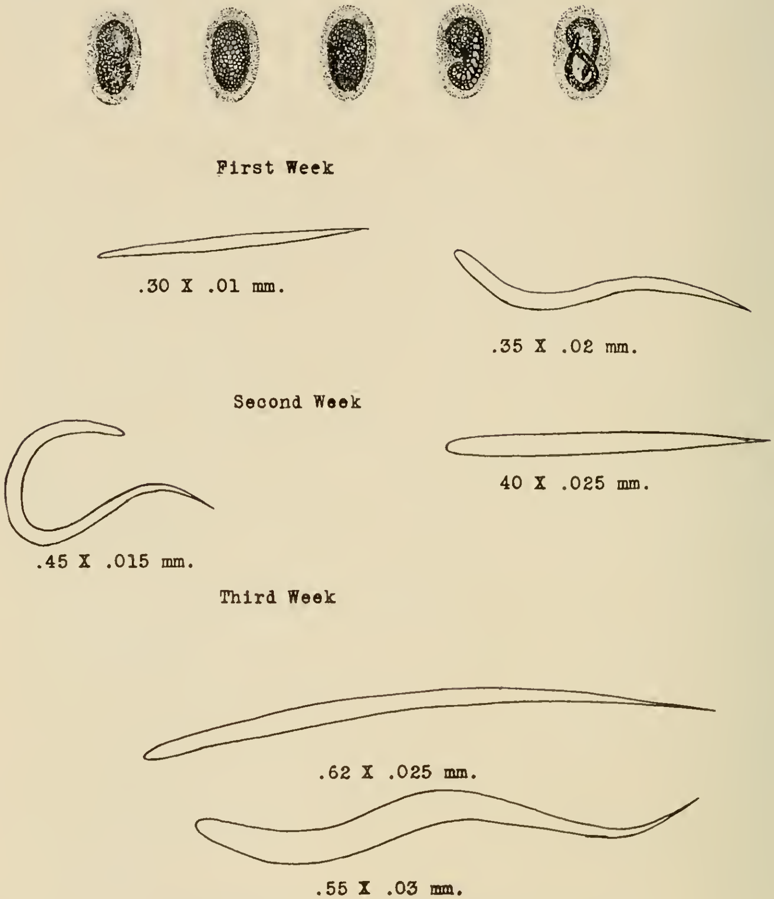
Besides the soil types mentioned above, moisture and temperature were found to be factors of prime importance. The temperatures that gave the best results and at which the larvae were the most active, ranged from 35 to 40 degrees Centigrade, and preferably within the upper limits of this range. The moisture requirement is peculiar and must be very exact. As these parasites require an abundance of oxygen, all experiments involving them had to take this factor into consideration. Too much and too little moisture were both detrimental. The former excluded the air from the soil, and the latter condition inhibited motion and proper metabolic development. The larvae grew most rapidly in soils that were damp and porous, and that contained much organic matter. Moisture requirements were best controlled by means of vegetation growing within the plots. Newly hatched larvae are especially succeptible to these changes, and they are readily killed if the soil is allowed to dry out.

In their development these larvae showed many marked peculiarities. Under ideal conditions they increased rapidly in size during a period of four weeks. During this time the digestive tract and sex organs become well defined. The bodies of both sexes terminate in a spine-like process, which is much longer in the males. These last are also more slender and active than the females. Motion is effected by side to side contractions of the body, which cause the worm to move rapidly along especially in a media of semi-fluid consistency. Plate I shows the appearance of these larvae during different stages of growth.

A decided metabolic difference exists between partly developed larvae and those which are just hatched. Experiments conducted with different digestive ferments, such as bile, saliva, liver extract, etc., showed that the former larvae are much more resistant to the action of

PLATE 1

DEVELOPMENT OF METASTRONGYLUS APRI



DEVELOPMENT OF METASTRONGYLUS APRI

The eggs are intended to show the various developmental stages.
The larvae show actual measurements, and were drawn by means of the camera lucida.

these enzymes. Thus, two-weeks-old larvae individuals were not digested when left in these ferments for 24 hours. On the other hand, young embryos were all killed after five hours, unless they were protected by the egg membranes. Likewise, when subject to weak antiseptics of different kinds, the same general results were obtained. Freezing seems to kill at all stages of development, but experiments with dessication have shown that two-weeks-old larvae can withstand prolonged drying out without injury. Such larvae were revived three months

TABLE 4.

To Show the Rate of Growth of Metastrongylus apri in Millimeters, Attained Within the Soil.

First Week		Second Week	
Length	Width	Length	Width
.32	.015	.42	.011
.33	.015	.46	.015
.30	.012	.40	.010
.35	.016	.48	.020
.31	.014	.49	.021
.30	.012	.50	.025
.29	.011	.42	.011
.32	.015	.48	.020
.32	.012	.39	.018
.35	.015	.52	.025
Third Week		**Fourth Week**	
Length	Width	Length	Width
.55	.020	.63	.028
.50	.018	.72	.037
.60	.035	.74	.054
.65	.040	.60	.035
.50	.018	.67	.025
.65	.035	.70	.035
.63	.035	.72	.045
.59	.020	.69	.035
.57	.018	.74	.055
.62	.032	.65	.040

The above measurements are random selections of male and female larvae of both species. They attained their maximum size by the end of the fourth week, after which they began to die off. However they continued to persist indefinitely.

after they had been permitted to dry out in the soil at room temperature, by placing them in water. Incidentally it was noticed that many samples of these same larvae continued to live after they had remained in weak chloral hydrate solution for three months. Evidently, profound morphological changes occur during this time, which enable these parasites to withstand unfavorable environmental conditions.

Six weeks after this period of rapid growth, the larvae still remained active, but did not increase in size. Numerous cast skins and dead larvae began to appear. It is certain that moulting took place, but the actual number of these moults could not be determined. Unfavorable conditions seem to prolong the life cycle of these parasites, for they encyst and remain inactive, until such time as favorable conditions return. Apparently these larvae die off gradually if they do not find a suitable host. In the laboratory, they have persisted in this manner for almost a year.

There are also good grounds for belief that these worms may develop directly within the lungs. Since, in a majority of cases, the initial lesion begins at the very posterior tip of the lung, and often contains great numbers of worms, the theory is hardly tenable that all these worms entered as individual larvae, and all migrated to this particular area of the lung. Most lesions that were examined, were found to contain these strongylus in all stages of development. The adult specimens lay massed together at the terminal end of a bronchus, while the more active larvae, equivalent in size to those which had attained a week's growth within the soil, could be found in the mucous of the entire respiratory tract. Where two or more lesions occurred in a single lung, one was invariably found that was older than the rest. Such a typical old lesion was hard and watery to the touch, and when cut open, was found to contain numerous granules among which were the disintegrated bodies of adult worms. The suggestive thing is that a lesion of this kind always occurred at the lowest part of the lung, and the secondary lesions were scattered along branches of the same bronchus in which the older lesion was found. These conditions could be explained on the theory that the adult worms secrete toxic substances which cause an accumulation of lymph, that eventually kills them. The partly developed larvae, being active and resistant, make their way along the course of the bronchus until they lodge at the terminus of one of its branches. Here they begin to feed and grow, producing a new lesion light pink in color and of a dry, puffy nature. There seems to be no reason why sexual maturity could not be attained within the lung in this manner, and by this means the progeny of a single worm could infest an entire lung.

Modes of Infection.

The next question that suggests itself is, "How do these parasites gain ingress into the lungs?" Experimental proof is available to show that there are at least two methods. The rats already mentioned were given these larvae smeared on bread, in combination with which they were readily eaten. Most of these larvae subsequently passed out with the faeces, but apparently enough resisted the action of digestive ferments to find their way into the lungs, where they produced the characteristic lesions. Another experiment, conducted with three pigs to which these worms were fed in slop, gave very definite, positive results. These results are given in the appendix.

An additional mode of infection could be by inhaling the larvae as dust. For example, when the sweepings of a hog house, in which affected hogs were kept, were shaken up in a jar of water and allowed to stand over night, numerous, active larvae were found in the sediment, similar in all respects to those under discussion. The experiments on dessication further strengthen this theory, for, some of the larvae could be revived in fifteen minutes after they had undergone drying for a period of six days. The mucous of the nasal passages would be an excellent place for these dessicated parasites to lodge, and to continue their development.

Preventive Measures.

To effectively control these parasites prevention rather than cure must be the chief end in view. The common practice of continually raising hogs on the same piece of ground, can only result in a heavy infestation of the soil in all kinds of parasites. Changing the site of the hog lot every two or three years would certainly reduce this infection to a minimum. Experiments with the culture plots have shown that a heavy application of lime, is very effective in killing these parasites. In none of the plots which were subject to this treatment could living worms be found after two weeks. Other writers recommend a top dressing of kainit for the same purpose. Liberal application of these substances to pastures and yards, is the best method that can be recommended at this time.

As infection is especially likely in young pigs clean bedding and quarters should be provided for them. Dr. R. A. Craig has found adult lung-worms in three-weeks-old pigs, which fact together with the ascaris infection already mentioned, would indicate that young pigs may be parasitized directly by eating worms which have been excreted by older hogs. Segregation of affected individuals, and the careful examination of newly purchased stock, for symptoms as coughing, arching of the back, etc., are additional factors that can be recommended.

Appendix.

This experiment is a summary of the pig-feeding tests already referred to. This data could not be incorporated into the main body of the report as the pigs were being used for another purpose at the time this experiment was conducted. Altogether six pigs were used, and were selected to approximate the same size and development. These were divided into two groups of three each, which for convenience will be designated as Group A and Group B.

Group A.

These three pigs were used as checks. No worms were fed them, and they were simply kept in a clean concrete pen so that the chance of infection would be reduced to a minimum. Due to the fact that all of these pigs were some three months of age before they were segregated and had ranged in an open hog lot during this time, absolute freedom from infection could not be achieved. Examination of the lungs of these pigs, killed at the same time as Group B, gave the following results:

Pig	Right Lung	Left Lung	Male Worms	Female Worms
1	1 lesion	none	3	5
2	1 lesion	none	2	7
3	1 lesion	none	4	9

Group B.

