PROCEEDINGS

OF THE

INDIANA ACADEMY OF SCIENCE

—

1915

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Indiana Academy of Science

1915

H. E. BARNARD, Editor

FORT WAYNE PRINTING COMPANY
CONTRACTORS FOR STATE PRINTING AND BINDING
1916

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CONSTITUTION.

ARTICLE I.

SECTION 1. This association shall be called the Indiana Academy of Science.

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

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

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

ARTICLE II.

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

SEC. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the

State. In any case, a three-fourths vote of the members present shall elect to membership. Application for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 5. The members who are actively engaged in scientific work, who have recognized standing as scientific men, and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

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

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

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

BY-LAWS.

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

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

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

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

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

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

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

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

(Approved March 11, 1895.)

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

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

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

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

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

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the

Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

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

APPROPRIATION FOR 1915-1916.

The appropriation for the publication of the proceedings of the Academy during the years 1915 and 1916 was increased by the Legislature in the General Appropriation bill, approved March 9, 1915. That portion of the law fixing the amount of the appropriation for the Academy is herewith given in full.

For the Academy of Science: For the printing of the proceedings of the Indiana Academy of Science twelve hundred dollars: *Provided*, That any unexpected balance in 1915 shall be available for 1916, and that any unexpended balance in 1916 shall be available in 1917.

AN ACT FOR THE PROTECTION OF BIRDS, THEIR NESTS AND EGGS.

Sec. 602. Whoever kills, traps or has in his possession any wild bird, or whoever sells or offers the same for sale, or whoever destroys the nest or eggs of any wild bird, shall be deemed guilty of a misdemeanor and upon conviction thereof shall be fined not less than ten dollars nor more than twenty-five dollars: *Provided*, That the provisions of this section shall not apply to the following named birds: The Anatidae, commonly called swans, geese, brant, river and sea duck; the Rallidae, commonly called rails, coots, mud-hens gallinules; the limicolae, commonly called shore birds, surf birds, plover, snipe, woodcock, sandpipers, tattlers and curlew; the Gallinae, commonly called wild turkeys, grouse, prairie chickens, quails and pheasants;

nor to English or European house sparrows, crows, hawks or other birds of prey. Nor shall this section apply to persons taking birds, their nests or eggs, for scientific purposes, under permit, as provided in the next seciton.

SEC. 603. Permits may be granted by the Commissioner of Fisheries and Game to any properly accredited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to such Commissioner written testimonials from two well-known scientific men certifying to the good character and fitness of such applicant to be entrusted with such privilege, and pay to such Commissioner one dollar therefor and file with him a properly executed bond in the sum of two hundred dollars, payable to the State of Indiana, conditioned that he will obey the terms of such permit, and signed by at least two responsible citizens of the State as sureties. The bond may be forfeited, and the permit revoked upon proof to the satisfaction of such Commissioner that the holder of such permit has killed any bird or taken the nest or eggs of any bird for any other purpose than that named in this section.

PUBLIC OFFENSES—HUNTING WILD BIRDS—PENALTY.

(Approved March 15, 1913.)

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

Indiana Academy of Science.

Officers, 1915–1916.

President,
Andrew J. Bigney.

Vice-President,
Amos W. Butler.

Secretary,
Howard E. Enders.

Assistant Secretary,
E. B. Williamson.

Press Secretary,
Frank B. Wade.

Treasurer,
William M. Blanchard.

Editor,
H. E. Barnard.

Executive Committee:

Arthur, J. C.,
Bigney, A. J.,
Blanchard, W. M.,
Blatchley, W. S.,
Branner, J. C.,
Burrage, Severance,
Butler, Amos W.,
Cogshall, W. A.,
Coulter, John M.,
Coulter, Stanley,
Culbertson, Glenn,
Dryer, Chas. R.,
Eigenmann, C. H.,
Enders, Howard E.,
Evans, P. N.,
Dennis, D. W.,
Foley, A. L.,
Hay, O. P.,
Hessler, Robert,
John, J. P. D.,
Jordan, D. S.,
McBeth, W. A.,
Mees, Carl L.,
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 } ....A. W. Butler.
Ornithology }
Ichthyology..................................H. C. Eigenmann.

Committees Academy of Science, 1915–1916.

Program.

Stanley Coulter, Lafayette
L. F. Bennett, Valparaiso
Severance Burrage, Indianapolis

Membership.

E. R. Cummings, Bloomington
Edwin Morrison, Richomnd
H. L. Bruner, Indianapoils

Nominations.

Wilbur A. Cogshall, Bloomington
W. A. McBeth, Terre Haute
A. S. Hathaway, Terre Haute

Auditing.

J. P. Naylor, Greencastle
Glenn Culbertson, Hanover

State Library.

W. S. Blatchley, Indianapolis
A. W. Butler, Indianapolis
James Brown, Indianapolis

Restriction of Weeds and Diseases.

Robert Hessler, Logansport
F. M. Andrews, Bloomington
J. N. Hurty, State House, Indianapolis
Stanley Coulter, Lafayette
D. M. Mottier, Bloomington

Biological Survey.

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

Academy to State.

R. W. McBride, Indianapolis
Glenn Culbertson, Hanover
H. E. Barnard, Indianapolis
A. W. Butler, Indianapolis
W. W. Woollen, Indianapolis

Distribution of Proceedings.

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

Publication of Proceedings.

H. E. Barnard, Editor, Indianapolis
C. R. Dryer, Fort Wayne
M. E. Haggerty, Bloomington
R. R. Hyde, Terre Haute
J. S. Wright, 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			A. C. Waldo.
1892-1893	J. C. Arthur	Amos W. Butler	Stanley Coulter W. W. Norman		C. A. Waldo.
1893-1894	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894-1895	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895-1896	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896-1897	Thomas Gray*	John S. Wright	A. J. Bigney		W. P. Shannon.
1897-1898	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.
1898-1899	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899-1900	D. W. Dennis	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900-1901	M. B. Thomas*	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901-1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine	Geo. W. Benton	J. T. Scovell.
1902-1903	W. S. Blatchley	John S. Wright	Donaldson Bodine	G. A. Abbott	W. A. McBeth.
1903-1904	C. L. Mees	John S. Wright	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1904-1905	John S. Wright	Lynn B. McMullen	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1905-1906	Robert Hessler	Lynn B. McMullen	J. H. Ransom	Charles R. Clark	W. A. McBeth.
1906-1907	D. M. Mottier	Lynn B. McMullen	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1907-1908	Glenn Culbertson	J. H. Ransom	A. J. Bigney	G. A. Abbott	W. A. McBeth.
1908-1909	A. L. Foley	J. H. Ransom	A. J. Bigney	G. A. Abbott	W. A. McBeth.
1909-1910	P. N. Evans	Geo. W. Benton	A. J. Bigney	John W. Woodhams	W. J. Moenkhaus.
1910-1911	C. R. Dryer	A. J. Bigney	E. B. Williamson	Milo H. Stuart	W. J. Moenkhaus.
1911-1912	J. P. Naylor	A. J. Bigney	E. B. Williamson	Milo H. Stuart	W. J. Moenkhaus.
1912-1913	Donaldson Bodine*	A. J. Bigney	C. M. Smith	F. B. Wade	W. J. Moenkhaus.
1913-1914	Severance Burrage	A. J. Bigney	H. E. Enders	F. B. Wade	W. A. Cogshall.
1914-1915	Wilbur A. Cogshall	A. J. Bigney	H. E. Enders	F. B. Wade	W. M. Blanchard.
1915-1916	A. J. Bigney	Howard E. Enders	E. B. Williamson	F. B. Wade	W. M. Blanchard.

*Deceased.

MEMBERS.*

FELLOWS.

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

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

Anderson, H. W., 1 Mills Place, Crawfordsville, Ind. 1912
Professor of Botany, Wabash College.
Botany.

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

Arthur, Joseph C., 915 Columbia St., Lafayette, Ind. 1894
Professor of Vegetable Physiology and Pathology, Purdue University.
Botany.

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

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

Beede, Joshua W., cor. Wall and Atwater Sts., Bloomington, Ind. 1896
Associate Professor of Geology, Indiana University.
Stratigraphic Geology, Physiography.

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

†Date of election.

††Non-resident.

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

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

Bitting, Catharine Golden, Washington, D. C...................... 1895
Microscopic Expert, Pure Food, National Canners Laboratory.
Botany.

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

Bodine, Donaldson, Four Mills Place, Crawfordsville, Ind........... 1899
Professor of Geology and Zoology, Wabash College.
Entomology and Geology.

Breeze, Fred J., care American Book Company, New York, N. Y.... 1910
With the American Book Company.
Geography.

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

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

Burrage, Severance, care Eli Lilly Co., Indianapolis, Ind............ 1898
Charge of Biological Laboratory, Eli Lilly Co.
Bacteriology, Sanitary Science.

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

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

Cook, Mel T., New Brunswick, N. J............................ 1902
Professor of Plant Pathology, Rutgers College.
Botany, Plant Pathology, Entomology.

Coulter, John M., care University of Chicago, Chicago, Ill........... 1893
Head Department of Botany, Chicago, University.
Botany.

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

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

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

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

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

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

Dennis, David Worth, Richmond, Ind.......................... 1895
Professor of Biology, Earlham College.
Biology.

Dryer, Charles R., Oak Knoll, Fort Wayne, Ind.................... 1897
Geographer.

Dutcher, J. B., Bloomington, Ind.............................
Assistant Professor of Physics, Indiana University.
Physics.

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

Enders, Howard Edwin, 105 Quincy St., Lafayette, Ind............. 1912
Associate Professor of Zoology, Purdue University.
Zoology.

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

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

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

††Goss, William Freeman M., Urbana, Ill. 1893
Dean of College of Engineering, University of Illinois.

Haggerty, M. E., Bloomington, Ind. 1913

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

Hessler, Robert, Logansport, Ind. 1899
Physician.
Biology.

Hilliard, C. M., Simmons College, Boston, Mass. 1913

Hoffer, Geo. N., West Lafayette, Ind. 1913

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

†Huston, H. A., New York City 1893

Hyde, Roscoe Raymond, Terre Haute . . . .
Assistant Professor, Physiology and Zoology, Indiana State Normal.
Zoology, Physiology, Bacterialogy.

Kenyon, Alfred Monroe, 315 University St., West Lafayette, Ind. . . . . .
Professor of Mathematics, Purdue University.
Mathematics.

Kern, Frank D., State College, Pa. 1912
Professor of Botany, Pennsylvania State College.
Botany.

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

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

†Marsters, V. F., Santiago, Chile.............................. 1893

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

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

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

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

Moore, Richard B., Denver, Colo.............................. 1893
With U. S. Bureau of Mines.
Chemistry, Radio-activity.

Morrison, Edwin, 80 S. W. Seventh St., Richmond................
Professor of Physics, Earlham College.
Physics and Chemistry.

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

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

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

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

Pohlman, Augustus G., 1100 E. Second St., Bloomington, Ind........ 1911
Professor of Anatomy, Indiana University.
Embryology, Comparative Anatomy.

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

Ransom, James H., 323 University St., West Lafayette, Ind. 1902
Professor of General Chemistry, Purdue University.
General Chemistry, Organic Chemistry, Teaching.

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

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

Scott, Will, 731 Atwater St., Bloomington, Ind. 1911
Assistant Professor of Zoology, Indiana University.
Zoology, Lake Problems.

Shannon, Charles W., Norman, Okla. 1912
With Oklahoma State Geological Survey.
Soil Survey, Botany.

Smith, Albert, 1022 Seventh St., West Lafayette. 1908
Professor of Structural Engineering.
Physics, Mechanics.

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

Smith, Charles Marquis, 910 S. Ninth St., Lafayette, Ind. 1912
Professor of Physics, Purdue University.
Physics.

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

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

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

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

††Waldo, Clarence A., care Washington University, St. Louis, Mo. . . . 1893
Thayer Professor Mathematics and Applied Mechanics, Washington University.
Mathematics, Mechanics, Geology and Mineralogy.

††Webster, F. M., Kensington, Md. 1894
Entomologist, U. S. Department of Agriculture, Washington, D. C.
Entomology.

Westland, Jacob, 439 Salisbury St., West Lafayette, Ind. 1904
Professor of Mathematics, Purdue University.
Mathematics.

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

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

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

NON-RESIDENT MEMBERS.

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

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

Branner, John Casper, Stanford University, California.
Vice-President of Stanford University, and Professor of Geology.
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Mendenhall, Thomas Corwin, Ravenna, Ohio.
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Moore, George T., St. Louis, Mo.
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Newsom, J. F., Palo Alto, California.
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Purdue, Albert Homer, State Geological Survey, Nashville, Tenn.
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Balcom, H. C., Indianapolis.
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Banker, Howard J., Cold Spring Harbor, N. Y.
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    Retired Farmer.
    Conchology.

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    Chemistry.

Davis, D. W., Greencastle.
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Davis, Ernest A., Notre Dame.
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Davis, Melvin K., Anderson.
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Deppe, C. R., Franklin.
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Fisher, Martin L., Lafayette.
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Foresman, George Kedgie, Lafayette, Purdue University.
Chemistry.

Frier, George M., Lafayette.
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Goldsmith, William Marion, Oakland City.
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James, Glenn, West Lafayette.
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Weatherwax, Paul, Bloomington, Ind.

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Wicks, Frank Scott Corey, Indianapolis.
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Wiley, Ralph Benjamin, West Lafayette.
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Williamson, E. B. Bluffton.
Cashier, The Wells County Bank.
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Zoology.

Zufall, C. J., Indianapolis, Ind.

Fellows	80
Members, Active	277
Members, Non-resident	29
Total	386

Minutes of the Spring Meeting

of the

INDIANA ACADEMY OF SCIENCE.

Bloomington, Indiana, Thursday—Saturday, May 20-22, 1915.

The Spring meeting of the Indiana Academy of Science was held at Bloomington, Thursday to Saturday, May 20-22, 1915.

The first session was held in the Physics Lecture room in Science Hall at 8 o'clock P. M. May 20th to listen to a lecture on Electrical Discharges by Dr. A. L. Foley, Head of the Department of Physics in Indiana University It was fully illustrated. It was very interesting and instructive and greatly appreciated by the crowded house. After this lecture, the Faculty Club of the University entertained the Academy with a "Get-Acquainted Hour" which was very pleasant.

The annual tramp had been planned for eight o'clock the next morning, but on account of a heavy rain we could not start until ten o'clock. The remainder of the day was beautiful. The route was up Rocky Branch to Griffey Creek, then up that creek and one of its branches to the University Reservoir. Examining the reservoir and pumping station was full of interest.

A special committee of the University Faculty arrived in advance with a picnic lunch. The meat was roasted over the blazing fires. The fifty-one persons present testified to the superior quality of this picnic dinner.

After lunch, the Academy was met by automobiles which took them to the stone district south of Bloomington. Visiting some of the quarries and mills was particularly instructive.

At seven o'clock the members had a complimentary dinner at the Commons. The members lingered till a late hour telling stories and making speeches.

On Saturday morning a number of the members took the train at 6:20 for Cave farm near Mitchell. On arriving at Mitchell, they encountered a severe rain-storm which continued until noon. This prevented them from going to the farm.

Andrew J. Bigney,
Secretary.

Minutes of the Thirty-First Annual Meeting

INDIANA ACADEMY OF SCIENCE,

Claypool Hotel, Indianapolis, Ind.,

December 3, 1915

The executive committee of the Indiana Academy of Science met in the Moorish Room of the Claypool Hotel and was called to order by the President, W. A. Cogshall. The following members were present: W. A. Cogshall, W. A. McBeth, A. W. Butler, Glenn Culbertson, Stanley Coulter, A. L. Foley, Severance Burrage, R. W. McBride, Will Scott, F. B. Wade, W. M. Blanchard, C. R. Dryer, J. S. Wright and A. J. Bigney. The minutes of the executive committee meeting of 1914 were read and approved.

The President called for reports from the standing committees:

Program—Will Scott, chairman, reported work performed as indicated by printed program.

On motion, $100 was appropriated for the services and traveling expenses of Dr. C. B. Davenport of Cold Spring Harbor, New York, the principal speaker at the evening session.

Treasurer—W. M. Blanchard reported as follows:

Received from Treasurer of 1914	$241.02
Collected—1915	225.00
Total	$466.02
Expenditures—1915	139.02
Balance	327.00
	$466.02

State Library—A. W. Butler reporting—Some progress had been made toward binding exchanges. Two hundred fifty copies of the Proceedings go to Libraries. Many copies had to be returned. On motion, the committee was ordered to go over the list of applications for Proceedings so as to ascertain those who are in good standing, and such could receive copies. F. B. Wade reported a set of Chemical Journals at City Library.

After much discussion, on motion, the committee decided that as far as possible the Proceedings should be sent only to those who pay their dues.

Biological Survey—No report.

Distribution of Proceedings—A. J. Bigney reporting. The copies were in the hands of the State Librarian and would be mailed in a few days. Copies would be sent to the meeting so the members present could receive them.

Membership—Report to be made at general session.

Auditing—No report.

Restriction of Weeds and Diseases—No report.

Relation of the Academy to the State—R. W. McBride reporting. The appropriation of $1,200 had been made by the State.

Publication of Proceedings—Editor was not present. Dr. C. R. Dryer reported that the work had been done and that they were ready for distribution. On motion, it was decided that no paper should be received for publication after February 1st.

Attention was called to the Pan-American Scientific Congress that would be held by the U. S. Government in Washington beginning December 29, 1915.

The incoming president, later, appointed C. H. Eigenmann of Bloomington as delegate, and A. W. Butler of Indianapolis as alternate.

GENERAL SESSION—1:30.

Assembly Hall, Claypool Hotel,
December 3, 1915.

The Indiana Academy of Science met for its regular program, W. A. Cogshall, President, in the chair.

The minutes of the Executive Committee were read and approved. Dr. H. E. Barnard, Editor, reported that the Proceedings for 1914 had been published. He stated the great difficulty of securing the papers from the members.

On motion of A. W. Butler, the following resolution was adopted:

Whereas, the Scientific investigations and accurate records kept by representatives of the United States Fish Commission, concerning Lake Maxinkuckee, Ind., in our opinion make the report that has been made by

Dr. B. W. Evermann one of the most valuable compilations that has been prepared, and

WHEREAS, we learn that the Commission is unable to publish it out of its funds, therefore

BE IT RESOLVED, By the Indiana Academy of Science, in regular session, that we express our belief in the great value of this work, in its importance to scientific students, not only in America, but throughout the world, and in the desirability of having it published at an early date so as to be accessible, and

BE IT FURTHER RESOLVED, That a committee of five (5) members be appointed to represent the Academy in an endeavor to secure the early publication of this report.

On motion, the Academy appointed the following Committee: Amos W. Butler, Dr. Charles B. Stoltz, C. C. Deam, D. M. Mottier, and Glenn Culbertson.

The General Papers were then called for; "1" to "6" responded, after which the Academy went into Sectional Meetings as follows:

Section A.—Chemistry, Geology, Mathematics, Physics. W. A. Cogshall, Chairman, A. J. Bigney, Secretary.

Section B.—Anatomy, Bacteriology, Botany, Zoology. Stanley Coulter, Chairman, H. E. Enders, Secretary.

Adjourned at 5:30 for dinner at the Claypool at 6:15 at which the President's address was read on the "Origin of the Universe."

9:00 A. M. December 4.

GENERAL SESSION.

Business—

On motion of W. M. Blanchard the following resolutions was adopted:

RESOLVED, as the sense of the Indiana Academy of Science that the Commission having in charge the matter of adequate and proper celebration of the State's Centennial, could do no more fitting and practical thing in the way of a permanent memorial of the one hundredth anniversary of the State's admission to the Union, than to inaugurate at this time and carry to consummation a plan to purchase, through action by the General Assembly several tracts of land in Indiana for public park purposes for the people.

On motion the following committee was appointed to carry out the provisions of the resolution: Stanley Coulter, W. W. Woolen, and R. W. McBride.

As the Historical Commission was in session in the State House, the Committee at once presented the resolution to the Commission, also to the County Chairmen of the Commission, which was also in session. It was heartily endorsed by both bodies and the Academy thanked for its interest in the proposed Centennial celebration.

A copy of this resolution to be mailed to Mr. Harlow Lindley, Department of Archives and History, Indiana State Library.

Prof. L. F. Bennett, of Valparaiso College, extended an invitation to the Academy to hold the Spring meeting of 1916 at Valparaiso. On motion, the invitation was unanimously accepted.

On motion of A. W. Butler the Academy urged that all members and all organizations with which they are connected, use their influence to prevent any legislation for changing our present Fish and Game Laws.

The Membership Committee reported the following new members:

Dr. John Merton Aldrich, S. Grant St., W. Lafayette, Ind., Zoology and Entomology.

Russell Baldwin, Richmond, Ind., Physics.

Colonzo C. Balls, Russiaville, Ind., Botany.

Guy Richard Bisby, Lafayette, Ind., Botany.

Joseph Blose, Culerville, Ind., Physics.

Eugene Butler, Richmond, Ind., Physics and Mathematics.

Charles Crampton, Bloomington, Ind., Psychology.

A. B. Davis, Eli Lilly & Co., Indianapolis, Ind. Chemistry.

Elizabeth Downhour, 2307 Talbott Ave., Indianapolis, Ind., Geology and Botany.

Jesse Lyle Essex, 523 Russell St., W. Lafayette, Ind., Chemistry.

Leonard L. Huber, Hanover, Ind., Zoology.

Cloyd C. Hurd, Crawfordsville, Ind., Zoology.

H. Kremers, Wabash College, Crawfordsville, Ind., Chemistry.

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

Burr N. Prentice, 216 Sheetz, W. Lafayette, Forestry.

Charles C. Rees, 225 Sylvia St., W. Lafayette, Ind., Botany.

Robert G. Schaeffer, 508 E. Third St., Bloomington, Ind., Chemistry and Botany.

Ralph W. Showalter, Eli Lilly & Co., Indianapolis, Ind., Biology.

Rex Anthony Whiting, 118 Marsteller St., W. Lafayette, Ind., Veterinary.

Mrs. Etta Wilson, 1044 Congress Ave., Indianapolis, Ind., Botany and Zoology.

Herbert Spencer Jackson, 127 Waldron St., Lafayette, Ind., Botany.

Emory Hutchison, Atwater St., Bloomington, Ind., Zoology.

Harvey Geer Wood, West Lafayette, Ind., Physics.

Floyd R. Carter, Frankfort, Ind., Botany.

Irene Graybook, New Albany, Ind., Botany.

Paul Harmon, Bloomington, Ind., Physiology.

Mildred Hoge, Kirkwood, Bloomington, Ind., Zoology.

On motion they were elected.

The Committee on the nomination of officers, Severance Burrage, Chairman, reported as follows:

President—Andrew J. Bigney, Moores Hill College, Moores Hill.

Vice-President—Amos W. Butler, Indianapolis, Ind.

Secretary—Howard E. Enders, Purdue University, West Lafayette.

Assistant Secretary—E. B. Williamson, Bluffton.

Treasurer—W. M. Blanchard, Greencastle.

Press Secretary—F. B. Wade, Indianapolis, Ind.

Editor—H. E. Barnard.

On motion the report was adopted and the officers elected.

On motion of Prof. John M. Aldrich the following resolution was adopted:

WHEREAS, Thomas Say was one of the great entomologists of the world in his time, prominent among the men who made New Harmony, Ind., the scientific center of the United States about 1825, his grave at that place is one of the shrines of Indiana history, the Indiana Academy of Science therefore feels an especial interest in the project to establish a memorial to Say's name in the form of a publishing foundation for works in entomology. It is an ideal memorial to an unselfish and deserving scientific man, and at the same time promises great value in the cause of entomology for the present and future.

THEREFORE BE IT RESOLVED, That we commend the plan of the Say Foundation to the consideration of the people of Indiana as especially worthy of consummation in the Centennial year of our state.

Sections A and B then continued their programs until they were completed.

Adjourned.

W. A. COGSHALL,
President.

A. J. BIGNEY,
Secretary.

Program of the Thirty-First Annual Meeting

INDIANA ACADEMY OF SCIENCE,

CLAYPOOL HOTEL—INDIANAPOLIS

FRIDAY AND SATURDAY

December 3 and 4, 1915

General Program.

FRIDAY

Meeting of the Executive Committee	10:30 a. m.
General Session	1:30 p. m.
Sectional Meetings	3:45 p. m.
Informal Dinner	6:00 p. m.
Symposium on Heredity	8:00 p. m.

SATURDAY

General Session	9:00 a. m.
Sectional Meetings	9:45 a. m.

THE PRESIDENTIAL ADDRESS

The address of the retiring president, Wilbur A. Cogshall, will be delivered at the informal dinner.

THE SYMPOSIUM ON HEREDITY

A Resumé of the Work on Heredity. Dr. C. H. Eigenmann, Dean of the Graduate School, Indiana University.

Fifteen years of Mendelism; Mendelism, the Key to the Architecture of The Germ-plasm. Dr. Roscoe R. Hyde, Professor of Zoology, Indiana State Normal School.

Heredity in Man. Dr. Charles B. Davenport, Director of the Station for Experimental Evolution, Cold Spring Harbor, New York.

PAPERS TO BE READ

GENERAL

1. A Memoir of Donaldson Bodine .... H. W. Anderson
2. Memoir of Josiah T. Scovel, 20 min .... Charles R. Dryer
3. Twelve of Nature's Beauty Spots in Indiana, 45 min., lantern. Edward Barrett
4. Concerning the Report of the Survey of Lake Maxinkuckee, 10 min .... Amos W. Butler
5. A Field Trip in General Science, 15 min .... B. H. Schockel
6. The Tobacco Problem (abstract) 20 min .... Robert Hessler

Anatomy

7. Histological Changes in Testes of Vasectomized Animals, 10 min. .... Burton D. Myers

Bacteriology

8. The Minimum Lethal Infecting Dose of Trypanosomes, 25 min. .... C. A. Behrens
9. Tolerance of Soil Bacteria to Media Variations, 20 min... H. A. Noyes

Botany

10. Some Methods for the Study of Plastids in Higher Plants, 10 min. .... D. M. Mottier
11. The Morphology of Riccia fluitans, 5 min .... Fred Donaghy
12. Plants not Hitherto Reported from Indiana. VI. 3 min. .... Chas. C. Deam
13. Indiana Fungii. III. 5 min. .... J. M. Van Hook
14. The Second Blooming of Magnolia soulangiana, 5 min.. D. M. Mottier
15. Additional Notes on Rate of Tree Growth, 10 min.. Stanley Coulter
16. The Effect of Centrifugal Force on Plants, 15 min ...... F. M. Andrews
17. Some Preliminary Notes on the Stem Analyses of White Oak, 10 min. .... Burr N. Prentice
18. Botanic vs. Biologic Gardens. Illustrated by Specimens, 10 min. .... Robert Hessler

Chemistry

19. Soluble Salts of Aluminum in Water from an Indiana Coal Mine, 5 min. .... S. D. Conner

20. Detection of Nickel in Cobalt Salts, 8 min.,
A. R. Middleton and H. L. Miller
21. The Use of the Spectrophotometer in Chemical Analysis, 10 min. .... George Spitzer and D. C. Duncan
22. The Different Methods of Estimating Protein in Milk. . George Spitzer

Geology

23. A New Cave Near Versailles, 5 min.................. A. J. Bigney
24. Loess Deposits in Vigo County, Indiana, 10 min.... Wm. A. McBeth
25. Volume of the Glacial Wabash River, 10 min...... Wm. A. McBeth
26. A Geologic Map of the Terre Haute Region, 5 min.... B. H. Schockel
27. A Bibliography of Geographical Material, 10 min...... B. H. Schockel
28. Settlement and Development of the Lead and Zinc Mining Region of the Upper Mississippi, 20 min................ B. H. Shockel
29. A Few Science Wonders of the Cement Age, 15 min., lantern .... F. W. Gottlieb
30. The Fauna of the Trenton and Black River Series of New York .... H. N. Coryell

Mathematics

31. Gamma Coefficients with Applications to the Solution of Difference Equations and Determination of Symmetric Functions of the Roots of an Equation in the Terms of the Coefficients, 25 min........................ Arthur S. Hathaway
32. Some Determinants Connected with the Bernoulli Numbers,
K. P. Williams
33. Some Relations of Plane to Spheric Geometry, 10 min. .... David A. Rothrock

Physics

34. Some Notes on the Mechanism of Light and Heat Radiations, 15 min. .... James E. Wyant
35. A Standard for the Measurement of High Voltages, 10 min. .... C. Francis Harding
36. Ionization Produced by Different Thicknesses of Uranium Oxide, 5 min. .... Edwin Morrison
37. Radioactivity of Richmond Water, 5 min.......... Edwin Morrison

38. A Student Photographic Spectometer. 5 min., lantern .... EDWIN MORRISON
39. An Experimental Determination of the Velocity of Sound Waves of Different Intensities. 10 min., lantern .. ARTHUR L. FOLEY
40. A Simple Method of Harmonizing Leyden Jar Discharges. 5 min., lantern .... ARTHUR L. FOLEY
41. An Electroscope for Measuring the Radioacticity of Soils. 10 min., lantern .... R. R. RAMSEY
42. Some Photographs of Explosions in a Gas. 10 min., lantern .... JOHN B. DUTCHER
43. The Cause of the Variation in the Emanation Content of Spring Water. 10 min., lantern .... R. R. RAMSEY
44. A Standard Condenser of Small Capacity. 10 min., lantern .... R. R. RAMSEY
45. A Comparison of Calculated and Experimental Radii of the Ring System by Diffraction and an Extension of Lommel's Work in Diffraction. 10 min., lantern .... MASON E. HUFFORD

SOILS

46. Rate of Humification of Manures. 15 min .... R. H. CARR

ZOOLOGY

47. An Instance of Division by Constriction in the Sea-Anemone. Sagartia luciae, 5 min .... DONALD W. DAVIS
48. Data on the Food of Nestling Birds. 15 min. WILL SCOTT and H. E. ENDERS
49. Two New Mutations and Their Bearing on the Question of Multiple Allelomorphs. 5 min .... ROSCOE R. HYDE
50. A Study of the Oxygenless Region of Center Lake. 10 min WILL SCOTT and H. G. IMEL
51. The Lakes of the Tippecanoe Basin .... WILL SCOTT

Address of the President.

Wilbur A. Cogshall

The question of Evolution has long occupied the attention of scientists. Especially has this been true in biological lines, and we are apt to think of the probable (or certain) changes that have taken place, either in plants or animals, in connection with the word evolution. As soon as biological investigation had proceeded to a point where significant differences and likenesses were well established among certain forms, the laws underlying the changes were sought, and are being sought. We have now a more or less satisfactory theory built up based on certain fundamentals, though it contains in part some elements of the speculative and the probable. One of these truths that seems established is that some organisms have existed in the very remote past, in a quite different form from what they now have, and that it is very probable, if not certain, that they will change their forms, habits, etc., still more as time goes on.

In a little broader way we may say that evolutionary changes are just as certain in the earth as a whole, or in the entire system of plenatary bodies, or for that matter, in the whole visible universe. This conclusion is based on several physical laws which man has discovered and believes to be true. If the law of conservation of energy is true, then we have no alternative but to believe that the continued radiation of heat from the sun and the earth will eventually result in these bodies coming to a lower temperature, and that the sun will at some future date become dark, cold and dense. We must also believe that its power to radiate heat and light was very different in the remote past from what it is now. In as much as the sun is not essentially different from a million other stars in the sky, it seems very probable that the whole visible universe has undergone very great changes in past time, and will undergo changes just as great in the future.

There is really no more reason to suppose that the stars and the moon have always been as we see them now, than to suppose that because an oak tree has stood for a year without sensible change it has always been that way and will continue so indefinitely. The oak goes through its life history, or certain phases of it, in so short a time that we can see its whole history in less than a life time, but the changes in the tree while faster, are no more certain than those in the sun or earth.

There have been many attempts to formulate a theory of evolution for the earth, the solar system, and indeed the whole siderial universe. Unfortunately, most of these were based on comparatively little scientific data and any actual proofs of reliability or truth were lacking. Most of them might better be called speculations, pure and simple, and were produced largely from analogy. For example, we have known for some three hundred years that the planets circulate about the sun in nearly the same plane, the ones near the sun moving faster than those farther away. The visible universe is apparently arranged more or less in one plane or at least is very much extended in the plane of the Milky Way, the solid figure that would enclose the solar system not being greatly different, except in size, from the one which would enclose all the stars. What would be more matural then than to suppose that the whole universe was built up on a large scale much as the planetary system, the sun being in revolution with many others about some distant center. These, in turn, perhaps, revolving about another center till the whole Universe is accounted for. Some such idea was advanced by Kant who had only the Law of Gravitation upon which to base his speculations. Unfortunately he knew nothing of the distances of the stars. At that time no one knew from actual observation that the stars had any real motions of their own through space.

We know little enough of these things now, but a few facts have been established with certainty in the last hundred years, indeed most of our accurate knowledge of the stars being attained in much more modern times. It was not till 1839 that we knew the distance of a single star in the whole sky, and only in the last fifty years has it been possible to measure their motions in any very precise way.

Following the above general theory it was supposed for a while that the central point about which the whole siderial system revolved had been located in Alcyone, the brightest of the Pleiades. It is sufficient to say that there is not a particle of evidence to sustain this conclusion, or the conclusion that the stars, as a whole, revolve about any center whatever. As far as we know the stars move in all sorts of directions and with all sorts of velocities. We are lacking now as much as a thousand years ago any theory of the evolution of the system of the stars, which is based upon observed changes in the stars themselves. The theories and speculations regarding the origin and history of the planetary system are more numerous and in some cases as improbable and impossible as those regarding the universe. The best known of these and the one which has had the most influence on philosophic thought is known as the Nebular Hypothesis of La Place. It was first announced about a hundred years ago and has been accepted as probably representing planetary evolution until recent years although based largely on assumptions. La Place was one of the greatest of astronomers and mathematicians since the time of Newton and doubtless his name alone carried conviction where a little independent investigation and reasoning would have been more profitable. It is quite evident that La Place never regarded this theory as seriously as it was regarded by others after his death.

You are all familiar with the main outlines of the theory. It assumes that the matter now composing the sun, the planets and their satellites was once diffused though a sphere perhaps as large as the present orbit of Neptune, that in some way (unknown) the mass started to revolve and therefore to flatten at the poles and extent at the equator, and that with the radiation of heat and consequent shrinkage in volume, the revolution had been hastened and soon a point had been reached where the gravitational force at the equator was balanced by the centrifugal force due to the revolution. At this point, according to the theory, a more or less broad ring was abandoned by the revolving mass. It went on shrinking, and increasing its velocity of motion till the same process was repeated. Each ring was then supposed to collect into a sphere and go through the same process in a small way, thus accounting for satellite systems of the various planets, although there was no investigation to establish the way in which this was done, or even to show that it was possible. No doubt this whole scheme was suggested by the planet Saturn which shows a ring system very much as La Place supposed existed around the sun, but which we now know differs very materially from any of his hypothetical rings.

As stated above, this theory implies that the planets should all be very nearly, if not exactly, in one plane, that they should travel in the same direction around the sun, that the satellites of each planet should all go in the same direction and in one plane, and that the periods of revolution of the satellites should be longer than the rotation periods of their primaries. These conditions seemed nearly fulfilled at the time of La Place, but since then we have had the discovery of Neptune with its satellite very much inclined to the orbit of the planet, and revolving backward at that, we have had the discovery of the satellites of Uranus also revolving retrograde and very much out of the planet's plane of revolution. We have had, moreover, the discovery of the two satellites of Mars, one of which revolves very much faster than Mars rotates on its axis.

A theory that perfectly explains all the known facts may get a hearing and acceptance without any great amount of demonstration, but when many important facts appear at variance with a theory it becomes necessary to show how these facts may be accounted for by the theory, or to look with suspicion on the theory as a whole.

There are many other facts than those just mentioned which cause distrust. Take for example the probable density of the ring that is supposed to have formed Neptune. If all the matter now in the Solar system were expanded till it formed a sphere the size of the orbit of this planet its average density would be about $\frac{1}{216,000,000,000}$ the present density of the sun. The density at the center would probably be many times that at the equator, which would make the density of the abandoned ring much less than $\frac{1}{216,000,000,000}$th of the present density of the sun. This would be many times as rare as the best vacuum yet obtained. To suppose that any such mass of matter, spread out in a ring whose diameter must have been at least thirty times the diameter of the earth's orbit, ever collected in one place to form Neptune is a very great tax on the imagination. As a matter of fact it can be shown that this is physically impossible. This process involves long intervals of time and would make the outer planets much older than the earth, and other nearer planets. There is no observational data to support this idea; all that there are directly contradict it. On the supposition that the sun has radiated heat in the past as it does now, and that the shrinkage of the sun is responsible for the development of its energy, it is possible to tell how many years ago the sun was large enough to fill the orbit of the earth. The earth must therefore be younger than this. All evidences in the earth itself point to an age of a least sixty million years, and on the above assumptions upon which the theory of La Place rests, the sun, sixty million years ago, was much larger than the earth's orbit. The probability is then that the assumptions are wrong. Other more technical objections, some of which are even more conclusive, I must pass over.

Another theory of Evolution based on tidal relations among sun, planets and satellites has been elaborated in more recent years, and either by itself or in connection with the foregoing has been used to explain our present system. The application of this theory to the Earth—Moon system has been elaborated by Professor George Darwin. He supposes that the earth and moon were originally one fluid mass, that oscillations set up in the mass by the tidal effects of the sun resulted in the separation of the mass into two parts, that the two parts raised tides each in the other and that the friction of these large tidal waves resulted in the separation of the two bodies to their present distance and the lengthening of their rotation periods to their present values.

It is, no doubt, true that tidal friction does tend to lengthen the period of rotation of the earth, and, if the fundamentals of mechanics are to be trusted, this effect must result in an increased distance between the two bodies. Some observational data in support of this theory appears in the fact that the period of revolution of the moon about the earth coincides with its period of rotation, and that probably the two planets nearest the sun keep the same face to the sun. On the other hand we know that tidal friction or any other force has failed to change the length of our day by one-tenth of a second in five thousand years. There has more recently come into general favor another and a totally different theory, from Professors Chamberlain and Moulton, of the Departments of Geology and Astronomy, of Chicago University.

They suppose that the solar system took its form from a nebula, but from a spiral and not from a spherical or spherodial nebula. Observationally this supposition is sound. There is not in the sky, as far as I know, a nebula of the sort assumed by La Place. There are thousands, perhaps hundreds of thousands of the spiral sort. Of all the nebulae that have any regular shape the spirals outnumber all others. There are a few so called planetary nebulae which in the telescope look spherical, but which in a long exposure photograph show some other form. Some of them may be hollow spheres, but none appears as La Place's nebula was supposed to be. There are a few in the form of a ring with a star at the center, but again it must be remarked that this form in not the required form.

In a spiral nebula the matter forming the arms of the spiral is usually the smaller part of the whole mass, the greater part being at or near the center. If the law of gravitation holds among them, and we have never found an exception to it, then the particles in the arms of the spiral must be in motion in elliptical orbits about the central mass, the parts nearer the center moving faster than the more remote parts. This means that the arms must with time become more closely wrapped about the central mass and that any one particle is, in time, bound to come close to many others, and eventually to collide with many.

If any one particle were large enough to start with, it would therefore grow by collision with other particles, and the more it grew the more power of growing it would have by reason of its increasing mass. It seems likely then, that loose, widely extended nebulae of this sort must eventually come into a system of small bodies revolving about a large central mass. It can be shown that a mass revolving in this way and suffering collision with other masses must move in an orbit whose eccentricity is continually diminishing. We should therefore expect to find, if our system has been formed in this way, that the more massive planets have the least eccentric orbits and that the smaller ones have the greatest eccentricity. As a matter of fact all of the large outer planets have low eccentricity and the smaller planets a higher amount. The greatest eccentricity is found among the planetoids, or asteroids, many of which are only a few miles in diameter.

It has also been shown that a close approach of two masses in the arms of the spiral might not result in collision, but under conditions which might easily arise, the smaller might be made to revolve in an elliptical orbit about the larger, thus giving rise to a satellite or system of satellites, and these satellites might revolve in one direction as easily as another. We can therefore account for the retrograde motion of the satellite of Neptune, those of Uranus, for the fact that Jupiter has some going in one direction and others in the reverse direction, for the widely scattered zone of the Asteroids and even for the very rapid motion of the inner satellite of Mars.

These, and many other features are not speculations as to what may have happened. They have all been made the subject of rigorous mathematical calculations, and with the supposed initial conditions are all entirely possible.

As to whether these initial conditions that we have supposed, actually existed or not—whether or not our earth and the other bodies revolving about the sun ever developed from a spiral nebula, we can not be so sure. Here it is a question of what is most probable. We are practically certain that it did not come about as La Place supposed. There are too many things mathematically impossible about that. By this theory, the development into the present system was entirely possible, and certainly no more probable evolution has been proposed.

La Place did not and could not account for his nebula. On this plan we can. I have said that the spirals far outnumber any other class in the sky.

It has been shown that it is entirely possible for a spiral to be formed and that it is probable that more spirals would be formed *than any other kind.* Here we approach the speculative a little closer and I would remind you that we have no record of any permanent form of nebula ever being formed. Of course the time over which we have any accurate record of the nebulae is very short, only the last few years in fact. Very few of these objects can be recognized in the telescope, and it is only since the invention of the rapid photographic dry plate, and the perfection of the large reflecting telescopes, that their true form and number have been found. Even with our present equipment and resources if one should be recorded on a plate tonight it might be impossible to say that it was there a year ago, or that it was not, unless it should be exceptionally bright.

With this class of objects then we will not expect much observational confirmation. From mathematical investigation we know that it is possible for a spiral nebula to be formed from the close approach of two stars. We know of about two hundred million stars in the sky and there are probably many more that we can get no direct evidence of. We know that they are all in motion with velocities ranging up to 300 or even 400 miles per second. Under these conditions we will at times have collisions. These will be relatively rare because the average distance between stars is large, thickly as they seem to be sown in the heavens. A close approach without actual contact will be much more frequent, and it is from such an encounter that a spiral nebula might easily arise.

The moon with only $\frac{1}{80}$ the mass of the earth and at a mean distance of over a quarter of a million miles has enough attraction for the earth to cause a distortion of figure, the liquid surface showing the effect of course more easily than the solid parts. Under the action of the moon there are two tides raised in the earth, one of which tends to stay directly below the moon and the other at the opposite side. That is to say, the moon causes the earth to assume an ellipsoidal form, the long axis of which would point toward the moon if it were not for the rapid rotation of the earth. What would this effect be if the moon were as massive as the earth, or perhaps twenty times as massive? If, in addition to this increased mass, we should decrease the distance between the bodies to a few thousand miles, the tides would be many times as great as they are now.

When we remember that the stars for the most part are gaseous, in many cases with an average density less than that of air at sea level, and at the same time have very large diameters, it will be evident that the near approach of another massive body would be sufficient to cause great disturbance. The attraction of the foreign body would cause the star to elongate, the gravitational attraction at the ends of the longer axis would be decreased and the highly compressed gases of the interior would cause great eruptions toward the disturbing body and away from it. Even with the slight disturbances to which our sun is subjected we have these outbursts of materiaf from the interior, by which material is thrown out at times, to distances of a hundred thousand miles.

If another star were to come within a few hundred thousand miles of our sun this effect would be produced on a scale many times greater. While the star was a considerable distance away these ejections of matter would be less violent, increasing in violence as the distance decreased, and, what is just as much to the point, they would be in a slightly different direction as time went on. The first masses ejected would be drawn out of a straight line and would eventually fall back toward the sun, some of them striking the surface and some of the 1 so far drawn to one side as to miss the surface as they came back, in which case they would continue to revolve in elliptical orbits about the sun. Those masses, thrown off a little later, would travel farther and in slightly different directions, and would be diverted still more and move in longer orbits. After a maximum disturbance was reached the same process would go on with decreasing violence as the disturbing body retreated into space. It has been shown that the masses thrown off which did not go back to form part of the sun again, might under these conditions form themselves into two spiral arms, the whole, of course, being in one plane, as the motion of the two stars would be in a plane. That material which did fall back into the sun would give to the part where it fell a certain velocity of rotation, and we find in the sun a higher rate of rotation for the equator than for any other part. The direction of motion of the matter composing the arms of the spiral is not along the arms but across them, each particle moving in an ellipse around the central mass. If masses of different sizes were ejected, the large ones would tend to annex the smaller ones in the immediate neighborhood, and the process before described would result in a system of planets and satellites much as we have in the solar system.

We have this process still going on in a small way. The Earth attracts to itself several million small particles every day and occasionally there is a larger one. Many of these, perhaps most of them, are in all probability matter which left the sun when the rest did and which are now for the first time brought near enough the earth to be permanently annexed. In a region where no large masses existed, the matter would continue to revolve in a finely divided state, such as we actually find in the zone of the minor planets. This zone lies between the orbits of Mars and Jupiter. In it have been found some 800 planets large enough to make a record on a photographic plate, and there is little reason to doubt that the whole number is many times greater and the size of most of them so small that we can never see them except as they collectively make a faint band of light across the sky. In this zone we find what we should expect with small sizes—that is, *very* elliptical orbits and very high inclinations. One of these planets has an orbit of such eccentricity that while its mean distance is considerably greater than that of Mars, yet in one point in its orbit it comes much closer to the earth than any body, except the moon, and two others have perihelion distances less than that of Mars.

Thus it is entirely possible that our planetary system resulted from a spiral nebula, and it is entirely possible that spirals may result from close approaches of two stars and we may even say that it is all probable, at least more probable than any other plan yet proposed.

There are still some difficulties. We must say that if our system resulted from a spiral, this spiral was not at all on the scale observed among the spirals in the sky. Such a nebula, having a radius equal to that of Neptune's orbit, were it no farther away than the nearest star, would be a very insignificant object and might fail of detection entirely. At the probable distance of most of these objects it would certainly be invisible. We can see how a star might be torn apart so as to scatter material over a space the size of Neptune's orbit, but the case is different when we consider some of the large spirals in the sky. The largest is known as the Great Nebula of Andromeda. It covers an arc of over a degree in the sky. Assuming a parallax of $0''.1$, which is probably larger than the real value, this nebula from end to end must extend over a space more than 1,800 times the size of Neptune's orbit, or 54,000 times the size of the Earth's orbit.

We have never determined accurately the distance of a single nebula and so do not know the real size of any one of them, compared to the solar system, but there is no reason to suppose they are nearer than many of the faint stars. If this is true, their volumns are vast beyond comprehension and their density an inconceivably small fraction of the density of our best vacuum. It has been computed that if the Andromeda nebula had a density $\frac{1}{20,000,000}$ that of the sun it would have mass enough to attract the earth as strongly as the sun does. It attracts the earth not at all. Nor does it attract any other body as far as we know, many of them being much closer to it then we we are.

We do not know the chemical composition of the nebulae, except that it see is to be different from every thing else in the sky. Not one has ever been seen to change its shape, size ot brightness. We have always assumed that stars result from the contraction of nebulae and this is based on the idea that the nebulae radiate heat. It is not at all certain that these rare gases shine because of their heat. A mass of gas of such extreme rarity would have a comparatively small amount of heat and it would seem that this ought to be radiated into space very rapidly, and could not be miantained without rapid contraction. It is quite possible that nebular matter instead of being the raw material of stars and planets is matter in some final form after having gone through its life history. We have no observational data either way and will probably not have any for many centuries to come. There does not seem to be any very good reason for believing that matter is not being created now as much as it ever was nor for thinking that it must always endure in some of the forms we now know.

We think of space as infinite in extent. Whether or not matter, in the forms we know, is to be found in all parts of space, we do not know. That is to say we are not yet sure whether the universe is finite or infinite. There are some reasons for thinking that the system of the stars is as infinite as space itself, but it may also be possible that what we call matter is some manifestation peculiar to this part of space. The mere appearance or disappearance of matter in space would in itself be no more remarkable than the precipitation and evaporation of water would be if we knew nothing of the atmosphere, and perhaps not as remarkable as the production of water from two invisible and unknown gases would seem to people who know nothing of chemistry.

The most probable source of information it seems to me, will be the researches of the physicists and chemists on the real nature of matter. When they shall have told us what matter really is, what all of its possible forms may be and what all the sources of energy are, then we may be able to state with certainty what the life history of a star is, what relation the nebulae have to other bodies, and what in reality has been the past history of our planet and other planets.

A Memoir of Donaldson Bodine.

H. W. Anderson

To those of us who knew Professor Donaldson Bodine the news last August of his sudden death was a terrible shock. We knew him as a man of great activity and rugged constitution, one who never seemed to be troubled with physical weakness. His taking was so sudden that the shock seemed all the greater, yet those who knew him best realized that it was as he wished, for he had often expressed a desire to have life end suddenly, without pain, prolonged illness, or weakening of mental faculties. So all was well with him.

Donaldson Bodine was born in Richboro, Pennsylvania on December 13, 1866. His father, a Presbyterian minister, died at an early age, leaving the young son to support his widowed mother and a sister. After graduating from a preparatory academy, he entered Cornell University and received his A. B. degree from this institution in 1887. For several years following graduation he was principal of the Academy at Gouverneur, New York. Returning to Cornell on a Fellowship he secured a Doctor of Science degree in the spring of 1895. His major was in the subject of Entomology, his first minor in Zoology and second minor in Botany. His thesis, presented in the spring of 1895, was entitled, "The Taxanomic Value of the Antennae of Lepidoptera".

Professor Bodine came to Wabash in the fall of 1895 to fill the chair of Zoology and Geology which was established at that time. This chair he occupied during the remainder of his life. Thus he had given, at the time of his death, twenty years of loyal and efficient service to this Institution.

As a student of Professor Bodine's I can speak with some authority when I say he was a wonderfully inspiring teacher. He had a very clear and interesting manner of presenting his subject and this, combined with an unusually pleasant voice, made the presentation of his lectures all that could be desired. It was a real pleasure to listen to him. The students were always loyal to him and they were especially impressed with his perfect fairness. He did not make his subject difficult but he expected his students to make an earnest effort to get that which was presented.

As a man, I cannot better express the opinion of all who knew him than give you the words of appreciation of one of his former students, "Professor Bodine was a man among men, a teacher among teachers seldom, if ever, equalled. He was a true gentleman who would be classified as 'One who carefully avoided whatever may have caused a jar or jolt in the minds of those with whom he was cast; who avoided all clashings of opinion or collision of feeling or restraint, or suspicion of gloom, or resentment, his great concern being to make everyone at his ease and at home. He was tender toward the bashful, gentle towards the distant and merciful towards the absurd; he guarded against unseasonable allusions or topics which irritated and was seldom prominent in conversation—and never wearisome. He made light of favors while he did them and seemed to be receiving when conferring. He never spoke of himself except when compelled, had no ear for slander or gossip, was scrupulous in imputing motives to those who interfered with him and interpreted everything for the best.' "

Professor Bodine published little—not from lack of ability to do research work or unfamiliarity with his subject, but because he was primarily a teacher and believed in giving all there was in him to his students. He was unusually well informed on all subjects whether or not connected with his work. His sense of fairness and his desire for accuracy and truth were so acute that to those who were given to the expression of opinions hastily formed, he seemed at times over critical; but he was equally sincere in his enthusiastic praise of work well done.

Professor Bodine was a lover of music and always took an active interest in the development of this art in the college and in the community. He also interested himself in the civic welfare of the city of Crawfordsville and stood for everything that was best regardless of political or other affiliations. Although for many years an officer in the Presbyterian church he was not "orthodox" in the narrower sense of the term. In this as in other affairs of life he followed the apostolic injunction, "Prove all things; hold fast that which is good." He believed thoroughly in the rule of Reason and would not accept any statement unless supported by and based upon facts, scientifically established. He was especially desirous of eliminating from religious teaching all superstitions and traditions. At the same time he was deeply religious by nature and was a thorough believer in the Church as an institution.

The members of this Society will remember with what great pleasure Professor Bodine attended the spring meeting. He was a lover of nature and delighted in the open air meeting held by the Society, not only because of the long tramps over the hills, but also because of the chance for companionship and discussion with his fellow scientists. He has often told me that his chief interest in the Society was the fellowship it afforded and his cordial hearty greetings are well remembered by all the older members of this Society.

As a scientist and a student of science he was recognized throughout the country. He was a Fellow both of the American Association and of the Indiana Academy and served as the president of the latter organization during the year 1913. His presidential address was one of unusual interest.

In 1914 Professor Bodine was married to Mrs. Emma Clugston of Crawfordsville. In the early days of August of the past summer they went to northern Michigan to plan a summer home. They selected a site for their cottage and on the day when the fatal end came had been busily engaged with their final plans. In the evening while visiting some friends and in the midst of a lively conversation death came without the slightest warning.

H. W. Anderson.

Memoir of Josiah Thomas Scovell.

Charles R. Dryer.

Josiah Thomas Scovell was born at Vermontville, Mich., July 29, 1841. His parents, Stephen D. and Caroline (Parker) Scovell were of New England stock dating from the 17th century. He was educated first at Olivet College and later at Oberlin, graduating A. B. in the class of 1866 and M. A. in 1875. While at Olivet he went home to spend a week-end, and in his determination to get back to college for Monday morning, forded a swollen river with his clothes tied in a bundle on his head. In 1864 he served one hundred days in Company K, 150th Ohio National Guards. His comrades speak highly of his services as company cook. During the defense of Fort Stevens at Washington against the attack of General Early, he was given command of a gun. President Lincoln stood on the parapet beside Scovell's gun to watch the progress of the battle, and was dislodged only by the command of General Wright. Visits to an uncle living at Lewiston, N. Y., were occasions for a study of Niagara Falls and gorge. A fellow student at Oberlin, now Professor J. E. Todd of the University of Kansas, tells how he and Scovell were overtaken by nightfall in the gorge and compelled to escape by climbing a pine tree and a pole reaching from its top to the edge of the cliff. He had field work in geology at Oberlin with Professor Allen, and in 1867 was one of a party which accompanied Professor Alexander Winchell from Ann Arbor to the mines of Marquette, Houghton and Hancock. He was boss of the crew which secured and shipped the famous boulder of jasper conglomerate from Marquette to the University campus at Ann Arbor. In 1866-7 he took a special course in chemistry and mineralogy in the Medical Department of the University of Michigan and was graduated M. D. from Rush Medical College, Chicago, in 1868. He practiced medicine a year or two at Central City, Colo., then a lumber camp near Middle Park, He found the Garden of the Gods, the over blow of snow from the Pacific slope, the sound of running water under summer snows, the milky glacial streams, a storm in Platte Cañon seen from above, a flood in Cherry Creek, and the phenomena of mountains and forest more instructive than anything at college. In 1871-2 he was instructor in Chemistry at Olivet College, and in

1872 came to the Indiana State Normal School at Terre Haute as head of the Department of Natural Science. He at first taught only physiology and geography. The woman who had been teaching geography had spent fourteen weeks on the Great Western Plains using them as an instrument for teaching pedagogy, "the law in the mind" being illustrated by "the fact in the thing." Scovell had actually seen the Great Plains and was able to arouse greater interest in the facts in the thing. The use he made of pictures and specimens was an innovation and they had to be shown outside the regular class period. With the permission of the President, he introduced some instruction in physics, chiefly in meteorology, using home made apparatus. He also used the Wabash in field lessons on rivers, and his advent at Terre Haute marked one of the early inoculations of the Indiana schools with the scientific virus.

In 1873 he joined Todd at Portland, Me., as a volunteer assistant with the U. S. Fish Commission and visited Nova Scotia to study the tides. In 1880 he visited Cuba and Mexico to familiarize himself with tropical nature, corals and Aztec civilization.

He was married in 1876 to Joanna Jameson of Lafayette, who survives him. In 1881 he resigned from the Normal School and during the next ten years was engaged in the business of abstractor of titles at Terre Haute. During this period he acted as friend, companion and guide to a succession of younger men who came to teach and study science in the schools of the city. Among these Jenkins, Evermann, Rettger, Blatchley, Cox and Dryer are well known members of this Academy. Dr. Scovell's buckboard and horse, "Jim" were always ready for a Saturday and Sunday excursion anywhere within fifty miles. Every one of his proteges can testify to the genial, enthusiastic and scientific spirit with which he was thus introduced to the features and problems of the Terre Haute field.

In the summer of 1891 Scovell organized a party for the ascent and scientific study of the volcano, Orizaba, in Mexico. It consisted of H. M. Seaton, botanist, U. O. Cox, ornithologist, A. J. Woodman, ichthyologist, and W. S. Blatchley, entomologist, while Scovell acted as director, topographer, geologist and geographer. The general expenses were paid from his own pocket, but railroad transportation in the United States was otherwise secured. He was abetted and perhaps financially assisted by Dr. F. C. Mendenhall, then Superintendent of the U. S. Coast and Geodetic Survey. On Orizaba spirit levels were extended from the railroad up to 14,000 feet, whence aneroid readings to the summit made the height 18,179 feet. Considerable collections were made by the naturalists of the party and reported in various journals. In April, 1892, Scovell returned to Orizaba, and by triangulation from the 13,000 feet level, determined its height to be 18,314, which was accepted by the Coast and Geodetic Survey. A rather full general report of results was published in *Science* of May 12, 1893.

In the autumn of 1891, Scovell joined Evermann, then of the U. S. Fish Commission, in a study of the rivers of Texas. In 1894 he was sent by the Commission to study the whitefish of Lake Huron, and later assisted Evermann in a study of the spawning habits of salmon in the mountain streams of Idaho. About this time he did some work on the geological survey of Arkansas under Branner.

In 1894 Scovell returned to teaching as the head of the science department of the Terre Hautte High School, a position which he held until his death twenty-one years later.

In 1895 he contributed an elaborate report on the geology of Vigo County to the 21st Report of the Indiana Geological Survey, the result of twenty years of study in that field. He assisted Ashley in his report on the coal deposits of Indiana, published in 1898, and in 1905 made a report on the Roads and Road Materials of Western Indiana.

In 1899 he began his work in cooperation with Evermann on the physical and biological survey of Lake Maxinkuckee, which was carried on for fifteen successive seasons. His best work was done at home in Vigo County and at his summer cottage on Maxinkuckee. He never wearied of the features and problems of his home field and returned to them with fresh interest whenever any one started a new question. The writer was surprised to note after twenty years of study of the Terre Haute field how little he could add to what Scovell had shown him at the beginning.

I can best sum up the estimates of Dr. Scovell contributed by all his intimate colleagues and pupils, among whom I am glad to enroll myself, by saying that he was a naturalist rather than a specialist in any one department of science. He was more deeply interested in botany than in zoology and his interest in plants was more ecological than taxonomic. He had the most complete and beautiful collection ever made of the mussels of the Wabash River, representing forty-seven species. He gave considerable attention to the Indian mounds of western Indiana, and in 1912 sent his notes and collections to the Bureau of Ethnology, which accepted them as material for a projected *Handbook of Aboriginal Remains.* The catholicity of his taste was indicated by the collection of minerals, fossils, corals, shells, ferns and implements in his house and the pile of rare glacial boulders in his yard, both of which were well worth going to see. He was most of all interested in topography, land forms and the weather. I should classify him as primarily a geographer of broad sympathies. He was always at his best in the field. "His mind," says one of his most intimate associates, "was essentially analytical and judicial. He was not apt to reach conclusions hastily. After having arrived at a tentative conclusion, he was always disposed to try to discover objections, which he would examine critically and modify his conclusions accordingly. He was a keen observer and his comments on what he saw were always interesting and illuminating. A day spent with him in the field was sure to be a day filled with interest and profit." "In disposition," says another, "he was genial and kindly, and gave freely to his companions of the varied store of knowledge which he had accumulated during his life time of study of the great out-of-doors."

He was a charter member of this academy and at its first meeting gave a resumé of geographical studies in Indiana. He contributed to the programs twenty-two titles, of which ten papers were published in the Proceedings.

In 1874 he published *Lessons in Geography* which were re-written and reissued as a *Commercial Geography* in 1910, and in 1879, *Lessons in Physiology*, all of which had more than local use as text-books. In 1894, he contributed *Practical Lessons in Science* to the Werner series. In 1912 he prepared an account of *Fort Harrison in 1812* for the centennial celebration. He was a student to the last, making credits at the University of Chicago in 1909.

Dr. Scovell's death from pneumonia on May 8, 1915 removes perhaps the last survivor of those who could be called pioneers of science in Indiana. He was one of the "old guard," whose place can never be filled, but whose memory

"Smells sweet and blossoms in the dust".

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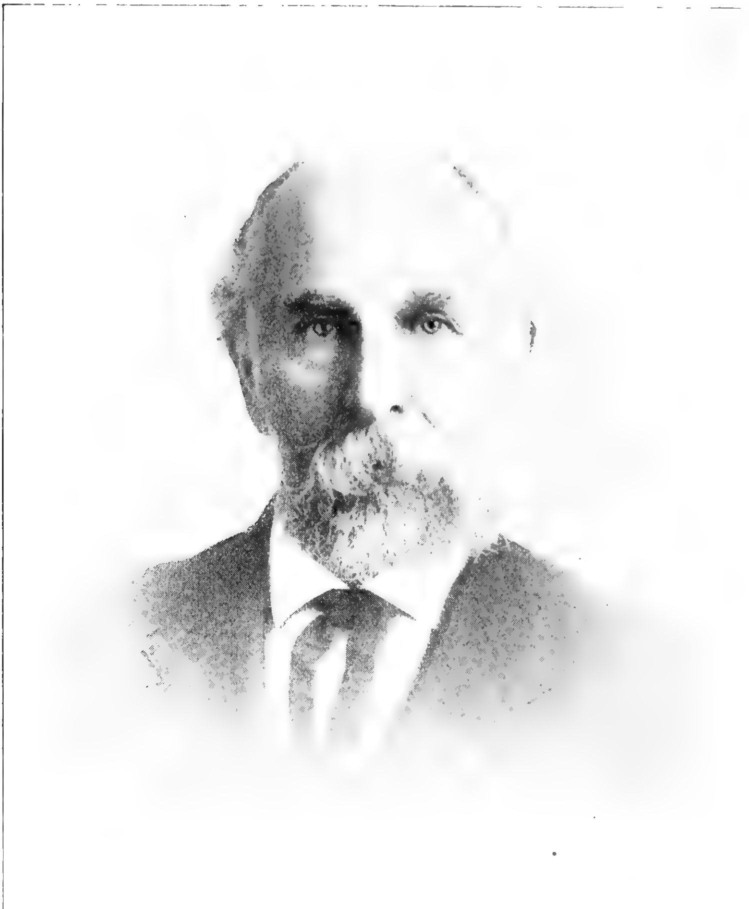

DR. [redacted] SCOVALL
TERRE HAUTE

The Tobacco Problem.

(Abstract)

Robert Hessler.

In going over a large mass of notes on the Tobacco Problem, I arranged them for convenience of classification into periods of my own life. After 1900 notes are grouped under papers published since, such papers forming "nest eggs," so to speak. In practically every paper I have had before this Academy during the last fifteen years the tobacco problem can be read between the lines. Here I intend to go over the subject very briefly in the light of observations and work done, merely a note here and there.

As a boy I saw others smoke and tried it myself, with the usual result—an acute tobaccosis. Should a teacher use tobacco and set a bad example? Practically all my boy friends smoked and a few years later I became a pipe smoker—influence of example. At the age of seventeen years there was a change of environment; I came in contact with boys and young men who did not smoke, and so I quit and bought books: Again influence of example.

Then came a year in the southern mountains in which I saw many things; others I did not see then but "saw" that is, understood, later. For instance, why the mountaineer can use tobacco and alcohol with seeming impunity. Hė takes these in pure air, without an admixture of infection of all kinds.

Next came college days. At that time few of the instructors set a "horrible example" by smoking. Students with few exceptions, did not use tobacco.

Then came medical college days in a large city under horribly bad air conditions, due to the many sick and diseased who visited the clinics. Here for the first time I saw the vicious circle that exists between bad air and tobacco, and, I might add, alcohol and sedatives and narcotics generally. The building was gloomy and dirty; artificial light was used all day long. Patients spat on the floor; students reacted more or less; they got relief by the use of tobacco, and in turn spat on the floor and thereby set a bad example to the patients who did not hesitate to add their catarrhal and tubercular sputum. The students reacted still more and chewed and smoked more; more filth meant less care on the part of the patients. And so on, you can readily see this vicious circle.

I myself soon reacted, I felt bad; fellow-students advised the use of tobacco. Instead I frequently bolted lectures and took open air vacations. While sitting on the benches I formulated a theory regarding my own ills and of those about me; I thought I saw why I felt bad and why I felt so well in the mountains a few years before, without having usual winter colds. I saw too why the mountaineers are so healthy and live long in spite of alcohol and tobacco. In the course of time this theory was elaborated; a brief account was given before this Academy in my paper on Coniosis, in 1911.

The following year was spent in a smaller and comparatively clean medical college, and I got along very well. Next came observations on hospital and dispensary cases, noting the influence of enviornment: How poor people taken from the heart of the city promptly recover under good sanitary surroundings. I clearly saw that in order to reduce the ills of a city more hospitals was not the remedy—clean up and stay clean.

Then came one or two minor periods, followed by a prolonged period of observation among the insane, especially at the Northern Indiana Hospital for Insane. Did time permit I should like to tell of efforts made to keep buildings and wards in good sanitary condition. Even the insane with few exceptions can be taught not to spit on the floor. When you see a man so greedy for a chew of tobacco that he will take a quid out of a cuspidor and rechew it with a relish you begin to realize what a hold tobacco has. The same may be said regarding alcohol when you consider the stories of English sailors draining the casks in which bodies of dead English sailors and soldiers were sent home. In cities gutter snipes can be seen picking up stubs, and there are women who apparently inhale tobacco smoke of others with pleasure, at least they make no objection. Suppose Aristotle, Plato, Socrates, or old Hippocrates came back and could see our men smoking and meeting under bad air conditions, what would they say? Has the world gone tobacco mad? Should a hospital physician smoke and set a bad example?

During a year in Europe I acquired a stock of comparative data. It was a surprise not to see any tobacco juice on sidewalks. The only time I saw a splotch in Continental Europe was in front of the medical school at

Vienna—evidently some American student had left his mark.* Moreover men smoked slowly and in moderation and spat very little. Any of you who have travelled in the Old World know the difference in cleanliness between European cities and our own. On getting back home I saw things I never really had noticed before, especially the sort of air we breathe habitually.

In 1900 I took up a systematic study of dusty air and prevalent ill health, and gradually enlarged the scope of inquiry to the domestication and urbanization of man. What this means can in a general way be seen from my various papers before the Academy. This period from 1900 to 1915 may be divided into subperiods:

The period from 1900 to 1906 may be characterized as one of disgust and contempt for the tobacco user, in the light of the harm he does to others, especially to women and children. I held to the old belief that men smoked (and drank) because they wanted to. But I found that to neglect the tobacco users means to get little data, and beginning with 1906 I gave some men and boys considerable attention, trying to find out why tobacco had such a hold and why some could readily discontinue the habit and others only with the greatest difficulty, if at all. Naturally one is apt to pity the man who sees the harm the tobacco habit does to others and yet can not quit, to whom tobacco is a sedative. Some of these men found that by using it "medicinally" a very small quantity sufficed. I believe if there were a high tax on tobacco it would be used very sparingly; old habitues could get along with a small quantity.

Up to the close of 1905 I had been accustomed to call patients who reacted to bad air Dust Victims. Then a bright woman said, "Why not call them Tobacco Victims? The tobacco user is the one who is responsible for air pollution, directly or indirectly." I kept a record for the year 1906 and at least every other patient was what may be called a Tobacco Victim. This included those dust victims who used tobacco, who had ill health on account of infected air. I trust you see the distinction.

In time one gets all sorts of data and all sorts of reasons why a man uses

*How do you know it was an American student? I was asked after the paper was read. I did not know; I only inferred, for I had not seen a single continental medical student chew and spit. A few days later I spoke to an observant German physician about this. The moment I mentioned "in front of the medical school," he interrupted, "Some American student did that; German students don't chew tobacco; the man who would chew and spit would be ostracized." He thus confirmed my own opinion.

tobacco. In such a study there is the eternal Where, When and Why. If a man says he feels better through the use of tobacco, then the question arises, Why do you feel bad? Why do you feel bad in the winter time, during the closed door season, and feel comparatively well in the summer? Why do you feel well when you leave the city and go on a vacation to the country or spend a winter in the South, where you do not care for sedatives, neither tobacco nor alcohol and can readily do without them?

Where a man smokes and drinks, and one might say eats, is an important question. One realizes it after keeping individuals under observation for a long series of years, particularly men and women who are willing to keep a daily record.

As long as tobacco is used sparingly and produces no evil results, neither in the user nor in those about him, there is no occasion to speak of a Tobacco Problem; the same is true of alcohol. Men who drink sparingly and "can leave it alone" do not create an alcohol problem. But the man who uses tobacco or alcohol sparingly may still be setting a bad example to those who can not use them, that is, in moderation and without injury to themselves and others.

I shall now briefly comment on some of my papers presented before this Academy. This is not a medical paper; remarks will be along the line of Coniosis.

MOSQUITOES AND MALARIA. 1900. The chief reason for writing that paper was to clear the field of work of an affection frequently confounded with malaria, an affection very common in our State, under various names, such as False Malaria, Atypical Malaria, Latent Malaria, a Touch of Malaria, Mal-aria, and others, including "bilious attacks" and "auto-intoxication".

This paper could be re-written, by one who has access to all the old literature, under the title, Indiana: A Redemption from Malaria. It would be appropriate for the Centennial next year. As a companion volume the man with ample leisure could write a volume on False Malaria, that is, dust infection.

Real malaria, that is malarial fever, is transmitted through the bite of the anopheles mosquito; false malaria, or Coniosis, is transmitted through infected dust. The proper season for malaria is late summer and autumn; that of false malaria from autumn through the winter to late in spring, in other words, throughout the closed door season. In early days malaria dominated everything; there was comparatively little other sickness. Agricultural communities as a rule were healthy if there was no malaria about. Today false malaria dominates wherever people are massed, as indicated in my cases for 1906. The student who desires to study malaria will find little opportunity in Indiana today. I have not seen a case for about thirteen years. But for material for a study of False Malaria Indiana can not be excelled.

Just as malaria has disappeared by cleaning up the breeding places of the rural anopheles mosquito, so false malaria will also disappear when we begin to clean up generally, when we get clean air to breathe. When once an overgrown town begins to become a real city by putting in sewers, paved streets, getting filtered water and a clean high school, a sort of civic center, you can readily see why people become less tolerant of the chewer and spitter and in time of the smoker. The smoker, it should be noted, is usually also a spitter.

If I had time I should like to review briefly several medical papers in which I developed the theory of dust infection or coniosis, and show how one can distinguish between other affections and diseases. One can treat the subject from two viewpoints, medical and biological. Medically, coniosis can be considered as a disease; biologically, coniosis is a reaction. Regard it as a disease and at once there come to mind treatment, medicine, remedy, cure. Regard it as a reaction, then naturally there comes to mind prevention. From the physicians' standpoint, there are two classes of people, those who Take Something and those who Do Something. Some when feeling bad will take all sorts of drugs, including tobacco and alcohol. Others will take a change of environment, of occupation, or of residence. The latter are the wise; there will be more of these when the relationship of cause and effect is once properly understood.

The second viewpoint, the biological, is to regard coniosis or false malaria as a reaction. Now how can a reaction be cured in the constant presence of a cause? Why are there so many isms and pathies, so many pseudo remedies and new ones constantly arising? Looked at in this light you knock the props out from under the patent medicine man and the symptom-prescribing doctor and quack.

COLD AND COLDS. 1903. It is scarcely necessary to comment on this paper because the tobacco factor stands out all over.* The inhalation of tobacco smoke, especially in those wholly unaccustomed to it, produces a depressed circulation; it may be expressed as "reduced vitality," allowing the germs of infection, of colds and various inflammations, to take hold.

CITY DUST, CAUSE AND EFFECT. 1904. This paper was aimed to bring out the relationship between infected dust and the size and number of patent medicine ads. in newspapers, how the number and size of these depend on the amount of infected dust in the community. Such ads are indicators. In the light of later observations, the list of "dust ads" should be enlarged to include other ads, notably health food ads and ads relating to teeth and skin, similarly tobacco ads.

Tobacco along with alcohol must be considered a sedative. Both give ease. The Chinese get ease through opium; the East Indian through hasheesh. People the world over use certain drugs for ills that accompany life under unsanitary house and town conditions. They are pseudo remedies. The proper remedy is to clean up. This can not be over-emphasized.

Did time permit here should come a review of tobacco ads, how they can be classified. It is interesting to study these. Some are sensible, they are worth studying; on the other hand some are downright drivel, evidently written by old men in their dotage. Which are "the best" tobaccos, cigars and cigarettes? Men who must use tobacco find less need for smoking or chewing constantly if strong brands are used. I could tell how men who used two-for-a-quarter cigars and smoked constantly changed to "tufers" and smoked less, and at a greatly reduced cost.

I could tell of men who "came back," men who had lost health, perhaps not so much by the use of tobacco itself as through the infected air they inhaled while using it. I have in mind men whom I advised to get ease by the use of good air rather than attempt to get ease through tobacco. In other words, offset bad air by good air and reduce the reaction and thus reduce ills. (Tables to show how this works out were given in my paper on The Alcohol Problem, last year.)

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*Those desiring further details can be referred to a number of my papers, such as the Anti-Spitting Ordinance, in the Bulletin Indiana State Board of Health. (August, 1901.) Dust, A Neglected Factor in Ill Health, in the Proceedings of the Indiana State Medical Association for 1904, and to Atypical Cases and Dust Infection in American Medicine for October, 1904.

On the other hand I could tell of women who did not object to the husband smoking, in fact enjoyed tobacco. When you consider under what conditions some women spend their time, perhaps in a flat with bad air, with visits down town, to theatres or clubs or shopping, living under "high tension", which often though not necessarily means a high blood pressure, you can readily see why they get ease from inhaling the smoke of others. It is only one step further for them to take up smoking. Such homes are usually childless; if there is a child the physician may be called late at night to find an acute attack of tobaccosis, especially after a friend has visited the father and they have "smoked up" and filled the house, to which those not accustomed react acutely. The anaphrodisiac effect of tobacco and its influence on divorce and on race suicide can not here be discussed.

THE CHRONIC ILL HEALTH OF DARWIN, HUXLEY, SPENCER AND GEORGE ELLIOT. 1905. This was an attempt to interpret, through their biographies, the ill health of those no longer living, in the light of a study of living people who seemed to have similar ill health. What can the living learn from the lives of the dead? I shall refer to this again.

Parenthetically I might refer to a paper, vintage of 1905, on NEURASTHENOID CONDITIONS, in other words, American Nervousness, presented before the American Medical Association, at Portland, Oregon. On that trip I saw all sorts of people and noted the environment under which they lived, from the simple Indian in the open air to John Chinaman in Chinatown. The Indian in former days, and still in isolation and away from the white man, uses tobacco sparingly. People living under slum conditions use sedatives to excess. John Chinaman at home smoked opium, but since occidental pressure has practically forced him out of that, he has taken up tobacco. From the standpoint of coniosis, that is worse, for the tobacco user is a greater germ distributor than the opium smoker.

1906. At this place I would have to review my Presidential Address on the EVOLUTION OF MEDICINE IN INDIANA. I could amplify the five pages on Malaria into many chapters and similarly the five pages on Tuberculosis. The tobacco habit and the chewing habit are referred to but I did not like to mention these too frequently; it rather grates on the ear. Malaria has practically disappeared from Indiana by cleaning up the breeding places of the anopheles mosquito. Tuberculosis will disappear when our cities are clean. Today one in every seven or eight of us dies of tuberculosis. This rate should be enormously reduced, not by erecting more hospitals and putting them in charge of doctors who chew and smoke, but by teaching the people the necessity, the importance, of clean air.

The ills of civilization call for more civilization. The man who is constantly seen with a cigar in his mouth or whose clothes reek with tobacco surely does not represent the highest type. The people have suffered much at the hands of the tobacco using doctor, usually a robust individual who uses tobacco because he gets ease. He does not understand the ills of his patients, and so they apply elsewhere; as a consequence he has all sorts of competitors. There are all sorts of isms and pathies, with new ones springing up.

Here should come a review of several papers relating to high blood pressure, a very interesting subject, especially in the light of coniosis. What causes a rise in blood pressure, and how can it be reduced? Why do seemingly robust men drop off suddenly and prematurely? I have at times discussed these things with physicians who smoke and who in their ignorance advised me also to smoke or to become accustomed to bad air conditions, to become acclimated, or, to put it in still another way, to develop an antitoxin, an antitoxin that will enable one to live under unsanitary conditions.

A physician constantly speaks of Case Reports.* In the course of time some of my own short case reports have developed into biographies. They cover a series of years. At first one may be greatly in doubt as to interpreting facts, but in time one sees the reason. For instance, I have in mind a physician who for a number of years practised in a small country town; he made long drives; he had perfect health; he did not use tobacco nor alcohol, had no desire for either. Then he removed to the heart of a medium sized city, that means he exchanged good air for bad air. He began to feel bad; the symptoms of dust infection appeared, finally to such an extent that he was almost disabled. I advised him to get out; others advised him to stay and become accustomed, become adapted. We use the term adaptation to a great extent, but if you look at it properly adaptation comes about in the race, phylogenetically, not ontogenetically. The unadapted are constantly killed off. This doctor concluded to follow the advice of the many rather than of the one. In time he did develop an "anti-toxin." He even took

*To quote illustrative case reports in a short paper is not satisfactory; one cannot go into details and there is a danger of a reader drawing wrong conclusions in the absence of details. Often brief case reports are worse than none, and one may hesitate to give any at all.

up smoking and enjoyed a roomful of tobacco smoke. He did not know until I examined that he had developed a high blood pressure. When I tell you that my own pressure under good air conditions runs from 100 to 110 m. m. while his under bad air runs about 200, you will realize that the life of such a man hangs on a mere thread and that at any time he may break a blood vessel, resulting in an apoplexy, or, if that does not occur, the kidneys will give out. Such men die suddenly as a rule and prematurely.

But the most interesting phase of the subject is the mental reactions, especially such as go under the terms irritability, nervousness and overwork. The efforts some men make to feel better are pathetic. For instance, I have in mind a captain of industry who did his planning in the early morning hours, usually from four to five, in bed. He saw things very clearly at that time. Then he would go down town and soon begin to feel dull and irritable, but would feel better by smoking, and he smoked one cigar after another. The single evening cigar and the postprandial cigar in time increased in number (as the blood pressure went up) until he wanted to smoke all the time. If alcohol were not taboo he would of course use that. When I examined I found he had a blood pressure of nearly 200 m. m. I pointed out that his pressure was due to the life down town, and that if he would reduce that to a minimum, and offset bad air by good air, likely he would have twenty-four hours a day for mental work, so to speak, rather than only one or two hours in the early morning, and that instead of tobacco being a stimulant to him during the day, which enab'ed him to think, it really did nothing of the sort; what it did was to lower the tension and the mind no longer ran riot. It enables him to pick out thoughts and ideas that he had seen very clearly in the early morning, after he had had no tobacco at all for a number of hours.

The newspaper cartoons, such as of "Abe Martin" and "Roger Bean," are interesting. The one might represent the low pressure type in the country with a family of children; he is seen only occasionally with a cigar. The other, Roger Bean, might represent the high pressure city man, with a cigar in his mouth almost constantly and usually childless. Race suicide and the use of tobacco under crowded conditions go hand in hand.

In early days Uncle Sam was represented as a lean, lank country man. The cartoonists nowadays are filling him out, in other words, making a hearty, robust Uncle, one is almost inclined to say grandfather. To the initiated he is a "high blood pressure case," with attendant ills, including race suicide.

THE INFLUENCE OF ENVIRONMENT. 1907. This paper appeared in a brief abstract; it took up in detail some of the things here mentioned. I repeatedly refer to John Chinaman who is adapted to live under slum conditions, who thrives in large city slums where even the white man can not live. Now if we look at it from the proper angle, we may conclude that our educators are reducing us to the condition of John Chinaman. They give no attention to the air conditions under which children live and meet. Instead of having teachers who react and who can tell by their own senses whether air conditions are good or bad, who are living barometers or thermometers, our schools are supplied with teachers of the robust kind (but who nevertheless react and readily use tobacco, as a sedative, to get ease, to feel less irritable). Under unsanitary conditions the susceptible are constantly weeded out, killed off, and what remains? In the end the John Chinaman type survives, a type which thrives bodily but at the expense of mentality; all the energy being required to ward off infection, leaving nothing for the brain.

Indiana today is stationary in population, as I attempted to show a year ago. It is due mainly to bad air conditions which lead to the use of sedatives and narcotics. As long as a country is thinly settled, alcohol and tobacco can be used with impunity, but under massed conditions these become racial poisons. The individual who reacts wants a sedative and (as I attempted to show a year ago) there are many that can be used. The most universally used today is tobacco. Tobacco leads to the spitting habit, alcohol not.

Here I shall not take up the statistics of our sedative and narcotic bill, the cost of tobacco and alcohol, and opium and patent medicines, and the various expenses that accompany life under unsanitary conditions, including needless doctor bills, the increased expense for fuel required to feel comfortable under bad air conditions, the desire for "overheated" houses, public buildings, railway coaches and trolleys, etc. It must suffice to say the cost runs into the billions of dollars annually in our country.

FLORA OF CASS COUNTY. 1908. I mentioned in the beginning that the tobacco factor can be traced into practically every paper I have given before this Academy. Does that apply to the flora of a particular region? People who feel bad want ease, they want relief from distressing symptoms; they will experiment, they will try anything and everything. An old belief was that every plant has a use, particularly a medicinal use, if we could only discover it. Today we know this is not true, that very few have any medicinal properties at all, and that practically none cure; at best they can give but transient relief. Relieving is not curing. Our native plants are chiefly remarkable in what they will not cure. The man who gets the most benefit is the one who gathers them. Some of you may recall O. Henry's story.

BIOGRAPHY AND THE INFLUENCE OF ENVIRONMENT. 1908. Short case reports there cited have been continued into biographies. You will readily understand that the longer a history, a biography, is continued the more valid the conclusions that can be drawn. Two of the individuals mentioned have since died, and died just as predicted, not to them however. The value of a theory is in enabling one to predict. By the way, Case 3 was a man who could not do without tobacco. He had used it all his life. He readily saw my reasoning, how, if he did not harm himself, he at least harmed others. He attempted to quit but found it impossible; he had to use a little tobacco, shall one say medicinally?*

THOUGHT STIMULATION. 1909. The reference to tobacco is very brief, but there is a relatively long mention of high blood pressure. This is a very interesting phase of the tobacco problem, especially to those who use their brains rather than their hands to make a living. Under what conditions can a man work at his best and when is he disabled? What will tide him over? I have already referred to this.

Years ago I had a discussion with a physician who did more or less surgery. He was a warm advocate of tobacco; even advised me to use it—the old story of "Take Something" in place of "Do Something." Whenever he did work under high tension tobacco soothed him, he said. When he had an unusual case he would be under high tension, very nervous, and tobacco would steady his nerves, he asserted, or, in other words, steady his hand when he operated. On investigating I found this state of affairs:

Ordinarily he was not under "high tension," but this was produced when he locked himself in a small room full of dusty books for several hours, looking over the latest literature regarding such operations, and at the same time filling himself with infected dust. Then his mind would run riot during the night, he was sleepless, of course thinking about the operation in the morning.

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*Coming down on the interurban with me was an old patient. We had a discussion of dust victims and tobacco victims. He is a low pressure man. His observations bore out my own. The advantage of discussion over a printed paper is that one can answer questions and make obscure points clear.

He would be practically unfitted for work but for the steadying effect of tobacco. It acted as a sedative. Why not prevent the reaction and make the use of tobacco unnecessary? When you point out these things you knock the props from under the tobacco argument. Doctors are notorious smokers. When they meet, especially at a banquet, the air is usually full of smoke, so full that you can not see across the room. Naturally those who do not smoke stay away, as they do from other "smokers."

In a general way in youth and up to middle age individuals may be grouped under three classes according to the blood pressure—low, medium or high, under unsanitary city conditions. At middle age and after there are really only two groups, those with a low pressure and those with a high pressure. Ordinarily we speak of the action of tobacco on man; in reality it is the reaction of man to tobacco. When the low pressure individual is exposed to tobacco smoke his pressure declines still more, his pulse may become imperceptible, he feels bad, and he gets out: He is a victim of tobaccosis. On the other hand is the high blood pressure individual: To him tobacco smoke may act as a sedative, it lowers the tension, he feels better. He is the one who attends "smokers;" he does not object to tobacco. But as a rule he does not realize the significance of high blood pressure and the danger he is in, how his very life hangs on a thread.*

Moreover mental changes are marked. The low pressure man is stupefied by tobacco smoke, he can not think. The bright things he might have said come to him the next day. On the other hand the high blood pressure man whose mind is constantly running riot is steadied. Such a statement taken without the context might be considered as a plea for the use of tobacco!