The pigs of this group were fed lung-worm larvae at two different times, namely, on March 24 and May 12, 1921. The larvae were of different ages (from one to five weeks), and had been grown in culture plots in the laboratory. The feeding of these worms was effected by

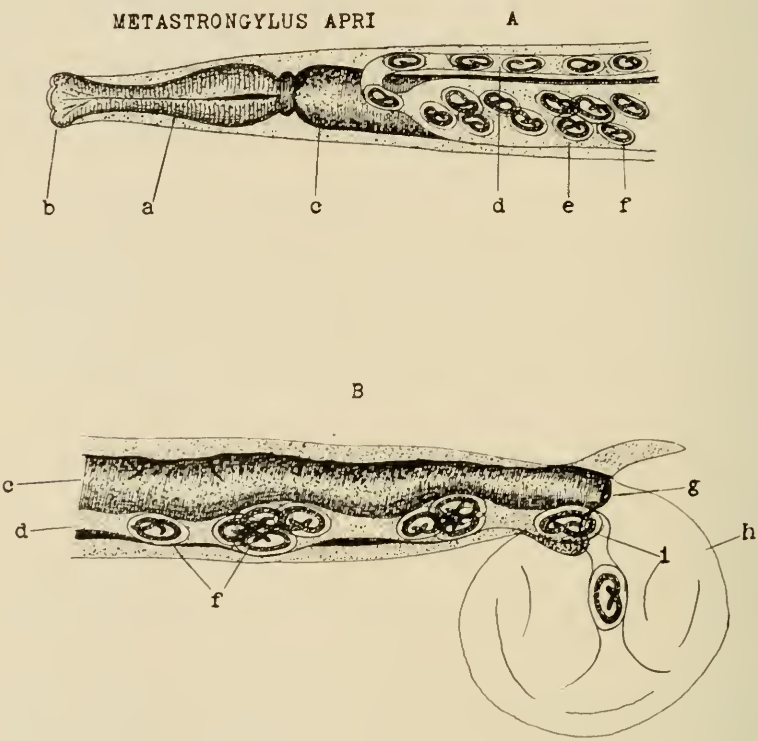
Pig	Right Lung	Left Lung	Male Worms	Female Worms
1	3 lesions	2 lesions	39	57
2	4 lesions	2 lesions	42	63
3	General verminiferous	bronchitis		

mixing them with grain in the form of a slop, and pouring this mixture into a trough. These pigs were killed on June first, of the same year, and the lungs, when examined were found to be badly infested. The following table shows the number of worms and lesions that were found.

The lungs of pig three were badly affected with these worms, although no localized lesions could be found. Partly developed worms were found in all of the bronchi of the lungs, which showed also a swollen, oedemic condition. The large number of males present in all of these lesions was a noticeable feature, and was doubtless due to some selective influence in the culture media.

Although these experiments are not as conclusive as could be desired, they undoubtedly prove that partly developed larvae will infect hogs under favorable conditions. *Purdue University.*

PLATE II.



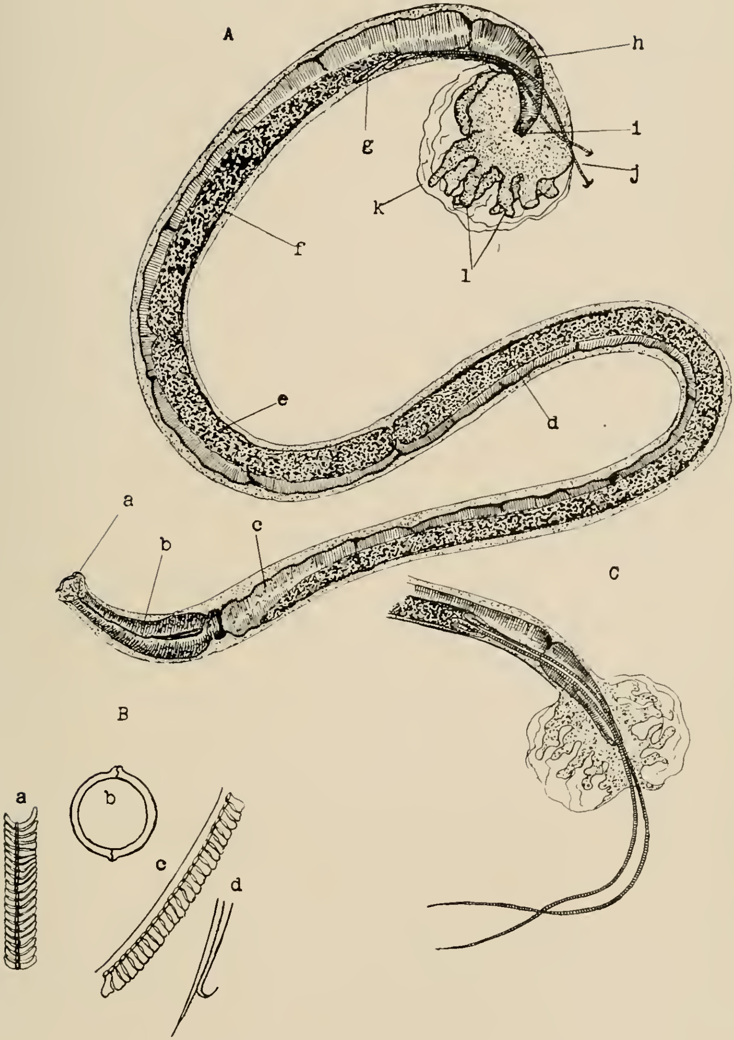
METASTRONGYLUS APRI.

A. Anterior view of female: a, esophagus; b, mouth with six lips; c, intestine; d, oviduct; e, uterus; f, eggs.

B. Posterior view of female: c, intestine; d, oviduct; f, eggs; g, anus; h, vulva; i, vagina.

PLATE III.

Metastrongylus Brevivaginatus.



METASTRONGYLUS BREVIVAGINATUS.

A. View of male: a, mouth with six lips; b, esophagus; c, intestine; d, e, testicles; f, seminal vesicle; g, anterior end of spicule; h, rectum; i, anus; j, spicules; k, bursa; l, costae.

B. Structure of spicule: a, top view; b, cross section; c, side view; d, end view.

C. M. apri, posterior view of male. Note comparative length of spicules.

Crop Rotation as Affecting Nitrate Production.

I. L. Baldwin, U. L. Coble and J. W. Chamberlain.

One of the great outstanding problems of the modern scientific farmer is that of maintaining and improving the soil fertility. It is in connection with this great problem that the science of Soil Bacteriology, the study of the habits and activities of the microbic flora of the soil and their relation to soil fertility and plant growth, has recently developed. Although investigations in this field have just begun, enough has been done to prove that such scientific studies are highly valuable in solving some of the problems relative to the question of soil fertility and plant growth.

As yet few scientific investigations have been reported on the effect of various crops and crop rotations on the nitrate content of the soil. As a result the following studies relative to the nitrate content and nitrifying power of the Rotation Plots of the Purdue Experiment Station Field No. 6 were undertaken.

A brief description of the plots and the experiment being conducted by the Purdue Station will be of value in interpreting the results of these studies.

The soil is a Sioux silt loam, containing some gravel and is underlaid by a gravel subsoil. The top soil is shallow, and just below at varying depths there is a hard layer somewhat similar to a hardpan. This soil dries quickly and packs easily. The organic matter content is fairly high.

The plots were laid out in 1889, as test plots one-tenth acre in size in strips fourteen feet wide separated by strips seven feet wide. In each series there are seven test plots, four treated with manure or fertilizer, and three checks. The purpose of the experiment was to test the relative value of manure and commercial fertilizers applied to different rotations.

At first only one crop of the rotation was grown each year, but in 1911 the plots were divided so that each crop of the rotation is grown every year. As a result some plots are smaller than others.

The accompanying map will give some idea of the relative size and position of the plots.

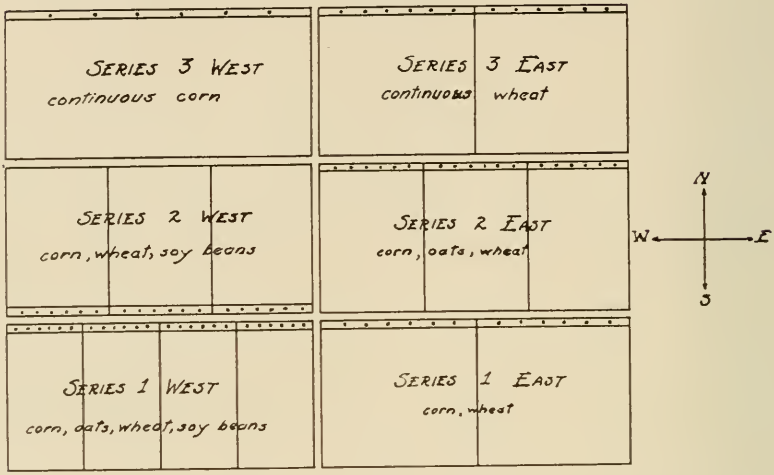
History of Literature.

Until within a generation ago it was not known that nitrification was a bacterial process. The transformation of organic nitrogen was regarded as a purely chemical reaction and was extensively studied from that standpoint.

The work of Kuhlman, Bossingault, Schlosing and Muntz, Warrington and Winogradski and other investigators showed the true nature of nitrification and the organisms responsible were isolated and studied.

PLATE I MAP OF PLOTS

Shows check plots from which samples were taken
Dots show location of borings



Later investigations have brought out many of the factors influencing the process in the soil.

In 1893 Deherain,[2] and later in 1901 King and Whitson,[3] compared soil stirred and soil not stirred, and found that nitrates were produced more rapidly in the stirred soils. This they attributed to better aeration.

In experiments conducted in 1907, Voorhees, Lipman and Brown,[6] found decomposition slower under oats and clover than in bare soils.

In later studies King and Whitson,[3] found differences in the nitrates produced under the same crop in different plots and under different crops. Although the differences in some cases were quite considerable, they did not feel justified in drawing any conclusions relative to the effect of certain crops.

Later Deherain,[2] claimed that if soil moisture was not lacking, and if the loss of nitrate nitrogen in the drainage water and the nitrogen in the crop were added, similar nitrification would be found in fallow and in cropped lands. This statement, however, has been severely criticized and with respect to the question of nitrification under legumes, a proposition which has received considerable attention, experiments have shown that sometimes more and sometimes less nitrate nitrogen may be found than under grain crops. Among the more recent experiments are those performed by Brown[1] of Iowa which shows the following:

1. "The rotation of crops brought about a greater nitrifying power in soils than continuous cropping either to corn or to clover.

2. A soil under a three-year rotation of corn, oats and clover possessed a greater nitrifying power than one under a two-year rotation

of corn and oats, or one under a two-year rotation in which clover and cowpeas were used as a green manure.

3. There was an indication that the influence of the crop present on the soil was greater than the influence of the previous cropping on the bacteria in the soil, and this was probably due to the difference not only in the crop but in the treatment of the soil and preparation for the crop."

Technic.

The object of this investigation was to determine the effect of different crops and crop rotations on the nitrate content and nitrifying power of the soil.

To accomplish this end samples were taken monthly from each plot over a period from March, 1920, to October, 1920, inclusive, and these samples were analyzed for moisture, nitrates and nitrifying power.

Samples were taken at as near the same date each month as circumstances would permit. In order to eliminate as nearly as possible the factor of denitrification, no samples were taken when the soil was wet enough to "ball up".

Samples were evenly distributed over the plot as shown by dots on the accompanying map, and were taken from about the same places each month. In order to eliminate the factor of fertilizer, the samples were taken from the check plots of each series. (The check plots on the south side of Series V West were used because those on the north side were considerably lower than those of the other series.)

Moisture determinations were made by drying in an oven at 100° C for several hours, duplicate samples of 10 gms. soil each in 30 c.c. tarred crucibles.

The nitrate content was determined by the phenol-di-sulphonic method, as modified by Noyes[5] for soil investigation work.

To determine the nitrifying power of the soil, duplicate samples of 100 gms. each were placed in glass tumblers covered with petri plates, and incubated at room temperature for two weeks. In any instance where the moisture content was noticeably lower than normal, which ran about 20 per cent, distilled water was added to bring it back to normal. At the end of two weeks nitrate determinations were made as in the case of the fresh samples.

In tabulating the data the averages of the duplicates were used, and the nitrate content calculated on the basis of moisture-free soil and in terms of parts per million parts of water-free soil.

Discussion of Results.

Before entering into a discussion of the tables it would be well to note that the factors affecting bacterial activities and hence nitrate formation in the soils as determined by previous investigators are, moisture, temperature, aeration, crop growth, organic matter and plant food content of the soil, presence of toxic substances, cultivation, previous cropping and treatment, and type of soil. Of these many factors, those which may be taken as different in the different plots are aeration, kind of crop grown, cultivation, previous crop and treatment, and possibly the presence of toxic substances. However, the last named factor is probably of very little importance. The effect of these differences can only be estimated in comparing plots.

The nitrate content of the fresh samples is taken as an indication of the surplus of the amount produced over that used by the crop.

The difference between the incubated and fresh samples is taken as a measure of the additional work done in the laboratory under optimum conditions by those groups of bacteria which change the nitrogen of complex organic nitrogenous compounds first into ammonia, then into nitrites and further to nitrates.

TABLE 1.

Series I East—Rotation Corn, Wheat

Month	Moisture %	Plot 1 Wheat		Moisture %	Plot 2 Corn	
		Nitrates—Parts per million			Nitrates—Parts per million	
		Fresh Samples	Incubated Samples		Fresh Samples	Incubated Samples
March..	21.4	28.45	65.04	20.20	16.42	32.85
April...	21.1	1.04	26.31	21.70	8.16	36.73
May....	17.23	3.86	19.30	16.48	3.83	19.12
June...	12.58	1.83	21.96	18.49	35.30	82.35
July..	16.99	11.56	15.41	15.28	79.32	83.01
Aug....	14.16	7.45	9.07	15.05	132.62	188.30
Sept..	11.98	....	3.62	15.10	26.36	56.52
Oct..	22.93	....	4.14	22.48	12.38	24.76
Total per period		57.19	164.85		194.39	523.64
Ave. per month		7.15	20.60		24.29	65.45

Discussion of Table 1.

Series I East—Rotation Corn, Wheat.

The average nitrate content of the entire period for the fresh samples for the corn plot is 24.29 parts per million, as compared to 7.15 parts for the wheat plot.

The highest content for fresh samples was reached for corn in August, just after the corn ceased drawing heavily on the nitrates of the soil. The highest content for the wheat plot was in March, before the crop started good growth, but a second high nitrate content was found in July, just after the crop was removed.

The fresh samples for the corn plot showed low from March to June, high from June to September, and low again for September and October. The wheat plot was high in March, low until July, high for July and August, and low again for the remainder of the period.

For the corn plot, the incubated samples show a much higher average for the eight months than do those of the wheat plot,—for corn 65.45 parts, and for wheat 20.60 parts of nitrates per million parts of moisture-free soil.

It will be noticed that the incubated samples for corn showed highest in August, for wheat highest in March. As would be expected, the incubated samples showed highest during the growing season and lowest during the months of less favorable conditions for bacterial action.

During the first part of the season these crops were feeding heavily on the nitrates of the soil, but the corn plot produced a larger surplus over the amount used than did the wheat plot. These differences noted above are in large part due to the corn crop being cultivated and having a larger growing season, thus making a longer period of more favorable conditions for bacterial activities.

TABLE 2

Series II East—Rotation Corn, Oats, Wheat

Month	Moisture %	Plot 1 Corn: Nitrates—Parts per million, Fresh Samples	Plot 1 Corn: Nitrates—Parts per million, Incubated Samples	Moisture %	Plot 2 Oats: Nitrates—Parts per million, Fresh Samples	Plot 2 Oats: Nitrates—Parts per million, Incubated Samples	Moisture %	Plot 3 Wheat: Nitrates—Parts per million, Fresh Samples	Plot 3 Wheat: Nitrates—Parts per million, Incubated Samples
March..........	22.5	8.24	32.98	22.1	28.74	55.44	21.30	22.35	38.61
April............	23.8	5.24	29.35	20.45	14.04	40.16	21.00	12.10	40.48
May............	19.65	3.97	25.84	17.22	5.79	23.16	17.07	9.63	25.04
June............	18.05	15.61	63.28	11.01	3.59	14.36	12.70	3.66	32.96
July............	16.05	38.11	64.76	17.21	7.73	23.19	14.18	11.18	24.20
August..........	18.07	58.58	73.52	17.23	7.73	15.46	16.44	7.65	9.52
September.......	13.11	25.91	44.18	19.84	11.95	25.94	16.07	3.81	9.20
October.........	24.52	4.22	10.59	22.85	4.41	12.44	12.95	2.08	8.30
Total for period..		151.84	344.47		83.71	210.15		72.46	188.31
Ave. per month..		18.98	43.05		10.46	26.26		9.05	23.53

Discussion of Table 2.

Series II East—Rotation Corn, Oats, Wheat.

Table 2 shows that the average for the fresh samples for the eight months were corn, 18.98 parts, oats 10.46 parts, and wheat 9.05 parts of nitrate per million parts of moisture-free soil.

The highest nitrate content of the fresh samples was found in August for the corn plot, in March for the oat plot and in March for the wheat plot. The corresponding low content was found in May for corn, in June for oats, and in June for wheat.

The untreated samples showed an average of 43.05 parts for the corn plot, 26.26 parts for the oats and 23.53 parts for the wheat. The highest content for the corn plot was found in August, with June and July also high; for oats in March with several other months of the growing season high.

The similarity in the nature and feeding habits of the oat and wheat crops can be correlated with the similarity in the results for these crops. The difference between the results of the corn plot and these plots is in all probability due mostly to the difference in lengths of growing season and the cultivation received by the corn crop.

Discussion of Table 3.

Series III East—Continuous Wheat.

Table 3 shows an average for the eight months for the nitrate content of the fresh samples of 14.66 parts per million for the unlimed continuous wheat plot, and 12.78 parts per million for the limed plot.

TABLE 3

Series III East—Rotation Continuous Wheat

Month	Plot 1 Unlimed			Plot 2 Limed		
	Moisture %	Nitrates—Parts per million		Moisture %	Nitrates—Parts per million	
		Fresh Samples	Incubated Samples		Fresh Samples	Incubated Samples
Mar.	21.5	28.51	40.73	22.4	26.80	43.29
Apr.	18.35	21.55	50.88	21.0	4.05	36.43
May	15.48	7.56	26.46	16.15	11.42	26.66
June	10.65	14.30	3.57	9.01	7.03	31.63
July	12.23	10.93	21.85	13.17	11.05	33.14
Aug.	14.50	11.21	17.92	15.88	11.40	15.99
Sept.	15.28	16.98	22.68	13.03	22.47	33.10
Oct.	23.16	6.24	20.82	24.37	8.46	19.03
Total per period		117.28	204.91		102.28	239.27
Ave. per month		14.66	25.61		12.78	29.90

The content of the fresh samples for the unlimed plot was high in March, April, and fairly high in June, July, August and September, while that of the limed plots was high in March and September, and fairly high in June, July, and August.

The incubated samples gave an average of 25.61 parts for the unlimed and 29.90 parts for the limed. Here again the samples taken during the growing season contained the most nitrates.

The addition of lime to the soil brings about conditions more favorable to plant growth and bacterial activities. This in all probability accounts for the higher averages of the treated and untreated samples of the limed plots compared with the unlimed plots. The limed wheat no doubt made greater growth during the months of April, May and June than did the unlimed wheat, and therefore the fresh samples showed a lower average than those of the unlimed wheat.

TABLE 4

Series I West—Rotation Corn, Oats, Wheat, Soybeans

Month	Plot 1 Oats			Plot 2 Wheat		
	Moisture %	Nitrates—Parts per million		Moisture %	Nitrates—Parts per million	
		Fresh Samples	Incubated Samples		Fresh Samples	Incubated Samples
Mar.	21.8	20.44	39.87	22.3	28.80	49.18
Apr.	20.60	14.10	37.45	22.2	12.32	36.96
May	16.55	3.83	21.07	16.12	7.61	28.47
June	12.61	1.83	21.96	16.09	3.81	30.47
July	14.90	11.28	22.56	13.14	11.05	25.78
Aug.	18.07	7.81	9.96	17.78	7.78	15.56
Sept.	11.79	9.05	21.76	12.61	5.48	10.98
Oct.	22.17	6.16	12.33	22.74	4.14	8.28
Total per period		74.50	186.96		80.99	205.68
Ave per month		9.31	23.37		10.12	25.71

Discussion of Table 4.

Series I West—Rotation Corn, Oats, Wheat and Soybeans.