How do these two classes, the high and the low pressure, react from the standpoint of coniosis under infected dust conditions and without tobacco effects, say in the poorly ventilated church, as during the closed door season when some leave early because they feel bad? As a general rule those who leave "deathly pale" are low pressure with the pressure still further reduced, while those who go out with flushed face are high pressure, with the pressure heightened. We thus see the two-sided effect of bad air, air with infected dust.

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*In my search for original data I have questioned many physicians, including both smokers and non-smokers, as well as an occasional chewer. Strange to relate I have met men whom I suspected to have a high blood pressure who refused to have the pressure taken; they preferred to live on in ignorance and smoke. The average physician knows as little about the effect of tobacco as the man on the street who has no education and in whom one does not expect any matured opinion.

The subject of thought stimulation is intimately connected with the subject of the Air of Places, a subject on which Hippocrates wrote 2,500 years ago, but that was long before the days of bacteriology. The old chemical standard for purity of the air was based on the amount of carbonic acid gas. From the standpoint of coniosis it is the amount of infection in the air that counts. Need I again refer to the role of the tobacco chewer and spitter and smoker?

PLANTS AND MAN. 1910. This was a paper made up largely of analogies, tracing living conditions between plants and their "ills and diseases" and of man and his ills and diseases, and the need of clean air, need of placing a man under good surroundings.

Today we hear much of eugenics, of the influence of heredity. It is a very important subject. But still more important is euthenics, the influence of environment, because we have little control over heredity but we have a far reaching influence over our environment. If a man does not feel well, is ill at ease under a given environment, he should change it; instead of getting drugs, or advice about the use of drugs, he should understand the situation so he can Do Something rather than Take Something. But because people are unwilling to pay a doctor for his time but are willing to pay for his medicine, you readily see the result. The less a physician tells his community about unsanitary conditions, the smoother his sailing, and the better for his purse. (Naturally when a physician offends and antagonizes chewers and spitters they stay away, ditto the man who smokes and drinks; when they do apply they may be so far advanced in actual disease that the student of ill health can do little for them, he may have in mind the opinion or verdict of the mechanical engineer: Not worth while, consign to the scrap heap; but he does not say that aloud.)

Where the medical man keeps still and says nothing, the newspaper reporter is apt to run wild. From simple statements "The health of the city is good," there soon appear claims, at a time when there are few cases of "contagious disease" and few deaths, of "The healthiest city in the State." At the same time a city may be "full of ill health," of people who complain, who are neither actually sick and yet are not at all well. The newspaper itself may be full of patent medicine ads, for ills that are indicators of unsanitary city conditions. Patent medicine men are shrewd, they advertise only where there is a demand for their wares, for their nostrums.

To the physician and especially to the student of prevalent ill health there are all sorts of symptoms of diagnostic import: Does an applicant for professional service use sedatives and narcotics (alcohol, tobacco, opium, etc.) and use them to excess, or, on the other hand, does he use stimulants (notably coffee and tea)? What does such use indicate? The statement is sometimes made that tobacco is the poor man's friend, that after a hard day's work he enjoys his pipe; it calms him. But when you study the poor man and the conditions under which he works, you can see that the great trusts may well make an effort to keep tobacco as cheap as possible. Offering Mr. Common People a cigar, especially one with a colored band, only too often makes him tolerate what are really intolerable conditions. Men working for some of the great trusts twelve hours a day, seven days a week, may be even too tired to smoke. Tobacco is also a great solace to the soldier in the trenches; it makes him contented, it dulls his mind and keeps him from thinking.

CONIOSIS. 1911. As already mentioned, this paper is a general statement of the dust theory. My time limit is running to a close and I must refer you to the paper itself, which among other things treats our Triad of American Diseases (catarrh, dyspepsia, and nervous prostration) as reactions, similarly regarding blood pressure changes. The term disease at once brings to mind treatment, medicine, while reaction brings to mind prevention.

CONIOLOGY. 1912. This paper was a plea for a new science and the need for an institution for working out problems. The dust particles emitted by the tobacco smoker are included.

In 1913 I was unable to present my paper on RACE SUICIDE, in which the subject was also traced into the schools. There I asked, as this paper has already asked, regarding the use of tobacco by the teacher: Is he justified in using it? If he feels cross and irritable, shall he take something or do something—seek better air conditions, the proper construction of school buildings and proper ventilation and general cleanliness? Child mortality today is enormous. It should be greatly reduced, many bright children who now die could be saved to a life of usefulness. There is much truth in the old saying, The good die young.

THE ALCOHOL PROBLEM IN THE LIGHT OF CONIOSIS. In my paper for 1914 the Tobacco Problem comes up on every page, and I believe after the remarks I have made you will readily see it. I mentioned how on entering medical school I found horribly bad air conditions. The drinking water was equally bad; it was raw muddy river water. A number of students contracted typhoid fever. Some who had never used beer resorted to clean beer; which is the greater evil?

The first duty of the prohibitionist should be to give the people clean water; it is useless to argue with people who are compelled to drink muddy water. The next step is to give people clean air. That takes away the craving for a sedative, be that tobacco or alcohol or opium.

This paper properly should close with a questionnaire, asking for more data, especially from men who lead a mental life. Why do you use tobacco? Why do you not use it? Under what conditions do you demand it? When do you not care for it? Are you keeping down a high blood pressure by the excessive use of tobacco? Can you stop long enough, under bad air conditions, to find out what your real pressure is?

It is difficult to get good data; observations should cover at least one year. I am not inclined to draw conclusions from case reports which cover a period of less than a year, and as already mentioned, the longer the series of years, the more valuable data become.

Tolerance of Soil Micro Organisms to Media Changes.

H. A. Noyes.

Our text books all give space to the discussion of the food requirements of bacteria. The discussion, although general, is liable to lead us to believe that most organisms may not grow if we change the composition of media slightly. Just what is the minimum ration for most bacteria is not known. Our knowledge of the effects of modifying the composition of culture media is meager, especially when environmental factors are considered.

The Horticultural Research Chemistry and Bacteriology Laboratories, of the Purdue Agricultural Experiment Station have been investigating media for the platings and subsequent culturing of soil bacteria. This paper reports a part of this investigation.

Soil Used.

Two types of soil were used in this work, silty clay from the Experimental orchard at Laurel, Indiana, and brown loam from the Station orchard where a cover crop investigation is under way. All samples reported on in this paper contained from 16 to 20 per cent. of moisture at time of sampling. The method of sampling was by means of Noyes' sampler for soil bacteriologists. Samples were taken of the upper nine inches of soil.

Media Used.

Lipman and Brown "synthetic" agar.

15 gms. *best* agar.
10 gms. Dextrose.
.05 gms. Witte Peptone.
.2 gms. Magnesium sulphate.
.5 gms. Di potassium hydrogen phosphate.
Trace Ferrous sulphate.
1,000 cc. Distilled water.

H. J. Conn's sodium asparaginate agar.

15 gms. *best* agar (used instead of 12).

1 gm. Sodium asparaginate.
1 gm. Dextrose.
.2 gm. Magnesium sulphate.
1.5 gm. ($NH_4H_2PO_4$) ammonium biphosphate.
.1 gm. Calcium chloride.
.1 gm. Potassium chloride.
Trace Ferrous chloride.
1,000 cc. Distilled water.

Soil Extract (Unheated).

15 grams of *best* agar dissolved in 1,000 cc. of solution made as follows: Two kilos of the brown loam soil were placed in a glass bottle, and 5 liters of distilled water added, the bottle was shaken at intervals and at end of 16 hours the mixture was filtered. One thousand cc. of the filtrate was used in place of distilled water in making up this media.

Soil Extract (Autoclaved).

Fifteen grams of *best* agar dissolved in 1,000 cc. of solution made the same as the soil extract (unheated), except that the two kilos of soil were wet well and heated under 25 lbs. pressure in the autoclave for three hours.

Soil and agar, leaf extract and agar, and wheat straw extract.

These three media were made as follows: To 15 gms. of the *best* agar were added 10 gms. of the material desired and 1,000 cc. distilled water. The mixture was heated in a double boiler until the agar was dissolved. After making up to volume the media was filtered and tubed.

Other Media.

To 15 gms. of *best* agar was added 1 gm. per liter of chemicals appearing as part of the name of the media and 1,000 cc. of distilled water.

Figure 1 expresses graphically the acidity of the various media. The procedure in titrating was as follows: To about 125 cc. of distilled water that has been boiling about 3 minutes in a Jena erlenmeyer flask was added 50 cc. of the media by means of a tall 50 cc. graduate (of small cross-section). Two drops of phenolpthalein solution was added and titration made with tenth normal sodium hydroxide. The only media neutralized at all was H. J. Conn's sodium asparaginate agar, and this was done with half normal soda, using a pipette graduated to one-twentieth of a cc.

Tube Media Test I.

Sample of 6/14, 1915.

Sample from Tree XIII—13 Plot F.

Laurel.

One cc. portions of the 1–400,000 dilution of the sample were plated on the following media:

Lipman and Brown agar.
Conn's sodium asparaginate agar.
Agar alone.
Soil and agar (Purdue soil).
Soil extract (autoclaved) and agar.
Soil extract (unheated) and agar.
(15 gms. agar in all media.)

Transfers were made from best colonies on each media to slants of other media. Tables give results of growth on these agar slants at end of 5 and 14 days' incubation at 22° C.

8 Colonies from L and B agar to

	5 Days.	14 Days.
Na. asp. agar	8 g.*	8 g.
	0 —	0 —
Soil ext. (unheated)	6 g.	7 g.
	2 —	1 —
Soil ext. (autoclaved)	5 g.	5 g.
	3 —	3 —
Agar alone	5 g.	5 g.
	3 —	3 —
Agar and soil	4 g.	5 g.
	4 —	3 —

*8 = growth. — = no growth unless otherwise specified.

8 Colonies from Na. asp. agar to

	5 Days.	14 Days.
L and B agar	7 g. 1 —	7 g. 1 —
Soil ext. (unheated)	5 g. 3 —	7 g. 1 —
Soil ext. (autoclaved)	5 g. 3 —	7 g. 1 —
Agar alone	7 g. 1 —	7 g. 1 —
Agar and soil	6 g. 2 —	7 g. 1 —

3 Colonies from Soil Extract (unheated) to

	5 Days.	14 Days.
L and B agar	3 g.	3 g.
Na. asp. agar	2 g. 1 —	3 g.
Soil ext. (autoclaved)	3 g.	3 g.
Agar alone	3 g.	3 g.
Agar and soil	3 g.	3 g.

3 Colonies from Soil Extract (autoclaved) to

	5 Days.	5 Days.
L and B agar	3 g.	3 g.
Na. asp. agar	3 g.	3 g.
Soil ext. (unheated)	3 g.	3 g.
Agar alone	3 g.	3 g.
Agar and soil	2 g. 1 —	2 g. 1 —

3 Colonies from Agar Alone to

	5 Days.	14 Days.
L and B agar	3 g.	3 g.
Na. asp. agar	3 g.	3 g.
Soil ext. (unheated)	2 g.	2 g.
	1 —	1 —
Soil ext. (autoclaved)	3 g.	3 g.
Agar and soil	2 g.	2 g.
	1 —	1 —

3 Colonies from Agar and Soil to

	5 Days.	14 Days.
L and B agar	2 g.	2 g.
	1 —	1 —
Na. asp. agar	2 g.	2 g.
	1 —	1 —
Soil ext. (unheated)	2 g.	2 g.
	1 —	1 —
Soil ext. (autoclaved)	2 g.	2 g.
	1 —	1 —
Agar alone	2 g.	2 g.
	1 —	1 —

Summary 5 Day Results.

20 transfers to L and B agar..................................18 made growth.
20 transfers to Na. asp. agar..................................18 made growth.
25 transfers to Soil ext. (unheated)..................................18 made growth.
25 transfers to Soil ext. (autoclaved)..................................18 made growth.
25 transfers to Agar alone..................................20 made growth.
25 transfers to Agar and soil..................................17 made growth.

Summary 14 Days.

20 transfers to L and B agar..................................18 made growth.
20 transfers to Na. asp. agar..................................19 made growth.
25 transfers to Soil ext. (unheated)..................................21 made growth.

25 transfers to Soil ext. (autoclaved)..............................20 made growth.
25 transfers to Agar alone..20 made growth.
25 transfers to Agar and soil......................................19 made growth.

Notes.

When tubes of organisms grown originally on same media were put side by side the following differences were noted.

(1) Agar alone supported very poor growths.

(2) Agar and soil supported fully as poor growths as agar alone.

(3) The two extracts acted about the same, although the heated extract grew the organisms originally grown on Na. asp. agar a little the best.

(4) L. and B. agar and Na. asp. agar supported good growths.

(5) From any macroscopic test the growths on the L. and B. agar were far superior to those on the Na. asp. agar.

Tube Media Test II.

Samples of 6/14, 1915.
Samples from Tree VI—24. Plot C.
Laurel.

One cc. portions of the 1–400,000 dilution of the sample were plated on the following media:

Lipman and Brown agar.
Conn's sodium asparaginate agar.
Agar alone.
Soil and agar (Purdue soil).
Soil extract (unheated) and agar.
Soil extract (autoclaved) and agar.
(15 gms. agar in all media.)

Transfers were made from best colonies on each media to slants of other media. Tables give results of growth on these agar slants at end of 5 and 14 days' incubation at 22° C.

8 Colonies from L and B agar to

	5 Days.	14 Days.
Na. asp. agar	7 g.	7 g.
	1 —	1 —
Soil ext. (unheated)	6 g.	5 g.
	2 —	3 —
Soil ext. (autoclaved)	5 g.	6 g.
	3 —	2 —
Agar alone	4 g.	6 g.
	4 —	2 —
Agar and soil	4 g.	4 g.
	4 —	4 —

8 Colonies from Na. asp. agar to

	5 Days.	14 Days.
L and B agar	8 g.	8 g.
Soil ext. (unheated)	7 g.	6 g.
	1 —	2 —
Soil ext. (autoclaved)	8 g.	8 g.
Agar alone	8 g.	8 g.
Agar and soil	8 g.	6 g.
		2 —

Summary 5 Days.

8 transfers to L and B agar................................ 8 made growth.
8 transfers to Na. asp. agar................................ 7 made growth.
16 transfers to Soil ext. (unheated)........................13 made growth.
16 transfers to Soil ext. (autoclaved)......................13 made growth.
16 transfers to Agar alone..................................12 made growth.
16 transfers to Agar and soil...............................12 made growth.

Summary 14 Days.

8 transfers to L and B agar................................ 8 made growth.
8 transfers to Na. asp. agar................................ 7 made growth.
16 transfers to Soil ext. (unheated)........................11 made growth.
16 transfers to Soil ext. (autoclaved)......................14 made growth.
16 transfers to Agar alone..................................14 made growth.
16 transfers to Agar and soil ....10 made growth.

Notes.

When tubes of organisms grown originally on same media were put side by side the following differences were noted:

(1) Agar alone supported very poor growths.

(2) Agar and soil supported fully as poor growths as agar alone.

(3) The two extracts acted about the same, although the heated extract grew the organisms originally grown on Na. asp. agar a little the best.

(4) L. and B. agar and Na. asp. agar supported good growths.

(5) From any macroscopic test the growths on the L. and B. agar were far superior to those on the Na. asp. agar.

Tube Media Test III.

Samples of 6/25, 1915.

Sample No. 6. Rye Plot.

Cover Crop Investigations.

One cc. portions of the 1 to 400,000 dilution of this sample were plated on the following media:

Lipman and Brown agar.

Conn's sodium asparaginate agar.

Agar alone.

Soil and agar (Purdue soil).

Soil extract (unheated) and agar.

Soil extract (autoclaved) and agar.

(15 gms. agar in all media.)

Colonies developing well on first two media listed were put on other media and growth noted at end of 5, 11, and 15 days' incubation at 22° C.

From 4 Colonies on L and B agar to

	5 Days.	11 Days.	15 Days.
Na. asp. agar	3 g. 1 —	4 g.	4 g.
Soil ext. (unheated)	2 g. 2 —	2 g. 2 —	3 g. 1 —
Plain agar	3 g. 1 —	3 g. 1 —	3 g. 1 —

From 4 Colonies on Na. asp. agar to

	5 Days.	11 Days.	15 Days.
L and B agar	4 g.	4 g.	4 g.
Soil ext. (unheated)	2 g.	3 g.	4 g.
	2 —	1 —	
Plain agar	3 g.	3 g.	3 g.
	1 —	1 —	1 —

Summary 5 Days.

4 transfers to L and B agar.......4 made growth.
4 transfers to Na. asp. agar.......3 made growth.
8 transfers to Soil ext. (unheated).......4 made growth.
8 transfers to Agar alone.......6 made growth.

Summary 15 Days.

4 transfers to L and B agar.......4 made growth.
4 transfers to Na. asp. agar.......4 made growth.
8 transfers to Soil ext. (unheated).......7 made growth.
8 transfers to Agar alone.......6 made growth.

Notes.

When tubes of different media containing the same organism from the same original colony were put side by side, the following was noted:

(1) The growth on agar alone, soil and agar or on soil extract (unheated) was small.

(2) The soil extract carried a better growth than the soil alone.

(3) L. and B. agar and Na. asp. agar carried a good growth.

(4) There was more development of distinguishing characteristics as to form of streaks and chromogenisis present, with the L and B agar.

TUBE MEDIA TEST IV.

Samples of 6/25, 1915.

Sample No. 7. Clean Culture Plot.

Cover Crop Investigation.

One cc. portions of the 1 to 400,000 dilution of this sample were plated on the following media:

Lipman and Brown agar.

Conn's sodium asparaginate agar.

Agar alone.
Soil and agar (Purdue soil).
Soil extract (unheated) and agar.
Soil extract (autoclaved) and agar.
(15 gms. agar in all media.)

Colonies developing well on each media were transferred to slants of other media. Tables give results of growth on these agar slants at end of 5, 11, and 15 days. Incubation at 22° C.

From 4 Colonies on L and B agar to

	5 Days.	11 Days.	15 Days.	Shown in Plate
Na. asp. agar	2 gr.	2 gr.	3 gr.	I
	2 —	2 —	1 —	
Agar alone	3 gr.	3 gr.	3 gr.	
	1 —	1 —	1 —	
Soil ext. (unheated)	2 gr.	3 gr.	3 gr.	
	2 —	1 —	1 —	

From 4 Colonies on Na. asp. agar to

	5 Days.	11 Days.	15 Days.	Plate.
L and B agar	4 g.	4 g.	4 g.	II
Agar alone	3 g.	3 g.	3 g.	
	1 —	1 —	1 —	
Soil ext. (unheated)	3 g.	4 g.	4 g.	
	1 —			

From 3 Colonies on Plain Agar to

	5 Days.	11 Days.	15 Days.
L and B agar	2 g.	2 g.	2 g.
	1 —	1 —	1 —
Na. asp. agar	2 g.	2 g.	2 g.
	1 —	1 —	1 —
Soil ext. (unheated)	2 g.	2 g.	2 g.
	1 —	1 —	1 —

From 3 Colonies on Soil and Agar to

	5 Days.	11 Days.	15 Days.
L and B agar	{2 g. 1 —	2 g. 1 —	2 g. 1 —
Na. asp. agar	{2 g. 1 —	3 g.	3 g.
Soil ext. (unheated)	3 g.	3 g.	3 g.
Agar alone	{2 g. 1 —	3 g.	3 g.

From 3 Colonies on Soil Extract (unheated) to

	5 Days.	11 Days.	15 Days.
L and B agar	3 g.	3 g.	3 g.
Na. asp. agar	3 g.	3 g.	3 g.
Agar alone	3 g.	3 g.	3 g.

From 3 Colonies on Soil Extract (autoclaved) to

	5 Days.	11 Days.	15 Days.
L and B agar	3 g.	3 g.	3 g.
Na. asp. agar	3 g.	3 g.	3 g.
Agar alone	{2 g. 1 —	2 g. 1 —	2 g. 1 —
Soil ext. (unheated)	3 g.	3 g.	3 g.

Summary (5 Days Results).

16 transfers to L and B agar....................14 made growth.
16 transfers to Na. asp. agar....................12 made growth.
17 transfers to Plain agar....................13 made growth.
17 transfers to Soil Ext. (unheated)....................13 made growth.

Summary (15 Day Results).

16 transfers to L and B agar....................14 made growth.
16 transfers to Na. asp. agar....................13 made growth.
17 transfers to Plain agar....................14 made growth.
17 transfers to Soil ext. (unheated)....................15 made growth.

General Notes.

When tubes of different media containing the same organism from the same original colony are put side by side, the following is noted:

(1) The growth on agar alone, soil and agar or on soil extract (unheated) is small.

(2) The soil extract carries a better growth than the soil alone.

(3) L. and B. agar and Na. asp. agar carry a good growth.

(4) There is more development of distinguishing characteristics as to form of streaks and chromogenisis present, with the L. and B. agar.

Tube Media Test V.

Sample of 7/16, 1915.

Sample No. 8. Millet Plot.

Cover Crop Investigations.

One cc. portions of the 1 to 400,000 dilution of this sample were plated on the following media:

A. Wheat straw extract.
B. Leaf extract.
C. Starch.
D. Agar alone.
E. Ammonium nitrate.
F. Conn's sodium asparaginate.
G. Soil.
H. Soil and starch.
I. Lipman and Brown agar.
J. Ammonium nitrate and starch.
(15 gms. agar is basis of all media.)

Colonies developing well on each media, plates III and IV, were transferred to slants of other media. Tables give results of growth on these slants at end of 6, 10 and 14 days' incubation at 22° Centigrade.

4 Colonies from L and B agar to

	6 Days.	10 Days.	14 Days.	Shown in Plate
Wheat Straw Ext.	3 g. 1 —	3 g. 1 —	3 g. 1 —	V
Leaf Ext.	1 g. 3 —	1 g. 3 —	1 g. 3 —	
Starch	4 g.	4 g.	4 g.	VI
Agar alone	3 g. 1 —	4 g.	4 g.	VII
Ammonium Nitrate	4 g.	4 g.	4 g.	VIII
Na. asp. agar	3 g. 1 —	3 g. 1 —	4 g.	IX
Soil	3 g. 1 —	3 g. 1 —	3 g. 1 —	X
Soil and Starch	2 g. 2 —	2 g. 2 —	2 g. 2 —	
L and B agar	4 g.	4 g.	4 g.	XI
Ammonium Nitrate and Starch	3 g. 1 —	3 g. 1 —	4 g.	
Soil and Ammonium Nitrate	2 g. 2 —	2 g. 2 —	3 g. 1 —	
Soil Extract (unheated)	2 g. 2 —	3 g. 1 —	4 g.	

4 Colonies from Na. asp. agar to

	6 Days.	10 Days.	14 Days.	Plate.
Wheat Straw Ext.	4 g.	4 g.	4 g.	V
Leaf Ext.	3 g. 1 —	3 g. 1 —	3 g. 1 —	
Starch	4 g.	4 g.	4 g.	VI
Agar alone	4 g.	4 g.	4 g.	VII
Ammonium Nitrate	4 g.	4 g.	4 g.	VIII
Na. asp. agar	4 g.	4 g.	4 g.	IX
Soil	4 g.	4 g.	4 g.	X
Soil and Starch	4 g.	4 g.	4 g.	
L and B agar	4 g.	4 g.	4 g.	XI
Ammonium Nitrate and Starch	4 g.	4 g.	4 g.	
Soil and Ammonium Nitrate	3 g. 1 —	3 g. 1 —	4 g.	
Soil Ext. (unheated)	4 g.	4 g.	4 g.	

4 Colonies from Starch to

	6 Days.	10 Days.	14 Days.
Wheat Straw Ext.	2 g. 2 —	2 g. 2 —	2 g. 2 —
Leaf Ext.	1 g. 3 —	1 g. 3 —	1 g. 3 —
Starch	3 g. 1 —	4 g.	4 g.
Agar alone	3 g. 1 —	3 g. 1 —	3 g. 1 —
Ammonium Nitrate	4 g.	4 g.	4 g.
Na. asp. agar	4 g.	4 g.	4 g.
Soil	4 g.	4 g.	3 g. 1 —
Soil and Starch	2 g. 2 —	2 g. 2 —	2 g. 2 —
L and B agar	4 g.	4 g.	4 g.
Ammonium Nitrate and Starch	3 g. 1 —	3 g. 1 —	3 g. 1 —
Soil and Ammonium Nitrate	4 g.	4 g.	4 g.
Soil Ext. (unheated)	3 g. 1 —	3 g. 1 —	4 g.

4 Colonies from Agar alone to

	6 Days.	10 Days.	14 Days.	Shown in Plate.
Starch	2 g. 2 —	2 g. 2 —	2 g. 2 —	
Na. asp. agar	2 g. 2 —	3 g. 1 —	3 g. 1 —	XII
L and B agar	3 g. 1 —	4 g.	4 g.	XII

4 Colonies from Ammonium Nitrate to

	6 Days.	10 Days.	14 Days.	Shown in Plate
L and B agar	4 g.	4 g.	4 g.	XII
Na. asp. agar	4 g.	4 g.	4 g.	XII
Starch	4 g.	4 g.	4 g.	

4 Colonies from Soil and Starch to

	6 Days.	10 Days.	14 Days.
L and B agar	4 g.	4 g.	4 g.
Na. asp. agar	4 g.	4 g.	4 g.
Starch	2 g. 2 —	2 g. 2 —	2 g. 2 —

4 Colonies from Soil alone to

	6 Days.	10 Days.	14 Days.
L and B agar	3 g. 1 —	3 g. 1 —	4 g.
Na. asp. agar	4 g.	4 g.	4 g.
Starch	4 g.	4 g.	4 g.
Soil and starch	4 g.	4 g.	4 g.

4 Colonies from Ammonium Nitrate and Starch to

	6 Days.	10 Days.	14 Days.
L and B agar	4 g.	4 g.	4 g.
Na. asp. agar	3 g. 1 —	4 g.	4 g.
Starch	4 g.	4 g.	4 g.
Soil and starch	3 g. 1 —	3 g. 1 —	3 g. 1 —

Summary 6 Days.

12 transfers to Wheat Straw Ext.	9 made growth.
12 transfers to Leaf Ext.	5 made growth.
32 transfers to Starch.	27 made growth.
12 transfers to Agar alone.	10 made growth.
12 transfers to Ammonium Nitrate.	12 made growth.
32 transfers to Na. asp. agar.	28 made growth.
12 transfers to Soil.	10 made growth.
20 transfers to Soil and Starch.	15 made growth.
32 transfers to L and B agar.	30 made growth.
12 transfers to NH_4NO_3 and St.	10 made growth.
12 transfers to Soil and NH_4NO_3.	9 made growth.
12 transfers to Soil Ext.	12 made growth.
212 transfers.	177 made growth.

Summary 14 Days.

12 transfers to Wheat Straw Ext.	9 made growth.
12 transfers to Leaf Ext.	5 made growth.
32 transfers to Starch.	28 made growth.
12 transfers to Agar alone.	11 made growth.
12 transfers to Ammonium Nitrate.	12 made growth.
32 transfers to Na. asp. agar.	31 made growth.
12 transfers to Soil.	10 made growth.
20 transfers to Soil and Starch.	15 made growth.
32 transfers to L and B agar.	32 made growth.
12 transfers to NH_4NO_3 and St.	11 made growth.
12 transfers to Soil and NH_4NO_3.	11 made growth.
12 transfers to Soil Ext.	12 made growth.
212 transfers.	187 made growth.

Notes.

(1) In this set of tests, as in those run previously, there was very little growth on the agar alone, the soil, and the soil extract slants. Practically all the organisms tested made some growth on these media.

(2) Ammonium nitrate furnishing nitrogen both in NH_4 and NO_3 did not grow better cultures than agar alone. This latter is from observations made after fourteen days' incubation.

(3) Wheat straw extract grew but little better cultures than the soil extract, while leaf extract was a total failure as a media.

(4) Starch furnishing sources of energy, and being capable of being

split in many ways by enzymatic action, grew good cultures both alone and in combination with other materials.

(5) As noted in all other tests the Lipman and Brown agar grew the best cultures and apparently developed their distinguishing chromogenic characteristics much better than the sodium asparaginate agar.

(6) From macroscopic comparisons the starch media seemed to be the real competitor of the Lipman and Brown agar.

Tube Media Test VI.

Testing Organisms from Laurel Soils.

Plated on Lipman and Brown Agar.

When transferred to slants of different media.

Samples taken 7/27/1915.

Description of colonies from which transfers were made:

No. 1. Round, curled edge, wrinkled in structure, green in color, a mold 1.5 cm. in diameter.

No. 2. Elliptical, curled edge, wrinkled in structure, green in color, a mold 1.5 cm. long.

No. 3. Round, lobate edge, wrinkled structure, brown (pale) in color, a mold 1 cm. in diameter.

No. 4. Round, entire edge, granular structure. White raised center with brown ring outside, apparently a mold about .5 cm. in diameter.

No. 5. Discoid, crenate edge, smooth structure, milk white in color, .5 cm. in diameter, a mold.

No. 6. Round, entire edge, smooth structure, salmon red in color, 3 mm. in diameter.

No. 7. Round, ciliate edge, granular structure. Yellow in color, deep yellow at center, about 1 cm. in diameter.

No. 8. Round, ciliate edge, granular center and fibrant outer portion describes structure. Center dark green, border light green, about 4 mm. in diameter.

No. 9. Round, plain edge, smooth in structure, salmon red with yellowish outside ring, produces yellow pigment soluble in media, about 4 mm. in diameter.

No. 10. Round though dented, crenate edge, spotted structure, white in color, about 8 mm. in diameter.

No. 11. Discoid, lobate edge, spotted structure, white in color with heavy black center, about 6 mm. in diameter.

No. 12. Round, entire edge, granular structure, heavy center, milk white in color, about 1 cm. in diameter.

No. 13. Round, entire edge, smooth structure, yellow in color, about 3 mm. in diameter.

No. 14. Round, entire edge, smooth structure, dark red in color, about 4 mm. in diameter.

No. 15. Round, entire edge, spotted structure, white with brown center, about 8 mm. in diameter.

No. 16. Discoid, lobate edge, wrinkled structure, yellowish white in color, about 8 mm. in diameter.

Observations of Growth and Relative Growth were made at end of 5th, 7th, and 15th days. Temperature of incubation, 22° to 23° C. on following media:

Lipman and Brown agar.
Conn's sodium asparaginate agar.
Ammonium nitrate agar.
Starch agar.
Ammonium nitrate and starch agar.

Observations of Growth and Ranking 5 Days.

No.	L and B agar.	Na. asp. agar.	NH_4NO_3 agar.	Starch agar.	NH_4NO_3 and Starch.
1	– 5%	* 1	* 4	* 3	* 2
2	* 4	* 1	* 3	* 2	– 5
3	– 5	* 1	– 5	* 2 or 3	* 2 or 3
4	– 5	* 3	* 1	* 5	* 2
5	* 5	* 1	* 3	– 5	* 2
6	* 2	* 1	* 5	* 4	* 3
7	* 3	* 1	– 5	* 2	* 4
8	* 1	* 2	* 4	* 3	* 5
9	* 2	* 1	* 4	* 5	* 3
10	* 1	* 4	* 3	* 2	– 5
11	* 1	* 3	– 5	* 2	– 5
12	* 1	* 1	* 1	* 1	* 1
13	* 5	* 2	* 3	* 4	* 1
14	* 1	* 4	* 5	* 3	* 2
15	* 4	* 3	* 5	* 2	* 1
16	* 2	* 1	* 3	– 5	* 4
Av. all	2.94	1.87	3.69	3.16	2.97
Av. 6-16	2.10	2.10	3.91	3.00	3.10

* = Growth.
– = No growth.
(%) No growth, ranked lowest so that a relative general average may be made.

Observations of Growth and Ranking 7 Days.

No.	L and B agar.	Na. asp. agar.	NH_4NO_3 agar.	Starch agar.	NH_4NO_3 and Starch Agar.
1.	— 5 (%)	* 1	* 3	* 2	* 4
2.	* 3	* 2	— 5	* 1	— 5
3.	— 5	* 1	* 4	* 2	* 3
4.	* 4	* 1	* 5	* 3	* 2
5.	— 5	* 2	* 1	— 5	* 3
6.	* 5	* 4	* 2	* 1	* 3
7.	* 1	* 2	* 5	* 3	* 4
8.	* 2	* 1	* 4	* 3	* 5
9.	* 1	* 2	* 5	* 4	* 3
10.	* 1	* 2	* 1	* 3	— 5
11.	* 2	* 1	* 5	* 4	* 3
12.	* 1	* 2	* 1	* 1	* 1
13.	* 1	* 2	* 5	* 4	* 3
14.	* 1	* 4	* 5	* 3	* 2
15.	* 1 or 2	* 1 or 2	* 5	* 4	* 3
16.	* 2	* 1	* 4	— 5	* 3
Av. all	2.50	1.81	3.76	3.00	3.25
Av. 6-16	1.64	2.00	3.72	3.18	3.18

* = Growth.
— = No Growth.
(%) No growth, ranked lowest so that a relative general average may be made.

Observations of Growth, Color of Growth and Ranking 15 Days.

No.	L and B agar.	Na. asp. agar.	NH_4NO_3 agar.	Starch agar.	NH_4NO_3 and Starch Agar.
1.	– 5	* 1 Bl. Br. Gr.	* 4 White	* 2 Li. Green	* 3 Bl. Gr.
2.	* 1 Bl. Gr.	* 3 Li. than 2	* 4	* 2 Li. than 1	* 5
3.	– 5	* 1 Green	– 5	* 2 Green	* 3 Wh.-Gr.
4.	* 4 Cream	* 1 White	* 3 White	* 5 Li.-Gr.	* 2 D.-Brown
5.	– 5	* 1 Heavy Wh.	* 3 White	* 4 White	* 2 White
6.	* 4 Red	* 3 Red	* 5 White	* 1 Red	* 2 White
7.	* 1 Y.-White	* 3 Green	* 5 White	* 4 Y.-Green	* 2 Yellow
8.	* 2 Green	* 1 Green	* 4 White	* 3 Y.-Green	* 5 White
9.	* 1 Y.-Red	* 4 R.-Yell.	* 5 White	* 3 Y.-White	* 2 Y.-White
10.	* 1 White	* 3 White	* 4 White	* 2 White	– 5
11.	* 3 Brown	* 1 Brown	* 5 White	* 4 White	* 2 White
12.	* 4 Br.-Wh.	* 5 White	* 3 Br.-Wh.	* 2 Br.-Wh.	* 1 Br.-Wh.
13.	* 1 P.-Gr.	* 4 P.-Gr.	* 5 P.-Gr.	* 3 P.-Gr.	* 2 P.-Gr.
14.	* 1 Red	* 4 Cream	* 5 D.-Wh.	* 3 Red	* 2 Red
15.	* 1 Br.-Wh.	* 2 D.-Wh.	* 5 D.-Wh.	* 4 Br.-Wh.	* 3 Br.-Wh.
16.	* 2 Br.-Wh.	* 3 Y.-Wh.	* 4 Br.-Wh.	– 5	* 1 Br.-Wh.
Av. all	2.56	2.50	4.31	3.06	2.56
Av. 6-16	1.91	3.00	4.55	3.09	2.45

* = Growth.
– = No growth.

Summary.

Average All Sixteen Organisms.

	L and B agar.	Na. asp. agar.	NH_4NO_3 agar.	Starch agar.	NH_4NO_3 and Starch Agar.
5 days.......	2.94	1.87	3.69	3.16	2.97
7 days.......	2.50	1.81	3.76	3.00	3.25
15 days.......	2.56	2.50	4.31	3.06	2.56

Summary.

Average Organisms 6 to 16 Inc.

	L and B agar.	Na. asp. agar.	NH_4NO_3 agar.	Starch agar.	NH_4NO_3 and Starch Agar.
5 days.......	2.10	2.10	3.91	3.00	3.10
7 days.......	1.64	2.00	3.82	3.18	3.18
15 days.......	1.91	3.00	4.55	3.09	2.45

Notes.

(1) The comparisons between the growth of an organism on the different media were practically as marked at 5 days as they were at 15.

(2) The five molds Nos. 1, 2, 3, 4, 5, were more easily transferred to sodium asparaginate agar than to some of the media.

(3) Where molds are included the greatest number of failures of growth occurred on Lipman and Brown agar.

(4) Studying Nos. 6 to 16 inclusive, it was found that the Lipman and Brown and the Sodium asparaginate agar were about alike in amount of growths produced on slants, and that the ammonium nitrate agar was the poorest media considered.

(5) When chromogenesis is considered, Starch alone and in combination with the Ammonium nitrate brought out as much chromogenesis as the Lipman and Brown agar.

Summary of Investigation.

This paper gives the results of tests made on agar slants where the two media most commonly used for plating soils are compared. The results of comparisons between these media, and comparisons of them—with agar alone, with soil, wheat and leaf extract media, with ammonium nitrate and starch media, both alone and in combination—showed that organisms once grown on media will generally grow when transferred to other media.

The rate of development seemed more important than the fact that the organism grew. Comparisons of growth at end of different periods of incubation were usually the same. Where growth was good it developed slowly enough so that it could not be termed a flash growth. Where growth was poor, distinguishing characteristics peculiar to the organism were rarely apparent.

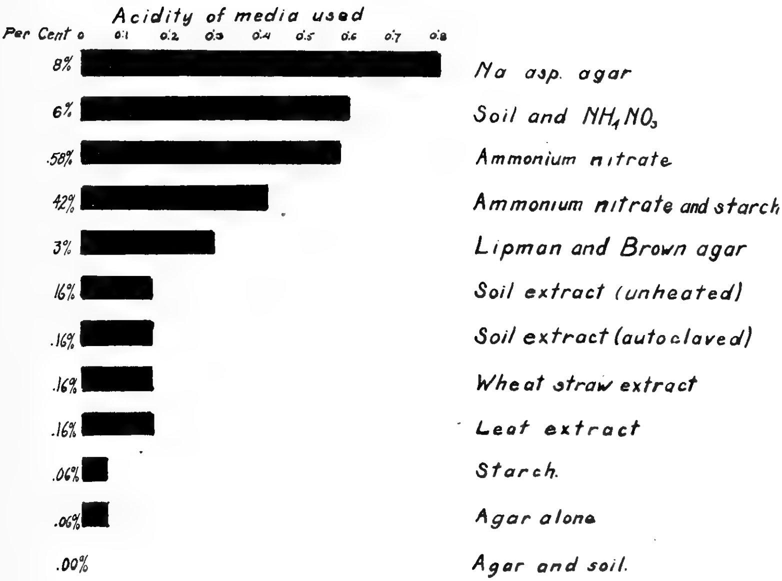
The explanation of the tolerance observed is not that those organisms growing when soil is plated on inferior media are probably the same organisms that yield the best colonies on better media. Picking out organisms plated on the best media and growing them on poorer media supports the above statement. Chromogenesis was augmented by the presence of carbohydrate in the media.

Comment.

Many expect that soil biology will explain results for which chemical and physical causes have not been found. Many look to the control of plant growth through the application of principles of microbiology.

Soils with their large or small amounts of decaying organic matter, of both plant and animal origin, must be a possible medium for the growth of all kinds of bacteria. One reason why the number of bacteria in our prairie soils has not been found to vary with the crop-producing power of the soil may be the tolerance of many kinds of bacteria to all present chemical and physical differences between types of prairie soil. In sandy and poor soils some believe that there is a relationship between the number of bacteria and the crop-producing power of the soil. The factors of temperature, aeration and moisture are more constant in the rich soil, and for this reason the changes in soil moisture, the variation in soil temperature, and the movement of soil gases must exert a more marked influence on the presence of and the activities of certain micro-organisms than the food factor does.

FIGURE 1


Acidity of media used
Per Cent 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
.8% Na asp. agar
.6% Soil and NH_4NO_3
.58% Ammonium nitrate
.42% Ammonium nitrate and starch
.3% Lipman and Brown agar
.16% Soil extract (unheated)
.16% Soil extract (autoclaved)
.16% Wheat straw extract
.16% Leaf extract
.06% Starch.
.06% Agar alone
.00% Agar and soil.

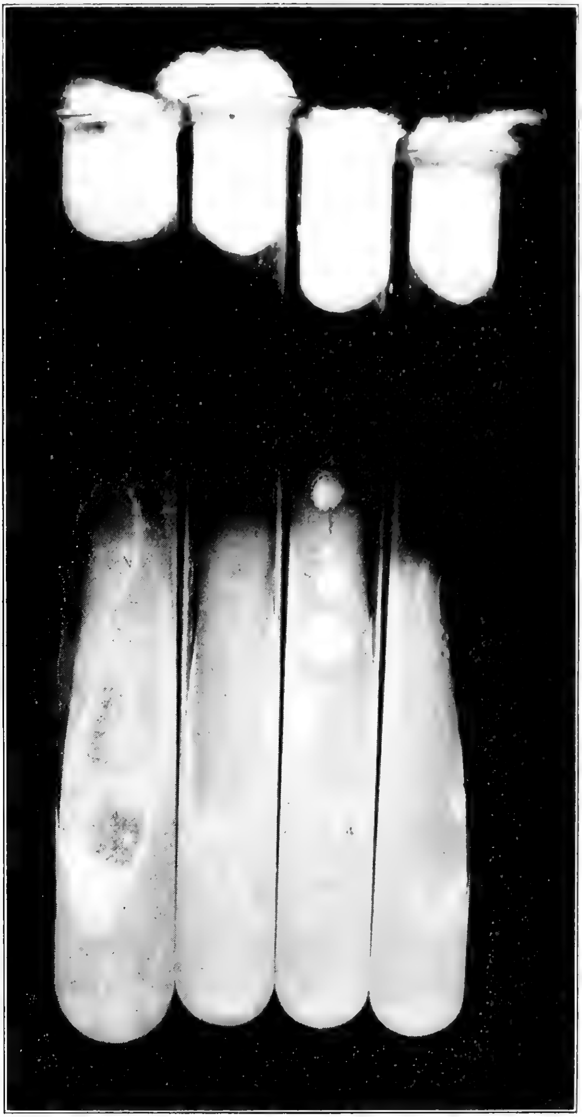


PLATE I.
4 Colonies from L. and B. agar on Na. asp. agar.