The average of the nitrate content of the fresh samples for the period was 11.92 parts per million parts of moisture-free soil for the

TABLE 4—Continued

Month	Plot 3 Beans			Plot 4 Corn		
	Moisture %	Nitrates—Parts per million		Moisture %	Nitrates—Parts per million	
		Fresh Samples	Incubated Samples		Fresh Samples	Incubated Samples
Mar.	21.1	12.14	32.38	20.8	4.15	20.20
Apr.	18.6	1.96	19.64	19.75	1.99	23.90
May	14.98	3.75	20.67	15.95	3.80	19.01
June	14.58	14.90	114.73	14.93	18.80	48.87
July	13.36	40.62	40.59	17.5	42.66	54.26
Aug.	13.41	5.54	5.54	17.18	14.24	27.02
Sept.	9.78	3.54	10.68	15.95	5.70	17.12
Oct.	21.33	2.04	4.06	21.39	4.09	10.24
Total per period		84.49	248.29		95.43	220.62
Ave. per month		10.56	31.03		11.92	27.57

corn plot, 9.31 parts for the oats, 10.12 parts for the wheat, and 10.56 parts for the soybean plot.

The highest content of the fresh samples was found in July for the corn plot, in March with April and July also high for the oat plot, in March with April and July also high for the wheat plot, and in July with March and June high in the case of the soybean plot. During the latter part of the period, when conditions were less favorable for the formation of nitrates, and during the months of heaviest crop growth, the content of the fresh samples ran low for all plots.

Table 4 shows an average nitrate content for the incubated samples of 27.57 parts per million parts of moisture-free soil for the corn plot, 23.37 parts for the oat plot, 25.71 parts for the wheat plot and 31.03 parts for the soybean plot.

The highest content of the incubated samples was found in July for the corn plot, in March for the oat and wheat plots, and in June for the soybean plot.

The results for the corn and soybean plots check very closely with each other in regard to high and low periods and also the averages of the fresh and incubated samples. Both are cultivated crops. Also, as would be expected, the results on the oat and wheat plots check closely.

Discussion of Table 5.

Series II West—Rotation Corn, Wheat and Soybeans.

Table 5 shows the average nitrate content of the fresh samples for the eight months to be 32.60 parts of nitrate per million parts moisture-free soil for the corn plot, 7.64 parts for wheat and 7.48 parts for the soybean plot.

The corn plot contained the highest amount of nitrates in August, with June and July also high; the wheat plot showed highest in March, with April, May and July also high; the soybean plot contained most nitrates in June and July.

The corn plot showed an average of 59.58 parts in the incubated samples, the wheat plot an average of 20.80 parts, and the soybean plot an average content of 28.12 parts nitrates per million parts moisture-free soil. The highest results for these samples were found in August,

TABLE 5.

Series 1 West—Rotation Corn, Wheat, Beans.

Month	Moisture %	Plot 1 Corn — Nitrates—Parts per million		Moisture %	Plot 2 Wheat — Nitrates—Parts per million		Moisture %	Plot 3 Beans — Nitrates—Parts per million	
		Fresh Samples	Incubated Samples		Fresh Samples	Incubated Samples		Fresh Samples	Incubated Samples
March	25.5	12.87	37.55	20.4	18.07	42.16	22.5	4.12	37.11
April	27.7	6.63	22.12	21.1	12.14	36.43	22.2	4.11	36.96
May	18.37	5.87	35.18	18.88	9.84	27.55	17.27	1.93	19.30
June	17.41	38.70	88.97	12.38	3.65	18.24	16.13	19.00	53.33
July	18.23	78.27	93.75	17.39	7.74	19.34	15.32	18.85	33.96
August	19.76	99.60	179.28	16.26	5.73	8.74	18.96	5.92	13.80
September	14.58	14.79	7.48	14.30	1.86	5.60	14.11	1.86	22.35
October	22.56	4.13	12.38	23.44	2.09	8.36	21.59	4.08	8.16
Total per period		260.86	476.71		61.12	166.42		59.87	224.97
Ave. per month		32.60	59.58		7.64	20.80		7.48	28.12

June and July for the corn plot, in March, April and May for the wheat plot, and in March, April, June and July for the soybean plot.

The highest results for the corn and soybean plots conform very closely to the period of cultivation, while the highest results for the wheat plot were obtained just before and immediately after the growing season, for the fresh samples, and from March to August for the incubated samples.

TABLE 6.

Series III West—Continuous Corn.

Month	Moisture %	Plot 1 Corn — Nitrates—Parts per million	
		Fresh Samples	Incubated Samples
March	25.4	21.41	34.26
April	27.5	4.43	22.02
May	18.32	29.35	78.27
June	15.88	22.80	60.83
July	18.01	42.93	50.68
August	16.63	14.97	40.22
September	14.17	9.31	18.63
October	22.21	6.17	8.23
Total for period		151.37	313.14
Ave. per month		18.92	39.14

Discussion of Table 6.

Series III West—Continuous Corn.

The average nitrate content of the fresh samples for the period was 18.92 parts of nitrate per million parts of moisture-free soil. The content was high from March to July, inclusive, with the exception of the month of April, the sample for which was taken just after the plot was plowed, and was lower from August to October. The highest point was reached in July.

The average for the incubated samples was 39.14 parts of nitrate. The months of May, June and July were highest, but the first six months all showed a high content for the incubated samples.

TABLE 7.

Nitrifying Power—Difference Between Fresh and Incubated Samples.

Series		Nitrates–Parts Per Million								
Number and Rotation	Plot No. and 1920 Crop	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Ave.
I, E.—	1 Wheat...	36.59	22.27	15.44	20.13	3.85	2.62	3.62	4 14	13.58
Corn, Wheat.......	2 Corn.....	16.43	28.57	15.29	47.05	3.69	55.68	30.16	12.48	26.17
II, E.—	1 Corn.....	24.74	24 11	21.87	47.67	26.65	14.94	18.27	6.27	23.07
Corn, Oats, Wheat..	2 Oats.....	26.70	26.12	17.37	10.77	15.46	7.73	13.99	8.30	15.81
	3 Wheat...	16.26	28.38	15.41	29.30	13.02	1 87	5.39	6.22	14 48
III, E.—	1 Unlimed..	12 22	29.33	18.90	10.73	10.92	6.71	5.70	14.58	10.95
Cont. Wheat.......	2 Limed...	16.49	32.39	15.24	24.60	23.09	4.59	10.63	11.57	17.32
I, W.—	1 Oats.....	19.43	34.59	17.24	20.13	11.28	2.15	12.71	6.17	15.46
Corn, Oats, Wheat	2 Wheat...	20.38	24.64	20.86	26.65	14.73	7.78	5.50	4 14	15.58
Beans...........	3 Beans....	20 24	17.68	16.92	99.83	—.03	0.	7.14	2.02	20.48
	4 Corn.....	16.05	21.91	15 21	30.07	11 60	13 38	11.42	6 13	15.72
II, W.—	1 Corn.....	24.68	15 49	29.31	50.27	15.48	79.68	7.31	8.25	26.98
Corn, Wheat, Beans.	2 Wheat...	24 09	24.29	17.71	14.59	11.63	3.01	3.74	6.27	13.17
	3 Beans....	32.99	32.85	17.37	34.33	15 11	7.88	20.49	77.52	29.81
(Cont. Corn) III, W............	1 Corn.....	12.85	17.59	48.92	38.03	7.75	25.25	9.32	2.06	20.22
Ave. all Plots..	....	21 34	25.33	20.21	32.89	12 28	15.47	10 51	11.87	

Discussion of Table 7.

Nitrifying Power of the Various Plots as Determined by the Differences between the Untreated Incubated and the Fresh Samples.

The averages for the period of the differences between the untreated and fresh samples are 13.58 parts, 14.48 parts, 10.95 parts, 17.32 parts, 15.58 parts and 13.17 parts of nitrates per million parts of moisture-free soil for the plots containing wheat. The lowest average was found for the unlimed continuous wheat plot, and the highest average for the limed continuous wheat plot.

The averages for the period for the corn plots were 26.17 parts, 23.07 parts, 15.72 parts, 26.98 parts and 20.22 parts of nitrate per million parts of moisture-free soil. The lowest difference, 15.72 parts, was for the corn plot in the corn, oats, wheat, soybean rotation, Series I. W., which plot also showed a low average for the fresh samples. This plot contains a large amount of gravel when compared with the other plots.

The averages for the oat plots were 15.81 parts and 15.46 parts of nitrate per million parts of moisture-free soil.

The averages for the soybean plots were 20.48 parts and 29.81 parts per million.

These results in Table 8 show that the nitrifying power of the corn and soybean plots as measured by this test is nearly the same, and is much higher than the nitrifying power of the wheat and oat plots, which plots are about equal in nitrifying power.

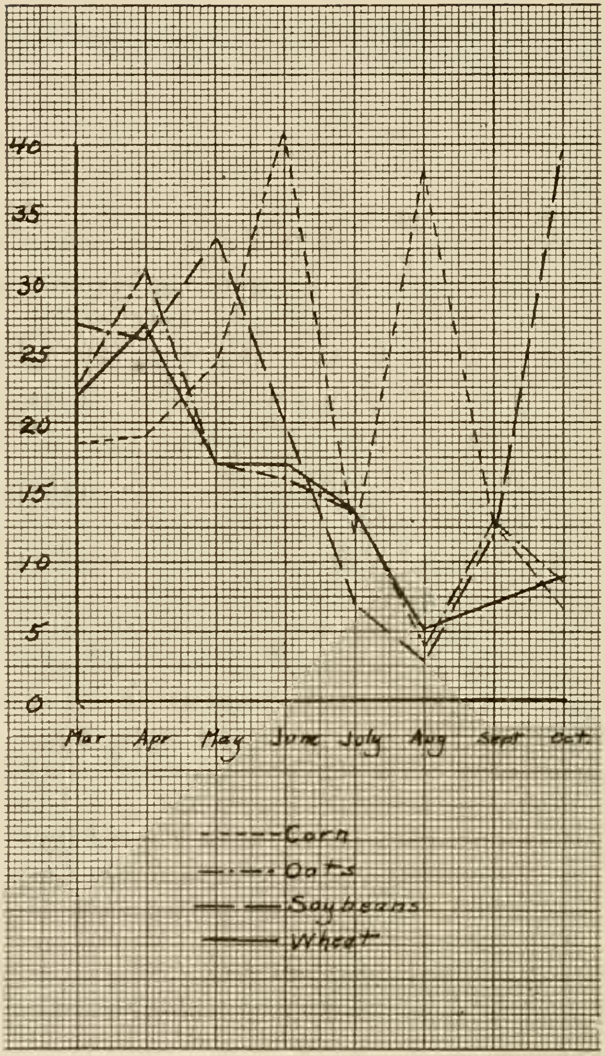


FIGURE I.
Nitrifying Power of Crops.