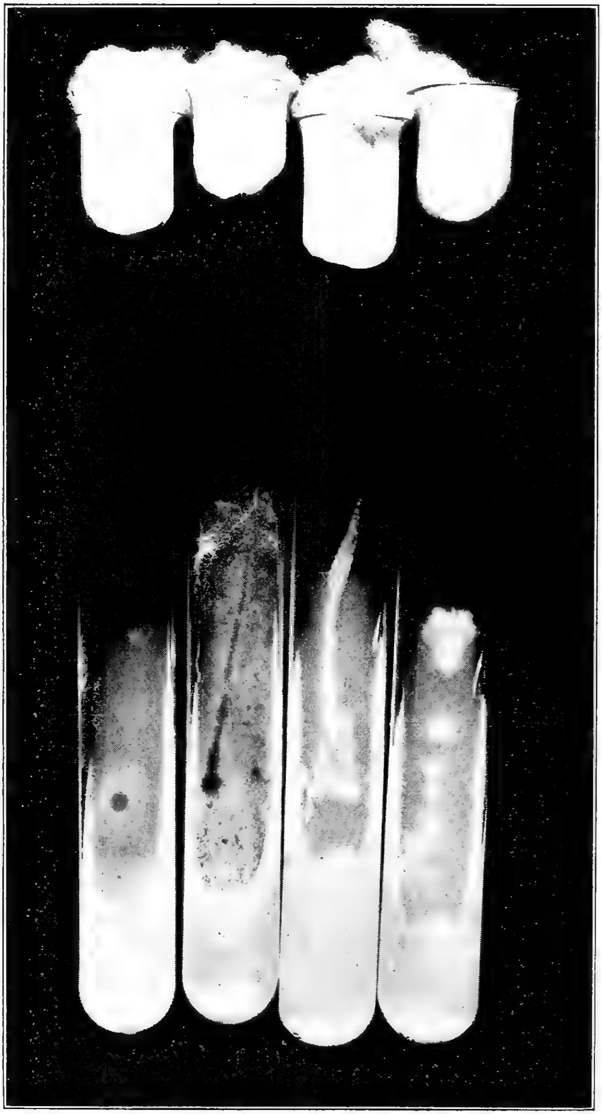


PLATE II.
4 Colonies from Na. Asp. agar on L. and B. agar

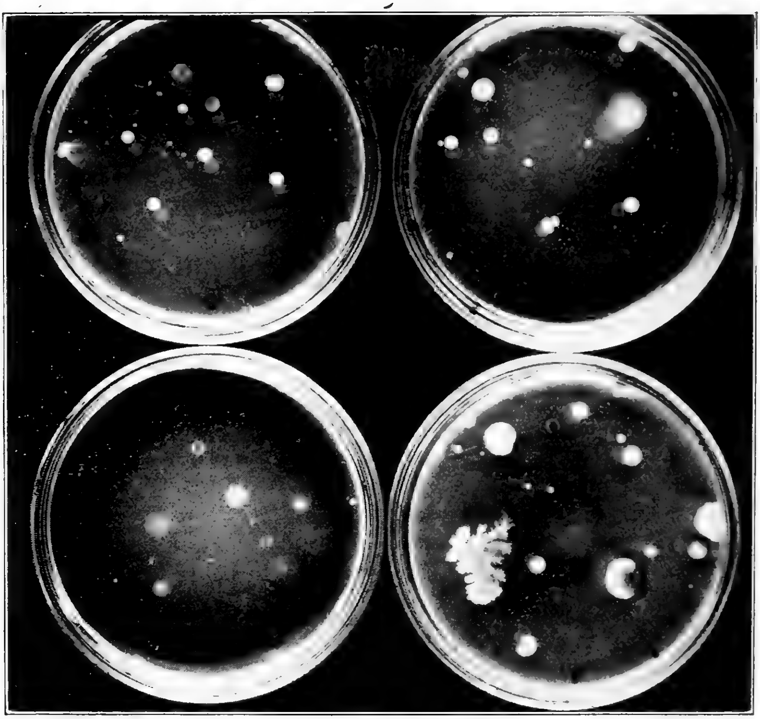


PLATE III.
Some of the plates from which organisms were obtained for tube media test V.

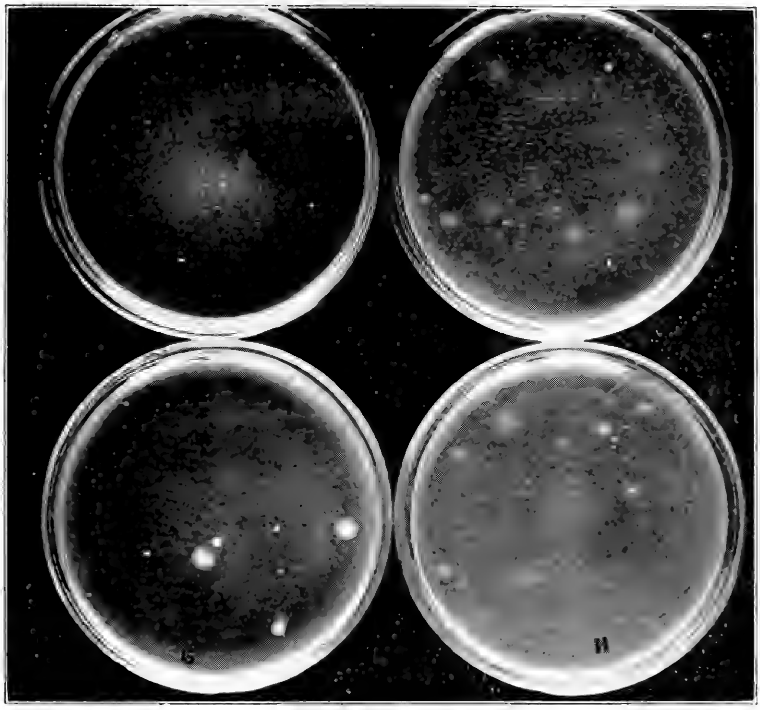


Plate IV.
Some of plates from which organisms were obtained for tube media test V.

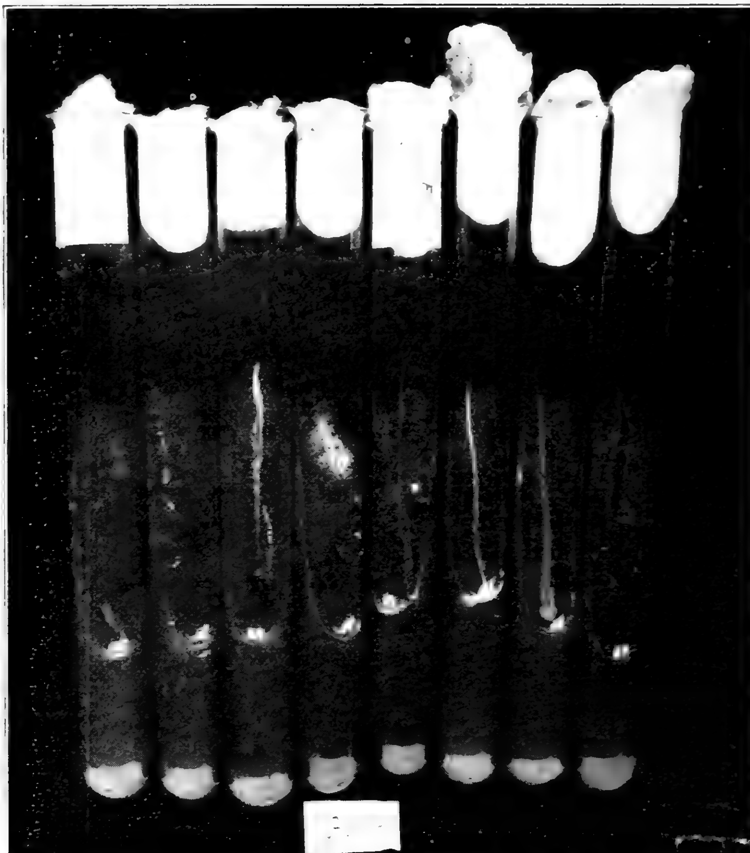


PLATE V.

At left: 4 organisms from L. and B. agar to wheat straw extract agar.
At right: 4 organisms from Na. asp. agar to wheat straw extract agar.

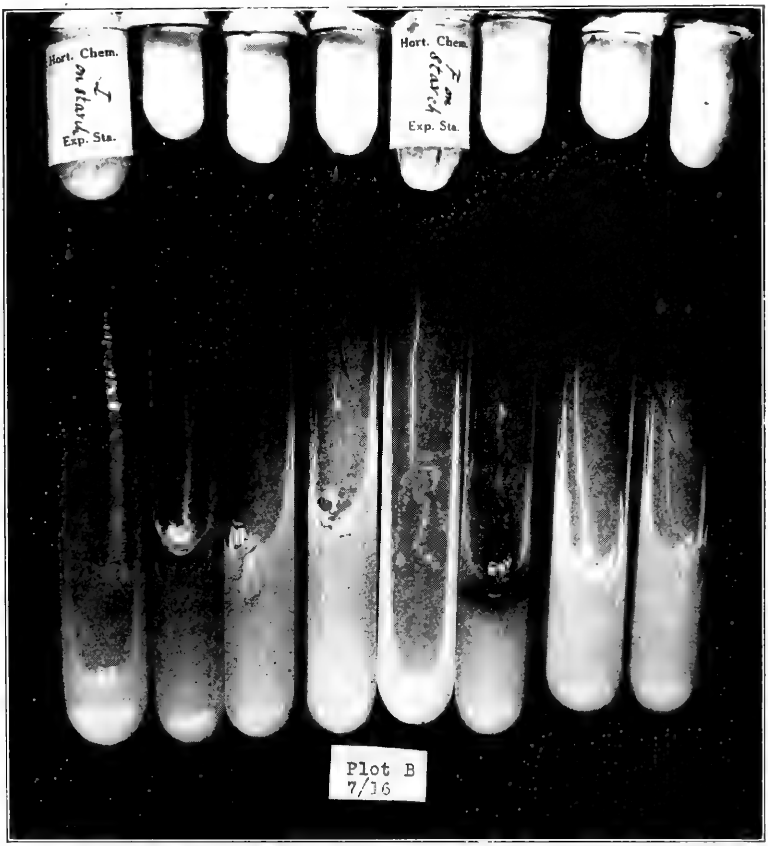


PLATE VI.

At left: 4 organisms from L. and B. agar to starch agar.
At right: 4 organisms from Na. asp. agar to starch agar.

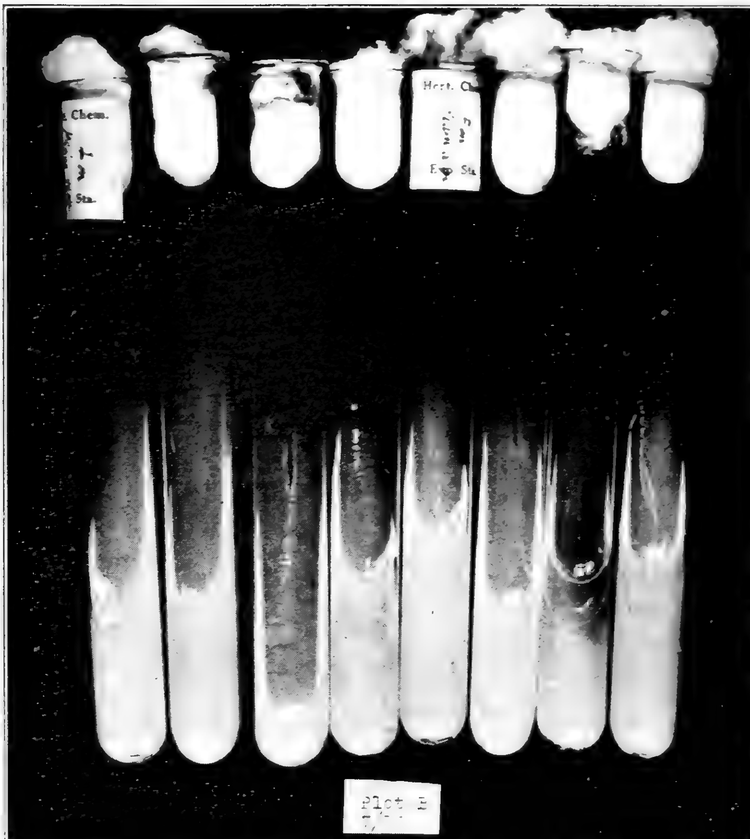


PLATE VII.
At left: 4 organisms from L. and B. agar to agar alone.
At right: 4 organisms from Na. asp. agar to agar alone.

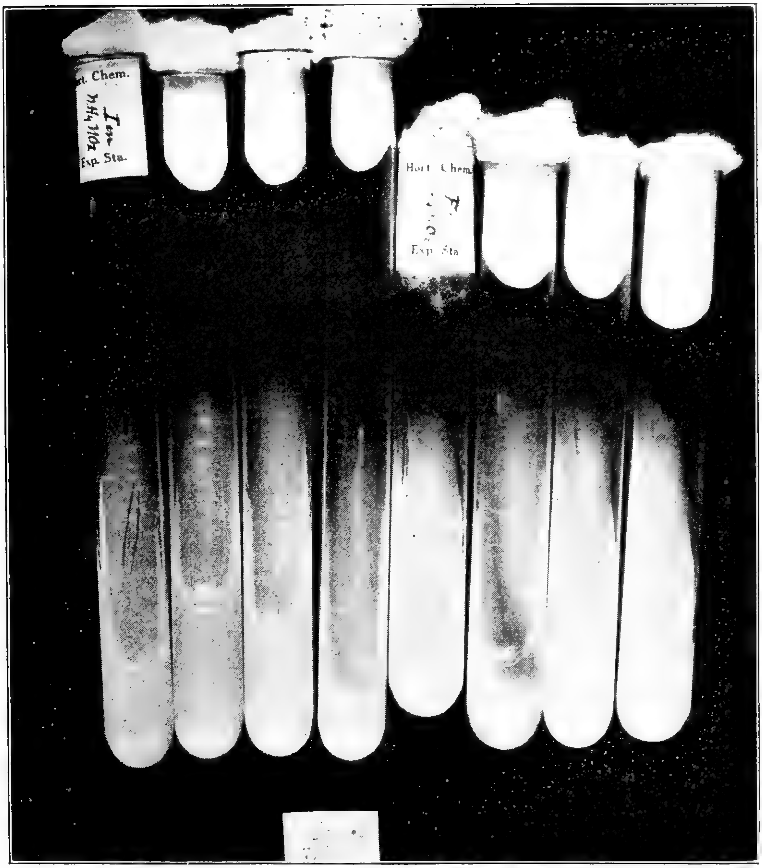


Plate VIII.

At left: 4 organisms from L. and B. agar to ammonium nitrate agar.
At right: 4 organisms from Na. asp. agar to ammonium nitrate agar.

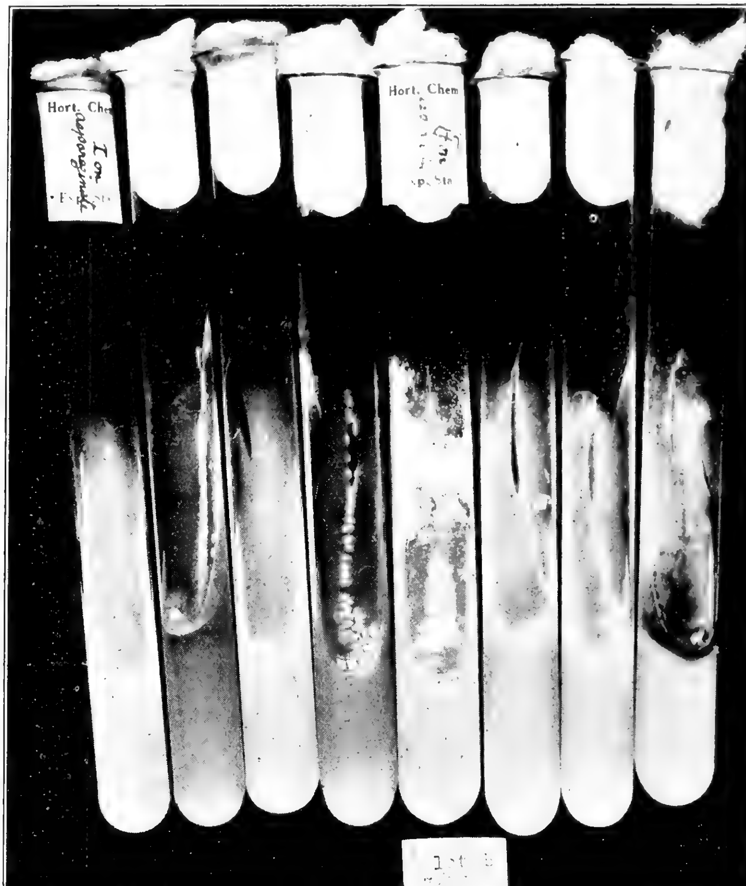


PLATE IX.

At left: 4 organisms from L. and B. agar to Na. asp. agar.
At right: 4 organisms from Na. asp. agar to Na. asp. agar.

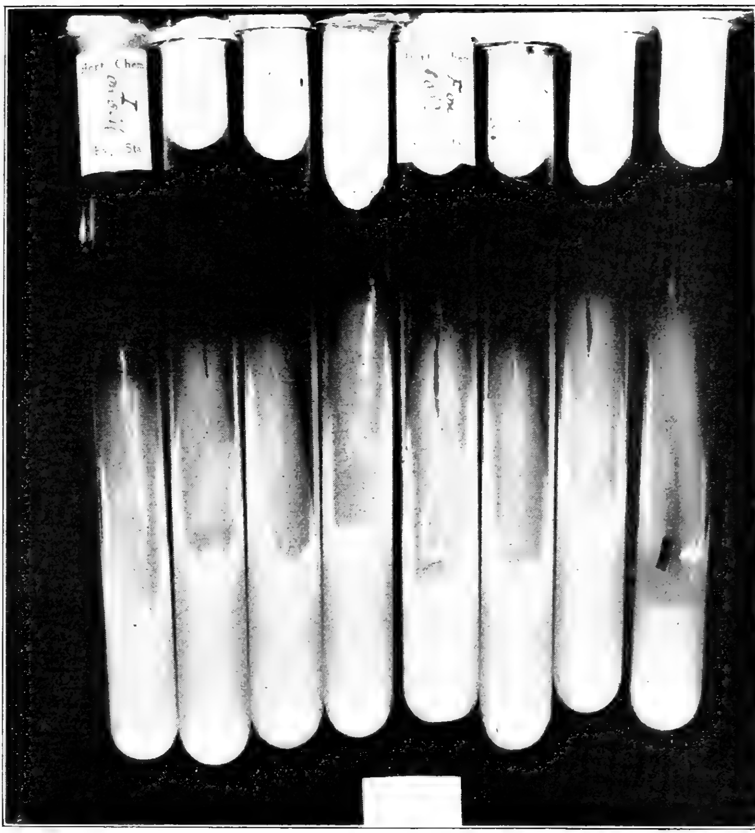


PLATE X.
At left: 4 organisms from L. and B. agar to soil and agar.
At right: 4 organisms from Na. asp. agar to soil and agar.

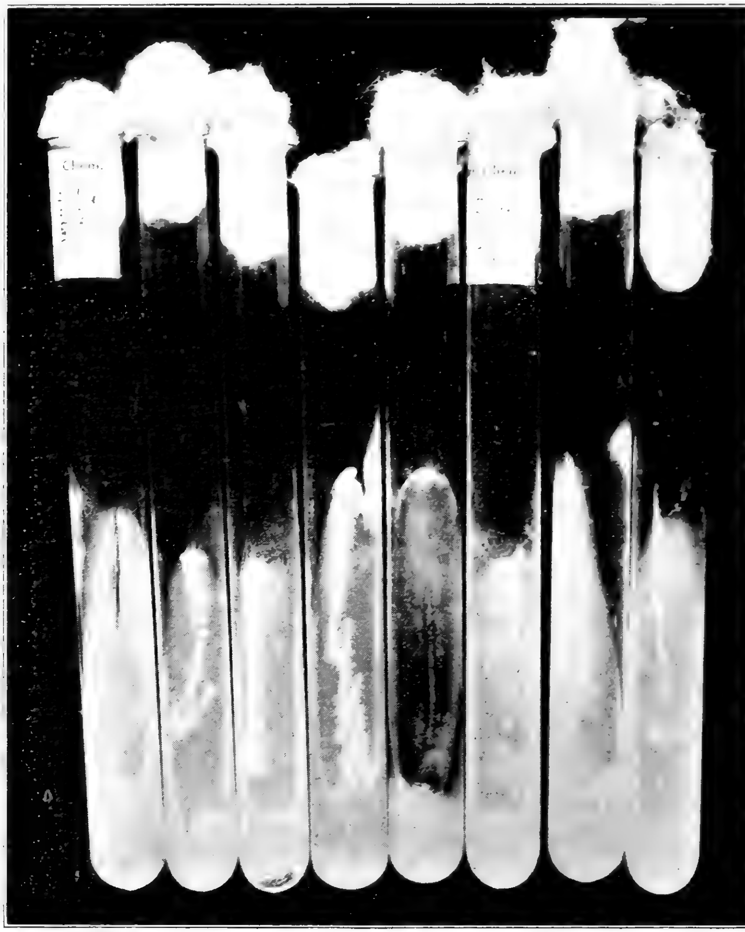


PLATE XI.

At left: 4 organisms from L. and B. agar to L. and B. agar.
At right: 4 organisms from Na. asp. agar to L. & B. agar.

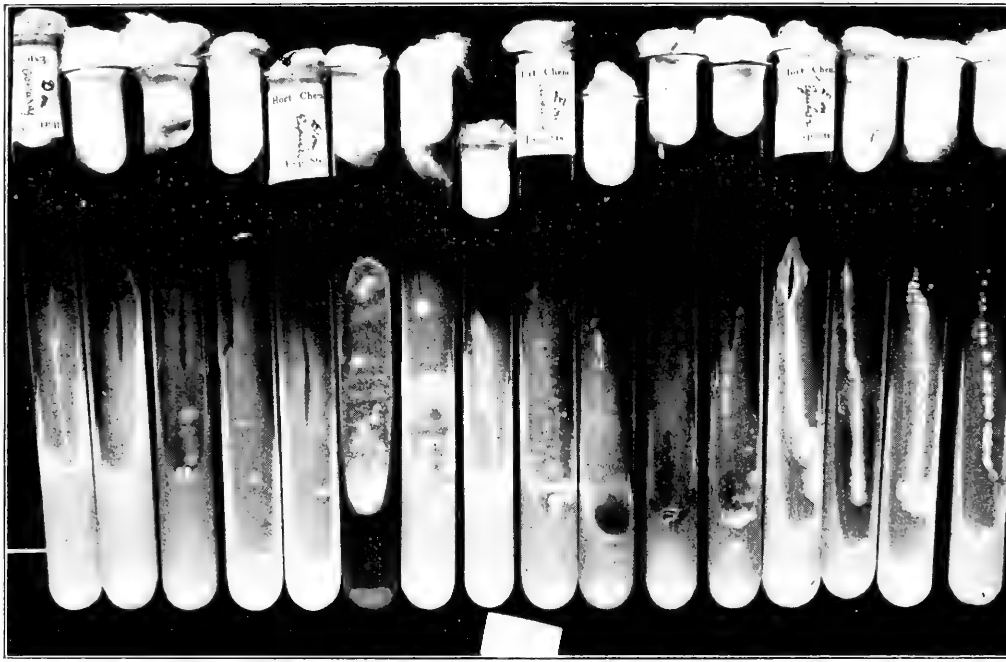


PLATE XII.
Extreme left: 4 organisms from agar alone on Na. asp. agar.
Left center: 4 organisms from agar alone on L. and B. agar.
Right center: 4 organisms from Na. asp. agar on Na. asp. agar.
Extreme right: 4 organisms from Na. asp. agar on L. & B. agar.

Some Methods for the Study of Plastids in Higher Plants.

D. M. Mottier.

The following methods have been found to be satisfactory in the study of the primordia of chloroplasts, leucoplasts, and other apparently similar bodies in cells of liverworts and higher plants that are known under the name of chondriosmes.

Fixing.

Chrom-osmic acid is the fixing agent chiefly used, and in the following proportions:

Chromic acid, 1 %	17 cc.
Osmic acid, 2 %	3 cc.
Glacial acetic acid	3 drops

The specimens remain in this fluid from 36 to 48 hours, after which they are washed 12 to 24 hours in flowing water, or in several changes of water if flowing water is not available.

After careful dehydration the specimens are brought into paraffin, using chloroform as the solvent. Sections from 3 to 5 microns in thickness are cut, depending upon the nature of the tissue under consideration, and stained in the well-known iron-alum-haematoxylin stain. As a counter stain orange G dissolved in clove oil is sometimes very desirable.

Procedure with the Iron-Haematoxylin.

After the preparations have been freed from paraffin and from the solvent used in removing the paraffin (turpentine or xylol) by means of absolute alcohol, they are allowed to stand in the mordant from two hours to over night. As a mordant a 3 per cent. aqueous solution of the double iron salt is used (ferric ammonium sulphate $(NH_4)_2\ Fe_2(SO_4)_4 \cdot 24\ H_2O$. The preparations are now poured off with water and stained over night in a $\frac{1}{2}$ per cent. aqueous solution of haematoxylin. From the stain they are again poured off with water and destained with the above iron salt. The destaining is watched under the microscope. After the desired stain has been reached, and this is determined by trial, the preparations are washed for about 15 minutes in gently flowing water. They are now dehydrated by treating with absolute alcohol, after which they may be counter stained with clove oil orange G or merely cleared in clove oil and cedar oil and mounted in balsam.

In case counter staining is desired, the process should be watched in order to avoid over-staining with the orange. In some cases the clove oil orange G need remain on the sections but half a minute. This stain may be removed by xylol, cedar oil, or pure clove oil, when the preparation is ready to be mounted in balsam.

By this method the primordia of chloroplasts and leucoplasts and other similar bodies are stained black or a blue-black.

The foregoing is much simpler than Benda's procedure, and it gives results that are as satisfactory. However, since it is desirable in cytological studies to check up one method with another, the procedure devised by Benda is recommended, although it is more tedious and time-consuming. The following modification of Benda's method has been used with excellent results:

1. Fix in chrom-osmic acid of the above-mentioned composition 24 to 48 hours.
2. Wash in water 1 to 2 hours.
3. Treat objects with equal parts pyroligneous acid (rectified) and 1 per cent. chromic acid 24 hours.
4. Treat with 2 per cent. solution bichromate of potassium 24 hours.
5. Wash in water 24 hours.
6. Bring into paraffin and section in case sections are to be made.
7. Treat with the iron mordant 12 to 24 hours.
8. Pour off with water and treat 10 to 20 minutes with alizarin.
9. Pour off with water and let dry in the air.
10. Stain now with Benda's crystal violet by warming gently to the point of forming vapor. Allow the preparation to cool for 5 to 10 minutes, after which pour off with water and let the preparation dry in air, standing the slide on end.
11. Destain with 5 per cent. acetic acid under microscopic control. This requires from a few seconds to a minute.
12. When the desired stain is reached, pour off with water, dehydrate with absolute alcohol, and counter stain, if desirable, with clove oil orange G. This stain is now removed with xylol or cedar oil, and the preparation is mounted in balsam.

As a result, the chloroplasts, chondrisomes, etc., are stained a deep blue, the cytoplasm a light orange or almost colorless, and the cell walls varying intensities of orange.

The writer has never been able to see the use of the treatment with alizarin, and this part of the process may be omitted. However, Benda's solution of alizarin is made as follows: Make a saturated solution of Kahlbaum's alizarin-sulfo-saurem Natron (mono.) in 70 per cent. alcohol. One cc. of this solution is added to 80 to 100 cc. of water.

Benda's crystal violet solution is made as follows:

Saturated solution crystal violet in 70% alcohol	1 part.
1% hydrochloric acid in 70% alcohol	1 part.
Anilin water	2 parts.

The Morphology of Riccia Fluitans L.

Fred Donaghy.

Since 1835 the Riccias have received more or less attention by the botanists. Bischoff, Lindenburg, Hoffmeister, Leibgeb, Garber, Lewis, Campbell, Black and Atwell, have in turn made many valuable contributions to our knowledge of this group. Still many problems of morphology and ecology confronts us. Several species common to Indiana remain almost unstudied as to detail. Among these none seem more interesting than the study of *R. fluitans*.

This species is widely distributed over the temperate zone and over glaciated Indiana. Botanists recognize two forms, an aquatic and a terrestrial type. The aquatic form is very abundant around Angola, Fort Wayne, Logansport and Terre Haute. During the summer and autumn mats of aquatic *R. fluitans* can be found floating in the ponds and sluggish streams. In winter these mats sink to the bottom of the ponds and remain there till spring. The continued cold does not seem to injure the plants which lie below the ice, but those plants which are frozen in the ice are much winter-killed, the apical ends alone remaining green. During the warm spring these plants make rapid growth, and by summer patches of thalli again dot the ponds and streams, showing that under favorable weather conditions the thalli reproduce vegetatively very rapidly.

Aquatic *R. fluitans* is sterile, branches dichotomously, the sprouts diverging widely, and often become recurved. The apical ends are deeply notched, and truncate. Both dorsal and ventral surfaces bear chlorophyll. Rhizoids and ventral scales are absent.

When evaporation is excessive and the ponds are low, the narrow thalli widen at their apical ends somewhat, and lose some of their characteristic color. This is especially noticeable in those plants which grew in unshaded ponds. The thalli which grew in ponds bordered by forest trees did not show a marked change in width and color, due no doubt to the protection afforded by the overhanging boughs and leaves. When single thalli are washed ashore they generally die. More often, mats of plants are washed upon the wet edges of the ponds. In favored places the thalli coming in contact with the wet soil develop rhizoids, ventral scales, and open air chambers, while those whose apical ends do not touch the soil dry and soon die, giving some shade to the delicate plants below. My observations have not been conducted over a sufficient period of time to determine fully whether these plants produce sex organs and fruit as some observers would have us think actually occurred. In the Deming ponds east of the city limits of Terre Haute aquatic *R. fluitans* grows abundantly. During the summer and autumn of 1913 these loess encircled ponds became dry due to the long continued drought; however, many thalli remained alive in wet shaded places throughout the dry season. These plants remained in contact with the earth sufficiently long to fruit, judging from experiments made upon other Riccia, however, no sporophytes were found. When weather conditions were more favorable for hepatic growth searches were made for rosettes and thalli typical of terrestrial *R. fluitans* but none were found, indicating that spores had not been produced or had not had time to germinate. Weather conditions of 1914 were similar to those of the fall of 1913. At intervals during the autumn frequent observations were made but yielded no satisfactory evidence. Again in 1915 careful searching was done, without gaining additional results. Similar observations were made at Rosedale in the "Niggar Lake" region, no rosettes or thalli on the mud were found. Judging from these observations it seems very doubtful if the aquatic form ever changes into the terrestrial form or fruits but reproduces vegetatively only. It is very doubtful if the so-called terrestrial *R. fluitans* and the aquatic *R. fluitans* belong to the same species.

The terrestrial *R. fluitans* is not common in this region; however, it occurs in small patches on mud flats and wet fields during the autumn. It generally grows in rosettes due to the fact that the spores are not scattered but held within the archeground pit, and that the sporophyte is generally buried in the mud. The thalli are about one-quarter inch long and less than an eighth of an inch wide. The plants have a characteristic green which is tinged with purple late in the autumn. Numerous rhizoids develop from the ventral side. A single row of scale leaves which split into two rows grow just beneath the apical cell. The most prominent ventral mark of identification is the protruding sporophyte. The dorsal surface is cut by a furrow which deepens at the apical end into which the pores of the alternating sex organs open, and down which the sperms are carried by moisture. Above the fertilized egg develops a tongue-like projection which covers the mouth of the archegonial pore, much the same as a similar structure does in Pellia. Stoma each being surrounded by four cells open into deep air chambers.

The thallus develops from one or more apical cells as do other Riccias described. This is a large triangular cell in longitudinal section, situated at the forward end of the growing thallus. The thallus is only three or four cells thick beneath the dorsal furrow. In section air chambers appear very large and numerous. They develop probably in three ways: (1) by internal splitting; (2) by the parting of cell rows for long distances; and (3) by the process so well described by Leibgeb for the hepatics.

The sex organs develop in general in the same way as described for other liverworts. The mature archegonium consists of two base cells, ventral and neck cells, four cover cells, four neck canal cells, ventral canal cell and an egg. The funnel-shaped mouth of a mature archegonium opens often just below the pore of a mature antheridium or recurves away from the growing point. This is a fine adaptation to catch the sperm as they come from the antheridium.

The antheridium consists of a stalk, a sterile coat of tabular cells, and a mass of deeply staining cubical cells. It never protrudes above the surface of the thallus but lies buried deeply in the thalloid tissue.

The sporophyte develops rapidly. In its early stages it is oval but as it matures it becomes spheroid. The sporogenous tissue round off and tetrads are produced in the usual manner. The mature spore varies much in size, being 75-90 microns wide. Its outer surface is deeply areolate, the other faces being less areolate. Three distinct walls can be seen in cross-section, an inner wall that does not stain well, a middle deeply-staining wall, and an outer which seems to separate readily. The nucleus containing a distinct nucleolus is small. Starch and oil are stored throughout cytoplasm.

Conclusions.

Botanists recognize two distinct forms of *R. fluitans*, a terrestrial and an aquatic form. It seems very doubtful if the aquatic ever changes into the terrestrial and fruits as observers have portrayed, but always reproduces vegetatively.

The thallus, sex organs, and sporophytes develop in general as described for other liverworts. The spores remain within the archegonial pit, are not generally scattered by the elements, and vary much in size.

Plants Not Hitherto Reported from Indiana. VI.

C. C. Deam.

The following plants have not been recognized as members of the Indiana flora. Specimens of the species reported are in the writer's herbarium. The species in Rubus and Viola were determined by Ezra Brainard. The Parthenocissus and Vitis were determined by C. S. Sargent. The Gramineae were determined by Agnes Chase. The determination of the remaining species was checked by the Gray Herbarium. The species in Rubus and Viola have been made possible by the breaking up of aggregates and the recognition of hybrids.

Paspalum pubescens Muhl.

Martin county, July 11, 1915. No. 17,161. In a woods pasture about three miles north of Shoals near Cedar Bluffs along White River. In Sullivan county, August 25, 1915. No. 18,229. On the border of a woods road in a beech woods about three miles northeast of Grayville.

Sorbus Aucuparia L.

Laporte county, May 2, 1911. No. 7,992. In a sandy black oak woods about three miles north of Laporte. This tree upon my authority was reported by J. A. Nieuwland in the Midland Naturalist, Vol. 4, 175, 1915, as *Sorbus americana Marsh.*

Prunus Mahaleb L.

Jefferson county, September 9, 1915. No. 18,862. In a woods pasture along Thrifty Creek about one mile above Clifty Falls. Martin county, August 31, 1915. No. 18,403. Several trees about four inches in diameter along the roadside about half a mile north of Loogootee. Ripley county, June 18, 1915. No. 16,129. A tree six inches in diameter on the rocky wooded slope of Laugherty Creek just east of Versailles.

Rubus allegheniensis Porter.

Allen county, June 3, 1906. No. 1,051. Wooded bank of the St. Joe River near Robison Park. Fountain county, June 4, 1905. In a woods just west of Veedersburg. Lagrange county, June 6, 1915. No. 15,946.

In sandy soil along the road on the east side of Pretty Lake. Steuben county, June 12, 1904. In a woods near Clear Lake. Wells county, May 21, 1903. Along a rail fence about two miles east of Bluffton.

Rubus allegheniensis x argutus.

Lagrange county, June 6, 1915. No. 15,883. On the low border of a marsh which is just south of Twin Lakes which are about two miles northwest of Howe.

Rubus argutus Link.

Clarke county, July 30, 1909. In a fallow field on the Forest Reserve. Decatur county, May 26, 1912. No. 10,777. Wooded slope along Flat Rock River about a half mile north of St. Paul. Dubois county, July 6, 1912. No. 11,621. Roadside bordering a woods a half mile north of Birdseye. Greene county, May 26, 1911. No. 10,711. In an open woods one mile southeast of Bushrod. Harrison county, June 24, 1915. No. 16,365. In a sandy woods about three miles east of Elizabeth. Marion county, May 30. 1913. No. 8,513. Along the C. H. & D. Railroad near Irvington. Monroe county, July 17, 1915. No. 17,471. Roadside five miles south of Bloomington. Perry county, July 4, 1912. No. 11,501. Along a rail fence about six miles west of Derby. Pike county, July 7, 1915. No. 16,967. In a beech woods one mile east of Union. Posey county, May 23, 1911. No. 8,277. Roadside bordering a woods three miles west of Hovey Lake. Ripley county, June 19, 1915. No. 16,136. In a beech and sugar maple woods two miles northwest of Cross Plains. Shelby county, June 29, 1912. No. 11,337. Taken by Mrs. Chas. C. Deam in a woods southwest of Morristown. Spencer county, June 28, 1915. No. 16,588. Roadside one mile south of St. Meinard. Wells county, July 26, 1914. No. 14,468. In a beech woods eleven miles northeast of Bluffton.

Rubus argutus x invisus.

Hendricks county, June 1, 1912. No. 10,825. Taken by Mrs. Chas. Cf Deam on the flood plain bank of Little Walnut Creek about two and a hal. miles south of North Salem.

Rubus argutus x procumbens.

Decatur county, July 15, 1911. No. 9,210. Wooded bank of Flat Rock River about a half mile north of St. Paul.

Rubus invisus Bailey.

Brown county, June 16, 1912. No. 11,144. Along the road between Helmsburg and Nashville about one mile from Helmsburg. Clarke county, July 30, 1909. No. 5,418A. In a fallow field on the Forest Reserve.

Rubus procumbens Muhl.

Allen county, June 3, 1906. No. 994. In a sandy clearing about two miles south of Fort Wayne. Greene county, May 26, 1911. Frequent in fields and along the railroad near Bushrod. Perry county, July 4, 1912. No. 11,499. Roadside about six miles west of Derby. Ripley county, May 19, 1912. No. 10,611. Common in fields south of Morris. Steuben county, May 28, 1905. In a low thicket on the east side of Clear Lake.

Rubus recurvans Blanchard.

Elkhart county, June 4, 1912. No. 10,935. In an open woods two miles northwest of Middlebury. Lagrange county, June 5, 1915. No. 15,981. In a dry sandy clearing along Pigeon River about ten miles northeast of Lagrange. Whitley county, July 19, 1914. No. 14,426. On the wooded bank of the south side of Round Lake.

Stylosanthes biflora var. hispidissima (Michx.) Pollard & Ball.

Knox county, July 8, 1915. No. 17,068. In the Knox sand along the railroad about three miles south of Vincennes.

Tragia macrocarpa Willd.

Crawford county, September 4, 1915. No. 18,583. Roadside at the base of the Ohio River Bluffs a quarter of mile west of Leavenworth. Orange county, July 14, 1915. No. 17,387. Rocky bluff along Lick Creek about two miles west of Paoli. This species was noted in other Ohio River counties but no specimens were taken.

Euphorbia Peplus L.

Wells county, August 5, 1915. No. 17,913. Abundant in the side ditch and in the yard of E. Y. Sturgis at the north end of Johnson street in Bluffton. It has been established here several years.

Vitis cinerea Engelm.

Bartholomew county, September 15, 1912. No. 12,412. On the wooded border of a gravel pit three miles north of Columbus. Gibson county, September 4, 1911. No. 9,945. Wooded bank of White River about five miles northwest of Patoka. Johnson county, September 15, 1915. No. 19,081. Dry sandy bank along the roadside three miles north of Edinburg. Marion county, September 5, 1911. No. 10,058. Wooded bank of White River near Buzzard's Roost. Scott county, June 22, 1915. No. 16,303. In a clearing one mile south of Scottsburg. Shelby county, July 14, 1912. No. 11,666. Taken by Mrs. Chas. C. Deam along Brandywine Creek one mile east of Fairland. Vermillion county, September 29, 1912. No. 12,469. In an open woods two miles west of Hillsdale. Also along the Wabash River two miles south of Hillsdale.

Parthenocissus vitacea Hitch.

Blackford county, July 9, 1910. No. 7,032. Along a fence two miles northeast of Hartford City. Miami county, July 23, 1915. No. 17,903. Limestone ledge of the Mississinewa River about five miles southeast of Peru. Porter county, August 22, 1915. No. 18,043. On top of a wooded dune bordering Lake Michigan at a point five miles north of Chesterton. Steuben county, July 5, 1914. No. 14,384. On a roadside fence about two miles northwest of Pleasant Lake. Tippecanoe county, July 22, 1915. No. 17,742. Roadside fence seven miles north of Battle Ground. Wayne county, July 3, 1913. No. 13,548. In a woods one and a half miles west of Centerville. Wells county, June 24, 1906. No. 1,127. On a rail fence forty rods east of Bluffton.

Viola affinis LeConte.

Allen county, May 2, 1915. No. 15,569. In a sandy clearing on the Godfrey Reserve about three miles south of Fort Wayne. Grant county, May 22, 1915. No. 15,760. Low border of a lake about five miles northeast of Fairmount. Lagrange county, May 17, 1915. No. 15,641. In a tamarack swamp three miles east of Howe. Noble county, May 17, 1915. No. 15,673. In a wooded swamp about one mile southwest of Rome City. Wells county, May 12, 1915. No. 15,633. In sphagnum on the south side of the lake in Jackson Township.

Viola affinis x triloba.

Clarke county, May 25, 1910. No. 6,460. In a woods just west of Tract thirty-three on the Forest Reserve.

Viola cucullata x sororia.

Lagrange county, June 5, 1915. No. 15,998. Growing in sphagnum in a low woods bordering Pigeon River about four miles east of Mongo. My numbers 15,881, 15,915, 15,993 and 16,002 are the same species and taken in different parts of the same county.

Viola incognita var. Forbesii Brainard.

Allen county, May 9, 1915. No. 15,606. In an old tamarack swamp on the south side of Lake Everett about ten miles northwest of Fort Wayne. Lagrange county, May 17, 1915. No. 15,650. In a tamarack swamp about three miles east of Howe. Wells county, May 12, 1915. No. 15,619. In the low border of the small lake in Jackson Township associated with *Acer saccharinum* and *Populus tremuloides.*

Viola nephrophylla Greene.

Grant county, May 22, 1915. No. 15,745. In a boggy creek bottom near the bridge over the Mississinewa River about four miles southeast of Gas City. Noble county, May 17, 1915. No. 15,674. In the low marl border of Deep Lake one mile south of Wolf Lake.

Viola papilionacea x triloba Brainard.