DISCUSSION OF TABLE 8.

Effect of Different Crops on Nitrifying Power of the Soil Measured by the Averages of all Plots Growing the Same Crop.

In Table 8 the differences between the incubated and fresh samples for all the corn, all the wheat, all the oats and all the soybean plots, are averaged and tabulated.

The curves for these averages are shown in Figure I.

TABLE 8.

Nitrifying Power—Difference between Fresh and Incubated Samples.

Crop	Average of Nitrates—Parts Per Million								
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Ave. Mo.
Corn	18.95	19.53	26.12	42.61	13.03	37.78	12 37	7.04	22.18
Oats	23.06	30.35	17.30	15.45	13.37	4.94	13.35	7.23	15.63
Wheat	21.00	26.89	17.26	17.42	12.87	4.43	7.56	7.82	14.65
Beans	26.61	25.26	32.92	22.36	7.55	3 94	13.81	39.77	21.48
Average	22.40	25.51	23 40	24.46	11.70	12.77	11.77	15.46	....

The highest average difference between the fresh and incubated samples was found in June for the corn plots, in April for the oats and wheat plots, and in May for the soybean plots. The amount of nitrates used by the crops and leached from the soil would affect this curve directly.

SUMMARY.

1. The rate of nitrate formation is very greatly increased by cultivation of the soil.

2. The corn and soybean plots, which were cultivated, showed a high nitrifying power as compared to the wheat and oat plots, which were not cultivated during the growing season.

3. The effect of the previous crop and treatment of the soil on nitrate production is not nearly as important as that of the growing crop and the soil treatment.

4. Corn and soybeans are heavy feeders while wheat and oats are less vigorous nitrate feeders.

5. The highest nitrifying power as determined by the methods employed in this work was in July for the corn plot, and in June for the wheat, oat and soybean plots.

6. The addition of lime to acid soils makes conditions for the development of nitrifying bacteria much more favorable.

7. The rate of nitrate production in the plots in the Purdue Experiment Station Field No. 6 is not a limiting factor to plant growth.

Purdue University.

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Fertilizer Treatment as Affecting Nitrate Production.

I. L. Baldwin, W. E. Walters and F. K. Schmidt.

Nitrate production is one of the most important problems of soil fertility. The ability of a soil to produce sufficient amounts of nitrate nitrogen for desirable plant growth over and above the natural losses, as denitrification and leaching, depends primarily upon soil management and treatment.

The problem of the farmer is to know the methods that can be employed to furnish and maintain this element in available form most economically. Natural losses occur more readily than in the more stable compounds of potassium and phosphorus.

There are many factors entering into the production and utilization of this important plant food and it has been the purpose of this investigation to try to throw some light upon a few of them.

Review of Previous Work.

It has been known for a long time that nitrates are formed from organic nitrogenous substances in the soil. Investigators were discussing the process as far back as the middle of the nineteenth century. At that time they considered it as a purely chemical process. The great chemist Liebig held this view and his support was probably the reason that the actual cause of nitrification was not discovered at an earlier period. Boussingalt 1860 showed that the nitrogen of nitrate was not derived from the air.

It was demonstrated by Schloessing and Muntz 1878 that microorganisms in the soil oxidized ammonia to nitrate. His conclusions were drawn from the work he did on sewage disposal. Since this time many attempts were made to isolate the organism in pure culture and it was not until about 1890 that this was accomplished.

King and Whitson (2) found that nitrates were produced more rapidly in stirred soil due to better aeration.

Brown (4) concluded that media prepared from soil extracts permitted fewer organisms to develop than the modified synthetic agar. Fresh soil offers conditions as closely approximating field conditions as possible.

Lyon, Bizzell and Conn (5) state that a very definite relation exists between the crop yields and nitrate contents of the soil. Higher yielding plots show a larger accumulation of nitrates before planting than do the very low yielding plots. Evidently higher yields in these plots are associated with a more rapid formation of nitrates.

Brown (7) ran nitrification tests to find the nitrifying power of the soil. He treated the soils with dried blood and with ammonium sulphate. His tests show agreement to crop producing power of the soil, that is, the high nitrifying soils produced large crops.

Brown and Halversen (10) concluded that the number of molds present in the soils fluctuated from one sampling to the next but was apparently unaffected by moisture, temperature or soil treatment. Some factors as yet uninvestigated probably account for the fluctuation. The small number of molds in soil compared with bacteria may not necessarily mean that they are less important and certainly will not prove that they are unimportant.

Greaves and Carter (12) found in their study of twenty-two soils that each one gave a maximum ammonification when its water content was sixty per cent of its water holding capacity. Nitrification was at its maximum at fifty or sixty per cent and varied with specific soils.

Whiting and Schoonover (13) conclude that soil treatment is a very important factor in nitrate production.

History of the Plots.

The field where this experiment was carried on is a part of the Purdue Experimental plots and is located on a brown silt loam underlaid with gravel at a depth of about two feet. It has been classified by the United States Department of Soils as a Sioux Silt Loam.

The field consists of thirteen one-sixteenth-acre plots. The first, fifth, ninth, and thirteenth plots are untreated or check plots and the other nine received the treatments shown in Table 1. The crop rotation of the field consists of corn, oats, wheat, clover and timothy. In 1920, the year this experiment was conducted, the field was in oats followed by fall sown wheat.

This field was laid out in 1889 and the different treatments were begun in 1890. A different system of treatment was used at first and it was not until 1918 that the present treatment was started, the field having received no treatment during 1917. The object of the change of treatment, which involved only the amount and method of application, was to secure more efficient use of the nitrogen applied.

TABLE 1

Series IV East—Field 6—Purdue Farm
Fertilizer Treatment in Pounds Per Acre

Plot No.	Corn	Oats	Wheat	Clover	Timothy	Treatment
1	None	None	None	None	None	Check
2	12,000	6,000	6,000	None	6,000	Horse Manure
3	12,000	6,000	6,000	None	6,000	Cattle Manure
4	N 30	N 15	N 15	None	N 15	N. P. K.
	P 30	P 15	P 15	....	P 15	
	K 30	K 15	K 15	.....	K 15	
5	None	None	None	None	None	Check
6	N 30	N 15	N 15	None	N 15	N. P. —
	P 30	P 15	P 15		P 15	
7	P 30	P 15	P 15	None	P 15	
	K 30	K 15	K 15	. . .	K 15	— P. K.
8	N 30	N 15	N 15	None	N 15	N — K
	K 30	K 15	K 15	.....	K 15	
9	None	None	None	None	None	Check
10	P 30	P 15	P 15	None	P 15	— P —
11	N 30	N 15	N 15	None	N 15	N —
12	K 30	K 15	K 15	None	K 15	— K
13	None	None	None	None	None	Check

Rotation Corn, Oats, Wheat, Clover and Timothy—
P=lbs. P_2O_5 per acre.
K=lbs. K_2O per acre.
N=lbs. N per acre.

Although there is now more total nitrogen applied to the manure plots than is applied to the plots receiving nitrogen in commercial form, the nitrogen in the manure must be converted into soluble nitrate while the commercial nitrogen is applied in the readily available form of nitrate of soda, so that the available nitrogen on these plots is probably comparable.

Object of the Investigation.

Although a great many investigations have been conducted in a study of nitrification, few pertain to comparisons of the efficiency of different fertilizer treatments for nitrate production. The following points were deemed important in this study and they express the aim of this work.

1. The comparison of the amount of nitrate nitrogen produced in the same field but with different fertilizer treatment.
2. Correlation between amount of nitrate production and crop yield.
3. Correlation between nitrates found in the soil under natural conditions with growing crops and amount accumulating under optimum conditions.
4. Nitrifying power of a soil compared to crop growth and nitrate content in a fresh soil.
5. Comparison of the effect of soil treatments on bacteria and molds.

Technic.

There was no effort made to discover or try out new methods in this work and the technic employed was adapted to the needs and conditions of this experiment from methods already in common use in soil nitrate and bacteriological studies.

The monthly sampling time varied from the twentieth to the end of the month, but all samples for each month were taken on the same day. The time chosen for taking samples was when all conditions were most favorable thereby lessening the possibility of denitrification occurring during the incubation period. Sampling was done with a soil auger, ten borings made to a depth of ten inches were taken from representative parts of a plot. Judgment was exercised in taking the samples to make them as representative as possible of the soil of the plots.

The samples were taken from the field to the laboratory and all work performed with the fresh samples was done immediately, thus not allowing time for any material bacterial action to take place before the tests were started.

The soil from each plot was used for the following five tests:

1. Fresh nitrates;
2. Nitrates after two weeks incubation;
3. Nitrates after two weeks incubation plus ammonium sulphate;
4. Plate count of bacteria and molds;
5. Moisture content of the fresh soil.

The colorimetric method employing the phenol-di-sulphonic acid color reaction, as modified by Noyes (11) was used in determining the amount of nitrates present. Although the accuracy of this method has been severely criticized it is the one most widely used and most practical for this type of work where comparative rather than absolute results are sought.

A one hundred gram aliquot of soil was weighed into tumblers marked for the respective plots 1A to 13A. Each tumbler was covered with a petri plate lid and set away in a locker. After two weeks incubation nitrates were determined as before.

One hundred grams of each sample were placed in tumblers marked 1B to 13B and one cubic centimeter of a ten per cent solution of ammonium sulphate was dropped over the soil in each tumbler. They were covered and incubated two weeks then tested as in the case of the fresh nitrates. In the case of both incubated samples when too dry equal amounts of distilled water were added to each tumbler or if too wet the covers were left off of each tumbler for equal periods until of the proper moisture content.

Duplicate plates were made of dilutions 1 : 100,000 and 1 : 1,000,000 from each sample. A 1 : 10,000 dilution was also plated for a few of the tests but the colonies were too crowded to make the count accurate. Several different media recommended by soil bacteriologists were tried in an effort to determine which of them would give the best growth of bacteria and not encourage the spread of molds over the plates. The following synthetic agar media seemed most satisfactory and was used through the major part of the investigation:

5 grams of sodium potassium tartarate;
.5 gram of di-basic potassium phosphate;
1 gram of peptone;
.2 gram of magnesium sulphate;
15 grams of agar;
1 liter of distilled water.