Clay county, May 4, 1913. No. 12,613. Frequent along the bank of Croy Creek about one mile east of Harmony.

Viola pedatifida x sororia Brainard.

Wells county, May 12, 1915. No. 15,626. In rather dry soil on the shaded bank of the lake in Jackson Township.

Viola sagittata x triloba Brainard.

Whitley county, May 17, 1915. No. 15,682. In a white oak woods about four miles east of Columbia City.

Viola triloba Schwein.

Clarke county, May 11, 1910. No. 5,882. In a wooded ravine at the base of the "knobs" on the Forest Reserve. Decatur county, May 5, 1912. No. 10,459. Taken by Mrs. Chas. C. Deam on a wooded slope along Flat Rock River about a half mile north of St. Paul. Hancock county, May 14, 1912. No. 10,517. Taken by Mrs. Chas. C. Deam in a wet woods one and a half miles southeast of Juliette. Henry county, May 10, 1911. No. 8,117. In a moist rich woods one mile northeast of Spiceland. Jefferson county, September 9, 1915. No. 18,855. In a woods one mile west of Chelsea. Johnson county, May 8, 1910. No. 5,782. Wooded hillside about three miles south of Franklin. Lagrange county, June 6, 1915. No. 15,865. In a woods on the north side of Cogg Lake about four miles south of Lagrange. Vermillion county, May 8, 1910. No. 5,840. Wooded hillside one mile northwest of Hillsdale. Whitley county, August 23, 1914. No. 14,543. In a white oak woods about four miles east of Columbia City.

Verbena bracteosa Michx. x urticaefolia L.

Lawrence county, July 13, 1915. No. 17,287. In sandy soil along the roadside about a half mile north of Lawrenceport.

Bacopa rotundifolia (Michx.) Wetts.

Orange county, July 14, 1915. No. 17,376. In a pond near the Washington county line along the Paoli and Salem road one and a half miles south of Bromer. Also noted in a pond near the road about three miles south of Orleans. Washington county, September 12, 1915. No. 18,983. In a pool in a pasture field about six miles west of Pekin. Also noted in a pond about four miles west of Salem.

Solidago erecta Pursh.

Clarke county, September 11, 1915. No. 18,946. On a Quercus Prinus Ridge about two miles southwest of Borden. Harrison county, September 6, 1915. No. 18,720. On a Quercus Prinus ridge about a half mile west of Stewart's Landing, which is three miles east of Elizabeth. Washington county, September 12, 1915. No. 19,000. On a Quercus Prinus ridge about ten miles north of Salem, and about one mile south of the Muscatatuck River. In all the locations where this species was noted it was growing in sterile soil, associated with *Solidago bicolor*.

Indiana Fungi—III.

J. M. Van Hook.

The fungi recorded in the following list, were for the most part collected from 1911 to 1914. Two of these years (1913 and 1914) were so dry that the collecting of certain groups of fungi was practically abandoned. The year 1915 was a record one for the growth of all kinds of fungi and large collections were made for future study.

A limited number of fungi already recorded occur herein, as these have been found on new hosts.

Great care has been exercised in determining the host species, a thing too much neglected by collectors in the past.

Most of the species have been collected in Monroe county. Where the name of the county is not given, it is understood that the specimen was found in Monroe county. All collections were made by myself unless otherwise specified.

PHYCOMYCETES.

Albugo bliti (Biv.) O. Kuntze. On living leaves of Amaranthus retroflexus. Common. Monroe county, September, 1915.

Albugo ipomoea-panduratae (Schw.) Swingle. On leaves and stems of Ipomoea hederacea. Monroe county, August 2, 1915.

Chaetocladium jonesii Fresenius. Parasitic on Mucor in culture, in the greenhouse. December 28, 1912. C. E. O'Neal.

Piptocephalis freseniana De Bary. On Mucor. Greenhouse, December 28, 1912. O'Neal.

Phycomyces nitens (Ag.) Kze. On horse dung brought into greenhouse, January 7, 1913. O'Neal.

Plasmopara viticola (B. & C.) Berl. & DeToni. On leaves of Vitis cordifolia. July, 1915. Very destructive.

Thamnidium elegans Link. On dung in greenhouse, December 22, 1912.

BASIDIOMYCETES.

Ustilagineae.

Ustilago neglecta (Niessl.) Rab. On Chaetochloa. Montgomery county, 1913. Flora Anderson.

Ustilago rabenhorstiana (Kuehn.) Hedw. On Syntherisma sanguinale. Montgomery county, 1913. Anderson.

Tilletiineae.

Entyloma lobeliae. Farlow. On living leaves of Lobelia inflata. October 16, 1915. Forms discolored (light yellow) spots on the upper surface of the leaves.

Urocystis anemones (Pers.) Wint. On Hepatica acutiloba. Brown county. May 16, 1915. Donaghy. University Farm, Lawrence county, June, 1915.

Polyporceae.

Spongipellis occidentalis Murr. On dead oak log. Helmsburg, Brown county, May 16, 1915. Donaghy.

Spongipellis unicolor (Schw.) Murr. On Acer, Cascades, fall of 1914. Donaghy.

Agaricaceae.

Crepidotus fulvotomentosus Pk. On decayed log, Brown county, October 24, 1914.

Lycoperdineae.

Bovistella ohiensis Morg. On the ground in an open field. November, 16, 1914. Donaghy.

ASCOMYCETES.

Helvellineae.

Helvella elastica Bull. On the ground. University Water Works, May 19, 1915. Harvey Stork.

Pezizineae.

Pseudopeziza medicaginis (Lib.) Sacc. On alfalfa. Autumn of 1912.

Sarcoscypha occidentalis Schw. On buried sticks. University Water Works, May 19, 1915. Stork.

Hysteriineae.

Hysteriographium gloniopsis Gerard. On dead wood of Acer saccharinum. Huckleberry Hill, November 25, 1910.

Hysteriographium mori (Schw.) Rehm. On rails of Liriodendron tulipifera and Juglans nigra, East campus, October 26, 1915.

Pyrenomycetineae.

perisporiales.

Erysiphe cichoracearum D. C. On living leaves of Plantago rugelii. Vernonia noveboracensis, Ambrosia trifida and Solidago. Summer of 1911. Sutton.

Microsphaera alni (D. C.) Wint. On leaves of Platanus occidentalis. Summer of 1912. Sutton.

Microsphaera elevata Burr. On leaves of Catalpa speciosa. Autumn of 1911. Sutton.

Phyllactinia corylea (Pers.) Karst. On Fraxinus sambucifolia, Ladoga, Montgomery county, September 16, 1913. Anderson.

Sphaerotheca castagnei Lev. On living leaves of Taraxicum officinale, 1911. Sutton.

Uncinula necator (Schw.) Burr. On cultivated grapes. September, 1912.

Uncinula adunca Lev. On leaves of Salix nigra, autumn of 1911. Sutton.

hypocreales.

Gibberella saubinetii (Mont.) Sacc. On wheat, 1911.

sphaeriales.

Hypoxylon annulatum (Schw.) Mont. On Fraxinus americana. January 17, 1914. Ramsey.

Hypoxylon effusum Nitschke. On Fagus ferruginea, March 4, 1909; Quercus, November 20, 1913. Ramsey.

Hypoxylon perforatum (Schw.) Fr. On Juglans nigra. January 17, 1914. Ramsey.

Massaria inquinans (Tode) Fr. On Acer. December 8, 1911.

Rosellinia aquila (Fr.) DeNot. On Acer. March 6, 1902. Mutchler; on Juglans, Unionville, 1911; on Ostrya, November 20, 1913, and on Fagus ferruginea, December 16, 1913. Ramsey.

Rosellinia glandiformis E. & E. On Liriodendron tulipifera, 1907; on Juglans, November 20, 1913; and on Fraxinus, Boone county, January 17, 1914. Ramsey.

Rosellinia ligniaria (Grev.) Nke. On Ostrya virginica, January 28, 1914, J. M. V. & Ramsey; on Fraxinus, Boone county, March 28, 1914. Ramsey.

Rosellinia medullaris (Wallr.) Ces. & DeNot. On Cercis canadensis, February 4, 1911; on Juglans cinerea, 1914. Ramsey.

Rosellinia mutans (Cke. & Pk.) Sacc. On Juglans, 1914. Ramsey.

Rosellinia pulveracea (Ehr.) Fckl. On Carpinus caroliniana and Platanus occidentalis, November 20, 1913; on the same hosts in Boone county, December 18, 1913. Ramsey.

Rosellinia subiculata (Schw.) Sacc. On Liriodendron tulipifera, 1911. On Quercus, 1914, J. M. V. & Ramsey.

Venturia pomi (Fr.) Wint. On leaves and fruit of Pyrus malus, July 19, 1912. Common.

Xylaria corniformis Fr. On rotten Acer. Harrodsburg, August 7, 1915.

FUNGI IMPERFECTI.

Sphaeropsidales.

Ascochyta mali E. & E. On living leaves of Pyrus malus, 1911. Sutton.

Ascochyta rhei E. & E. On living leaves of Rheum rhaponticum. September, 1912.

Cicinobolus cesatii DeBary. Parasitic on Erysiphe cichoracearum on leaves of Rudbeckia or Helianthus. Campus, October 5, 1915.

Darluca filum (Biv.) Cast. Parasitic on Phragmidium potentillae and Uredo biglowii, 1911. Sutton.

Phoma limbalis Passer. On leaf veins of Platanus occidentalis, 1912.

Phyllosticta celtidis Ell. & Kell. On leaves of Celtis occidentalis, October 5, 1915. These leaves were also affected with a leaf mite. Spores of fungus, bacteria-like, 2 to 3 by 1 micron.

Phyllosticta fraxini Ell. & Mart. On leaves of Cornus florida, autumn of 1912. Spores, 4 by 9.5 microns. On leaves of Fraxinus americana, Unionville, October 3, 1914. J. M. V. & Paul Weatherwax.

Phyllosticta grossulariae Sacc. On leaves of Ribes cynosbati, October 3, 1914. J. M. V. & P. W.

Phyllosticta hammamelidis Pk. On living leaves of Hammamelis virginiana, Campus, October 5, 1915. Associated with Pestalozzia funerea Desm. Peck reports Phyllosticta consocia Pk. as being associated with this Pestalozzia and describes the spot as the same and the Phyllosticta as the cause. However, P. consocia is described as having six cells with four middle ones colored and as being 30 to 35 microns long; setae, 22.5 to 27.5 long. Our spores are about 25 microns long with short setae. Spores, five-celled, the three inner being colored. This Phyllosticta is very similar if not identical with P. sphaeropsidea E. & E. (Bull. Torr. Bot. Club. 1883, p. 97.) Reported on Aesculus hippocastanum.

Phyllosticta kalmicola (Schw.) E. & E. On living leaves of Kalmia latifolia, one-half mile northeast of Borden, Clark county, February 20, 1915.

Phyllosticta linderae E. & E. On Lindera benzoin, Brown county, July, 1912.

Phyllosticta sambuci Desm. On leaves of Sambucus canadensis, Campus, October 5, 1915. The pycnidia are described as being very minute. In our specimens, they measure from 90 to 200 microns with spores 4 to 7 by 2 to $2\frac{1}{2}$ microns.

Phyllosticta sambucicola Kalchbr. On the same host as the above and associated with it as was also Cercospora sambucina and a Septoria. The pycnidia are 50 to 90 microns and spores $2\frac{1}{2}$ to 5 microns. The spores are subglobose. Kalchbrenner describes them as being very minute.

Septoria evonymi Rabh. On Evonymus atropurpurius, Campus, October 5, 1915. Our species is undoubtedly identical with the one described by Rabenhorst, though differing somewhat. The following is a description of our fungus: Spots epiphyllous, 3 to 10 microns in diameter or by confluence, covering large areas, irregular in shape, often limited by veins making them angular in outline, olive brown, bounded by a dark purplish line, lighter colored on the lower surface of the leaf; pycnidia 75 to 125 microns in diameter, black, protruding and with a large irregular opening; spores 15 to 30 by 2 to 3 microns, for the most part one-septate, straight, crescent-shaped or irregularly curved.

Septoria helianthi Ell. & Kell. On Helianthus annuus, autumn of 1912.

Septoria lactucae Pass. Common on Lactuca scariola, Harrodsburg, August 7, 1915. Spores filiform, 20 to 35 by $1\frac{1}{2}$ to 2 microns.

Septoria mimuli Wint. On leaves of Mimulus alatus, summer of 1911. Sutton.

Septoria oenothera West. On Oenothera biennis, Harrodsburg, August 7, 1915.

Septoria polygonorum Desm. On Polygonum persicaria, July 29, 1915. This fungus was very common and very destructive to its host throughout the summer. It varies slightly from the description as follows: Spots 2 to 3 mm. in diameter. Leaf fades to yellow, curls, dries on the plant or falls to the ground. Some spores exceed 25 microns in length.

Septoria rubi West. On cultivated raspberries. September, 1912. Also common on blackberries.

Septoria scrophulariae Pk. On Scrophularia nodosa or marylandica. Summer of 1911. Sutton.

Septoria verbascicola B. & C. On Verbascum blattaria, autumn of 1912.

Sphaeropsis asiminae E. & E. On dead twigs of Asimina triloba, Boone county, December, 1913. Ramsey.

Melanconiales.

Cylindrosporium capsellae E. & E. On leaves of Capsella bursa-pastoris, 1911. Sutton.

Cylindrosporium padi Karst. On Prunus serotina, summer of 1911. Sutton.

Gloeosporium caryae Ell. & Dear. Common on leaves of Carya alba, Harrodsburg, August 7, 1915.

Gloeosporium intermedium Sacc., var. poinsettiae Sacc. On dead stems of Poinsettia pulcherrima, greenhouse, March 16, 1915. Plants grown from Florida stock.

Marsonia juglandis (Lib.) Sacc. On leaves of Juglans cinerea, Helmsburg, Brown county, July, 1912; Unionville, Monroe county, October 3, 1914. On leaves of Juglans nigra, Unionville, October 3, 1914. On leaves of Juglans sieboldiana, Campus, October 5, 1915.

Marsonia martini Sacc. & Ell. On leaves of Quercus acuminata, Harrodsburg, July 7, 1915.

Pestalozzia funerea Desm. On leaves of Hammamelis virginiana, Campus, October 5, 1915.

Hyphomycetes.

Cercospora ampelopsidis Pk. On living leaves of Ampelopsis quinquefolia, October 5, 1915. The conidiophores of this fungus measure 30 to 112 by 5 to 6 microns and are 2 to 4 septate; the spores are 25 to 125 by 6 to 8 microns and are 4 to 9 septate. There seems to be no doubt as to the identity of the fungus as the remainder of the description corresponds admirably.

Cercospora bartholomaei Ell. & Kell. On living leaves of Rhus glabra, summer of 1911. Sutton.

Cercospora condensata Ell. & Kell. Summer of 1911. Sutton.

Cercospora elongata Pk. On Dipsacus sylvestris, Harrodsburg. July 7, 1915. Spores attain a length of 275 microns. Peck gives 50 to 150 microns.

Cercospora kellermani Bubak. On leaves of Althaea rosea, October 5, 1915. This species seems too closely related to C. malvarum Sacc. and to C. althaeina Sacc. Conidiophores to 110 microns long and spores from 20 to 152 microns.

Cercospora plantaginis Sacc. On leaves of Plantago rugelii, Campus, October 5, 1915. Very common. Forms brown spots. Conidiophores as much as 250 microns long. Spores, 75 to 175 microns long.

Cercospora rhoina E. & E. On leaves of Rhus glabra, Unionville, October 3, 1914. J. M. V. & P. W.

Cercospora ribis Earle. On cultivated Ribes rubrum, autumn of 1912. Very severe on its host.

Cercospora rosicola Pass. On Rosa carolina, Campus, October 26, 1915. The description of this species gives the measurement of the conidiophores 20 to 40 by 3 to 5 microns and spores, 30 to 50 by 3½ to 5 and 2 to 4-septate. Our conidiophores are 20 to 75 by 4 to 5 and spores 30 to 80 by 5 to 7 microns and are mostly 3-septate. The very dark hemispherical base from which the conidiophores arise, is very characteristic of this species.

Cercospora sambucina Ell. & Kell. On leaves of Sambucus canadensis, Campus, October, 1915.

Cercospora septorioides E. & E. On leaves of Rubus villosus, Harrodsburg, August 7, 1915. This species has many characters which place it near C. rubi Sacc., C. rubicola Thuem. and C. rosicola Pass. The spots are very characteristic and the resemblance of the spores to those of a Septoria is very striking.

Cercospora toxicodendri (Curt.) E. & E. On leaves of Rhus toxicodendron, Harrodsburg, August 7, 1915.

Haplographium apiculatum Pk. On leaves of Hammamelis virginiana, Griffey Creek, October 3, 1914.

Macrosporium catalpae Ell. & Mart. On leaves of Catalpa speciosa, Campus, 1911 and 1912. Common. This fungus seems to follow the injury produced by an insect a very characteristic brown spot.

Macrosporium sarciniaeforme Cav. On Trifolium pratense, Campus, October 6, 1915. The swollen nodes of these conidiophores somewhat resemble those of Polythrincium trifolii so common on clover.

Macrosporium solani Ell. & Mart. Common on Datura stramonium, Griffey Creek and Harrodsburg, July and August, 1915.

Piricularia grisea (Cke.) Sacc. On leaves of Panicum sanguinale, autumn of 1915. Very common every year.

Tubercularia vulgaris (Tode.) Meckl. On twigs of Asimina triloba, Boone county, December, 1913. Ramsey.

(In conforming with the original plan, the following Myxomycetes are here appended, though out of the sphere of fungi.)

MYXOMYCETES.

Arcyria incarnata Pers. On rotten wood, Griffey Creek, October 29, 1914. Donaghy.

Diderma crustaceum Pk. On dead leaves, Brown county, October 24, 1914. Donaghy.

Enteridium splendens Morg. On rotten wood, Brown county, October 24, 1914.

Lycogola flavo-fuscum (Ehr.) Rost. On sawed end of maple log, November 16, 1914. Donaghy.

Mucilago spongioa (Leyss.) Morg. On stems of living weeds, November 12, 1914. Donaghy.

Physarum cinereum (Batsch.) Pers. On living grass, Campus, June 4, 1915. Mottier.

Stemonitis caroliniana Macbr. On rotten wood, 1915.

Stemonitis morgani Pk. On rotten wood. Griffey Creek, October 29, 1914. Donaghy. Also on dead maple log, Campus, June 1, 1915. Donaghy.

Stemonitis nigrescens Rex. Greenhouse under bottom of palm tub. Sporangia on the sand. May 20, 1915.

Tilmadoche polycephala (Schw.) Macbr. On bark of fallen elm. Running over moss and bark. Griffey Creek, June 5, 1915.

Indiana University,

January, 1916.

A Second Blooming of Magnolia Soulangiana.

D. M. Mottier.

This note is to call attention to the fact of a second blooming in the same year of a purple variety of Magnolia Soulangiana. On the campus of Indiana University a group of thrifty magnolias is cultivated. Among these there are two varieties of M. Soulangiana, one with pink flowers and the other bearing blossoms of a deep purple color. Last spring at the usual time all trees of the two varieties bloomed profusely and, from a number of the flowers, fruits and seeds were developed. In midsummer (July 25 to August 10) three trees of the purple variety bore each two or three fine large flowers, which were normal in every respect. No flowers were seen on the variety bearing pink blossoms. This is the first time the writer has observed the occurrence of a second crop of blossoms on a magnolia. It has been learned through acquaintances that the purple variety bloomed a second time this year in one of the eastern states.

As the blossoms were removed from the trees by children or by unscrupulous admirers, it was impossible to know whether such flowers would develop fruits.

The Effect of Centrifugal Force on Oscillatoria.

Frank M. Andrews.

Filaments of Oscillatoria were centrifuged in order to ascertain if it were possible to displace the contents to any extent. First I used a force of 1,738 gravities. This force did not change the position of the contents in any respect, although the plants were centrifuged two days and four hours. The growth of the filaments also had not ceased and the movements so characteristic of the plant had not been interrupted. The filaments were not harmed in any way by such centrifugal action as a comparison with control specimens showed.

In a second experiment the filaments were subjected to 4,400 gravities for two hours and later to 5,843 gravities for three hours, but no displacement of the contents was caused.

In a third experiment 13,467 gravities were used transversely on the filaments for one hour with no change in the position of the contents; neither cessation of the growth nor of the usual movements. When Oscillatoria was centrifuged between the slide and cover-glass the filaments were usually broken, yet very short pieces consisting of a few cells often withstood a force of 1,738 gravities. For the use of very high centrifugal forces, as indicated above, it was necessary to place the filaments directly on the bottom of the glass cylinders and centrifuge them transversely as stated above. The filaments were then broken apart into their disk-like cells and observed from the end, but no displacement of the contents could be seen. The amount of resistance of such delicately constructed plants is rather surprising. It is also interesting to note that in all the experiments with centrifugal force on Oscillatoria, the characteristic movements were not stopped or apparently retarded by a force varying from 1,738 gravities to as much as 13,467 gravities. This was shown by specimens of Oscillatoria which were placed directly on the bottom of the glass cylinders on the outside of which was fastened a graduated scale. The machine was stopped in a few seconds and by observation it could be seen that the specimens that had been centrifuged for one hour or more and with any amount of centrifugal force had moved or radiated as far as the control specimens had in the same time. These movements may therefore be carried out under great difficulty and against great resistance, at least of certain kinds such as centrifugal force when applied laterally. In the first experiment on the study of movements when 1,738 gravities were used for one hour, the centrifuged filaments during that time moved or radiated away from the center of the small mass of filaments equally in all directions. Actual measurements showed that the filaments had moved out in the usual way to a distance of 5 mm. The control specimens had also moved 5 mm. during the same time. There was absolutely no difference between the centrifuged specimens and the controls as to the general arrangement or appearance of the filaments which had, in each case, radiated from the very small central mass. In all cases the only requisite was the presence of a very shallow film of water about the specimens.

When the specimens were centrifuged for one hour with a force of 5,000 gravities instead of 1,738 gravities, the amount of movement in both centrifuged and control specimens was exactly the same. Both moved away in a radiating direction from the small central mass 5 mm. during the one hour of experimentation. This shows the amount of movement to be as great, as far as could be determined, in the presence of a force of 5,000 gravities as when 1,738 gravities was used. Longer periods of time than one hour, using 5,000 gravities, were not used, and it has not yet been investigated what effect, if any, this might have on the movements.

In the third experiment, where 13,467 gravities were used, both the centrifuged specimens of Oscillatoria and the controls moved 2 mm. during the half-hour of centrifuging. So far then as experiments have been performed, it has not been found possible to stop, or apparently retard, the amount or kind of movements of Oscillatoria princeps by centrifugal force.

Indiana University.

Some Elementary Notes on Stem Analyses of White Oak.

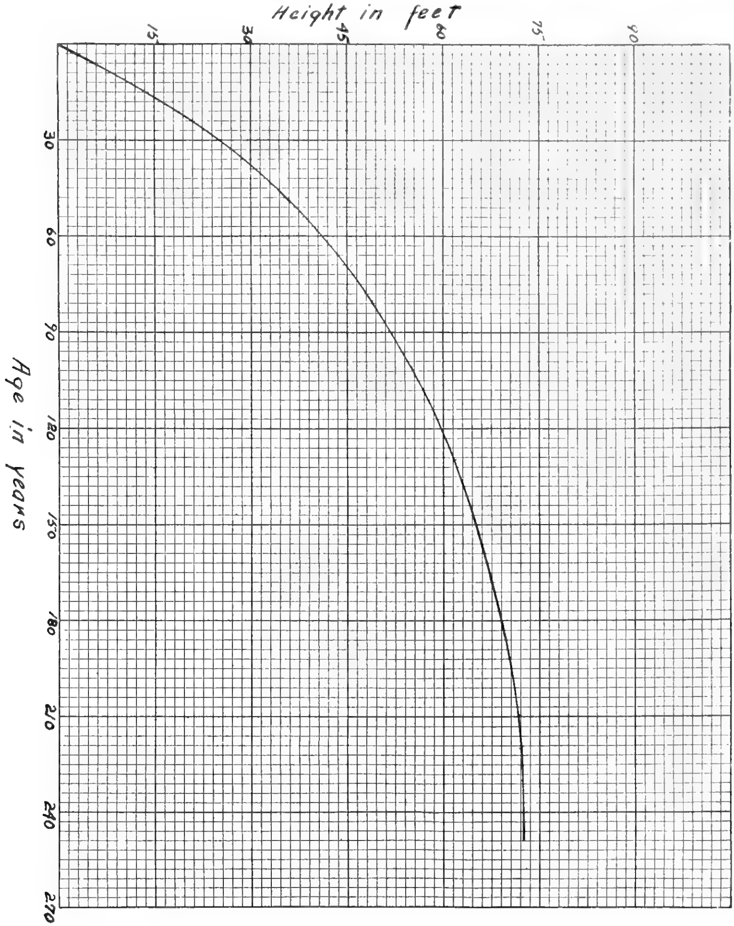
Burr N. Prentice.

In the fall of 1915 I had the opportunity to gather some facts concerning the growth of White Oak (Quercus alba). The opportunity was in the form of a small logging operation which took place in a woodlot of mature White Oak belonging to Mr. George Justice, in Tippecanoe county, Indiana, about seven miles north of Lafayette. The woodlot is located on rolling to flat land only a short distance from the Wabash river. The soil is typical of that region, being a sandy loam underlain with gravel. The cutting was not a large one, only covering about thirty trees, but the majority of the trees were old and fully mature, so that a good idea of the life history and growth of White Oak on similar situations in Indiana could be ganied by a study of their stems.

Complete stem analyses of the trees were taken. These included the following measurements on each bole; the diameter at the stump, together with the distance from the center to each tenth ring, counting from the outside in, and similar measurements at each of the other crosscuts on the tree, thus getting the diameter of each section at any decade throughout the life of the tree. The diameter at breast height, i.e., four and one-half feet from the ground, was taken in each case. The following height measurements were also included; height of stump, length of each section above the stump, length of tip above the last section, and the length and width of crown. Careful record was kept of the number of rings in decades at each section since by these are determined the various periods of growth.

From this data was worked out the mean annual volume growth of the average tree of the stand for the entire period of its life. The method outlined by Mlodjianski, as modified by Graves, was followed. This requires the construction of a height growth table showing the average time required for the trees to grow from the ground to the various crosscuts. The accompanying curve drawn from plotting height in feet against age in years shows how such a table was obtained. This height table is given as a part of table three.

The next step is the determination of the average stump height. By averaging the heights of the stumps of the entire plot, this height was determined as one and one-half feet.



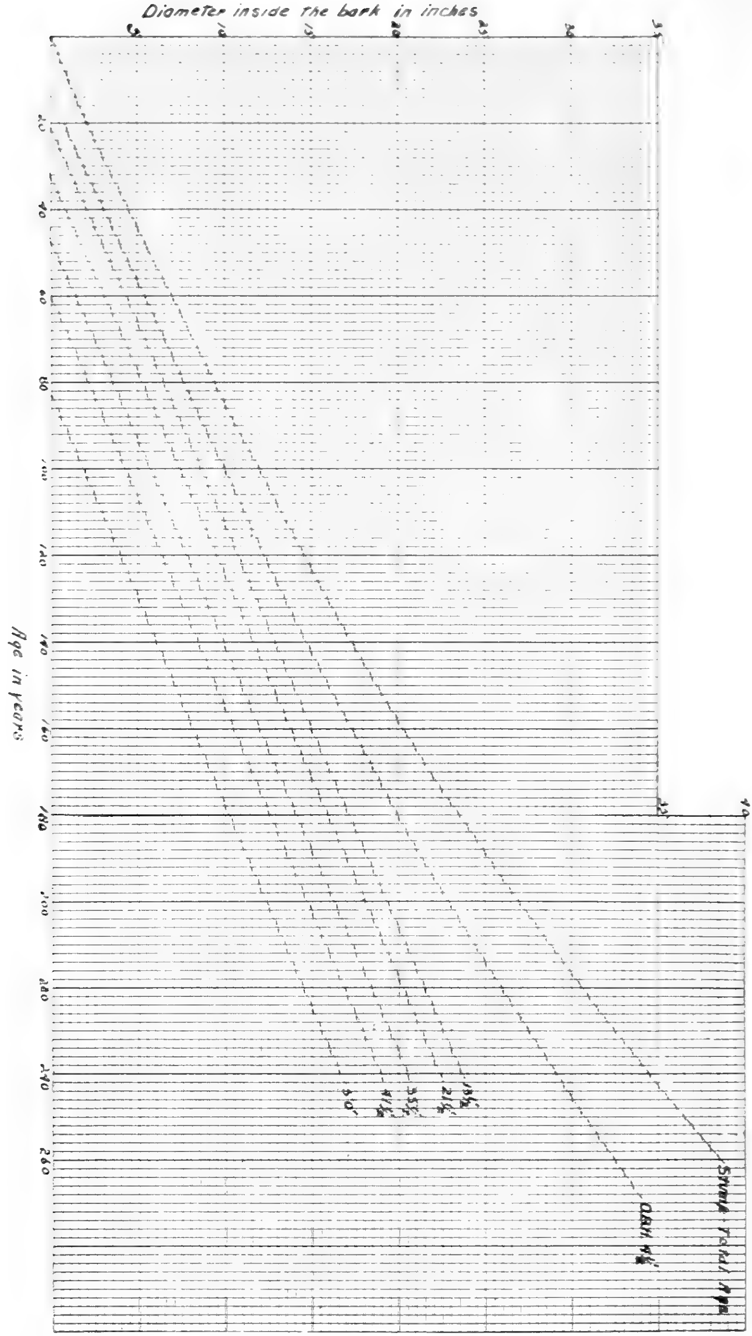
Curve based on age and total height of White Oak (Quercus alba), showing time required to grow to any specified height. Based on measurement of thirty trees.

A curve based on diameter and age at the stump was then drawn, to show the average diameter growth at the stump for each decade. This curve smoothed out any irregularities in growth at the stump for the entire number of trees measured. A similar curve was drawn for each of the other crosscuts above the stump. It has already been noted that the average stump height was one and one-half feet. Therefore the curve for the top of the first twelve-foot log represents the diameter growth at a point thirteen and one-half feet above the ground. The same is, of course, true for the other curves as well.

These curves were then all transferred to one sheet in such a manner that the growth at the respective crosscuts was shown on the basis of total age, i.e., each curve begins as many years to the right of the intersection of the two axes as it took the tree to grow to the height of the crosscut in question. These points are determined from the height growth table.

These curves represent the diameter growth at their respective distances above the ground, on the basis of total age (age at the ground), and not on the basis of the age at the respective crosscuts. We are able to get from this series of curves, for any age, the average total height and the dimensions of the trees inside the bark at various points along the bole.

A diameter breast height curve was also constructed in the following manner. On the same sheet with the stump curve a second curve was drawn, letting the ordinate represent diameter breast height values instead of diameter inside the bark at the stump. Since there were but a small number of trees, all of uniformly large diameter, it was impossible, as yet, to continue this curve into the early age of the trees. But when the curves for the other points on the bole were also transferred thus to a single sheet, the diameter breast height height curve was prolonged by a process of interpolation to the younger ages of the trees.



Series of curves based on age at the ground and diameters at various cross cuts, showing time required for the tree to grow from the ground to any specified diameter at various points up the bole. Based on the measurement of thirty White Oak trees.

From this series of curves Table No. 1 was taken. The cubic contents (Table 2) of the average tree at ten year periods throughout its life, was computed according to the Schiffel formula, which is $(.16B + .66b)h = V$, in which B represents the area of cross section at breast height, b represents the area of cross section at mid-height, h represents the total height of the tree, and V represents the volume.

TABLE I.—Diameters at various points along the bole for every decade throughout the life of the tree; white oak.

Height of Section Above Ground, in Feet.	Age in Years.												
	10	20	30	40	50	60	70	80	90	100	110	120	130
	Diameter inside the bark, in inches.												
(Stump) 1½.......	1.0	2.2	3.3	4.5	5.8	6.9	8.2	9.5	10.7	12.0	13.2	14.5	15.9
D.B.H. 4½.......	....	1.0	2.0	3.2	4.3	5.4	6.5	7.5	8.6	9.8	10.9	12.2	13.4
13½.......	....	....	1.0	2.2	3.4	4.3	5.3	6.5	7.5	8.6	9.8	10.7	11.8
21½.......	....	....	....	.9	2.0	3.0	4.2	5.3	6.3	7.4	8.5	9.6	10.6
35½.......	....	....	....	....	.4	1.4	2.5	3.4	4.6	5.7	6.7	7.8	8.9
41½.......	....	....	....	....	....	....	1.1	2.2	3.3	4.3	5.3	6.4	7.5
50........	....	....	....	....	....	....	....	....	....	1.8	2.8	3.9	5.0

TABLE I—Continued.

Height of Section Above Ground. in Feet.	Age in Years.										
	140	150	160	170	180	190	200	210	220	230	240
	Diameter inside the bark, in inches.										
(Stump) 1½.....	17.4	18.8	20.3	22.0	23.8	25.4	27.2	29.0	30.7	32.7	35.0
D.B.H. 4½.....	14.6	16.0	17.4	18.7	20.2	21.5	23.0	24.5	26.0	27.6	29.3
13½.....	13.0	14.0	15.2	16.3	17.4	18.4	19.4	20.5	21.5	22.6	23.6
21½.....	11.7	12.8	13.9	15.0	16.0	17.1	18.2	19.3	20.3	21.4	22.6
35½.....	10.0	11.0	12.2	13.2	14.2	15.3	16.3	17.4	18.4	19.5	20.5
41½.....	8.5	9.6	10.6	11.6	12.7	13.7	14.8	15.8	16.9	17.9	19.0
50......	6.0	7.2	8.3	9.3	10.3	11.4	12.4	13.4	14.5	15.6	16.6

TABLE II.—Total height and *cubic volume of white oak for each decade of the life of the tree.

Age, Years.	Height, Feet.	Volume, Cu. Ft.	Age, Years.	Height, Feet.	Volume, Cu. Ft.
10	10.0	.003	130	61.6	29.691
20	18.2	.054	140	63.2	36.846
30	25.5	.178	150	65.0	45.330
40	31.8	.668	160	66.5	54.397
50	37.4	1.159	170	67.9	63.962
60	41.8	2.590	180	69.0	75.348
70	45.6	4.332	190	70.0	87.220
80	49.2	6.494	200	71.0	100.678
90	52.1	9.482	210	71.8	115.885
100	54.8	13.481	220	72.4	128.076
110	57.2	20.821	230	72.8	146.037
120	59.4	23.522	240	73.0	156.658

*Volumes computed according to Schiffel: V = (.16B .66b)h, where,
V = Volume.
B = Basal area of cross section at breast height.
b = Area of cross section at middle height.
h = Total height of tree.

TABLE III.—Volume in board feet of Merchantable stem for even decades.

Age, Years.	Volume, B. M.	Age, Years.	Volume, B. M.	Age, Years.	Volume, B. M.
70	10	130	170	190	535
80	15	140	225	200	630
90	40	150	275	210	725
100	65	160	335	220	830
110	100	170	405	230	955
120	140	180	460	240	1,095

It must be remembered that these figures are based on trees growing under an entire absence of management. Proper management should easily materially increase the rate of growth shown here. Even among these trees there were many that were above the average rate here given. A curve drawn for the maximum growth in diameter at the stump showed the following comparison:

Age at Stump.	Average D. I. B.	Maximum D. I. B.	Age at Stump.	Average D. I. B.	Maximum D. I. B.
20	2.5	3.0	140	18.0	21.5
40	5.0	5.8	160	21.0	25.0
60	7.0	8.0	180	24.4	28.8
80	10.0	11.9	200	28.0	32.5
100	12.4	15.0	220	31.4	36.4
120	15.0	18.2	240	35.2	40.6

It will be noticed that there is a difference of approximately 20 per cent. in diameter for any given age, between the average maximum growth and the average growth. Allowing for a proportionate increase throughout the stem, this would give a maximum volume for table three as follows:

Age Years.	Volume B. M. (Maximum).	Age Years.	Volume B. M. (Maximum).	Age Years.	Volume B. M. (Maximum).
70	12	130	205	190	642
80	18	140	270	200	756
90	48	150	330	210	870
100	78	160	402	220	996
110	120	170	486	230	1,146
120	168	180	552	240	1,314

This 20 per cent. increase could hardly be regarded as reliable, however, when applied to later life of the tree. Artificial plantations both at home and abroad show that it is not at all out of proportion with what may be expected during the early life of well managed plantations.

A study of the crowns of this plot showed the average width of crown to be forty feet. This would allow in a fully stocked stand, about forty mature trees to the acre. During the extremely early years of the stand, an acre would bear upwards of one thousand trees. *Mr. Earl Frothingham, Forest Assistant in the Forest Service, shows that from observed plots an acre is able to support seven hundred and twenty-four oak trees to the age of forty-

*Second Growth Hardwoods in Connecticut. Bulletin 96, U. S. Forest Service by Earl H. Frothingham. Forest Assistant.

five. Our analyses show that the trees in the present study did not attain a diameter breast height of six inches until they were seventy years of age. If we allow approximately one-half of the seven hundred and twenty-four, or three hundred and fifty, to remain at the age of seventy, and reduce this number by a series of intermediate acceleration thinnings, to the final forty at the age of one hundred and fifty, we get the following result:

Number Trees Per Acre.	Age, Years.	Number Feet B. M.
350	70	3,500
	80	5,250
	90	14,000
	Thinning.	
175	100	11,375
	110	17,500
	120	24,500
	Thinning.	
85	130	14,450
	140	19,125
	150	23,375
	Thinning.	
40	160	13,400
	170	16,200
	180	18,400
	190	21,400
	200	25,200
	210	29,000
	220	33,200
	230	38,200
	240	43,800

While the problem of reforestation with oak is somewhat more difficult than that connected with coniferous plantations, nevertheless these figures look interesting, to say the least. It is true that there is little material that is actually merchantable that can be looked for under one hundred years. There are many poor plots of land, however, on nearly every farm in Indiana which at present detract from the value of the whole property. If these plots were planted with even so slow growing a tree as the white oak the result would be an increase in the value of the entire property many years before the trees themselves actually attained merchantable size.

Analysis of Water Containing Aluminum Salts and Free Sulphuric Acid from an Indiana Coal Mine.

S. D. Conner.

Within the past year the writer was called upon to test some drainage water from a coal mine for the Vandalia Coal Company of Terre Haute with a view of determining whether such water could be used for irrigation purposes.

A qualitative examination indicated only a trace of chlorides and nitrates, but an abundance of sulphates.

The following substances were quantitatively estimated:

$Al_2(SO_4)_3$	.016 per cent.
$CaSO_4$	.141 per cent.
$MgSO_4$	.074 per cent.
Free H_2SO_4	.005 per cent.
Total solids	.42 per cent.

Contrary to expectations, no soluble iron was found, although a slight flocculent precipitate of iron (probably basic ferric sulphate) was noted in the bottom of the bottle, indicating that originally some iron had been in solution.

In the mining of coal more or less iron pyrites (FeS_2) is exposed to the air. This pyrites in the presence of oxygen and moisture is oxidized, forming ferrous sulphate and sulphuric acid. The sulphuric acid coming in contact with clay, shale, etc., would dissolve calcium, magnesium, aluminum and other basic elements which might be present. Upon continued exposure to air the ferrous sulphate ($Fe\ SO_4$) in solution would be oxidized to basic ferric sulphate ($Fe(OH)SO_4$) and precipitated.

Water such as the writer analyzed is acid in reaction, due to the presence of free sulphuric acid and also to the hydrolysis of the aluminum sulphate. Such water would be injurious to vegetation and consequently unfit for irrigation purposes.

The presence of soluble aluminum instead of soluble iron is a condition similar to that found in the acid soil of the Wanatah experiment field in Laporte county (as reported by Abbott, Conner and Smalley in Bul. 170 of the Ind. Exp. Station).

There is little danger of soluble salts of iron being present in well-drained and aerated soils or in irrigation water which has been exposed to the air for any length of time. This is due to the fact that soluble salts of iron readily oxidize and are precipitated on exposure to air. Soluble salts of aluminum are not readily precipitated and there is danger of these being present in injurious amount in acid soils either drained or undrained and in mine waters.

On the Wanatah field it was necessary to apply some form of lime to neutralize the acidity before crops could be grown. It was also found that aluminum nitrate was just as injurious to corn grown in water cultures as was an equivalent amount of nitric acid. It would undoubtedly be necessary to neutralize the acidity of the coal mine water with some form of lime before it could be utilized for irrigation purposes.

Detection of Nickel in Cobalt Salts.

A. R. Middleton and H. L. Miller.

The use of dimethylglyoxime as a reagent for the detection and determination of nickel, discovered by Tschugaev[1] in 1905 and developed by Brunk,[2] has become a general practice. For simplicity of manipulation and freedom from interference this reagent is unrivalled; the brilliant scarlet color and extreme insolubility of the nickel glyoximine renders possible the detection of one part of nickel ion in at least 350,000 parts of water. By a modified method of applying the reagent, which was developed in the course of this investigation, we found it possible to detect one part of nickel ion in more than 4,000,000 parts of water.

For detection of traces of nickel in cobalt salts this reagent, hitherto, has not been very satisfactory. Cobalt combines with dimethylglyoxime to form an extremely soluble compound of brown color. Either because the nickel salt is soluble in this compound, or, as is much more probable, because the cobalt appropriates most of the reagent, no nickel is precipitated by ordinary amounts of reagent from cobalt salt solutions, even though a considerable amount is present. The object of this investigation was to devise a method by which the cobalt ion should be suppressed, thus permitting the reagent to react with nickel only thus avoiding the necessity for large amounts of reagent. Treadwell,[3] following a suggestion of Tschugaev, accomplishes this result by transforming the cobalt salt into a cobaltic ammin by strong ammonia and hydrogen peroxide before adding dimethylglyoxime. We shall show that this method is unsatisfactory and fails when much cobalt is present.

The most striking differences in the chemical behavior of nickel and cobalt are (1) the greater readiness of oxidation to the trivalent condition and (2) the greater stability of the complex ions, both positive and negative, of cobalt. Of the various complex ions formed by cobalt the most stable are the complex cyanides, that of trivalent cobalt being decidedly more stable than that of bivalent cobalt. Nickel forms soluble complex cyanides of a

[1]Ber. *38*. 2520.
[2]Z. angew, Chem., *20*, 3444.
[3]Analyt. Chem., Vol. I. 151. (7te Aufl.)

different type, resembling those of bivalent copper, whereas the cobalt cyanides are analogous to the iron cyanides. In the classic method of Liebig[4] for detecting nickel in cobalt salts, the inferior stability of nickelocyanide ion together with the ready oxidizability of cobaltocyanide to cobalticyanide ion has long been used to effect a separation. For a solution containing cobalticyanide, nickelocyanide and cyanide ions the following equilibria are involved:

$$[Co^{\cdot\cdot\cdot}] \times [CN']^6 = K \text{ inst.} \times [Co(CN)_6^{\cdot\cdot\cdot}] \text{ and}$$
$$[Ni^{\cdot\cdot}] \times [CN']^4 = K \text{ inst.} \times [Ni(CN)_4^{\cdot\cdot}].$$

The values of the instability constants are not accurately known, but it is certain that that of cobalticyanide ion is extremely small and that of nickelocyanide ion much larger. Any reduction of the concentration of cyani de ion in the solution must result in decomposition of the nickelocyanide ion and considerable increase of nickel ion concentration while the much more stable cobalticyanide ion is less affected. In Liebig's method as modified by Gauhe,[5] cyanide ion is removed by oxidation with alkaline hypobromite or hypochlorite, the nickelous ion being simultaneously oxidized and precipitated as $Ni(OH)_3$. This method is not altogether satisfactory, first, because, owing to the necessity of adding an excess of the oxidizing agent, cobaltic hydroxide is also precipitated invariably so that the appearance of a brown precipitate is not *per se*, proof of the presence of nickel; second, because the manipulation, particularly the amounts of reagents, requires experience and care.

Nickel glyoximine is decomposed by cyanide ion. Our problem, then, was to remove the cyanide ion so gradually that the cobalticyanide ion should remain practically unaffected. For this purpose we made use of the great stability of complex silver cyanide ions, together with the high insolubility of silver argenticyanide, $Ag\,Ag(CN)_2$, 0.0004 g. per liter[6] at 20°. For argenticyanide ion, $[Ag] \times [CN]^2 = 10^{-21} \times [Ag(CN)_2']$. The comparative insolubility of silver cobalticyanide, $Ag_3Co(CN)_6$, accurate data for which are lacking, should also tend to prevent decomposition of cobalticyanide ion. When dimethylglyoxime is added to very dilute solutions of nickel salts,

[4]Ann., *65*, 244 (1848); *87*, 128 (1853).
[5]Z. analyt. Chem., *5*, 75 (1866).
[6]Bredig, Z. physik. Chem., *46*, 602.

a yellow color at once develops and the red precipitate flocculates after a brief interval. At extreme dilutions where no precipitate forms, a yellow tint is observable. This was suspected to be due to colloidal glyoximine which should be flocculated by another precipitate, in which case, since both silver cyanide and silver cobalticyanide are white, the red nickel glyoximine would be readily detectable and the delicacy of the test increased. The correctness of this view seems to be confirmed by the experimental results detailed below.

Experimental.

Solutions and Reagents. $NiSO_4$ solution, approx. 0.05 molar, from Kahlbaum's "Kobalt-frei" salt, was standardized by electrolysis (0.05008 molar) and by precipitation and weighing as nickel glyoximine (0.0496 molar). The discrepancy is due probably to a trace of iron which was detected, the removal of which appeared unnecessary for our purpose. The more dilute solutions used were prepared from this by accurate dilution.

7) Bodlander, Z. anorg. Chem, 39, 227.

$CoSO_4$, approx. O. 1 molar, was prepared by working up residues from cobaltammin salts. Nickel was removed by dimethylglyoxime according to the method we have developed and the solution as used gave no evidence of nickel by any of the tests applied. Electrolysis showed this solution to be 0.0921 molar. Potassium cyanide, 10 per cent. solution. Dimethylglyoxime, 1 per cent. solution in alcohol. Silver nitrate, 1 per cent. solution.

Sensitiveness of Dimethylglyoxime as a Reagent for Nickel in Presence and in Absence of Cyanide Ion.

Ten cc. of $NiSO_4$ solution of molarity stated in the table below was warmed to about 80° and 1 cc. of the reagent added and a drop or two of dilute ammonia. To the same volume of each $NiSO_4$ solution two or three drops of KCN were added. At these high dilutions no precipitate was formed. The solution was warmed to 80°, 1 cc. of reagent added and then the $AgNO_3$ solution dropwise until a permanent white or pink precipitate formed. The more concentrated solutions gave at once a pink precipitate; the more dilute ones a white precipitate which turned pink on standing. In those solutions which required more than one hour to form a precipitate the exact time required for the pink precipitate to appear was not recorded. The samples were observed after standing 24 hours. From the results tabulated below it is apparent that the test is at least as delicate in the presence as in the absence of cyanide and that the results are obtainable much more quickly from the complex than from the simple ion. In the extreme dilutions of the simple ion the precipitate was frequently a single red crystal very minute and difficult to see.

TABLE I.

Molarity.	Time.		Mg. Ni per cc.	Ratio Ni : H_2O
	$NiSO_4$	$K_2Ni(CN)_4$		
0.0005	Immediate	Immediate	0.02934	1 : 34,000
.00005	1 hour	3 min.	.002934	1 : 340,000
.00001	24 hours	5 min.	.000587	1 : 1,700,000
.000009	24 hours	10 min.	.000528	1 : 1,900,000
.000008	24 hours	20 min.	.000470	1 : 2,130,000
.000007	24 hours	30 min.	.000411	1 : 2,430,000
.000006	24 hours	1 hour	.000352	1 : 2,840,000
.000005	24 hours	24 hours	.000293	1 : 3,400,000
.000004	No ppt.	24 hours	.000235	1 : 4,260,000
.000003	No ppt.	No pink color	.000176	1 : 5,700,000
.000002	No ppt.	No pink color	.000117	

3. Oxidation of Cobaltocyanide Ion to Cobalticyanide Ion.

When KCN is added to a solution of cobalt salt, brown-red $Co(CN)_2$ is first precipitated and then redissolved to a brown solution of $K_4Co(CN)_6$. On heating this soon changes to a pale yellow and the color change is generally assumed in manuals of analysis to indicate the completion of oxidation to cobalticyanide. We at first proceeded upon this assumption, but when the first drops of $AgNO_3$ were added to some of our complex cyanide solutions, soon after the color change took place, the solution darkened and addition of more $AgNO_3$ produced a dark-gray precipitate while solutions which had stood for several hours did not darken and gave a pure white precipitate. When one of the darkened solutions became distinctly opalescent, we suspected that colloidal silver had been formed. This was explainable by the assumption that $AgNO_3$ had been reduced by cobaltocyanide which was still present according to $K_4Co(CN)_6 + AgNO_3 = K_3Co(CN)_6 + Ag + KNO_3$.

By adding $AgNO_3$ to freshly prepared solutions of cobaltocyanide we found that this reaction takes place very slowly in cold but rapidly in hot solutions. When the $AgNO_3$ was added dropwise, the hot solutions first became lighter in color, then gradually turned orange and darkened until a gray precipitate was formed. If the addition of $AgNO_3$ was stopped when the orange tint appeared, no precipitate formed, but the solution darkened on standing and became opalescent, showing that colloidal silver had formed. We found that this phenomenon was regularly reproducible in solutions of cobaltocyanide not less than 0.005 molar. These experiments clearly show that the oxidation of cobaltocyanide is by no means complete when the color change takes place. We next investigated the time required to complete the oxidation, taking the failure to form metallic silver as evidence that the oxidation was essentially complete.

10 cc. of 0.1 molar $CoSO_4$ solution was treated in a casserole with just enough KCN to dissolve the $Co(CN)_2$, the solution heated nearly to boiling and continuously rotated in the casserole for a definite time to promote oxidation. The solution was then diluted to 100 cc. with water at 85° and $AgNO_3$ added dropwise with vigorous stirring. Results are given below.

TABLE II.

Cc. 0.1 molar $CoSO_4$	Time Heated.	Result.
10	2 min	Colloidal Ag.
10	3 min	Orange soln.; gray ppt.
10	4 min	Orange soln.; gray ppt.
10	5 min	No darkening of soln.; ppt. white.

These results show that heating with constant agitation must be continued for some time after the change of color. Presumably the time required increases with the amount of cobalt present.

Detection of Nickel in Cobalt Salts.

We next determined the minimum amount of nickel that could be detected in varying amounts of cobalt by our silver method and, for comparison, by Treadwell's and the modified Liebig.

A. The Silver Method.

Definite volumes of solutions of $NiSO_4$ and $CoSO_4$ of known concentration were measured from burets into a casserole, KCN added until the precipitate just dissolved, and the solution heated and rotated until complete oxidation was effected. The solution was then diluted with water at 85° to 50 cc., 1 cc. of dimethylglyoxime solution added, and then $AgNO_3$ dropwise with vigorous stirring until a permanent precipitate was produced. The time required for the pink color of nickel glyoximine to appear was observed. In cases where the time exceeded one hour, observations were made at the end of 24 hours. The results are given below.

TABLE IV.

In each expt. 10 cc. $CoSO_4$ 0.0921 molar, equivalent to 54.31 mg. Co, was used.

$NiSO_4$		Mg. Ni.	Ratio Ni : Co.	Ratio Ni : H_2O	Results.
Vol.	Conc.molar				
2 cc....	0.0005	0.0587	1 : 925	1 : 852,000	Ppt. pink immediate.
1.5 cc....	0.0005	.0440	1 : 1234	1 : 1,140,000	Ppt. pink 4 min.
1.0 cc....	0.0005	.0293	1 : 1851	1 : 1,707,000	Ppt. pink 6 min.
4.5 cc....	.0001	.0264	1 : 2054	1 : 1,894,000	Ppt. pink 10 min.
4.0 cc....	.0001	.0235	1 : 2314		Ppt. pink 20 min.
3.5 cc....	.0001	.0205	1 : 2644	1 : 2,440,000	Ppt. pink 30 min.
3.0 cc....	.0001	.0176	1 : 3085		Ppt. pink 24 hours.
2.5 cc....	.0001	.0137	1 : 3702	1 : 3,650,000	Ppt. pink 24 hours.

Taking the minimum amount of nickel that could be detected in cobalt in 30 minutes, 0.0205 mg., we observed the effect of larger proportions of cobalt. The procedure and final total volume of solution were the same as in the preceding experiments.

TABLE V.

$CoSO_4$ 0.0921 molar	Mg. Co.	Ratio Ni : Co	Results.
15 cc......................	81.47	1 : 3966	Ppt. pink 30 min.
20 cc......................	108.62	1 : 5288	Ppt. pink 30 min.
25 cc......................	135.78	1 : 6610	Ppt. pink 30 min.
30 cc......................	162.93	1 : 7932	Ppt. pink 30 min.

These results show that the sensitiveness of the test is not impaired by the presence of large amounts of cobalt.

B. The Tschugaev-Treadwell Method.

10 cc. portions of 0.0921 molar $CoSO_4$, equivalent to 54.31 mg. Co., with varying small amounts of $NiSO_4$ were heated with ammonia until a clear solution was obtained, hydrogen peroxide added and the solutions heated till excess of peroxide and ammonia was removed, diluted to 50 cc., 1 cc. of dimethylglyoxime solution added and the time required for the red precipitate to appear was observed. Results below.

TABLE VI.

$NiSO_4$				
Vol.	Conc. molar	Mg. Ni.	Ratio Ni : Co.	Results.
10 cc.	0.0005	0.2934	1 : 185	Red ppt. 1 hour.
9 cc.	0.0005	.2641	1 : 206	Red ppt. 1 hour.
8 cc.	0.0005	.2347	1 : 231	Red ppt. 1 hour.
7 cc.	0.0005	.2052	1 : 264	Red ppt. 24 hours.
6 cc.	0.0005	.1760	1 : 309	Red ppt. 24 hours.
5 cc.	0.0005	.1467	1 : 370	Red ppt. 24 hours.
4 cc.	0.0005	.1172	1 : 462	Red ppt. 24 hours.

Taking the minimum amount of nickel that could be detected in 1 hour, 0.2347 mg., we observed the effect of larger proportions of cobalt. The procedure and final volume were the same as in the experiments recorded In Table VI.

TABLE VII.

$CoSO_4$ 0.0921 molar	Mg. Co	Ratio Ni : CO	Results.
10 cc.	54.31	1 : 231	Red ppt. after 1 hr.
15 cc.	81.47	1 : 346	No ppt. after 1 hr.
20 cc.	108.62	1 : 462	No ppt. after 1 hr.
25 cc.	135.78	1 : 577	No ppt. after 1 hr.
30 cc.	162.93	1 : 693	No ppt. after 1 hr.

These results indicate that this method is not very sensitive and fails when much cobalt is present.

C. The Liebig-Gauhe Method.

10 cc. portions of $CoSO_4$, 0.0921 molar, with varying amounts of $NiSO_4$ were treated with a slight excess of KCN over that required to dissolve the precipitate, and heated and rotated until complete oxidation of the cobalto-cyanide had taken place. They were then diluted to 50 cc. and freshly prepared sodium hypobromite added. After the precipitate had flocculated, it was filtered off, washed, dissolved in dilute HCl, neutralized with ammonia and tested for Ni with dimethylglyoxime. Results below.

TABLE VIII.

$NiSO_4$ 0.0005 molar	Mg. Ni.	Ratio Ni : Co	Ratio Ni : H_2O	Results.
9 cc.	0.2641	1 : 206		Blk. ppt. Ni confirmed
6 cc.	.1760	1 : 309		Blk. ppt. Ni confirmed
4 cc.	.1172	1 : 462		Blk. ppt. Ni confirmed
3 cc.	.0880	1 : 617	1 : 568.000	Blk. ppt. Ni confirmed
2 cc.	.0587	1 : 925	1 : 852.000	Blk. ppt. No Ni
1 cc.	.0293	1 : 1850		Blk. ppt. No Ni
None.	None			Blk. ppt. No Ni

This method is shown to be capable of detecting 0.1 mg. nickel in a volume of 50 cc., but a confirmatory test must in every case be applied as the ppt. contains $Co(OH)_3$.

Comparing the results of the three methods, the minimum amount of nickel detectable within one hour in a volume of 50 cc. is found to be:

Silver .... 0.02 mg.
Tschugaev-Treadwell .... .23 mg.
Liebig-Gauhe .... .09 mg.

These figures do not adequately convey the relative merits of the three methods, for it should be noted in addition that the Liebig method requires a confirmatory test to make the result trustworthy; the Treadwell method failed to show the stated minmum amount of nickel when so little as 231 times as much cobalt as nickel was present, while the silver method appears to retain its full sensitiveness in presence of any amount of cobalt; and that it has been shown to increase the effectiveness of dimethylglyoxime about eight times and to be able to detect within 24 hours less than 0.002 mg. of nickel in a volume of 50 cc.

Summary.

1. A modified method of using dimethylglyoxime for detecting traces of nickel in cobalt salts is proposed which (1) avoids the use of large amounts of the reagent; (2) makes possible the detection of considerably smaller quantities of nickel than has been possible heretofore.

2. The sensitiveness of the test is shown to be unaffected by the presence of cobalt even in large quantities. The proposed method increases the ordinary sensitiveness of dimethylglyoxime about eight times and is capable of detecting about one-fifth the amount of nickel detectable by any of the previously known methods.

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The Different Methods of Estimating Protein in Milk.

George Spitzer.

It is often desirable to estimate the proteids in milk other than the official method. This is especially true in cheese factories where it is desirable to know the percent of casein in milk, since it is the casein in milk that gives it its nutritive value, as far as the proteins are concerned. It is frequently desirable to know the protein content in milk for infant and invalid feeding. With the present method of determining the fat by the Babcock method, which is quite accurate and can be done in all creameries, a rapid method for estimating the percent of casein and fat in milk gives us the necessary data to control the ratio of casein to fat in milk for feeding. Frequently a chemist is requested to determine the fat and casein in human milk where a physician has reason to beleve that there exists an unbalanced ratio of fats and proteids.

There are three methods for rapid estimation of casein or proteids in milk, all of which possess merits worthy of consideration and could be used in a great many laboratories that are equipped with the apparatus necessary to determine the proteids by the official method. Although such equipment is at hand, when only a few determinations are to be made, the methods reviewed in this paper save time and the results obtained are sufficiently accurate. For the volumetric estimations of milk proteids, two standard volumetric solutions are required, besides a few beakers and flasks, apparatus found in any laboratory, or if one wishes to fit up for this purpose only, the expense is quite nominal.

In discussing the different methods, the order in which they are taken up, is no indication of their priority. Since 1892 various attempts have been made in devising a volumetric method for the estimation of casein in milk, but most were unsatisfactory, either owing to the extensive equipment or to the complicated indirect methods used. The main characteristics that a method should possess are: first, it should be accurate; second, it should require only a short time in making an estimation; third, the apparatus should be simple; fourth, materials and apparatus used should be easily obtainable.

L. L. Van Slyke and A. W. Bosworth in 1909 published their volumetric method (Technical Bulletin, N. Y. Ag. Exp. St.). The method worked out in their publication mentioned is briefly as follows: "A given amount of milk, diluted with water, is made neutral to phenolphthalein by the addition of a solution of sodium hydroxide. The casein is then completely precipitated by the addition of standard acetic acid, the volume is then made up to 200 cc. by the addition of distilled water and then filtered. Into 100cc. of the filtrate a standard solution of sodium hydroxide is run until neutral to phenolphthalein. These solutions are so standardized that 1 cc. is equivalent to 1 per cent. casein, when a definite amount of milk is used. Therefore, the number of cubic centimeters of standard acid used, divided by 2 less the amount of standard alkali used in the last titration gives the percentage of casein in the milk."

This method is based on the well known facts in chemistry and shows quite clearly the casein molecule has a constant molecular weight. First, uncombined casein is insoluble in milk serum, water or very dilute acids. Second, it has properties of an acid and combines with alkalies to form definite chemical compounds, neutral to phenolphthalein.

Now, if we know the molecular weight of casein or its equivalent in terms of a standard alkali, we can at once devise a definite method for estimating the casein by titration. Casein exists in milk in a colloidal condition combined with bases, upon addition of an acid sufficient to combine with salts in combination with casein, free casein is formed, insoluble in the serum (it must be remembered that casein and other albuminoids are soluble in excess of acids, the solubility depends on the kind of acid and temperature). There exists a definite relation between the amount of acid required to form free casein and the amount of casein present. It has been found that one gram of free casein neutralizes 8.8378 cc. of $\frac{N}{10}$ sodium hydroxide, or 1 cc. of $\frac{N}{10}$ sodium hydroxide neutralizes .11315 grams of casein. From this data the molecular weight of casein can be calculated.

From the above facts it is easy to determine the quantity of milk required, so that each cc. of $\frac{N}{10}$ acid used shall correspond to percents or fraction of a percent. Since 1 cc. of NaOH neutralizes .11315 grams of casein, it must require an equivalent amount of acid to set free the casein from its original combination in milk. If we wish to know the quantity of milk to be taken so that 1 cc. of acid used to separate the casein from its combinaion shall equal 1 per cent. of casein, we make use of the above equivalent, i.e.

1 cc. $\frac{N}{10}$ acid = .11315 grams casein, or in other words .11315 grams of casein is capable of neutralizing as much alkali as 1 cc. of $\frac{N}{10}$ acid, so if we take 11.315 grams of milk we see from the relation above that every cc. of $\frac{N}{10}$ acid used equals 1 per cent. casein. By using different quantities of milk we need only change the normality of our acid.

If by using 11.315 grams of milk (or 11 cc.) where each cc. of $\frac{N}{10}$ acid corresponds to 1 per cent., by using a greater or larger quantity of milk the normality would have to be correspondingly less or greater. When we use 8.75 cc. or 9 grams of milk the normality would not be $\frac{N}{10}$ but 795 cc. $\frac{N}{10}$ acid plus water to make 1,000 cc. which equals $\frac{N}{12.56+.}$ Upon the above facts the volumetric method of Van Slyke and Bosworth is based.

Procedure in carrying out in detail the volumetric estimation of casein: "A given amount of milk, diluted with water, is made neutral to phenolpthalein by the addition of a solution of sodium hydroxide. The casein is then completely precipitated by the addition of the standardized acetic acid; the volume of the mixture is then made up to 200 cc. by the addition of water, thoroughly shaken and then filtered. Into 100 cc. of the filtrate a standard solution of sodium hydroxide is run until neutral to phenolpthalein. The solutions are so standardized that 1 cc. is equivalent to 1 per cent. of casein when a definite amount of milk is used. The number of cc. standard acid used, divided by two (since only 100 cc. of the 200 cc. is used), less the standard alkali used in the last titration gives the percentage of casein in the milk examined." When 17.5 or 18 grams of milk are used the strength of acetic acid and alkali are made by diluting 795 cc. of $\frac{N}{10}$ to 1,000 cc. The same normality as was derived above. Since only 100 cc. of the 200 cc. were titrated this then represents the acid required to liberate the casein in 8.75 cc. or 9 grams of milk. Likewise by using 22 cc. or 22.6 grams of milk treated as above, then 1 cc. of $\frac{N}{10}$ acid equals 1 per cent of casein. By the use of a factor any convenient quantity can be used. Example, by the use of 20 cc. of milk and $\frac{N}{10}$ solution, adjustment is made by multiplying the final result by 1.0964.

Apparatus and reagents necessary to carry on the volumetric estimation of casein in milk are, first, two 50 cc. burettes, graduated to 1/10 cc. or better 1/20 cc., these must be accurate. One of the burettes should be supplied with a glass stop cock for the acid, and one with a pinch cock for the alkaline solution. Second, flasks, volumetric, holding 200 cc. At least two of these are needed and where a number of estimations are to be made more are required to do rapid work; ten to twelve are necessary for rapid work. The necks of these flasks should have an internal diameter of at least three-fourths of an inch. The reason for this diameter is necessary if the milk is neutralized in the flask. This neutralization can be done in the beaker into which the milk is weighed, if weights are taken. Third, pipettes, a Babcock milk pipette accurately graduated to deliver 17.5 cc. of milk, when 17.5 cc. or 18 grams of milk are used. When 22 cc. or 22.6 grams of milk are used it will be necessary to have a volume pipette graduated to deliver the above amounts or a 25 cc. Mohr pipette graduated into 1/10 cc. will be required. Fourth, one 100 cc. pipette or a volumetric flask graduated to hold 100 cc. Fifth, beakers of convenient sizes holding at least 200 cc. Sixth, if standard solutions are to be made, measuring cylinders or volumetric flasks holding 1,000 cc. are needed.

In regard to the making of the solutions it is best to prepare both the sodium hydroxide and the acetic acid as tenth normal. The accuracy of the succeeding work depends primarily on the correctness of the standard alkali and acetic acid. When it is desirable to make dilutions for different quantities of milk it can be made from the tenth normal stock solution. The *phenolpthalein solution* is prepared by dissolving one gram of phenolpthalein powder in 100 cc. of 50 per cent. alcohol. This should be neutralized by the use of a few drops of $\frac{N}{10}$ NaOH to a very slight pink color.

Carrying out the operation. Weigh out 22.66 grams of milk, or measure out 22 cc., neutralize in the beaker in which the weighing has been made, using only enough alkali to give a very faint pink, then transfer to a 200 cc. flask and wash out beaker with 75 to 80 cc. of distilled water, free from carbon dioxide, shake and warm to 22° to 25° C. At this point observe the color of the diluted milk. Frequently on dilution the pink color becomes quite pronounced; if so, add a few drops of $\frac{N}{10}$ acetic acid to a light pink. Run in from a burette 25 cc. of a $\frac{N}{10}$ acetic acid, frequently shaking, for milk rich in casein it would require 30 to 40 cc. of acid. Then fill up to the 200 cc. mark, insert stopper and shake thoroughly. After standing for 5 or 10 minutes, filter, after filtration pipette or measure 100 cc. of the filtrate into a 250 cc. or 300 cc. beaker and titrate to a permanent faint pink color, record the cc. used. Since 25 cc. were added to the total volume and only one-half titrated, we only take 12.5 cc. into consideration. From what has been said a portion of the 25 cc. $\frac{N}{10}$ acetic acid has been used in forming free casein, therefore the difference between 12.5 cc. and the amount of $\frac{N}{10}$ NaOH used to neutralize the acid in the 100 cc. filtrate equals the number of cc. acid used in liberating the casein. Since a quantity of milk has been taken so that each cc. of acid used equals 1 per cent. casein, then each cc. represents 1 per cent. of casein in the sample of milk. For example, it required 9.4 cc. to neutralize 100 cc. of the filtrate, and since it represented 12.5 cc. of the acid added to the 200 cc. of the diluted milk, we have 12.5-$\frac{N}{10}$ 9.4 = 3.10 per cent. casein.

Below are some of Van Slyke's results obtained by this method in comparison with the official method.

PERCENT CASEIN.

Volumetric Method (Van Slyke-Bosworth).	Official Method.
3.00	3.00
3.40	3.36
3.30	3.21
3.20	3.16
2.90	2.95
2.70	2.60

The second volumetric method which I wish to consider is that of E. B. Hart, of the University of Wisconsin, published in Research Bulletin, No. 10, 1910. For speed and accuracy this method offers no advantage over that of Van Slyke's and Bosworth's, just mentioned. However, the method is unique and sound in principle. The fact that free casein has the properties of an acid and can combine with an alkali in a definite proportion, it seems rational that if we dissolve casein in excess of alkali and the uncombined alkali is estimated by titration, using phenolpthalein as an indicator, we are in a position to calculate the casein equivalent per cc. of standard alkali used. This is true, and upon this principle rests Hart's volumetric method. Hart found the casein equivalent for each 1 cc. $\frac{N}{10}$ KOH to be .108 grams. Therefore, if we titrate the casein obtained from 10.8 grams of milk, we see that each cc. of alkali used must represent 1 per cent. of casein.

Details of the method. Measure 10.5 cc. or weigh 10.8 grams of milk into a 200 cc. Erlenmeyer flask, add 75 cc. of distilled water at room temperature and add to this 1 to 1.5 cc. of a 10 per cent. solution of acetic acid. The flask is given a quick rotary motion, usually 1.5 cc. of acetic acid gives a clear and fast filtering separation, but if the milk is low in casein a little less acetic acid should be used. The separated precipitate is now filtered through a filter (9-11 cm. filter), the flask rinsed out thoroughly and poured on the filter, preferably cold. If a strong stream of water is directed against the filter, the casein washing is facilitated. About 250 to 300 cc. of water should pass through the filter to insure the removal of all traces of acetic acid. The precipitate, together with the filter paper, is now returned to the Erlenmeyer flask in which the precipitation was made. To this is now added 75 cc. of distilled water, *free from carbon dioxide*, and then a few drops of phenolpthalein and 10 cc. of $\frac{N}{10}$ potassium hydroxide. A rubber stopper is placed in the flask and the contents shaken vigorously. Complete solution is easily indicated by the disappearance of the white casein particles. After solution the stopper is rinsed off into the flask with carbon dioxide free water and immediately titrated with $\frac{N}{10}$ acid to the disappearance of the red color. It is necessary that a blank be run parallel with the determination. For example, suppose it required 7.20 cc. of acid to make the pink color just disappear and the blank amounted to .2 cc., the percent of casein would be $10 - 7.4 = 2.60$ per cent. casein. *Precatuions necessary.* First, water free from carbon dioxide, must be used. Second, the titration should be made as soon as solution of casein has taken place. This will be from half an hour to an hour after adding the $\frac{N}{10}$ alkali. Repeated shaking hastens solution.

Results obtained by Hart as compared with the official method.

PERCENT CASEIN.

Official Method.	Volumetric Method (Hart).
3.78	3.75
3.12	3.05
2.87	2.85
1.90	1.85
2.30	2.25
2.37	2.30

The next volumetric method to be considered is the Formol titration method. This is perhaps the most rapid method of the three volumetric methods, for estimating the proteids in milk. It was pointed out in 1900 by Hugo Schiff that when formaldehyde was added to amino acids, the acid properties of the acid were developed and could be titrated as any organic acid.

S. P. L. Sorensen worked out the details and made it possible to estimate amino acids quantitatively by means of formaldehyde. It is well known that amino acids, such as are formed by the hydrolysis of proteins, especially milk proteids, are neutral to phenolpthalein, have both an acidic group, carboxyl and a basic (amino) group. These exist in the same molecule and being the alpha amino acids neutralize each other, or in other words we have an amphoteric molecule, but as soon as formaldehyde is added, it reacts with the alkaline or basic group forming a methylene compound and leaving the acid group free to act.

For example:

$$CH_3 - CH\begin{matrix}/NH_4 \\ \backslash COOH\end{matrix} + HCOH = CH_3 - CH\begin{matrix}/N = CH_4 \\ \backslash COOH\end{matrix} + H_2O$$

(Alanine) (Formaldehyde)

$$CH_3 - CH\begin{matrix}/N = CH_2 \\ \backslash COOH\end{matrix} + KOH = CH_3 - CH\begin{matrix}/N = CH_4 \\ \backslash COOK\end{matrix} + H_2O$$

From Emil Fisher's researches on protein and polypeptids there is no doubt that the protein molecule is conposed of amino acid units. The carboxyl group ($-COOH$) of one amino acid is combined with the amino group ($-NH_4$) of another amino acid, forming peptids, di, tri, etc., to polypeptids. For example, glycyl-glycine composed of two units of gylcine.

$$\begin{matrix}CH_2 - COOH \\ | \\ H_2N\end{matrix} \quad + \quad \begin{matrix}CH_2 - COOH \\ | \\ H - N - H\end{matrix} = \begin{matrix}CH_2\,CO & - & CH_2 - COOH \\ | & & | \\ H_2N & & NH\end{matrix} + H_2O$$

(Glycine) (Glycine) (Glycil-Glycine)

Likewise different units may combine, as example, alanyl-glycyl-tyrosine From which we see that each peptid has one carboxyl group ($-COOH$) acidic and one amino group ($-NH_2$) basic. Now if the protein molecule is built up from amino acids, we can expect it to split up into simpler molecules, by hyroloysis either with an acid or ferment into peptones, etc. Then we would expect the formol number to increase, double, if each protein molecule were split into two simpler ones. This is true, so formol titration gives a measure of the hydrolytic cleavage. We know that the proteids of milk are neutral to indicators, but on the addition of the formaldehyde become decidedly acid to these indicators.

Now if we can determine a factor or equivalent of the acidity produced on the addition of the formaldehyde to milk proteids, we can at once determine the percent of proteids in milk by titrating the acidity with a standard alkali.

In 1912, E. Holl Miller, of England, worked out a method for estimating the proteids in butter, and the same method is used in determining the proteids in milk.

Directions for estimating the proteids in butter. Weigh into a tared beaker exactly 10 grams of butter, which is placed in a water bath at 60° to 70° C. until the butter is completely melted. Twenty-five cc. of carbon dioxide free water is then added at about 60° C. and 1 cc. of phenolpthalein solution. The contents are well agitated. Run in $\frac{N}{20}$ NaOH until a faint permanent pink color is formed. It is found that the end point is masked by the yellow color of butter fat, the contents of the beaker should be allowed to settle and the bottom aqueous layer observed, and the addition of alkali continued until the pink tint is obtained. Five cc. of formaldehyde (40 per cent.) is added. The formaldehyde must either be neutralized before addition or its acidity equivalent for 5 cc. obtained and afterwards deducted. After the formaldehyde has been added the beaker is well shaken and again $\frac{N}{20}$ NaOH run in until a permanent faint pink color is produced in the aqueous layer. The number of cc. $\frac{N}{20}$ alkali used in the second titration less the amount equivalent to the acidity of the formaldehyde. No deduction is necessary if the formaldehyde was neutralized before being added to the butter. Now the number of cc. $\frac{N}{20}$ alkali used to neutralize the acidity produced on the addition of the formaldehyde is proportional to the protein present. One cc. of $\frac{N}{20}$ alkali is equivalent to .01355 grams of protein nitrogen or .0864 grams milk protein, assuming a definite proportion of casein and albumen. Then to calculate the percent of protein we have $\frac{.0864 \times 100 \times cc.}{10}$ = percent protein if 10 grams of butter were taken.

The following table shows the percent protein in butter by the Formol titration and official method:

Official Method.	Formaldehyde.
.65	.59
.48	.47
.46	.42
.48	.50
.60	.68
.45	.42
.42	.40
.41	.41
.49	.52

Procedure to estimate the protein in milk. To estimate the proteids in milk, weigh out 10 or 20 grams, preferably 20 grams, in a tared beaker, about 150 to 200 cc. capacity. Add 1 cc. of phenolpthalein solution, then run in from a burette $\frac{N}{20}$ NaOH until decided pink color is produced, a little practice will enable one to carry the shade of color in mind. Then add 10 cc. of neutralized formaldehyde, stir with a glass rod, when well mixed add $\frac{N}{20}$ NaOH until the same shade of pink is produced as that before the formaldehyde was added (note this last addition of alkali). For example, if 7 cc. of $\frac{N}{20}$ NaOH were required to neutralize the acidity produced on addition of formaldehyde to 20 cc. of milk, then as in the case of butter:

$$\frac{.0864 \times 100 \times 7}{20} = \text{percent protein} = 3.024$$

If we wish to estimate the casein alone and assuming the casein and albumen are in proportion of 3 per cent. casein and .5 per cent. albumen, then by using the equivalent of .075, we have as above:

$$\frac{.075 \times 100 \times 7}{20} = \text{percent casein} = 2.62$$

The following table gives the results of the three volumetric methods compared with the official methods on the same sample of milk:

PERCENT CASEIN.

Official.	Van Slyke-Bosworth.	Hart.	Formol Titration.
2.98	3.05	2.95	2.99
2.96	3.05	2.90	2.98
2.45	2.45	2.40	2.50
2.40	2.40	2.35	2.48
1.79 (d)	1.80	1.80	1.85
1.77 (d)	1.75	1.85	1.83
3.28	3.25	3.18	3.18
3.29	3.20	3.15	3.29
2.46	2.49	2.40	2.46
3.77	3.80	3.65	3.70
2.90	2.90	2.80	2.96
2.47	2.50	2.45	2.48
3.71	3.70	3.70	3.74
2.85	2.85	2.85	3.01
2.80	2.74	2.70	2.76
2.89	2.85	2.90	2.91

Note.—The two samples marked (d) were diluted milk.
Samples were taken on different days from the same source.

The above table shows the relative accuracy of the different methods. For the estimation of casein in milk the choice of the methods mentioned depends on the purpose for which the analysis is made. If total proteids are to be estimated, the Van Slyke-Bosworth and Hart methods must be excluded, unless an assumption is made as to the average amount of albumen in milk. This could be done on the same basis as that for the formol method and which would introduce only a slight error for normal milk and from a mixed herd.

In reviewing these methods and considering speed, and ease of carrying out the work, the formol titration method is to be preferred. In all three volumetric methods it is very essential that the water used for dilution should be free from carbon dioxide. Very little distilled water found in laboratories is free from carbon dioxide. This factor alone may introduce errors to vitiate the results. Titration after the addition of the formaldehyde should be carried to a sharp pink color and remain so for at least five minutes.

George Spitzer.

Purdue University.

New Cave Near Versailles.

Andrew J. Bigney.

It is known as the cave of Dr. Jim Sale of Dillsboro. It is situated one mile northeast of Versailles. It is located near the top of a high hill overlooking Laughery valley. The view from this position is most picturesque. The lover of nature is enchanted by the richness of the scenery. The climb up the hill from the Fallen Timber creek to the mouth of the cave is most exhilarating.

The entrance is guarded by an iron gate. Excavations have been made and walls built, so as to open a passage to the cave proper, thus making it convenient for the visitor. A stream of water had been passing through the cave. Now a pipe carries off the water. About thirty feet from the mouth of the cave is the main room, which is very beautiful because of the numerous pillars, stalactites and stalagmites. The ceiling is high enough for the tallest man to walk in freely, and in some places could not touch the ceiling with outstretched arms. Some of the pillars are four to five feet in height. The ceiling is decorated artistically with stalactites in great numbers and in various sizes, with many corresponding stalagmites. Passing to the right there is a smaller room also covered with typical cave formations. A passage extends about thirty feet beyond in the clay and limestone rocks with only a few stalactites. Extending from the main room is a narrow passage about seventy feet long where there is a spring from which flows a moderate stream in rainy weather. The ceiling and crevices above are likewise decorated with the stalactites. Undoubtedly there must be other rooms, but they have been naturally filled up with dirt and stone. Even outcropping on the side of the hill are large formations of stalactites and stalagmites. It is certainly a very interesting place.

The region round about Versailles has many caves, but this is the only one that has the cave formations. While it is not a large cave like the Marengo and Wyandotte, yet its geological structures are just as typical and interesting as in the larger caves. It is instructive, for it is near the margin of the cave region of southern Indiana and northern Kentucky. Geologically speaking, it is in the lower Silurian or Ordovician formation. It will be instructive for the schools to visit the cave so as to get some accurate information of cave structures. The entire region is most fascinating.

Loess and Sand Dune Deposits in Vigo County, Indiana.

Wm. A. McBeth.

Loess deposits are mentioned in various places as occurring along the bluffs of the lower Wabash river. Dr. J. T. Scovell, who in the twenty-first annual report of the State Geologist has given the most extended and detailed description of the geography and geology of Vigo county yet published,

Looking west along National Road from upland along east side of Wabash Valley.

mentions in a single sentence that "Along the eastern margin of the main valley there are extensive areas of dune sand and at some localities in the eastern bluffs there are thick beds of loess." So far as I have observed slight reference has been made to the distribution, appearance and extent of the loess or loess-like deposits of the lower Wabash valley. The loess is so involved with sandy material that it is difficult to distinguish between the two and interstratified clay. The inclination in examining these materials is to consider them but different phases of the same thing. The interstratified clay does not contain boulders and may be weathered or chemically decomposed loess, while the sandy covering may be due to wind assortment.

Occasional gasteropod shells of very small size are found. The deposits occur in ridges and dunes usually within less than a mile from the crest of

Dune in Highland Lawn Cemetery. North side National Road.
Note ridge beyond building at left and opposite a cross roads at right.

Dunes south of National Road ¼ mile. Looking west from level upland.
The valley is just beyond.

the east bluff and often within a few rods. Sometimes a single continuous ridge of uniform height and width crowns the bluff. In places there are successive ridges two or three and in instances four. In still other places the topography takes the form of dunes, low domes with no characteristic order or grouping. The gradients of the ridges on the leeward or east side if often remarkably steep. The height of the ridges is in a few cases as much as twenty-five feet. In most instances the height is not more than half the figure stated. An interesting observation is that the dunes and ridges extend along the north sides of tributary valleys still keeping a north-south direction in the ridges, which in some places are arranged in etchelon. This is noticed on the north side of Honey creek. The surface on the north side of Otter creek valley appears as one long wave after another, cloaking the bluff front

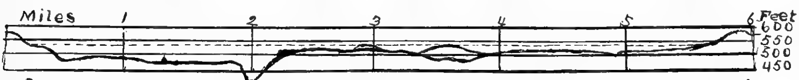
Blake Hill. A sand dune north side National Road.

and crest. This arrangement of ridges along the re-entrant valleys indicates that the valleys were made before the deposits. The direction of the bluffs has evidently influenced the deposition of the material as a section of the river bluffs running directly east-west on the south side of Honey creek shows no dunes or ridges. The deposits also show a marked relation to the terrace area in the valley. Where a broad stretch of terrace lies below the bluffs the ridges and dunes are more strongly developed. Where flood plains approach the bluffs the deposits on the crest and bordering uplands decrease or disappear. Conclusions as to the cause of the deposits and their source seems to be amply justified by the evidence that the deposits are wind blown, the materials, including the shells being collected from the terrace surface from the silts deposited by the valley-wide stream. This deposition probably occurred soon after the stream abandoned the terrace level and withdrew to the present deeper third of the valley width. The work was done mainly before the invasion by vegetation of the terrace, bluff front and upland border, after the retreat of the ice sheet from the region. The loess may be a wind deposit from the bare valley at the close of the Illinoisan ice invasion. This dust may have weathered through a long interglacial period of time to be covered with later deposits of dust and fine sand swept over the valley from the border of the Late Wisconsin ice which did not reach the present site of Terre Haute, but whose strong moraine lies fifteen or twenty miles upstream near Clinton and Rockville.

Volume of the Ancient Wabash River.

Wm. A. McBeth.

The Wabash valley at Terre Haute has a width of five to six miles. One-third this width has a depth of approximately one hundred feet, embracing a flood plain tract through which the river meanders in a channel averaging one thousand feet wide and twenty feet deep. The remaining half is a terrace about half the depth of the deeper part. The whole valley bottom shows the effects of stream deposition, the pre-glacial trench of two hundred to two hundred and fifty feet in depth being half-full of sand and gravel. A point



Generalized profile across Wabash Valley at Terre Haute.

of interest in connection with the stream and valley is the question of volume of water by which various phases of the work was done. The size and weight of pebbles in the gravel indicate a volume and velocity much greater than that of the present stream either in average volume or flood. Some suggestion as to the width and depth of the stream at its stage of greatest flow is furnished by features of the terrace surface consisting of sandbars and delta deposits. This terrace surface is marked with numerous shallow current lines or channels. The bars form ridges of greater length than width, often many times longer. They trend northeast, southwest, the direction of the valley and have the characteristic stratified structure of such features, the layers of finer or coarser sand dipping steeply down stream. Extensive areas of the terrace surface lie at an elevation of four hundred and ninety feet a.t.l. Some places are five feet lower while some of the ridge tops rise to the five hundred and thirty foot level. Low water in the present stream is four hundred and forty-five feet. Points in sections 3, 23 and 24 and a bluff side delta of a brook crossed by Fruitridge avenue at the south edge of Section 24, Town 12 N. Range 9 W., rise to nearly the five hundred thirty foot level. Sandbars and deltas are built under water and the surface of the stream in which these deposits were made must have been a few inches and possibly several feet above the ridge and delta tops when they were completed. The range of elevation four hundred ninety to five hundred thirty equals forty feet over large areas with places of forty-five feet or more. A cross profile from bluff to bluff shows these ridge tops to be the highest points between bluffs. Water covering these ridges must have covered the valley from side to side making a stream of from five to six miles wide and forty to fifty feet deep. Just how much of the year or for how long periods the water maintained such a volume it would seem impossible to say, but probably the maximum volume was reached in summer and maintained through the summer months, declining as winter came on. The assumption is that the largest volume of water was produced by the summer melting of the Great Ice Sheet that formerly overspread the Northern United States and much of Canada. Whether the west deeper side of the valley was then lower than the terrace portion cannot be stated certainly, deeper water probably covered the part of the valley that now shows the greatest depth. A depth of twenty feet of water is shown for the highest parts of the site of Terre Haute.