The plates were incubated for one week at room temperature before counting colonies of bacteria and molds. However, in two instances low temperature in the room deterred growth so that they were incubated longer.

TABLE 2.

Moisture Percentage.

Plot No.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Ave.
1	23.65	21.25	23.25	18.96	10.60	13.24	14.49	18.89	20.83	165.21	18.35
2	25.15	22.77	18.65	11.70	14.39	16.34	13.01	20.17	22.60	164.59	18.29
3	24.26	22.95	19.45	11.00	12.48	15.68	15.93	24.82	21.79	168.36	18.70
4	24.38	22.05	18.45	15.48	12.65	15.55	15.84	20.97	29.11	174.48	19.39
5	23.32	21.60	17.55	10.95	8.86	15.55	13.93	21.61	20.21	153.59	17.07
6	24.00	20.75	17.80	10.65	12.88	15.13	15.25	20.92	21.53	158.91	17.66
7	23.62	21.55	19.68	11.70	12.30	15.74	16.46	21.53	21.01	163.59	18.17
8	23.84	21.05	18.35	10.70	12.40	14.17	14.17	20.73	20.52	155.93	17.32
9	23.40	21.85	18.27	10.92	11.65	14.38	14.32	20.02	20.03	154.84	17.20
10	23.14	20.45	18.42	10.15	12.75	14.17	14.01	20.23	20.38	153.30	17.03
11	21.76	20.40	14.67	10.40	10.75	13.76	13.70	20.01	19.92	145.37	16.15
12	23.15	20.45	17.55	10.00	10.70	13.57	12.94	20.26	19.80	148.42	16.50
13	22.85	20.25	17.72	10.80	11.58	13.48	13.15	20.78	20.77	151.38	16.82
Total	306.52	277.37	239.81	153.41	153.90	190.77	187.20	270.94	278.50	....	226.43
Ave..	23.58	21.33	18.44	11.80	11.84	14.67	14.40	20.84	21.42	158.32	17.45

Ten gram samples were weighed into tarred crucibles and dried in an electric oven at a temperature of one hundred degrees centigrade for moisture determinations.

All calculations in the tables were based on moisture free soil. Nitrate parts per million were calculated on the average for the duplicates, however there was little variation in the duplicates. The bacteria and mold calculations were based on the average of the 1 : 100,000 dilution plates, except in a few cases where development was not normal. Calculations were then based on the 1 : 1,000,000 dilution plates.

Moisture Percentages (Table 2).

Moisture determinations were made in order to calculate the amount of nitrates produced on a dry soil basis. Although the moisture content of a soil probably does greatly influence nitrate production it was not primarily for the study of this factor that the moisture content of the samples was made in this experiment.

Table 2 shows that the range of moisture content between the plots in any one month is small, not over four per cent except in a few instances. Plots 1 and 4 were high in June causing a range of 8.96 per cent while the range for the remaining plots was less than two per cent. The highest moisture content occurred in March with a gradual decrease to June and July, which were nearly equal and lowest for the period.

The moisture content increased from August to the end of the period and the average for November was a little more than equal to April. But these figures cannot mean very much because this factor is largely dependent on the season and weather conditions at the particular time of sampling. The plot averages for the year showed a range of only 3.24 per cent. The average deviation from the average was only a .75 per cent. The moisture content of the soils of the different plots varied so little that it was probably a very small factor in causing the difference in the nitrate production of these plots.

TABLE 3

Molds

(Millions per gram of Dry Soil Calculated on a Dry Basis)

Plot No.	March	April	May	June	July	Sept.	Oct.	Nov.	Total	Ave.
1	1.57	1.40	.60	.12	.22	.17	.30	.44	4.84	.60
2	1.34	1.03	1.35	.45	.34	.28	.00	.32	5.13	.64
3	1.58	1.44	1.47	.33	.28	.23	.20	.25	5.80	.72
4	1.19	.83	.61	.41	.28	.29	.31	.21	4.16	.52
5	1.44	1.27	.36	.28	.11	.00	.32	.88	4.67	.58
6	.72	3.79	.55	.50	.34	.17	.69	.44	7.22	.90
7	1.31	1.02	.62	.28	.40	.12	.44	.82	5.02	.62
8	1.77	.89	.37	.61	.28	.40	.44	.37	5.15	.64
9	1.31	.31	.67	.28	.22	.11	.25	.25	3.42	.42
10	.58	1.88	.35	.27	.63	.11	.50	.56	4.90	.61
11	.26	.87	.52	.27	.44	.11	.81	.43	3.75	.46
12	.71	1.57	.54	1.22	.28	.11	.44	.62	4.50	.56
13	.32	1.69	.60	.78	.34	.11	.63	.79	5.28	.66
Total...	14.10	18.02	8.64	5.85	4.20	2.27	5.40	6.42	....	7.98
Ave.....	1.08	1.38	.66	.45	.32	.17	.41	.49	4.99	.62

Mold Counts Expressed in Millions Per Gram of Dry Soil (Table 3).

The results of mold counts given in Table 3 show that the mold counts of all plots averaged highest in March and April, gradually decreasing for May, June and July. The lowest count was for September, growth being very low at that time. The averages for October and November about equalled the average count for June.

The range in the counts for the different plots was wide, varying, for March, from .26 for the nitrogen plot, No. 11, to 1.77 for the N K plot, No. 8.

However, the range was usually much less as the count in September was from .11 for several plots to .40 for the N K plot, No. 8. This plot had a rather constant count, never falling below .37. This was much above the average for the July counts. The high average of plot 6 may have been due to an error since the April count was 3.79 while in March the count was only .72 and in May .55.

Mold counts for manure plots Nos. 2 and 3 were consistently above the averages for the monthly tests until October and November when the counts were much lower than the averages for these months. The cow manure plot, No. 3, had the higher count for March, April and May. But the horse manure plot, No. 2, had a little higher count for the remainder of the months, except in October when the failure of any growth to appear lowered the average count of Plot 2 noticeably below Plot 3.

Check Plot No. 9 had the low average count of .42 for the period. The N K Plot No. 8, had an average count of .64, which is .22 above this check plot. The P Plot, No. 10, had a count of .61, which is .19 above the check. But Plot No. 11, having only nitrogen treatment, has an average count of .46 which is approximately equal to the count of the check plot.

The potash and phosphorus treatments appeared to increase mold growth while nitrogen treatment had but slight effect. The average counts for check plots Nos. 1, 5 and 13 were considered equal to or higher than all the chemically treated plots. It would seem that either the source of error was very great, due perhaps to the small number of molds grown, or the various chemical treatments influenced mold growth but little.

Bacteria Counts Expressed in Millions Per Gram of Dry Soil (Table 4).

Bacteria counts of all plots averaged high for March, April, and October, medium for June and July, low for May and September with November lowest of all.

The range of counts for March was from 2.61 for the N plot, No. 11, to 19.60 for the cow manure plot, No. 3. But the range for July was only from 2.64 for the complete fertilizer plot, No. 4, to 5.48 for the horse manure plot, No. 2.

The check plots Nos. 1, 5, 9, and 13 showed a lower average count for the period than the intervening treated plots. Check plot, No. 1,

TABLE 4.

Bacteria

(Millions per gram of Dry Soil Calculated on a Dry Basis)

Plot No.	March	April	May	June	July	Sept.	Oct.	Nov.	Total	Ave.
1	9.95	7.25	3.39	4.75	3.92	2.40	5.80	1.58	39.04	4.88
2	12 70	10.05	9.21	4.93	5.48	4.61	2.25	3 11	52.34	6.54
3	19.60	11.40	4 92	6.10	4 28	5.05	7.58	3.38	62.36	7.79
4	6.60	13.85	4 41	6.34	2.64	2.85	5.82	2.31	44.83	5.60
5	7.05	8.18	1.46	1 74	3 62	1.86	5.87	1.38	31.16	3 89
6	4.94	5 41	2.32	4 76	4 70	1.88	5.69	3.94	33.64	4 20
7	6.15	10 20	2.48	2.84	4.90	2.52	7.00	3 10	39.19	4.89
8	5.81	11 14	4 55	2.01	5.51	8.40	6.95	1.51	45.88	5.73
9	10.92	1.50	3.37	2.02	3.84	1.63	6.50	2.50	32.28	4.03
10	10 11	9.82	1.04	3.90	4.30	2.21	6.27	2.32	39 97	4.99
11	2.61	6.90	3 22	11.10	4 58	1.62	10.00	2 12	42.15	5.27
12	4 96	3.77	3 64	6.68	4.64	2.64	5.14	2 37	33.84	4.23
13	5.82	4.34	4 26	6.40	2.66	1.27	4.05	2.91	31.71	3.96
Total...	107 22	103.85	48.27	63.58	55.07	38.94	78.92	32.53	....	66.05
Ave.....	8.24	7.98	3.71	4.89	4 23	2.99	6 07	2.50	40.64	5.07

had an average count of 4.88 which was lower than the average count for plots Nos. 2, 3 or 4.

The manure plots Nos. 2 and 3 had the highest average counts. The count for the cow manure plot, No. 3, was higher, for March, April, June, September, October, and November, than the horse manure plot No. 2. The average count for the period was 1.25 greater.

Three of the four plots having nitrogen in their treatments had higher average counts for the period than plots receiving no nitrogen in their treatments. The N K plot No. 8, was high with 5.73, the complete fertilizer plot, No. 4, was next with 5.60 and the N plot, No. 11, was lower with 5.27. However, the N P plot, No. 6, shows a slightly lower count than the P plot, No. 10, and the P K plot, No. 7, but nearly equal to the average count of the K plot, No. 12.

The results seem to indicate that manure treatment causes greatest bacterial growth. The nitrogen in commercial fertilizer treatments usually encourage bacterial growth more than phosphorus or potassium. All treatments increased bacterial numbers over the no treatment plots.

Fresh Nitrate Expressed in Parts Per Million Per Gram of Dry Soil (Table 5).