A Bibliography of Geographic Literature Concerning Foreign Countries.

Taken from Non-geographical Magazines 1900-1914; Government Documents; and Geographical Magazines.

B. H. Schockel.

INTRODUCTION.

This bibliography is submitted in the hope that it will be of some value to teachers of geography below the University, even though it is incomplete, and loosely organized. Each article has at least been briefly scanned. There are included many articles not written from a geographic standpoint, but it is thought that these also will be of some value to the geography teacher.

The accompanying key is employed to save space. The first reference under South America, for example, according to the key is *Bulletin of the Pan American Union*, volume 32, pages 240 to 251.

Acknowledgement is due to C. O. McFarland and Mrs. E. E. Rullman for assistance in preparing the bibliography.

KEY.

I. American Journal of Archaeology.
II. American Journal of Science.
III. Annals of the American Academy of Political and Social Science.
IV. Atlantic Monthly.
V. Bookman.
VI. Bulletin of the American Geographical Society (Journal).
VII. Bulletin of the Pan American Union.
VIII. Bulletin of the Geographical Society of Philadelphia.
IX. Bureau of American Republics. (Pan American Union.)
X. Century Magazine.
XI. Chautauqua.
XII. Engineering.
XIII. Everybody's Magazine.

XIV. Forum.
XV. Geographical Journal.
XVI. Harper's Magazine.
XVII. Harper's Weekly.
XVIII. Harvard Graduate's Magazine.
XIX. Independent.
XX. Johns Hopkins University Studies.
XXI. Journal of Geography. (Journal of School Geography.)
XXII. Journal of Geology.
XXIII. National Geographic Magazine.
XXIV. New England Magazine.
XXV. North American Review.
XXVI. Popular Science Monthly. (Scientific Monthly.)
XXVII. Records of the Past.
XXVIII. Review of Reviews.
XXIX. Science.
XXX. Scientific American Supplement.
XXXI. Scribner's Magazine.
XXXII. Scottish Geographical Magazine.
XXXIII. Smithsonian Institute Reports.
XXXIV. The Trend.
XXXV. University of Chicago Magazine.
XXXVI. Westminster Review.
XXXVII. World Today.
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A Study of the Collections from the Trenton and Black River Formations of New York.*

By H. N. Coryell.

The Trenton limestone in general is a formation made up of thin bedded, dark bluish gray, compact limestone separated by thin shaly layers, except the upper 25 to 35 feet which consist of a coarse crystalline, thick bedded limestone with thin shaly partings. This formation is everywhere very fossiliferous.

The type locality for the Trenton limestone is in the southwest part of the Remsen quadrangle, along West Canada creek, at Trenton Falls. A detailed section of the formation shown here is given by Prosser and Cummings, who have measured the entire thickness of 270 feet with great care. The upper portion does not appear in the Trenton Falls section, yet the work of W. J. Miller shows that there is only a few feet omitted, since the crystalline beds are at no place more than 35 feet thick upon which rest the Canajoharie shale.

The bottom of the Trenton formation is not shown in the Trenton Fall gorge, still the dip of the strata and the presence of the Lowville limestone a few miles to the southeast makes it seem very probable that the lowest beds in the gorge are not far from the base of the Trenton formation. Thus allowing for the necessary addition to the top and the bottom, the thickness of the complete section is at least 280 to 300 feet. The measurements taken at Rome and at the Globe Woolen Mills at Utica show a greater thickness of the Trenton to the southward and southwestward.

The formations during the early Paleozoic were deposited upon a sinking ocean bottom. The coast line receded to the northward. Younger formations overlap the older ones everywhere along the cost line and lay upon the precambrian rocks. The Trenton is 510 feet in the Globe Woolen Mills well at Utica, 575 feet in the Chittenango well, and 435 feet (including the Lowville) in the well at Rome. In the vicinity of Trenton Falls it has a maximum thickness of 300 feet. Along the Precambric boundary there are indications that it is much less. Considering the slope of the Precambric floor and differ-

*A summary of the literature is given by Prof. E. R. Cummings in the Bulletin of the New York State Museum, No. 34, Vol. 7, May, 1900.

ence of elevation between Bardwell Mill where the upper Trenton is shown, and the mouth of Little Black creek where the Precambrian outcrops, no such great thicknesses can be present. The Trenton at Bardwell Mill is probably not more than 150 feet.

To the south of Trenton Falls there is an increase in the thickness of about 20 feet per mile southwestward. Between the Globe Woolen Mills and Trenton Falls there is a difference in thickness of 210 feet in the distance of 14 miles. In the well at Rome the Trenton is 375 feet, and 20 miles to the northeast it is from 200 to 250 feet. The general fact drawn from these indicates a sloping floor on which the Trenton was deposited, of 6 to 20 feet per mile to the southwestward; the slope being less in the northwestern part.

The narrow gorge cut by the West Canada river extends for two and one-half miles up the river from Trenton Falls to the village of Prospect. Its walls are nearly vertical, varying in height from 100 to 200 feet. Throughout the entire course there are six waterfalls: the Sherman fall, near the southern end of the gorge, is about 30 feet high and a short distance above the power house; High falls is one-fourth mile south of the railroad bridge; it consists of an upper and a lower part with a total of 128 feet; the fall at the dam, just north of the railroad bridge, is about 40 feet high; and the Prospect falls at the upper end of the gorge is 25 or 30 feet high. The total fall of the stream within the two- and one-half miles is about 360 feet, according to the topographic map. In spite of the steep slope of the stream bed the southward dip of the strata permits an exposure of only 270 feet of the formation.

Two systems of joints predominate in the Trenton, which are distinctly indicated by the appearance of the walls of the gorge. Nearly everywhere the joints are vertical, at least at a very high angle, and extend in an east-west and a north-south direction. The east-west system can be seen extending across the gorge, especially at the falls, which are caused by the existing joints. When large blocks of stone are removed by the current during high water, a new perpendicular surface is exposed over which the water falls. Thus the falls recede. This is especially seen in the case of Sherman Falls. During high water, the water falls over one joint plane on the east and another on the west, while during low water the entire stream falls over the rear joint on the west. The block of limestone between them will eventually be removed.

The vertical walls of the gorge are maintained by the breaking off of large blocks of limestone along the north-south joints.

In the bed of the Cincinnati creek the joints are enlarged and forms an underground course. The stream disappears for several hundred yards.

The contorted layers in the Trenton Falls section are in two distinct horizons. The lower one is from 4 to 6 feet thick and lies at the crest of the lower part of High Fall. It outcrops also in the upper end of the gorge near Prospect.. According to the measurements of Prosser and Cummings it lies 144 feet below the top of the Trenton.

The second layer is from 8 to 15 feet thick and shown along the path opposite High Fall and may be traced to Prospect. It lies 65 to 70 feet below the top of the Trenton.

Such contortion of strata does not appear in the outcrop of Trenton exposed along Mill Creek.

Vanuxem suggested that as the folded layer was more cyrstalline than the layers above or below, the expansion of crystallization was manifested in the contortion of the crystalizing layer.

T. G. White discovered overturned fold, cross-bedded, channel filling structures that must be explained by other means which would yield a con siderable expansion in excess of the crystallization.

W. J. Miller states that it is thought that the folded structure at Trenton Falls was in reality caused by a differential movement within the mass of the Trenton limestone. That the whole body of the limestone has been moved is clearly demonstrated by the existence of the thrust fault at Prospect. It is easy to see how when the force of compression was brought to bear in the region there would be a tendency for the upper Trenton beds on the upthrow side to move more easily and consequently faster than the lower Trenton beds. A similar explanation would apply to the lower folded zone. The folded zones thus indicate horizons of weakness along which the differential movement has taken place. As thus explained it is evident why the strike of the minor folds, the strike of the fault, and the strike of the large low folds of the region should be parallel, and why the contorted strata should be so local in occurrence, because all the phenomena were produced by the same local pressure. The differential movement would also readily account for the rubbed or worn character of the upper and lower sides of the contorted zone.

The topography of the limestone region, underlain by the Trenton, Black river, Tribes Hill and Little Falls dolomite is given by E. R. Cummings, who states in describing the Mohawk valley near Amsterdam, that the limestone region is characterized by a low, rolling relief and shallow stream valleys, except where the streams have been forced to cut new courses through morainic material or because of the obstructions offered by such material have been turned aside to make new rock cuts. The latter is probably the case with the lower courses, at least of the north Chuctanunda and Evakill, for while they are at present making rock cuts, their banks show deep cuts through boulder clay, and their beds are in no respect those of mature streams, both from the abdundance of water-falls and the irregularity of their slope. The northwestern portion of this region is heavily covered with drift and the topography is more angular on this account. The limestone area is sheard off by the Hoffman ferry fault, along a line running nearly straight from the western central part of Charlton township to a point about one mile southwest of Pattersonville. The topography is also distinctly different upon the adjacent shales (Canajoharie and Schnectady) that abut the entire east face of the fault as shown on the Amsterdam sheet, except at the north where a small area of Trenton is found east of and adjacent to the fault.

Trenton Falls Section.

1. *Sherman Fall.*

The lowest strata that outcrop in the Trenton Falls gorge are those at the water level of the pool at the base of the Sherman Fall. They are compact, bluish grey, thin bedded limestones interstratified with coarser-grained layers containing numerous well preserved specimens of Prasopora simulatrix. The Prasopora beds form the entire fall. The upper layers of this fall are thin strata, 3 to 5 inches thick, which form a somewhat clearly defined band $2\frac{1}{2}$ feet thick. About the middle of the breast of the falls the Prasopora are much larger than elsewhere, forming a distinct layer. The second Prasopora zones are the fossiliferous layers just above the crest of Sherman Fall and forming the base of High Falls.

The lists of fossils below were identified from the collections made by Prof. E. R. Cummings in the summer of 1914.

a = abundant

c = common

r = rare

1. Calymene senaria Conrad c
2. Corynotrypa inflata (Hall) . . . . r
3. Crinoid segments . . . . a

4. Dalmanella testudinaria (Dalman) . . . . a
5. Hemiphragma tenuimurale Ulrich . . . . r
6. Isotelus gigas deKay c
7. Orthoceras junceum Hall . . . . r-c
8. Plectambonites sericeus (Sowerby) . . . . a
9. Prasopora simulatrix Ulrich . . . . aaa
10. Rafinesquina alternata (Emmons) c
11. Schizocrania filosa Hall . . . . r
12. Stigmatella n. sp . . . . r
13. Trematis terminalis (Emmons) . . . . r

2. *Below crest of the lower portion of High Fall.**

The strata, thin and shaly, lies at the base of the contorted layer. The following species were collected:

1. Crinoid segments . . . . a
2. Dalmanella testudinaria (Dalman) . . . . r-c
3. Eridotrypa aedilis minor (Ulrich) . . . . r-c
4. Prasopora simulatrix orientalis Ulrich . . . . aaa

3. *A collection at the crest of High Falls yielded the following species:*

1. Bythopora sp . . . . r
2. Crinoid segments c
3. Dalmanella testudinaria (Dalman) . . . . a
4. Hallopora ampla (Ulrich) . . . . r-c
5. Hallopora goodhuensis (Ulrich) . . . . a
6. Plectambonites sericeus (Sowerby) . . . . r-c
7. Prasopora simulatrix orientalis Ulrich . . . . aa
8. Rhinidictya exigua Ulrich . . . . r

4. *Upper High Fall.*

The rocks are thin bedded both in the upper and lower portion of upper High Fall. The contorted stratum lies at the base. The following species were collected:

1. Arthoclema cornutum Ulrich . . . . a
2. Calymene senaria Conrad c
3. Corynotrypa delicatula (James) . . . . r

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*From a collection made by Mr. T. F. Sayer, five feet below the crest of the lower portion of High Falls.

4. Crinoid segments ....aaa
5. Dalmanella testudinaria (Dalman)....................aaa
6. Hemiphragma tenuimurale Ulrich ....a
7. Isotelus gigas de Kay c
8. Mitoclema? mundulum Ulrich ....r-c
9. Nematopora ovalis Ulrich ....r-c
10. Pachydictya acuta (Hall)...................................c
11. Pachydictya fimbriata Ulrich ....r
12. Platystrophia trentonensis n. sp.........................c
13. Plectambonites sericeus (Sowerby).....................r-c
14. Prasopora simulatrix orientalis Ulrich ....a
15. Rafinesquina alternata (Emmons)..........................r
16. Rhinidictya exigua Ulrich ....r
17. Rhinidictya paupera Ulrich ....r-c

5. *Mill Dam Falls.*

The Mill Dam Falls or Fourth Falls is formed of thin bedded, rather coarse-grained and fossiliferous limestone. The following species were identified:

1. Chasmotopora reticulata (Hall)..........................c
2. Crinoid segments...a
3. Dalmanella testudinaria (Dalman).......................a
4. Plectambonites sericeus (Sowerby).......................a
5. Rhinidictya paupera Ulrich ....r-c

6. *Power Dam Interval.*

The Power Dam Interval includes almost all of the division of the Prosser and Cummings report except the upper few feet, which were collected from separately. The base of this interval is marked by a heavy stratum of limestone. Above this lies thin-bedded compact lime-stone, part of the strata somewhat crystalline, separated by shaly layers. At the upper end of the gorge the layers show the greatest amount of folding visible anywhere in the Trenton Falls section. The strata are very fossiliferous and the following species were collected:

1. Calymene senaria Conrad ....a
2. Ceramoporella distincta Ulrich c
3. Chasmotopora reticulata (Hall).......................aaa

4. Corynotrypa delicatula (James) . . . . . a
5. Corynotrypa inflata (Hall) . . . . . a
6. Corynotrypa turgida Ulrich . . . . . a
7. Crinoid segments . . . . . aa
8. Dalmanella testudinaria (Dalman) . . . . . aaa
9. Diploclema trentonense Ulrich . . . . . r
10. Eridotrypa cf exigua . . . . . r
11. Gastropod fragments . . . . . r-c
12. Hallopora angularis (Ulrich) . . . . . r
13. Hemiphragma tenuimurale Ulrich . . . . . r-c
14. Isotelus gigas de Kay . . . . . r-c
15. Leptaena charlottae W. & S . . . . . a
16. Leptaena unicostata (M. & W) . . . . . aa
17. Lioclema vetustum (Bassler) . . . . . r
18. Mitoclema? mundulum Ulrich c
19. Nematopora ovalis Ulrich . . . . . r-c
20. Orthoceras fragments . . . . . r
21. Ostracod fragments . . . . . r-c
22. Pachydictya acuta (Hall) . . . . . r-c
23. Pachydictya pumila Ulrich . . . . . r
24. Pianodema subaequata conradi (Winchell) . . . . . r
25. Platystrophia trentonensis n. sp c
26. Plectambonites sericeus (Sowerby) . . . . . a
27. Prasopora n. sp c
28. Prasopora conoidea Ulrich . . . . . r-c
29. Prasopora insularis Ulrich . . . . . aa
30. Prasopora simulatrix Ulrich . . . . . a
31. Rafinesquina alternata (Emmons) c
32. Rafinesquina deltoidea (Conrad) . . . . . a
33. Rhinidictya sp 2
34. Rhinidictya paupera Ulrich c
35. Rhynchotrema increbescens (Hall) . . . . . r
36. Stigmatella n. sp . . . . . aa

7. *Interval from top of High Falls to top of Mill Dam Falls.*

From these thin-bedded fossiliferous strata were collected the following species:

1. Arthoclema cornutum Ulrich c
2. Calymene senaria Conrad . . . . r-c
3. Chasmotopora reticulata Hall . . . . r-c
4. Crinoid segments c
5. Dalmanella testudinaria (Dalman) . . . . aaa
6. Escharopora recta (Hall) . . . . r
7. Hemiphragma tenuimurale Ulrich . . . . r
8. Leptotrypa sp . . . . r
9. Mitoclema? mundulum Ulrich . . . . a
10. Nematopora ovalis Ulrich . . . . r-c
11. Pachydictya acuta (Hall) c
12. Platystrophia trentonensis n. sp . . . . a
13. Plectambonites sericeus (Sowerby) c
14. Prasopora conoidea Ulrich c
15. Rafinesquina alternata (Emmons) . . . . r-c
16. Rhinidictya exigua Ulrich . . . . r-c
17. Rhinidictya mutabilis (Ulrich) . . . . r-c

8. *Prospect Quarry, below the crystalline layers.*

Below the heavy gray crystalline layer that caps the Trenton limestone and in a very thin parting of 8 to 10 inches, that outcrops on the east side of the gorge at Prospect in an old abandoned quarry opposite the large crusher quarry, bryozoa are exceedingly abundant and are weathered out from the matrix. A small Prasopora is very abdunant.

The crystalline layers above contain a few bryozoa, but difficult to prepare for study.

The species collected from the weathered parting are as follows:

1. Corynotrypa inflata (Hall) . . . . r
2. Crinoid segments . . . . a
3. Dalmanella testudinaria (Dalman) c
4. Eridotrypa exigua Ulrich c
5. Hallopora goodhuensis (Ulrich) . . . . a
6. Hemiphragma tenuimurale Ulrich . . . . a
7. Isotelus gigas de Kay c
8. Pachydictya acuta (Hall) c
9. Platystrophia trentonensis n. sp c
10. Pleclambonites sericeus (Sowerby) . . . . r-c

11. Prasopora n. sp c
12. Proboscina tumulosa Ulrich . . . . r
13. Stigmatella n. sp . . . . aa
14. Zygospira recurvirostris (Hall) . . . . r-c

9. *In the collection from the Quarry in the crystalline layers at Prospect were the following species:*

1. Cyrtodonta obtusa (Hall) . . . . r
2. Arthoclema sp . . . . r
3. Arthoclema cornutum Ulrich . . . . r
4. Calymene senaria Conrad . . . . r-c
5. Chasmotopora reticulata (Hall) c
6. Crinoid segments . . . . a
7. Dalmanella testudinaria (Dalman) . . . . r-c
8. Hallopora goodhuensis (Ulrich) c
9. Helopora quadrata Ulrich . . . . r
10. Isostelus gigas de Kay c
11. Mitoclema? mundulum Ulrich . . . . r
12. Pachydictya acuta (Hall) c
13. Pianodema subaequata (Conrad) . . . . r-c
14. Platystrophia trentonensis n. sp c
15. Plectambonites sericeus (Sowerby) . . . . r-c
16. Prasopora n. sp c
17. Prasopora sewyni (Nich.) c
18. Rafinesquina alternata (Emmons) . . . . r-c
19. Rhinidictya sp c
20. Rhynchotrema increbescens (Hall) . . . . r-c

Trenton and Black River of the Patterson Quarries.

At the east end of the quarries, about forty rods from the house of Joe Jeffers, is the following section in descending order:

6. Mesotrypa-Plectambonites bed, thin limestone. Trenton.
5. Strophomena bed, crystalline, massive limestone.

Amsterdam ls.

4. Massive crystalline bed with some Strophomena, and containing numerous light grey pebble-like masses of Stromatocerium and Solenopora. The layer rests directly with a sutured contact upon the Black river. Amsterdam ls.

3. About like No. 2 but even darker, more fossils, and containing numerous large fragments of a yellowish, sandy limestone. . . 1 ft. 3 in.
2. More massive than No. 1 and lighter colored. Very hard. Few fossils, some gastropods separated by rather uneven contact from No. 1. . . . . 1 ft. 6 in.
1. Drab, hard limestone, fine grained, light, weathering to rather thin layers. Columnaria abundant throughout. Batostoma varium abundant.

The Trenton in this section lies below the base of the Trenton of the Trenton Falls gorge, and is known as basal Trenton. The beds are massive, crystalline and contain light weathering "pebbles," (Solenopora and Stromatocerium). The Black river also contains similar pebbles and many angular masses of hard, blue, unfossiliferous limestone. The Lowville (Birdseye) is either absent or represented by a thin layer only. The Black river contains a large branching Batostoma (Batostoma varium) in considerable abundance, together with Tetradium and Columnaria. The latter is sometimes in very large masses.

The Strophomena is especially abundant in the massive lower part of the Trenton.

There is a disconformity between Nos. 1 and 2 and between 3 and 4.

The upper layers of the quarry are thin, very dark colored, with black shaly partings. They are very fossiliferous, containing especially Plectambonites, Mesotrypa and Cryptolithus. Small Bryozoa are abundant.

The dip of the rock is variable but is generally about two degrees southwest.

The Amsterdam limestone of Cushing includes the massive beds of the so-called Trenton and the Black river at this outcrop. The following species were collected:

1. Batostoma? decipiens Ulrich. . . . . r
2. Batostoma varium Ulrich . . . . r
3. Bythopora herricki (Ulrich). c
4. Calymene senaria Conrad c
5. Chasmotopora reticulata (Hall). . . . . a
6. Columnaria halli Nicholson c
7. Crinoid segments. . . . . a
8. Cryptolithus tessellatus Green. c

9. Dalmanella testudinaria (Dalman) . . . . r-c
10. Escharopora confluens Ulrich c
11. Escharopora? limitaris Ulrich . . . . r-c
12. Escharopora recta Hall c
13. Escharopora subrecta (Ulrich) c
14. Liospira subtilistriata (Hall) . . . . r
15. Mesotrypa whiteavesi (Nicholson) . . . . a
16. Mitoclema? mundulum Ulrich . . . . r-c
17. Nematopora ovalis Ulrich . . . . r-c
18. Pachydictya acuta (Hall) c
19. Pachydictya fimbriata Ulrich . . . . r-c
20. Pachydictya pumila Ulrich c
21. Phaenopora incipiens Ulrich . . . . r-c
22. Platystrophia trentonensis n. sp . . . . r-c
23. Plectombonites sericeus (Sowerby) . . . . a
24. Prasopora simulatrix Ulrich . . . . r-c
25. Rafinesquina alternata (Emmons) . . . . rr
26. Rhinidictya mutabilis (Ulrich) c
27. Rhinidictya paupera Ulrich . . . . r-c
28. Rhynchotrema increbescens (Hall) . . . . r-c
29. Solenopora compacta (Billings) . . . . aa
30. Stictoporella cribrosa Ulrich c
31. Stromatocerium canadense Nicholson and Murie c
32. Strophomena incurvata (Shepard) . . . . aa

The collection from the Black river of the Pattersonville section (Lower Amsterdam) formation, contains the following species:

1. Batostoma supberbum (Foord) . . . . a
2. Batostoma varium Ulrich . . . . aa
3. Calymene senaria Conrad . . . . a
4. Ceramoporella interporosa Ulrich . . . . r
5. Columnaria halli Nicholson . . . . a
6. Crinoid segments . . . . a
7. Eridotrypa aedilis minor (Ulrich) . . . . r
8. Escharopora subrecta (Ulrich) c
9. Isotelus gigas de Kay . . . . r
10. Lichenalia sp . . . . r

11. Leperditia fabulites (Conrad) . . . . r
12. Rhynidictya mutabilis (Ulrich) . . . . aa
13. Rhinidictya mutabilis senilis Ulrich c
14. Rhynchotrema increbescens (Hall) . . . . r-c
15. Solenopora compacta (Billings) . . . . aa
16. Streptelasma (Petraia) profundum (Conrad) . . . . a
17. Strophomena incurvata (Shepard) . . . . a
18. Zygospira recurvirostris (Hall) . . . . r-c

The Trenton B[6]* in the Pattersonville section contains well preserved fossils from which were collected the following species:

1. Batostoma? decipiens Ulrich . . . . r
2. Batostoma varium Ulrich . . . . r
3. Kloedenia initialis (Ulrich) . . . . r
4. Bollia subaequata Ulrich c
5. Bythopora herricki (Ulrich) c
6. Halloporina n. sp . . . . r
7. Calymene senaria Conrad c
8. Ceramoporella distincta (Ulrich) . . . . r-c
9. Ceramoporella interporosa Ulrich . . . . r-c
10. Ceraurus pleurexanthemus Green c
11. Chasmotopora retuculata (Hall) . . . . a
12. Chasmotopora sublaxa (Ulrich) c
13. Coelodema trentonensis (Ulrich) . . . . r-c
14. Cornulites flexuosus (Hall) . . . . r
15. Crinoid segments . . . . a
16. Cryptolithus tessellatus Green c
17. Dalmanella testudinaria (Dalman) c
18. Dinorthis pectinella (Emmons) . . . . r
19. Escharopora angularis Ulrich c
20. Escharopora confluens Ulrich c
21. Escharopora? limitaris Ulrich . . . . r-c
22. Escharopora recta Hall . . . . a
23. Escharopora subrecta (Ulrich) c
24. Graptodictya proava (Eichwald) . . . . r
25. Homotrypa subramosa Ulrich . . . . r

*B[6] New York State Museum No. 34, Vol. 7.

26. Isotelus gigas de Kay............................r-c
27. Mesotrypa regularis (Foord).........................a
28. Nematopora ovalis Ulrich.........................r-c
29. Pachydictya sp...................................r
30. Platystrophia trentonensis n. sp....................r-c
31. Plectambonites sericeus (Sowerby)...................a
32. Plectorthis plicatella (Hall).........................r
33. Prasopora simulatrix Ulrich.........................c
34. Primitia mammata Ulrich.........................r-c
35. Protocrisina exigua Ulrich..........................a
36. Rhinidictya mutabilis (Ulrich).......................a
37. Rhinidictya mutabilis major (Ulrich)................c
38. Rhinidictya paupera Ulrich..........................c
39. Rhynchotrema increbescens (Hall).................r-c
40. Schizocrinus nodosus Hall..........................c
41. Stictoporella cribrosa Ulrich........................c
42. Stictoporella angularis Ulrich.......................c
43. Strophemna incurvata (Shepard)....................aa
44. Tetradella subquadrans Ulrich....................r-c
45. Trematis terminalis (Emmons)........................r
46. Turrilepas canadensis Woodward..................r-c
47. Zygospira recurvirostris (Hall)......................r-c

Morphy Creek Section.

About one and one-half miles down the Mohawk river from Port Jackson on the south side of the river is an outcrop of the Trenton, Black river and Calciferous (Tribes Hill and Little Falls dolmite).

The basal Trenton resting on the Black river in this outcrop contains the pebble-like masses of Stromatoporoids (Stromatocerium canadense Nicholson and Murie) as at Pattersonville, and consisting of compact beds of dark crystalline limestone in which Strophomena abound. The difference in appearance of this section and that at Pattersonville quarries is chiefly due to weathering.

The Black river is underlain by a compact, nearly unfossiliferous blue limestone, which is probably the Birdseye (Lowville).

Collections were made only from the thin-bedded Trenton above the crystalline bed. Mesotrypa and Prasopora are most abundant about ten feet below the Canajoharie shale contact, but are common throughout the upper 10 feet. In the layers of hard limestone just below the Canajoharie (Utica) shale Cryptolithus is common and about the only fossil. Plectambonites is common in the upper thin Trenton.

At the Amsterdam waterworks just north of the city of Amsterdam, Mesotrypa whiteavesi (Nicholson) and Cryptolithus tessellatus Green are very abundant 10 feet or more below the top of the exposed Trenton. The portion outcropping extends almost to the top of the Trenton formation, but the contact with the Canajoharie shale is not shown. The creek flows in a syncline for some distance below the dam.

At the Barge canal dam across the Mohawk river just above Amsterdam station, there is a quarry, mentioned by Prof. E. R. Cummings, in the New York State Museum Bulletin No. 34, as showing a splendid section of the Birdseye, Lowville and Black river. The latter is of the same general character as at Pattersonville, being black, fossiliferous and thin-bedded. The most abundant fossils are Streptelasma (Petraia) profundum Conrad and Stromatocerium canadense Nicholson & Murie.

The following species were collected at Morphy's creek from the Trenton layers:

1. Bollia subaequata Ulrich . . . . r-c
2. Calymene senaria Conrad c
3. Chasmotopora reticulata (Hall) . . . . r-c
4. Chasmotopora sublaxa (Ulrich) . . . . r-c
5. Crinoid segments . . . . a
6. Cryptolithus tessellatus Green . . . . r-c
7. Cytherella? rugosa (Jones) . . . . r
8. Dalmanella testudinaria (Dalman) c
9. Eridotrypa aedilis minor (Ulrich) c
10. Eridotrypa exigua Ulrich . . . . r-c
11. Isotelus gigas de Kay c
12. Leperditia fabulites (Conrad) c
13. Mesotrypa whiteavesi (Nicholson) . . . . aa
14. Mitoclema? mundulum Ulrich . . . . r-c
15. Monotrypa n. sp . . . . aa
16. Nematopora ovalis Ulrich . . . . r-c
17. Pachydictya acuta (Hall) c
18. Pachydictya pumila Ulrich c

19. Plectambonites sericeus (Sowerby) c
20. Prasopora simulatrix Ulrich c
21. Rafinesquina alternata (Emmons) . . . . r-c
22. Rhinidictya paupera Ulrich c
23. Rhynchotrema increbescens (Hall) . . . . r-c
24. Turrilepas sp . . . . r
25. Zygospira recurvirostris (Hall) . . . . r-c

Sections in the Vicinity of Lowville.

The Lowville limestone capped by the Black river is exposed in a quarry near Mill creek at the corner of Church and Water Streets. It is exposed also in the bed and banks of Mill creek both above and below this point for some distance. This is the type section of the Lowville. Up stream just below where the exposure is covered by the heavy drift, the basal Trenton, with immense numbers of Dalmanella and Bryozoa, is exposed. The collections were made at this place. In several layers the Bryozoa are abundant. The following are the species collected:

1. Aparchites fimbriatus (Ulrich) . . . . r
2. Bythopora sp . . . . aa
3. Calymene senaria Conrad c
4. Conularia sp . . . . r
5. Crinoid segments c
6. Ctenobolbina ciliata (Emmons) . . . . r
7. Dalmanella testudinaria (Dalman) c
8. Escharopora recta (Hall) . . . . r
9. Hallopora ampla (Ulrich) . . . . aa
10. Hallopora splendens (Ulrich) . . . . aa
11. Helopora sp . . . . r
12. Pachydictya acuta (Hall) . . . . r
13. Plectambonites sericeus (Sowerby) c
14. Prasopora simulatrix Ulrich . . . . a
15. Rafinesquina deltoidea (Conrad) c
16. Rhinidictya sp . . . . r
17. Stictopora elegantula Hall . . . . r
18. Tentaculites sp . . . . r
19. Trematis terminalis (Emmons) . . . . r

The best exposure of the Lowville with overlying Black river and underlying Pamelia is on the State Road about one mile northeast of Lowville and in the several quarries nearby in the field along the limestone scarp. The country from here slopes southwest exactly with the dip of the rocks. Nothing higher than Black river is exposed. The Lowville weathers to a light drab or dove color, but some of the layers are darker and occasionally almost as dark as the Black river. The calcite tubes are always present in the Lowville except towards the base. In most of the layers they are extraordinarily abundant; usually perpendicular within the strata and lying horizontally at the surface. They are probably plants.

Fossils other than plant tubes are rare. Some of the thinner layers are ripple marked.

The whole mass of the Lowville must be 30 or 40 feet thick. Very little of the underlying Pamelia is seen.

The low country to the east and north of the exposure shows bosses of the Pre-Cambrian, and several of these are very near the bottom of the limestone scrap, so that the base of the limestone cannot be far below the lowest exposure on the State Road locallity.

The Black river (Leray) is dark colored and lumpy, thick-bedded, weathering to a light color but not so light as the Lowville limestone. It is massive in fresh exposure, showing the characteristic yellow streaks and blotches.

Columnaria, Tetradium and Stromatocerium are abundant. Silicified Bryozoa of large size are present. Near the base Strophomena is common. Leperditia is usually common throughout. In fact, the characterisites are practically the same as in the Mohawk Valley and at Valcour Island. The contact between the Black river and Lowville is usually very even and in unweathered masses appears merely as a slight change of color accompanied by the disappearance of the calcite tubes. Sometimes the contact is somewhat uneven. It is evidently a disconformity.

Species from the Watertown Section.

A short distance up the river from Watertown a collection was made from the lower Trenton, containing the following species:

1. Batostoma winchelli spinulosum Ulrich c
2. Dalmanella testudinaria (Dalman) c
3. Hallopora ampla (Ulrich) . . . . a

4. Hallopora goodhuensis (Ulrich) .... a
5. Hallopora splendens Bassler .... a
6. Homotrypa callosa Ulrich c
7. Prasopora simulatrix orientalis Ulrich .... a

The similarity of the New York fauna to that of upper Mississippi basin as given by Ulrich is shown by the following lists. Of the 108 species identified, 68 appear in the Trenton and Black river of the upper Mississippi Valley. The collections were made with special reference to the Bryozoan fauna, which accounts for the small number of species reported from the other classes. It is interesting to note the small number of new species found, especially among the Bryozoa, notwithstanding the fact that very little work had been done on that class from collections of the Trenton and Black river of New York. A description of these will be given in a successive paper.

Species from Trenton and Black River of New York.

(Those marked with an asterisk appear in the Trenton and Black River of the upper Mississippi Valley. T-Trenton. B-Black River.)

Bryozoa.

1. Arthoclema sp. (T)
*2. cornutum (T, B)
*3. Batostoma? decipiens (T, B)
*4. varium (T, B)
*5. supberbum (B)
*6. winchelli spinulosum (T, B)
7. Bythopora sp. (T, B)
*8. herricki (T, B)
*9. Halloporina n. sp. (T)
*10. Ceramoporella distincta (T, B)
*11. interporosa (T, B)
*12. Chasmatopora reticulata (T, B)
*13. sublaxa (T)
*14. Corynotrypa delicatula (T)
*15. turgida (T)
*16. inflata (T)
*17. Coeloclema trentonensis (T, B)

*18. Diploclema trentonense (T)
*19. Eridotrypa exigua (T)
*20. aedilis minor (T, B)
*21. Escharopora angularis (T, B)
*22. confluens (T, B)
*23. ? limitaris (T, B)
*24. recta (T)
*25. subrecta (T, B)
26. Graptodictya proava (T)
*27. Hallopora ampla (T, B)
*28. angularis (T, B)
*29. goodhuensis (T)
30. splendens (T)
31. Helopora sp. (T)
*32. quadrata (T)
*33. Homotrypa callosa (T)
*34. subramosa (T, B)
*35. Hemiphragma tenuimurale (T)
36. Leptotrypa sp. (T)
37. Lioclema vetustum (T)
38. Mesotrypa regularis (T)
39. whiteavesi (T)
*40. Mitoclema? mundulum (T)
41. Monotrypa n. sp. (T)
*42. Nematopora ovalis (T)
43. Pachydictya sp. (T)
*44. acuta (T)
*45. fimbriata (T, B)
*46. pumila (T, B)
*48. Phaenopora incipiens (T)
49. Prasopora n. sp. (T)
*50. conoidea (T, B)
*51. insularis (T)
*52. selwyni (T)
*53. simulatrix (T, B)
*54. simulatrix orientalis (T, B)
*55. Proboscina tumulosa (T, B)

56. Protocrisina exigua (T)
*57. Rhinidictya exigua (T, B)
*58. mutabilis (T, B)
*59. mutabilis major (T, B)
*61. mutabilis senilis (B)
*62. paupera (T, B)
63. Stictopora elegantula (T)
*64. Stictoporella cribrosa (T, B)
*65. angularis (T, B)
66. Stigmatella n. sp. (T)

Brachiopoda.

*67. Dalmanella testudinaria (T, B)
*68. Pianodema subaequata (T, B)
*69. Pianodema subaequata conradi (T, B)
*70. Dinorthis pectinella (T, B)
*71. Leptaena charolottae (T, B)
72. unicostata (T)
74. Platystrophia trentonensis (T)
*75. Plectambonites sericeus (T)
*76. Plectorthis plicatella (T, B)
*77. Rafinesquina alternata (T, B)
*78. deltoidea (T, B)
*79. Rhyncotrema increbescens (T, B)
80. Schizocrania filosa (T)
*81. Strophomena incurvata (T, B)
82. Trematis terminalis (T)
*83. Zygospira recurvirostris (T, B)

Crinoidea.

*84. Crinoid segments (T, B)
85. Schizocrinus nodosus (T)

Pelecypoda.

86. Ambonychia cf obtusa (T)

Ostracoda.

87. Aparchites fimbriatus (T)
*88. Kloedenia initialis (T, B)
*89. Bollia subaequata (T)
90. Ctenobolbina ciliata (T)
*91. Cytherella? rugosa (T)
*92. Leperditia fabulites (T, B)
*93. Primitia mammata (T, B)
94. Tetradella subquadrans (T)

Trilobita.

*95. Calymene senaria (T, B)
*96. Ceraurus pleurexanthemus (T, B)
97. Cryptolithus tessellatus (T)
*98. Isotelus gigas (T, B)

Cirripedia.

99. Turrilepas canadense (T)
100. Cornulites flexuosus (T)

Gastropoda.

101. Liospira subtilistriata (T)
102. Tentaculites sp. (T)
*103. Conularia sp. (T)

Coelentrata.

*104. Columnaria halli (T, B)
105. Solenopora compacta (T, B)
*106. Streptelasma (Petraia) profundum (B)

Stromatoporoidea.

107. Stromatocerium canadense (T)

Cephalopoda.

*108. Orthoceras junceum (T, B)

Gamma Coefficients and Series.

I. The Coefficients.

1. The function.

$$(axby\cdot\cdot) = (ax+by+\cdot\cdot)\ \frac{\Gamma(x+y+\cdot\cdot)}{\Gamma(x+1)\Gamma(y+1)\cdot\cdot}$$

will be called *a gamma coefficient of coördinates* x, y, $\cdot\cdot$, *and parameters* a, b, $\cdot\cdot$, and *a multinomial coefficient* when each parameter is unity. We shall use Greek letters to denote coördinates taken from the series 0, 1, 2, 3, $\cdot\cdot$.

At points of discontinuity, the sum of the coördinates is *zero* or a *negative integer.* These points are excluded in the following properties.

2. *A gamma coefficient with a negative integral coördinate is zero.*

3. *Zero coördinates and their parameters may be omitted*, as $(axbyc0) = (axby)$.

4. *The gamma coefficient of a point upon an axis equals the parameter of that axis*, as $(ax) = a$.

5. *The gamma coefficient of any point is the sum of the gamma coefficient of the preceding points* (a preceding point being found by diminishing one coördinate by *a unit*). Let $E\eta$ operate to diminish the n'th coördinate by a unit, then in symbols, *(Note)

$$(axby\cdot\cdot) = (E_1+E_2+..)(axby\cdot\cdot)$$

This may be extended to the n'th repetition of $E_1+E_2+\cdot\cdot = 1$, where the E's combine by the laws of numbers.

6. The above property furnishes an immediate proof of the multinomial theorem. Thus let

$$Fn = \Sigma(1\alpha 1\beta\cdot\cdot)\ p^{\alpha} q^{\beta}\cdot\cdot,\ \alpha+\beta+\cdot\cdot = n$$

i. e. the summation extends to every point the sum of whose coördinates is n, there being a given number of variables p, q, $\cdot\cdot$, and corresponding integral coördinates α, β, $\cdot\cdot$. Applying art. 5 to the coefficients of Fn, we find $Fn = (p+q+\cdot\cdot)F(n-1)$, and since $F1 = p+q+\cdot\cdot$, therefore $Fn = (p+q+\cdot\cdot)^{\eta}$.

7. *Zero parameters and corresponding coördinates may be omitted, if the result be multiplied by the multinomial coefficient of the omitted coördinates and one other, the sum, less* 1, *of the retained coördinates, as,*

$$(0x0ybzcw) = (bzcw)\ (1x1y1w'),\ w' = z+w-1$$

8. *Equal parameters and their coördinates may be omitted, except one to*

* (Note) Read n for η throughout this paper.

a coördinate the sum of the omitted coördinates, if the result be multiplied by the multinomial coefficient of the omitted coördinates, as

$$(axaybz) = (ax'bz)(1x1y), \; x' = x+y.$$

9. *The coefficient of a parameter of a gamma coefficient is the multinoimal coefficient of the corresponding preceding point.* In symbols,

$$(axby\cdot\cdot) = (aE_1 + bE_2 + \cdot\cdot)(1x + 1y\cdot\cdot)$$

II. Gamma Series.

10. Let there be m variables, p_1, p_2, $\cdot\cdot$, of weights 1, 2, $\cdot\cdot$, and m corresponding parameters, a_1, a_2, $\cdot\cdot$. The *gamma series of weight n* is the sum of all terms in the variables of weight n, each multiplied by the gamma coefficient of its exponents and the corresponding parameters:

$$(a) \quad (ap)n = \Sigma(a_1\alpha_1 a_2\alpha_2\cdot\cdot)\; p_1^{\alpha_1} p_2^{\alpha_2}\cdot\cdot, \; \alpha_1 + 2\alpha_2 + \cdot\cdot = n.$$

This series is not a function of an r'th variable and parameter for $r>n$, since the simultaneous exponent and coördinate αr, is zero.

By applying art. 5 to the coefficients of $(ap)n$, we have,

$$\text{(b)} \; (ap)n = p_1\,(ap)\,(n-1) + \ldots + p_{\eta-1}(ap)1 + a_\eta p_\eta$$

where, if $r>m$, $p_r = 0$.

The last term $a_\eta p_\eta$, which cannot exist if $n>m$, is determined by the fact that it is given by the coördinate $\alpha_\eta = 1$, and the other coördinates, zero.

11. The difference equation 10(b) has no solution except the gamma series, since all values of $(ap)n$ are determined from it by taking $n = 1, 2, 3, \cdot\cdot$, successively. It is an equation of permanent form only for $n>m$, when it is *the general linear difference equation of n'th order with constant coefficients* p_1, p_2, $\cdot\cdot$, *whose general solution with m arbitarty constants is therefore found in the form of a gamma series.* The equation whose roots determine its solution (in the ordinary theory of linear difference equations) is,

$$\text{(a).} \quad x^m = p_1 x^{m-1} + p_2 x^{m-2} + \cdot\cdot + p_m$$

Symmetric functions Fn of the roots of this equation will also satisfy the difference equation and can therefore be expresssed as gamma series by certain values of the parameters.

Since the roots of (a) are constants, the parameters will in general be certain functions of the roots, but we propose here to determine the symmetric functions that may be expressed by gamma series *with parameters independent of the roots*; and find two sets of such functions m in each set, which can be linearly expressed in terms of each other, and either of these sets suffice to express in linear form all of the symmetric functions sought.