The nitrate found in the fresh soil is not a real test of the amounts being produced. The amount of water present, due to physical condition of the soil, the amount lost by leaching, and the amount and rapidity of crop growth cause the nitrate content to vary unequally. The averages for the months indicate periods of consumption and excess production. The plot averages for the entire period probably indicate roughly the nitrate producing ability of the soil.

The amounts of soluble nitrates found to occur in the soils of the different plots at the monthly sampling times vary greatly. The plots average highest for March, medium for April, July, September, and November, low for October, May and August and lowest for June. The

TABLE 5

Fresh Nitrates

(Parts per million calculated on a Dry Basis)

Plot No.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Ave.
1	21.00	8.15	20.90	15.80	10.70	12.91	16.82	7.89	14.15	128.32	14.26
2	29.00	9.30	8.80	7.25	35.80	15.31	30.20	16.10	29.00	170.76	18.97
3	29.60	11.40	8.91	6.30	18.60	22.80	50.90	20.22	24.50	193.23	21.47
4	16.90	12.30	8.80	3.79	28.10	9.50	17.20	10.10	18.08	124.77	13.86
5	17.80	10.40	12.61	3.60	7.01	10.42	11.10	6.12	10.02	89.08	9.90
6	21.80	20.10	8.79	5.48	11.00	11.32	15.15	7.08	17.31	118.03	13.11
7	23.80	14.30	7.92	3.63	7.31	9.51	15.40	10.70	13.15	105.72	11.74
8	24.20	13.20	15.71	3.58	18.52	12.12	13.08	11.10	13.60	125.11	13.90
9	25.00	16.20	11.70	4.50	10.91	13.10	13.09	7.00	10.00	111.50	12.39
10	26.00	17.10	7.85	3.57	22.00	12.10	13.03	8.55	14.08	124.28	13.80
11	16.40	16.10	10.31	8.94	14.31	8.35	14.85	10.00	16.00	115.22	12.80
12	21.90	10.00	7.78	3.56	28.70	11.10	16.50	8.04	10.96	118.54	13.17
13	20.80	12.00	9.75	5.38	18.21	7.40	12.81	5.05	12.12	103.52	11.50
Total	294.20	170.55	139.83	75.38	281.37	155.94	230.13	127.45	203.07	....	181.87
Ave.	22.63	13.12	10.76	5.80	17.79	12.00	17.70	9.80	15.62	126.22	14.00

low average nitrate content for June was probably due to the rapid crop growth and dry weather occurring at that time. But the low average for October was probably influenced by heavy rains just preceding the taking of the samples.

Manure plots Nos. 2 and 3 were highest for March and November. This was probably due to the residual effect of the manure. In contrast with these plots the N plot, No. 11 was lowest for March and low in November; this plot was higher than the manure plots for April, May, and June, and showed the least variation for the period.

The average parts of nitrate for check plot, No. 1, was .26 higher than the average for all plots. The other three check plots Nos. 5, 9 and 13 were all low with an average for the three of 11.26 or 2.74 parts lower than the average for all plots, and .48 lower than the lowest treated plot, No. 7.

The three plots Nos. 4, 6, and 8 receiving N P K, N P, and N K, respectively, had an average for the period of 13.62. But the average of the plots Nos. 7, 10, and 12 which received no nitrogen in their treatments was 12.90 for the period. This was .72 less than the average for the plots receiving nitrogen in addition to these treatments.

It seems, from these results, that check plot, No. 1, was influenced by the treatment from the manure plots next to it. Manure treatment had a tendency to produce nitrates continuously throughout the period.

Any one of the treatments increased nitrate content over no treatment. Nitrogen combined with phosphorus or potassium gave a higher nitrate content than when nitrogen was used alone or when phosphorus and potassium were used without nitrogen.

Nitrates After Two Weeks Incubation Expressed in Parts Per Million Per Gram of Dry Soil (Table 6).

This test was intended to show the amount of nitrates that would accumulate when the soil was placed under optimum conditions. It

TABLE 6.

Nitrates After Two Weeks Incubation.

(Parts per million calculated on a Dry Basis)

Plot No.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Ave.
1	21.00	30 60	48.01	35.51	75.00	17 50	11.20	9 86	16.15	264 83	29.42
2	25.80	31.00	47.21	29.02	157.00	31 40	20.20	14.05	27.90	383.58	42.62
3	30.80	29 10	47 60	27.91	157.00	13.50	44.60	12.75	39.95	403.21	44.80
4	25.40	31.80	29 42	35 03	74 10	19 01	13.31	10 10	27 04	265 21	29.47
5	27.10	26.60	40.81	14.41	57.00	40.00	13 00	12.25	16.05	247.22	27.47
6	21.00	28.20	33.00	17.90	75.00	12.37	15.15	10 10	19.36	231.78	25.75
7	21.00	26.60	31.91	14 51	68.51	19.00	12 50	10 20	22.25	226.48	25 19
8	23 10	36.60	32.00	26.92	81 40	7.46	9.34	12 15	20 08	249 05	27.67
9	23.00	36.40	29 31	18 01	65.40	18.60	9.35	10 00	17.00	227.07	25.23
10	16.70	23.20	31.42	17.83	73.40	14 95	13.21	12.05	19 05	220.81	24.53
11	16.40	24.00	31.01	17.85	51.00	14 88	14 85	12.00	24.95	206.94	22.99
12	20.80	21.10	45.82	14.21	35 80	14.85	14 50	10 05	16.92	194 05	21.56
13	20.80	20.00	35.00	14.30	58.00	12.96	9.22	12.16	20.20	202 64	22.51
Total	292.90	365.20	482.52	284.41	1,028.61	236.48	200 43	147.71	286.90	....	369.21
Ave..	22.53	28.09	37.12	21.88	79.12	18.20	15 72	11.36	22.07	255 79	28.41

differed from the fresh nitrate test in that moisture content was controlled and there was no loss of nitrates from crop growth or leaching.

Table No. 4 shows that the nitrate content of the soils was high for May and July, medium for April, low for March, June and November and very low for August, September and October.

The manure plots, Nos. 2 and 3, were high for March, April, and November. The averages of these plots for the period were about equal and much above the average of all plots.

The three plots 4, 6, and 8 receiving nitrogen in addition to phosphorus or potassium or both had an average nitrate content of 27.63 for the period. The average nitrate content was 23.79 for plots 7, 10, and 12 which received the same treatments except the nitrogen was left out.

The average of the three check plots 5, 9, and 13, was 25.07 for the period. The check plots in this case were slightly higher in nitrate content than the plots receiving either phosphorus or potassium or both. This difference was not marked but it may have been caused by a greater lack of nitrogen in the treated soil due to a larger crop growth. However, the average of the untreated plots was also higher than the plot receiving only the nitrogen treatment. The average of the plots 7, 10, and 12 which had no nitrogen in their treatments was slightly higher than the average for the N plot No. 11.

The increase in nitrate content of the incubated samples over that of the fresh soil samples was proportionately much less when the fresh nitrates were low as in June and October. The average on both tests was highest for the period in July. The July increase in nitrate content after incubation was 350 per cent. But in October the increase with incubation was only 15.9 per cent. The increase for the high month of July was 62.33 parts but the increase for the low month of June was only 16.08 parts.

It then would seem in this instance that periods of low nitrate content may indicate times of low nitrifying power of a soil. The results seem to show that the addition of nitrogen to the phosphorus and potassium treatments causes the higher nitrate content of those soils.

TABLE 7.

Nitrates After Two Weeks Incubation and Addition of $(NH_4)_2SO_4$

(Parts per million calculated on a Dry Basis)

Plot No.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Ave.
1	35.60	28.50	41.61	50.51	114.50	17.50	19.70	13.80	21.22	342.94	38.10
2	37.40	36.10	55.12	108.20	187.00	50.70	25.07	36.08	41.45	577.12	64.12
3	36.00	37.40	60.51	108.00	178.00	60.45	36.09	44.52	47.00	607.97	67.55
4	31.80	37.00	39.21	44.51	100.00	27.25	24.61	16.25	33.90	254.53	39.39
5	29.40	32.70	30.22	36.01	97.50	16.11	14.90	13.25	20.02	290.11	32.23
6	33.60	31.40	38.90	35.82	109.00	28.12	21.68	14.17	21.40	334.09	37.12
7	34.60	28.80	32.81	36.23	146.00	21.91	15.40	16.35	26.28	358.38	39.82
8	35.80	35.00	39.23	52.01	168.90	29.92	16.75	15.15	22.18	404.94	44.99
9	35.40	27.00	39.12	35.94	173.00	41.20	20.25	16.00	18.00	406.21	45.13
10	35.40	24.10	39.32	41.03	147.50	34.50	24.21	12.05	20.10	378.21	42.02
11	32.80	28.10	30.01	42.81	103.50	28.39	18.61	14.00	19.95	318.17	35.35
12	33.10	36.10	38.92	35.50	100.50	37.10	27.25	12.02	15.95	336.44	37.38
13	34.80	20.00	39.00	39.50	132.00	29.81	14.80	14.15	18.15	337.21	37.47
Total	445.70	422.50	523.98	666.07	1,747.40	422.96	279.32	237.79	325.60	...	560.67
Ave.	34.28	32.50	40.30	51.23	134.41	32.53	21.48	18.28	25.04	390.05	43.23

Nitrates After Two Weeks Incubation Plus Ammonium Sulphate. Expressed in Parts Per Million Per Gram of Dry Soil (Table 7).

This test was intended to show the efficiency of the different soils in changing a soluble nitrogen compound into nitrate nitrogen. Any lack of nitrogen was supplied and variations in the amounts of nitrates formed in the soils were dependent on their ability to change ammonia to nitrate. However, this ability cannot be directly attributed to the original soil treatments as their power may have been changed because of the influence of the nitrogen added.

The monthly averages of the nitrates for the plots in this test were high for May, June, and July, low for September, October, and November and medium for March, April, and August. The manure plots Nos. 2 and 3 were high throughout the period with a general average of 65.83. The cow manure plot, No. 3, was slightly higher, for the period, than the horse manure plot, No. 2. The most noticeable variation between these manure plots and the other soils in the study occurred in October and November when the manure plots were nearly twice as high as any other plot.

Variations among all other plots were small. The range for any month was usually less than fifteen parts per million. The range of averages for the period was from 32.23 for check plot No. 5 to 45.13 for check plot No. 9.

The average for the check plots Nos. 1, 5, 9 and 13, was 38.23 for the period. The average of the plots Nos. 4, 6, 8, and 11 receiving nitrogen in their treatments was 39.21 for the period. The average of plots Nos. 10, 12, and 7 receiving phosphorus, potassium, and phosphorus and potassium respectively, was 39.74. Although the average for the check plots was slightly lower than for the treated plots the results as measured by this test seemed to show the nitrifying power of these soils to be very similar.

Comparing Tables 4 and 5 the results show that the nitrates in the ammonium sulphate treated samples were increased more for the fertilizer plots Nos. 7, 10, and 12 which received no nitrogen in their treatments, than were the nitrates for plots Nos. 4, 6, 8, and 11, which received nitrogen in their treatments. The average difference due to increase for the plots receiving no nitrogen in their treatments was 15.98. But the average difference for the plots receiving nitrogen in their treatments was only 12.74. The average difference due to increase was a little lower for the check plots, it being 12.12. The greatest increase occurred in the case of the manure plots which had an average difference of 22.12.

The results of this test seem to indicate that manure treated soil has the strongest nitrifying power because of the increased physiological efficiency of the bacteria. The check plot shows the lowest nitrifying power due to the lowered physiological efficiency of the bacteria. The treatment with phosphorus, potassium or both increased the nitrifying power of the soil. The nitrogen applied in the form of ammonium sulphate at the time this test was started made doubtful the effect of the original nitrogen treatments on the nitrifying power of the soils.

TABLE 8.

Table of Averages.

Plot No.	Per Cent Volatile Matter	Per Cent Moisture	Nitrate Parts Per Million on Dry Basis			Millions Per Gram of Dry Soil Calculated on Dry Basis	
			Fresh Soil	After 2 Weeks Incubation	After 2 Weeks Incubation Plus $(NH_4)_2SO_4$	Bacteria	Molds
1	6.10	16.13	14.26	29.42	38.10	4.880	.605
2	6.15	18.29	18.97	42.62	64.12	6.543	.641
3	5.91	18.70	21.47	44.80	67.55	7.795	.726
4	5.62	19.39	13.86	29.47	39.39	5.604	.521
5	5.75	17.07	9.90	27 47	32.23	3.895	.584
6	5.52	17.66	13.11	25.75	37.12	4.205	.903
7	5.90	18 17	11.74	25 19	39.82	4.899	.629
8	5.68	17.32	13.90	27.67	44.99	5.735	.645
9	5.75	17.20	12.39	25.23	45.13	4.035	.428
10	5.66	17.03	13 80	24 53	42.02	4.996	.613
11	5.66	16.15	12.80	22.99	35.35	5.270	.469
12	5.69	16.50	13 17	21.56	37.38	4.230	.563
13	5.86	16.82	11.50	22.51	37.47	3.964	.661

Table of Averages (Table 8).

Since it seemed that the plot averages for the period were a more accurate measure of the nitrate producing ability of the plots than figures for any one month, these plot averages for all the tests were brought together in Table 8. A study of this table as illustrated by Figure I shows that there is a direct correlation between bacterial activities and nitrate production. The nitrates were low in the fresh soil and correspondingly higher in the incubated soil. The highest nitrate production occurred in the ammonium sulphate treated soils. Bacteria and mold counts correlate closely, bacteria having the much higher count.

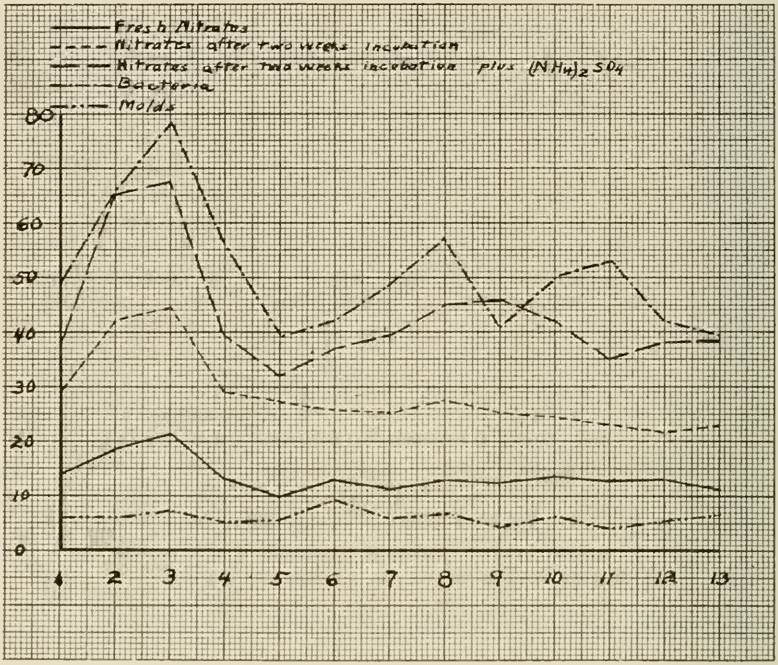

FIGURE I.
Correlation of Bacterial Activities and Nitrate Production.

Correlation of Bacterial Activities and Nitrate Production (Figure I).

This graph is based on the figures in Table 8. It can be readily seen that there is a marked correlation between these five basic factors. One noticeable disagreement may be seen in the case of the treated incubation test on Plot No. 9, when the nitrates were comparatively higher than in the other tests. Another disagreement occurs due to high bacterial counts for plots Nos. 10 and 11. With the exception of a few other minor differences these curves follow each other very closely.

Comparison of Crop Production With an Efficiency Factor (Figure II).

Any effort to compare the nitrate production and bacteriological efficiency of a soil with crop production makes it desirable that some common basis of comparison should be decided upon. For this purpose an efficiency factor for each of the tested plots was secured by adding together the parts per million of nitrates from the three tests with the mold and bacteria counts per million for each plot using the last five columns of figures in Table No. 8. The sums obtained for check plots Nos. 1 and 5 were added, divided by two, and the resulting figure taken

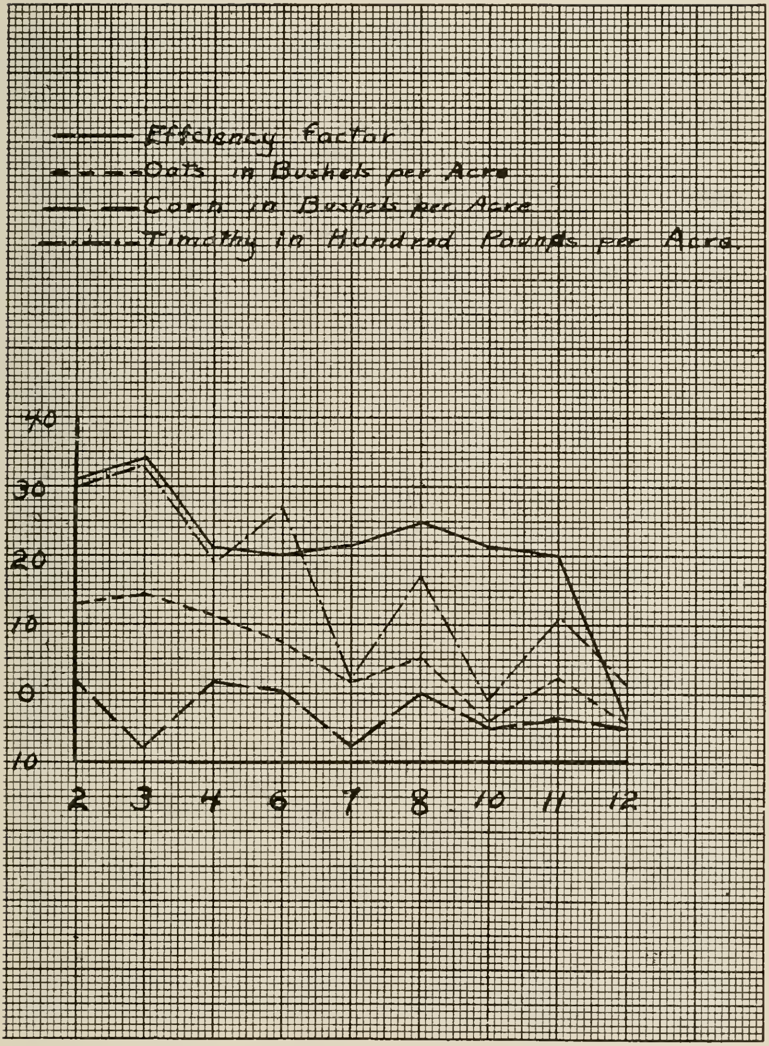

FIGURE II.
Comparison of Crop Production with an Efficiency Factor.

as 100. The intervening plots Nos. 2, 3, and 4 were then compared to this standard.

This efficiency factor was determined for all plots in a similar manner. The graphic crop yields based on a similar method of calculation were compared to the efficiency factor in Figure II. It is readily seen from this graph that there is a correlation of crop yield with biological activities and nitrate production. The closest correlation is shown by the oats and timothy yields. The yield of corn shows the least correlation. Plot No. 3 has the highest efficiency factor and its corn yield was lowest of all the plots. Again in Plot No. 4 the efficiency factor goes down and the corn yield is highest of all the plot yields. However, for the remainder of the plots the yield and the efficiency factor show a close agreement.

Summary.

A general study of the results of this experiment seem to show that the manure plots which were high in mold counts; highest in bacterial numbers; highest for fresh nitrates; equally high in incubated nitrates and very high in the ammonium sulphate treated samples, had the greatest efficiency for nitrate production. The cow manure treatment seemed to be somewhat more efficient than the horse manure treatment since the results of all tests were slightly higher in its favor.

Check plot No. 1, seemed to have been influenced by the manure treatment due to its nearness to those plots. The results from plot 1 usually were as high or higher than the average for all the plots and on the whole higher than the other check plots.

The use of nitrogen with phosphorus or potassium was superior to either of the treatments used alone for bacterial count and all nitrate tests except the ammonium sulphate treated samples where the difference was slight. Phosphorus and potassium treatments increased mold and bacteria growth, fresh nitrates and ammonium sulphate treated samples.

The results of ammonium sulphate treated samples which were least influenced by crop growth and seasonal variations seem to show that the greatest nitrifying power of a soil is in May, June and July. This power seems to decrease during the latter part of the summer and increase in the late fall and spring.

There seems to be a general correlation, when averages are taken for the entire season, between the amount of nitrate found in the soil under natural conditions with growing crops and the amount accumulating under optimum conditions.

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