12. The parameter a_η of $(ap)n$, n = 1, 2, $\cdot\cdot$, m, is the coefficient of p_η. Thus to determine the possible parameters of a given symmetric function, Fn, we must take a_η as the value of Fn for the roots of the equation $x^\eta=1$, this being what 11 (a) becomes when we put $p_\eta=1$, and other p's equal to zero. It remains to test the resulting equations,

$$F1=a_1p_1,\ F2=p_1F1+a_2p_2,\ F3=p_1F2+p_2F1+a_3p_3, \text{ etc.}$$

13. *The sum of the n'th powers,* s_η.

By art. 12, we find $a_\eta=n$, for the function s_η, and the difference equations are Newton's equations. Hence

$$s_\eta=\Sigma(1\alpha_1\cdot\cdot n\alpha_\eta)p_1^{\alpha_1}\cdot\cdot p_\eta^{\alpha_\eta},\ \alpha_1+\cdot\cdot+n\alpha_\eta=n$$

This is Waring's formula for s_η.

14. *The homogeneous products,* π_η.

Here, $a_\eta=1$, giving the correct difference equations,

$$\pi_1=p_1,\ \pi_2=p_1\pi_1+p_2,\ \pi_3=p_1\pi_2+p_2\pi_2+p_3, \text{ etc.}$$

Hence, $\pi_\eta=(1p)n$, *i. e. the coefficient of a term is the multinomial coefficient of its exponents.* Since the equations are symmetrical in π, $-p$, we have also, $p_\eta=-(1[-\pi])n$. These formulas seem to be new, as also those which follow.

15. *The homogeneous products, k at a time,* πnk.

Here a_η is a binomial coefficient of the n'th power, whose value is zero for $n<k$, and 1 for $n=k$, and,

$$\pi nk=(ap)n,\ a_\eta=(-1)^{k-1}(1K1.n-k.)$$

16. By applying art. 9 to the coefficients of $(ap)n$, and substituting $\pi_\eta=(1p)n$, we have

$$\text{(a).}\quad (ap)n=a_1p_1\pi_{\eta-1}+a_2p_2\pi_{\eta-2}+\cdot\cdot+a_\eta p_\eta$$

We have therefore,

	$p_1\pi_{\eta-1}$	$p_2\pi_{\eta-2}$	$p_3\pi_{\eta-3}$	$p_4\pi_{\eta-4}$	$p_5\pi_{\eta-5}$,	*etc.*
π_η =	1	1	1	1	1	*etc.*
$s_\eta=\pi_{\eta 1}$ =	1	2	3	4	5	*etc.*
$-\pi_{\eta 2}$ =		1	3	6	10	*etc.*
$\pi_{\eta 3}$ =			1	4	10	*etc.*
$-\pi_{\eta 4}$ =				1	5	*etc.*
$\pi_{\eta 5}$ =					1	*etc.*
etc.						

From the top line and the diagonal of units, we continue adding a number to the one above for the next number in the same line (a particular case of art. 5). When $n > m$, the number of functions in each set is m.

The solution of these equations for the second set in terms of the first is found by interchanging corresponding functions, $\rho k \pi n - k$ and $\pi n k$.

ROSE POLYTECHNIC INSTITUTE.

Some Relations of Plane and Spheric Geometry.

David A. Rothrock.

Our notions of *plane analytic geometry* date to the publication by Descartes of his philosophical work: "*Discours de la méthode . . . dans les sciences,*" 1637, which contained an appendix on "*La Geometrie.*" In this work Descartes devised a method of expressing a plane locus by means of a relation between the distances of any point of the locus from two fixed lines. This discovery of Descartes led to the analytic geometry of the plane, and the extension to three dimensional space gave rise to geometry of space figures by the analytic method. A single equation, $f(x,y) = o$, between two variables represents a plane curve; a single equation, $F_1(x,y,z) = o$, in three variables represents a surface in space; and two equations, $F_1(x,y,z) = o$, $F_2(x,y,z) = o$, represent a curve in space.

In the Cartesian system of coördinates, a space curve is determined by the intersection of two surfaces. If we wish to investigate the curves upon a single surface, that is, if we wish to devise a geometry of a given surface. it may be possible to discover a system of coördinates upon the surface, such that any surface-locus may be expressed by a single equation in terms of two coördinates, as in plane geometry. The sphere furnishes a simple example in which a locus upon its surface may be represented by a single equation connecting the coördinates of any point upon the locus.

Toward the end of the eighteenth century a fragmentary system of analytic geometry of loci upon the surface of the sphere was developed. This early work on *Spheric Geometry* seems to have originated with Euler (1707-1783), but many of the special cases of spherical loci were investigated by Euler's colleagues and assistants at St. Petersburg. In the present paper are enumerated a number of the early investigations on spherical loci, and a derivation of the equations of sphero-conics in modern notation. The correspondence of the *spheric equations* to the similar equations of plane analytics is shown.

Historical.

One of the first problems involving a locus upon a sphere to be solved by use of spherical coördinates was the following: *Find the locus of the vertex of a spherical triangle having a constant area and a fixed base.* With the base AB fixed, Fig. 1, and the area of the spherical triangle APB constant, the

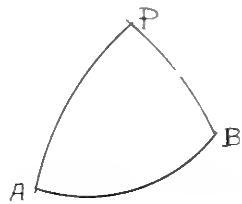


Fig. 1

locus of P was shown to be a small circle. This result was derived by Johann Lexell (1740-1784), an astronomer at St. Petersburg, in 1781. The problem was found to have been solved earlier, 1778, by Euler.[1] The result is sometimes known as Lexell's theorem.

A second spherical locus appeared as the solution of the problem: *To find the locus of the vertex of a spherical triangle upon a fixed base, such that the sum of the two variable sides is a constant.* This problem defines a locus

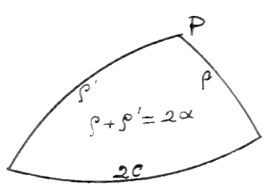


Fig. 2

upon the sphere analogous to the ordinary definition of an ellipse in the plane. The locus of P is called the *Spherical Ellipse.* The solution of this problem was found in 1785 by Nicholaus Fuss (1755-1826), a native of Basel, and an assistant to Euler at St. Petersburg from 1773 until Euler's death in 1783.

Frederick Theodore Schubert, a Russian astronomer, a contemporary of Fuss, published solutions to a number of spherical loci, types of which

[1] Cantor, Vol. IV, p. 384, p. 416.

are shown in the following: Given a triangle with a fixed base, find the locus of the vertex P such that the variable sides, ρ, ρ', Fig. 2, satisfy:

(1) $\sin\rho = k \sin\rho'$,

(2) $\cos\rho = k \cos\rho'$,

(3) $\sin\frac{\rho}{2} = k \sin\frac{\rho'}{2}$,

(4) $\cos\frac{\rho}{2} = k \cos\frac{\rho'}{2}$.

In Crelle's Journal, Vol. VI, 1830, pp. 244-254, Gudermann published an article "*Ueber die analytische Spharik,*" which contains a collection of spherical loci connected with *sphero-conics*, for example, such as: (1) *The locus of the feet of perpendiculars drawn from the focus of a spherical ellipse upon tangents to the spherical ellipse*; (2) *The locus of the intersection of perpendicular tangents to a spherical ellipse*; and other problems similar to those of plane analytics. The notation employed by Gudermann is not fully explained, and is an adaptation from that used by him in a private publication of his work "*Grundriss der analytischen Spharik,* to which the present writer does not have access.

Thomas Stephens Davies published, 1834, in the Transactions of the Royal Society of Edinburgh, Vol. XII, pp. 259-362, and pp. 379-428, two papers, entitled, "*The Equations of Loci Traced upon the Surface of a Sphere.*" In these extensive papers the author uses a system of polar coördinates upon the sphere, and derives the equations of many interesting curves, the spherical conics, cycloids, spirals, as well as many properties of these curves. The polar equations of Davies may be transformed into *great-circle* coördinates, giving equations of spherical loci in a form similar to the Cartesian equations of corresponding loci in the plane.

Spherical Analytics.

A system of analytic geometry upon the sphere may be derived in direct correspondence to that of the plane by a proper choice of axes of coördinates.

1. *Coördinates.* Let us select as axes two great circles XX′, YY′ perpendicular to each other at O, Fig. 3. The spherical coördinates of any point P are the intercepts, OA = ξ and OB = η, cut off upon the axes by perpendiculars drawn from P. Let the length of the perpendiculars from P be PB = ξ', and PA = η'.

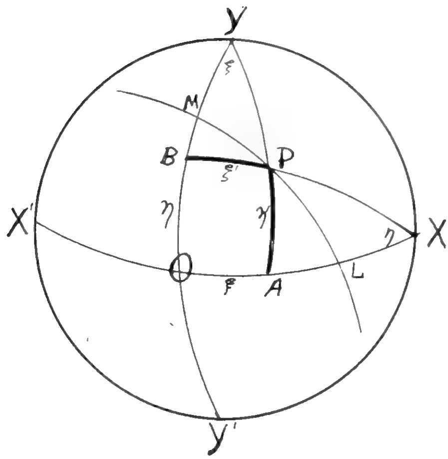


Fig 3

From the right spherical triangles PBY and PAX we have the following fundamental relations:

$$(1)\quad \tan\xi = \frac{\tan\xi'}{\sin BY} = \frac{\tan\xi'}{\cos\eta},\ \tan\eta = \frac{\tan\eta'}{\sin AX} = \frac{\tan\eta'}{\cos\xi}$$

2. *Equation of the Spheric Line LM in Terms of its Intercepts.*

The arc of a great circle we will call a *spheric straight line*. Let the intercepts be OL $=\alpha$, OM $=\beta$, and the angle OLM $=\phi$, Fig. 3. Then from the right triangles MOL and PAL we have

$$\tan\varphi = \frac{\tan\beta}{\sin\alpha},\ \text{and}\ \tan\varphi = \frac{\tan\eta'}{\sin AL} = \frac{\tan\eta'}{\sin(\alpha-\xi)}$$

Equating these values of $\tan\varphi$, and substituting the value of $\tan\eta'$ from (1),

$$\frac{\tan\beta}{\sin\alpha} = \frac{\tan\eta\cos\xi}{\sin\alpha\cos\xi - \cos\alpha\sin\xi} = \frac{\tan\eta}{\sin\alpha - \cos\alpha\tan\xi}$$

Expressing each function in terms of tangents and reducing, we find the equation of the spheric line in the intercept form:

$$(2)\quad \frac{\tan\xi}{\tan\alpha} + \frac{\tan\eta}{\tan\beta} = 1.$$

(1) *Special Cases.* (a) Parallels to the axes. A shperic line parallel to the OY-axis passes through the pole of the axis OX. Hence for a parallel to the OY-axis $\beta = 90°$ and the equation of the line becomes

$$(3) \quad \tan \xi = \tan \alpha$$

and for a parallel to the OX-axis, $\alpha = 90°$, and

$$(4) \quad \tan \xi = \tan \beta$$

(b) A line through one point. If a line (2) is to pass through (ξ_1, η_1), we have

$$(5) \quad \frac{\tan \xi - \tan \xi_1}{\tan \alpha} + \frac{\tan \eta - \tan \eta_1}{\tan \beta} = 0.$$

(c) A line through two points (ξ_1, η_1), (ξ_2, η_2), is given by

$$\frac{\tan \xi - \tan \xi_1}{\tan \xi_2 - \tan \xi_1} = \frac{\tan \eta - \tan \eta_1}{\tan \eta_2 - \tan \eta_1}$$

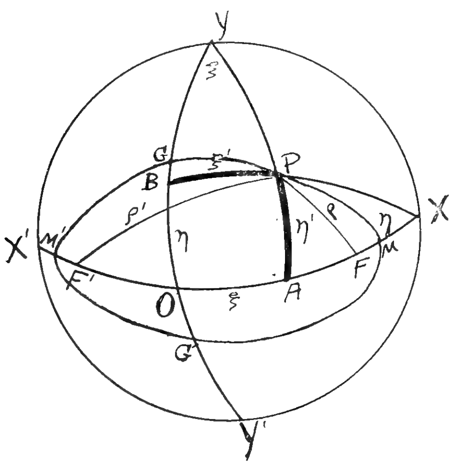


Fig. 4

Conditions of *perpendicularity, parallelism, angles of intersection* of spheric straight lines may also be expressed, but will not be included here.

(2) *Correspondence to plane geometry.* The intercept form of the spheric straight line is similar to the corresponding equation in plane geometry, and may be reduced to that form by letting the radius of the sphere increase without limit.

3. *The Spheric Ellipse. Find the locus of the vertex P of a spherical triangle with fixed base FF′, such that the sum of the sides is a constant,* $\rho + \rho' = 2\alpha$. Fig. 4.

This definition defines the Spheric Ellipse MGM^1G^1.

Take the origin at the center O of the base FF′. Let $FF' = 2c$, $\rho + \rho' = 2\alpha$, $OM = \alpha$, $OG = \beta$. When P falls at G, $FG = \alpha = F'G$.

Then from the right triangle FOG (hypotenuse not drawn), we have

$$(1) \quad \cos\alpha = \cos\beta \cos c;$$

and from PAX,

$$(2) \quad \tan\eta' = \cos\xi \tan\eta.$$

From the right triangles PAF and PAF′, we have

(3) $\cos\rho = \cos\eta' \cos(c - \xi)$, $\cos\rho' = \cos\eta' \cos(c + \xi)$.

Adding equations (3) and using $\rho + \rho' = 2\alpha$,

$$(4) \quad \cos\alpha \cos\frac{\rho - \rho'}{2} = \cos\eta' \cos c \cos\xi.$$

and subtracting (3),

$$(5) \quad \sin\alpha \sin\frac{\rho - \rho'}{2} = \cos\eta' \sin c \sin\xi$$

Eliminating $\frac{\rho - \rho'}{2}$ and c from (1), (4), (5) and reducing, we find the symmetrical equation of the spheric ellipse

$$\frac{\tan^2\xi}{\tan^2\alpha} + \frac{\tan^2\eta}{\tan^2\beta} = 1,$$

α, and β being the intercepts on the axes, OM, and OG, respectively.

Special Cases. (1) Let $\alpha = \beta$, and we have a circle

$$(A) \quad \tan^2\xi + \tan^2\eta = \tan^2\alpha,$$

with center at O and radius α. With $\alpha = 90°$, this circle becomes the boundary of the hemisphere on which our geometry is located, corresponding to the circle with infinite radius in plane geometry.

(2) Let $\alpha = 90°$, and the ellipse becomes the two "*parallel lines*", $\tan^2\eta = \tan^2\beta$, passing through the poles of the OY-axis.

(3) The equation of a circle upon a sphere may be derived quite readily, but the resulting equation is somewhat unsymmetrical. Let ξ_1, η_1, be the

coördinates of the center, and let α be the radius. Then the equation may be derived from the fundamental equations

$$\tan \eta_1' = \cos \xi_1 \tan \eta_1, \quad \tan \xi_1' = \cos \eta_1 \tan \xi_1,$$
$$\tan \eta' = \cos \xi \tan \eta, \quad \tan \xi' = \cos \eta \tan \xi,$$

and the polar equation

$$\cos \alpha = \sin \eta_1' \sin \eta' + \cos \eta_1' \cos \eta' \cos (\xi - \xi_1),$$

by the elimination of ξ_1', η_1' and ξ', η'.

The resulting equation is

$$(\tan \xi - \tan \xi_1)^2 + (\tan \eta - \tan \eta_1)^2 + (\tan \xi \tan \eta_1 - \tan \xi_1 \tan \eta)^2$$
$$= \tan^2 \alpha \, (1 + \tan \xi \tan \xi_1 + \tan \eta \tan \eta_1)^2.$$

When $\xi_1 = \eta_1 = 0$, this equation reduces to that given in (A) above.

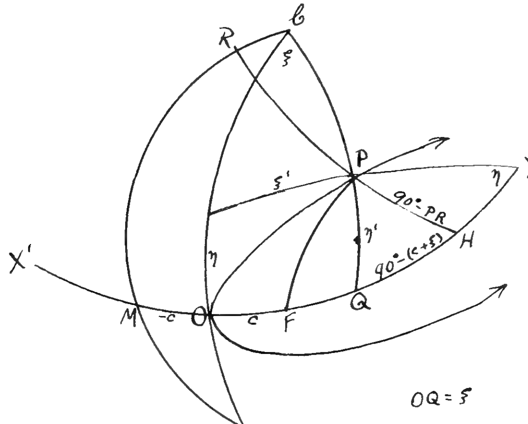


Fig 5

4. *The Spheric Hyperbola.* This spherical curve may be defined as *the locus of a point which moves so that the difference of its distances from two fixed points is constant,* $\rho - \rho' = 2\alpha$.

Using the notation of Fig. 4, but with $\rho - \rho' = 2\alpha$, this definition leads to the equation

$$\frac{\tan^2 \xi}{\tan^2 \alpha} - \frac{\tan^2 \eta}{\tan^2 \beta} = 1.$$

which is the spheric hyperbola. The locus does not intersect the OY-axis; the conjugate spheric hyperbola may be defined by

$$\frac{\tan^2 \xi}{\tan^2 \alpha} - \frac{\tan^2 \eta}{\tan^2 \beta} = -1,$$

and the spheric *asymptoles* to either by

$$\frac{\tan \xi}{\tan \alpha} = \pm \frac{\tan \eta}{\tan \beta}$$

5. *The Spheric Parabola.* A Spheric Parabola may be defined as *the locus of a point moving upon the surface of a sphere so as to be equally distant from a fixed point F and a fixed great circle CM, Fig. 5.*

From the definition PR = PF; let O bisect M F. Then from Fig. 5,

(1) $\tan \eta' = \cos \xi \tan \eta$,

(2) $\cos PH = \sin PR = \cos \eta' \sin (c + \xi)$,

(3) $\cos PF = \cos \eta' \cos (\xi - c)$.

Squaring and adding (2), (3)

$$1 = \cos^2\eta' \left\{\sin^2 (\xi + c) + \cos^2 (\xi - c)\right\},$$

or

$$1 + \tan^2\eta' = 1 + 4 \sin c \cos c \sin \xi \cos \xi.$$

Substituting from (1),

$$\tan^2\eta = 2 \sin 2c \tan \xi,$$

which is the required equation.

6. *Correspondence to Plane Geometry.* The above equations of the *spheric straight line, ellipse, hyperbola, parabola, and circle,* show a marked similarity to the corresponding equations in the plane. These equations may be reduced to the equations in plano by considering the radius of the sphere to increase without limit. This may be done by expressing the arcs in terms of the radius, and finding the limit of the functions in each equation as $r \doteq \infty$.

For example, in the spheric ellipse,

$$(1) \quad \frac{\tan^2 \xi}{\tan^2 \alpha} + \frac{\tan^2 \eta}{\tan^2 \beta} = 1,$$

let (ξ, η), (α, β) be radian measure of arcs on a unit sphere; then on a sphere of radius r, we have arcs (x, y), (a, b) determined by

$$\xi = \frac{x}{r}, \quad \eta = \frac{y}{r}, \quad \alpha = \frac{a}{r}, \quad \beta = \frac{b}{r}.$$

Equation (1) becomes

$$\frac{\tan^2\left\{\frac{x}{r}\right\}}{\tan^2\left\{\frac{a}{r}\right\}} + \frac{\tan^2\left\{\frac{y}{r}\right\}}{\tan^2\left\{\frac{b}{r}\right\}} = 1.$$

Expand the tangents into infinite series according to the law

$$\tan Z = Z + \frac{Z^3}{3} + \frac{2 Z^5}{15} + \frac{17 Z^7}{315} + \frac{\text{“7” exponent of Z,}}{}$$

and we find

$$\frac{\left\{\frac{x}{r} + \frac{x^3}{3 r^3} \ldots\right\}^2}{\left\{\frac{a}{r} + \frac{a^3}{3 r^3} \ldots\right\}^2} \quad \frac{\left\{\frac{y}{r} + \frac{y^3}{3 r^3} + \ldots\right\}^2}{\left\{\frac{b}{r} + \frac{b^3}{3 r^3} + \ldots\right\}^2} = 1.$$

Dividing r^2 from each fraction, and passing to the limit $r \doteq \infty$, and we have the equation of an ellipse in the plane.

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1.$$

Any equation in the “rectangular spheric” coördinates will reduce, in the limit when the sphere is made to increase infinitely, to the equation of a corresponding locus in the plane.

Some Notes on the Mechanism of Light and Heat Radiations.

James E. Weyant.

In all the realm of the natural sciences there has been no more fascinating and elusive problem than that relating to the mechanism involved in the transmission of light and heat. How energy may be transmitted at a distance; what action is involved at its source; what properties matter may possess that this may proceed over vast spaces; what atomic and molecular changes are involved in the emission and absorption of light and radiant heat, are all questions involving the ultimate structure of matter and are as yet incapable of complete solution.

Some of the familiar types of wave motion we observe in nature; for instance, wave motion in water; the transmission of sound waves through air, water and various solids are of such a character as to be easily reproduced under conditions whereby they can be accurately measured, their origin determined and their mode of propagation analyzed. In case of vibratory motion in matter capable of affecting the auditory nerve or in other words of producing sound, the mechanism is comparatively simple. As to source we have a material body, executing some form of simple harmonic motion; these vibrations being "handed on" to adjacent particles in a periodic disturbance or wave. This propagation stops, however, when the limit of matter has been reached, i. e., sound waves cannot traverse a vacuum. In all this process, matter has been concerned, both in the origin and the propagation of the wave motion. In light and heat waves, matter is concerned, also both in its production and absorption; but in its propagation they do not appear to depend in any way upon the presence of matter, as they pass readily through the best vacua and traverse the vast interstellar spaces with apparently the greatest ease.

Since we find that all radiations of light and heat energy originate in matter we must find the mechanism necessary for their production intimately involved in the constitution of matter itself. The kinetic theory served to give an incomplete mental picture of this mechanism and upon it was based many of the hypotheses of the past.

Various electrical and optical phenomena have been explained upon the ground of ether disturbances. These disturbances have been interpreted in different ways, but the consensus of opinion is to assign them to one of two kinds: first, magnetic and electro-static phenomena caused by strains in the ether and, second, based upon a dynamic disturbance; disturbances which can be propagated through the ether at the rate of three times ten to the tenth cm. per sec. (3×10^{10} cm.) These ether waves proceeding radially from the source carrying with them, not matter, in its old sense, but energy.

It is an established fact that all bodies emit radiant energy in some degree; the intensity of this radiation being dependent upon the character of the body, its surface peculiarities and upon its temperature. Kirchoff gave us a law which states a relation between the emissive and absorptive power of bodies, "that the ratio between the absorptive power and the emissive power is the same for all bodies at the same temperature and that the value of this ratio depends only on the temperature and the wave length." For a "black body" this ratio is considered unity in as much as it absorbs all the radiant energy which falls upon it. While we know of no substance which may be considered a "black body" in this sense, the radiations within a uniformly heated enclosure may be considered to approximate those emanating from a perfectly "black body."

Stefan's law takes us a step further and gives us a relative measure of the radiation of a black body emitted at different temperature. The law states that "the total energy radiated by a black body is directly proportional to the fourth power of the absolute temperature of the radiating body,"

i. e. $E = CT^4$ or $\frac{\Psi}{\Psi_o} = \left\{\frac{\Theta}{\Theta_o}\right\}^4$ whence $\frac{\Theta}{\Theta_o} = \frac{\lambda_o}{\lambda}$ or $\Theta\lambda$ = constant.

Observation shows that the color of a "black body" is a function of its temperature; for instance at 530° C. it glows with a dull red; at 1000° C. the red gives place to a yellow and when 1200° C. to 1250° C. has been reached it has grown white hot or incandescent. In the spectrum of a black body we find the distribution of energy to be dependent upon its temperature. Wien has shown "that as the temperature of the body rises that the peak of the energy curve is displaced towards the shorter wave length." While Wien's law and his proposed revision stated in his second law satisfied the conditions obtaining in a limited area of the visible spectrum it was found not to hold true with respect to facts relating to wave lengths lying in the region beyond the visible red. To satisfy these conditions Professor Max Planck proposed a modification as follows:

$$E = \frac{C \lambda^{-5}}{\varphi^{\frac{c}{\theta \lambda}} - 1}$$

C and c are constant.
where φ base of natural log.

As far as recent determinations have been carried out, this law holds true and gives practically a complete energy curve of a black body for desired temperatures. Not only did the statement of this law serve to reconcile purely theoretical conclusions with experimental determinations but paved the way for a more advanced step toward the explanation of the mechanism involved in radiation.

It is evident that we have yet to establish the connecting link between the thermal condition of a body and the radiant energy sent out into space by that body. If we go back to the theory developed by Maxwell we can easily see how this energy is propagated when once started in the ether. This theory clearly accounts for its speed, for interference and diffraction phenomena, but it apparently fails to closely associate thermal condition and the subsequent radiant energy. Planck found that this formula did not satisfactorily represent the relation existing between the frequency and the amount of energy involved, i. e. why, as a body grows hotter, does its color change from dull red to yellow and then white, unless there was some definite mathematical relation existing between the frequency and amount of energy given out by each vibratory particle. In an endeavor to determine this relation, Planck was led to advance the Quantum theory or hypothesis wherein he develops a type of function which apparently agrees with the facts better than any theories previously held. In doing this he has made a unique assumption, leaving the idea of the equi--partition of energy so necessary to the former theories, he has put forth the idea of the distribution of energy among the molecules of a substance through a mathematical consideration of probability. It is interesting to note in this connection that Planck states that the reason why no absolute proof of the second law of thermo-dynamics has ever been given is that it rests not on unchangeable mathematical relations, but upon mere probability or chance. Following out this idea he assumes that there may not be a steady, uniform flow of energy from a heated body, but that this may be propelled outward in quantities which are integral multiples of some fundamental unit of energy. This implies that energy is emitted from a body in some definite, finite unit and is closely related to his idea that the entropy of a body is a function of the probability of its present state.

Conceiving the emission of radiant energy as explosive in type and not continuous, Planck concludes that these energy units may not be necessarily of the same magnitude. When a system is vibrating with high frequency, a large amount or large unit of energy is associated with it, whereas one of low frequency gives out smaller quantities or units of energy, thus giving us an explanation why so little energy is found in one end of the spectrum. The fact that some bodies have low thermal capacities at low temperatures and that these increase with rise in temperature is indicative of the value of this theory. In this connection it is interesting to note that an explanation of the hydrogen lines in the spectrum has been proposed, based on the idea that no radiations take place except when one electron vibrating changes the form of its orbit, at which instant the energy change of the system is the same. Take the case of the line spectra; it has been asserted that the lines in the spectrum of hydrogen are due to various electronic vibration frequencies in the hydrogen atom, when the equilibrium of this atom has been disturbed; but when this electron is vibrating about the so-called positive core of the atom that we have an entire system in equilibrium. As long as these vibrations are regular no energy can be sent forth, inasmuch as by this, the equilibrium of the system would be disturbed. With this disturbance there would be a change in its vibration frequency and assuming the radiation emission to be continuous it follows that the frequency change will likewise be continuous; but this at once results in the destruction of the lines in the spectrum. An ingenious explanation of these hydrogen lines has been proposed based on Planck's Quantum theory. The electron is conceived of as vibrating about the central core in some form of a stable orbit, probably ellipical in shape. At the instant that one of these orbits changes form radiation will take place. At this instant the radiation will be of one frequency and the energy change will be represented by $E = hn$ where n is frequency of vibrations and h is the universal constant of radiation and is termed by Planck the "operating quantity."

The problem is a very complex one and has been approached from many angles. The Zeeman effect produced when a light and heat center is placed in a magnetic field offers additional evidence relative to the shifting of line spectra. It was found that the line spectra was materially changed when the center in question was placed in a strong magnetic field. Later this was shown to be related to the vibration of a negative charge of small magnitude, giving additional confirmation of the electron theory of radiation. We know that when a particle or particles of matter execute some form of simple harmonic motion with sufficient frequency that a note of definite pitch is produced. Why can not we carry the sound analogy over into the realm of electronic motion and conceive of one of these electrons executing some form of simple harmonic motion with, of course, some definite period, its frequency bearing some definite relation to its temperature, as proposed by Planck.

If the sound analogy referred to applies to combined waves of varying frequency and wave length so as to produce "spectral harmonics" to coin such a phrase, the center producing them must of necessity be very complex. Take for instance the fluorescent effects noted when the vapors of certain metals is examined; or the luminosity of a gas when a small portion of its molecular aggregate has been ionized. It has been found that when $\frac{1}{10,000,000}$ part of the molecules of a gas has been ionized that it becomes luminous. Likewise it has been observed that dissociation of some of the halogen group is accompanied by changes in its absorption spectrum. Many experiments also show that fluorescence and likewise phosphorescence are due to or accompanied by dissociation or ionization.

Considerable light has been shed upon this problem by the study of the emission of heat by radioactive substances. Curie and Laborde found in 1903 that the temperature of a radium compound was maintained by itself several degrees higher than its surroundings. It was found that radium emitted heat at a rate sufficient to more than melt its own weight of ice per hour. According to Rutherford the emission of heat from radioactive substances is a measure of energy of the radiation expelled from the active matter which are absorbed by itself and the surrounding envelope. This heating effect was supposed to be a measure of the kinetic energy of the expelled α particles; the heating effect was calculated by determining the kinetic energy of the α particles expelled from one gram of radium per second.

K.E. $= \frac{1}{2}$ mn ΣV^2 m = mass of particle.

n = no. emitted by each group per second.

v = the velocity of the different group of particles considering the energy of the recoil as equal and opposite that of the α particle, the energy of recoil of mass M is $\frac{1}{2}\frac{m}{M}MV^2$, therefore total energy is $\frac{1}{2}\ mn[1 + \frac{m}{M}]\ \Sigma V^2 + E$ where E is the energy of the β and λ rays absorbed under these conditions.

1.38×10^6 ergs per second corresponds to heat emission of 118 grams calories per hour.

Heating effect of emanations 94.5 calories per hour.

Observed values 94 calories per hour; calculated 94.5 calories per hour.

Rutherford and Robertson made an experimental determination to see how accurately this theoretical value harmonized with the experimental value and found a very close correspondence between the two values. This agreement led Rutherford to say that "there thus appears to be no doubt that the heat emissions of radium can be accounted for by taking into consideration the energy of the radiations absorbed." (The heat emitted is 2.44×10^9 calories per gram).

He gives an interesting comparison as to the amount of energy set free in the action accompanying the expulsion of the rays, as follows: "the heat emitted during the combination of 1 cc. of H and O to form H_2O is about 2 gram calories; the emanation during its successive transformations thus gives out more than ten million times as much energy as the combination of an equal volume of H and O to form water although the latter reaction is accompanied by a larger release of energy than that of any other known to chemistry."

Further, "the energy emitted by radioactive substances is manifest during the transformation of the atom and is derived from the initial energy of the atoms themselves. The enormous quantity of energy released during the transformation of active matter shows unmistakeably that the atoms themselves must contain a great store of internal energy;" "undoubtedly this is true of all but it is only perceived in the case of those which undergo atomic transformation."

Experiments conducted within the past three years at Munich in determining the interference effects produced by the passage of X-rays through crystalline substances have shown that X-rays possess many of the properties of light waves except in regard to their wave length, these being approximately 1/10000 the length of ultra-violet waves; these and the foregoing phenomena accompanying the ionization and dissociation of various gases; the disintegration of radioactive substances have given the champions of the undulatory theory of light some reason for alarm; the phenomena of interference was formerly considered as explainable only in the light of the wave theory, but the behavior of the X-rays when examined for interference effects in crystals seems to pave the way for a revision of this. Not only can the wave lengths of X-rays be measured by the method suggested but the atomic structure of the crystal itself is revealed and the motion of the atoms outlined. The imporatnce of this discovery in relation to thermal effects and heat emissions accompanying chemical reactions and rearrangements can hardly be overestimated.

As to the seriousness of the attempts to get at the ultimate constitution of light and heat centers and thereby gain a clearer knowledge of the mechanism of radiation, we have but to note the trend of thought as presented in recent papers read before the British Association for the Advancement of Science. At the recent Birmingham meeting of this association, a vigorous discussion arose as to the fundamentals involved in this question of radiation. At the meeting, J. H. Jeans, F. R. S., gave a very interesting and comprehensive summary of the facts relating to this fruitful topic; while he sets forth the new idea involved he retains faith in the truth of Maxwell's equations, but suggests that these equations can be made of more general application by the addition of the expression representing the unit quantities employed by Planck in his development. These quantities being respectively E and h. The magnitude of H has been determined to be 6.415×10^{-27} gm. cm./sec., an exceedingly small quantity. We might quote from Einstein in support of the quantum theory; he approached the problem from the standpoint of the theory of relativity. It may be necessary to revise our ideas of an all-pervading ether so essential to the working of the undulatory theory. We are just beginning to realize that we may have arrived at a point in our knowledge of light and heat centers where the wave theory fails to carry us any farther and that whereas it serves us well in explaining difficulties of elementary problems it does not carry us to an ultimate solution. We may conclude that as there are unmistakeable evidences derived from different sources that the undulatory theory fails to give satisfactory solution to many of the newer problems that have arisen. The additions which it must receive are in the region of photo-magnetic or photo-electric manifestations as evidenced by the Zeeman effect and the connection existing between ionization and light centers.

Perhaps some investigator in the field of electro-magnetic oscillations will be able some day to devise an oscillator of such frequency that not only will he be able to produce radiant heat but run the gamut of a photo-chromatic scale not of sounds and their overtones and harmonics but create for us the gorgeous colors of a sunrise or a sunset; or perhaps there may arise a counterpart of modern orchestral music executed not in a concord of harmonious sounds but of color, with shades and tints more marvelously beautiful than any the human mind has yet conceived.

A Standard for the Measurement of High Voltages.

C. Francis Harding.

Modern developments in the generation, transmission, distribution and utilization of electricity at high voltages have greatly outstripped the accurate measurement of such voltages. Those familiar with the very accurate standards and measurements of voltage, current and power at low potentials may be surprised to learn that the recognized standard for the determination of high voltages is the needle or sphere spark gap. In other words the voltage if measured simply by the distance that it will cause a spark to jump in air between needle points or spheres under specified conditions.

It is hardly necessary to point out that such a standard is readily affected by temperature, humidity and barometric changes, not to mention the presence of other conductors which may be in the immediate vicinity. It is therefore not readily reproducible and it is most difficult to make the two standards agree at 50 kilovolts at which voltage both should be accurate.

With these facts in mind, an attempt is being made in the electrical laboratories of Purdue University to develop a more satisfactory standard for the measurement of high voltages which is based upon the fundamental principles of the electrostatic field. Although many forms of electrostatic voltmeters have been developed in the past, in the endeavor to commercialize them and make them compact, the very uniform field upon which their accuracy depends has been sacrificed. No attempt has been made to make the standard voltmeter described herein portable or a thing of beauty, for it is believed that such qualities are quite subordinate in the consideration of a primary standard.

If a perfectly uniform electrostatic field is produced between two parallel metal plates it can be readily shown that the force action between such plates expressed in dynes is

$$P = \frac{AE^2K}{8\pi t^2}$$

where A = area of plate in square centimeters

E = potential expressed in electrostatic units

K = dielectric constant (unity for air)

t = distance between plates in centimeters.

The following relation exists, therefore, between the electro-motive force applied to the plates expressed in volts and the force in grams exerted between the plates.

$$E = 47098\,t\sqrt{\frac{P}{A}}$$

If the plates are made of very great area, it may be assumed that the electrostatic field at their center is uniform provided that the plates are not far apart.

In the apparatus constructed at Purdue University a circular disc of very small area was cut from the center of the lower horizontal plate and this disc was mounted upon a float supported in a tank filled with oil in such a manner that its surface is horizontal and concentric with the stationary plate but with its plane a small fraction of an inch below that of the stationary plate.

When an electromotive force is impressed upon the two stationary plates the movable disc is attracted by the upper plate and may be lifted into the plane of the lower plate by raising the voltage to the proper value. This condition can be readily detected by means of a telescope sighted along the surface of the lower stationary plate.

With the plates very near together, and a voltage sufficiently low to be readily standardized, the force necessary to raise the disc may be calculated from the above equation. If now an unknown high voltage be impressed upon the plates which have in the meantime been sufficiently separated to bring again the disc into alignment with the lower plate, the force will of course be the same as before and the new voltage may be determined by the relation $E^1 = \frac{t^1 E}{t}$ the voltages being directly proportional to the distances between plates.

Such a voltmeter has been constructed and the ratio of impressed voltages to distance between plates required for a balance has been found to follow surprisingly close to a straight-line law when a previously determined and constant value of force is used. Further studies are now being made to determine the range within which this apparatus may be considered standard for given dimensions of plates and further refinements are being made in its construction, method of reading, and calibration.

The writer is under obligation to Professor C. M. Smith for many helpful suggestions and to Messrs. Wright and Holman of the 1915 class in electrical engineering at Purdue University for the working out of details of design, construction and test.

Ionisation Standards.

Edwin Morrison.

It is very important under certain conditions in radioactive measurements to have an ionisation standard. (See Rutherford's Radioactive Substances and their Transformation, page 111, article 49.) It is also interesting and profitable for students to study the ionising effects of different thicknesses of radioactive substances. (See McClung's Conduction of ElectricityThrough Gases and Radioactive, page 131, article 86. Makower and Giger's Practical Measurements in Radioactivity, page 42, article 30, and Millikan and Milles' Electricity, Sound and Light, page 350, experiment 28.)

McCoy describes a method of making an ionisation standard in the Phil. Mag. May. XI page 176, 1906, and such a standard as determined by Geiger and Rutherford was found to emit 2.37×10^4 α particles per second per one gram of uranium oxide. (See Geiger and Rutherford, Phil. Mag. May. XX page 391, 1910.)

The following is a very convenient modification of McCoy's process of making such an ionisation standard and a method of preparation of material for student work. A brass rod 36 centimeters in length has a series of shelves

Fig. 1.

arranged spirally about it from bottom to top as shown in Fig. 1. These shelves are about four centimeters apart, and are designed to support small brass disks. The brass disks should each be accurately weighed and arranged in order upon the spiral shelves. Uranium oxide is carefully powdered in a morter and then thoroughly mixed with alcohol in a tall graduate or glass cylinder. The rod supporting the brass disks is next carefully lowered into the mixture of alcohol and uranium oxide. The uranium oxide settles to the bottom, and in doing so deposits a layer upon each disk, the thickness and amount of deposit depending upon the height of the shelf from the bottom.

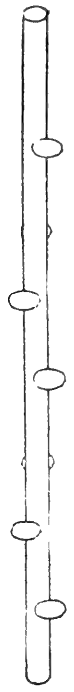


Fig. 1

After all the oxide has settled to the bottom the rod is removed and the disks allowed to dry. By again weighing the disks the weight of the oxide upon each one can be determined. Also by determining the density of the uranium oxide the thickness of the films can be calculated. These disks can now be mounted upon metal plates for permanent use as ionisation standards, or for student use in determining the fact that ionisation currents depend upon the thickness of the layer of material up to a certain maximum thickness.

A Simple Photographic Spectrometer.

Edwin Morrison.

Photographic spectrometers of several different types can be purchased from instrument makers. Attachments to convert ordinary prism spectrometers into photographic spectrometers can also be found upon the market. It is the purpose of this article to describe a method of constructing a simple photographic attachment for a prism spectrometer that can be constructed at slight expense in any well equipped laboratory.

Figure one shows a diagram of the camera attachment. The dimensions have to do with the one I have constructed, and would need to be modified to meet the conditions of available material. That is, the length and diam-

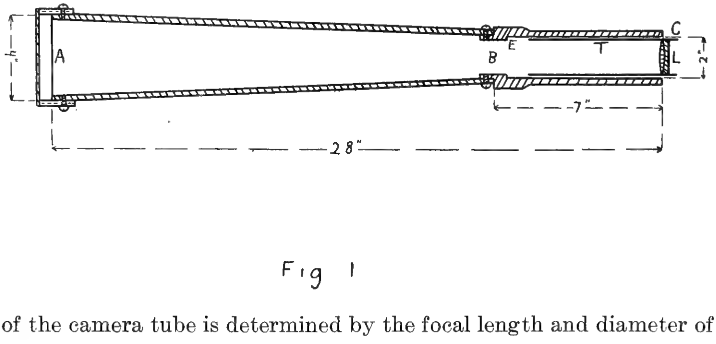


Fig 1

eter of the camera tube is determined by the focal length and diameter of the objective lense used. The figure is largely self explanatory. The section of the tube from C to B is constructed from a piece of wood 3x3x7 inches. A hole is bored lengthwise through this piece. From C to E this hole is 2 inches in diameter, and in order to shut out the stray light from around the focusing tube the remainder of the distance from E to B is 1¾ inches. A brass tube T, 2 inches in diameter is carefully fitted into the hole in this piece so that it can be slipped freely inward or outward for focusing purposes. At the outer end of this tube a 1¾-inch, 28 inches focal length, achromatic lense L is mounted. The tube from B to A is a tapering box, 2½ inches square at B and 4 inches square at A. This section is constructed from ⅜-inch lumber, the joints being carefully glued and reënforced by screws to make the box light tight. At A an attachment is arranged to hold a ground glass for focusing purposes, and a common camera plate holder for making the exposures.

The camera tube is mounted on a common prism spectrometer in place of the telescope as shown in Fig 2. The collimator slit, prism, and light source to be studied are adjusted in the usual way. When all adjustments, together

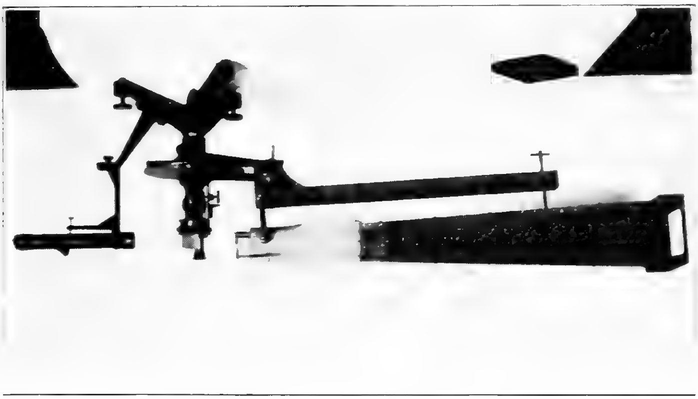


Fig. 2.

with focusing the objective lense of the camera, have been made, a clearly defined spectrum image, including the Fraunhofer lines, may be seen upon the ground glass. In the usual procedure a plate holder containing an unexposed plate may be substituted for the ground glass and the exposure made.

The instrument constructed in our laboratory has proven to be very successful for student work.

On the Relative Velocities of Sound Waves of Different Intensities.

Arthur L. Foley, Head of the Department of Physics, Indiana University,
Publication No. 42.

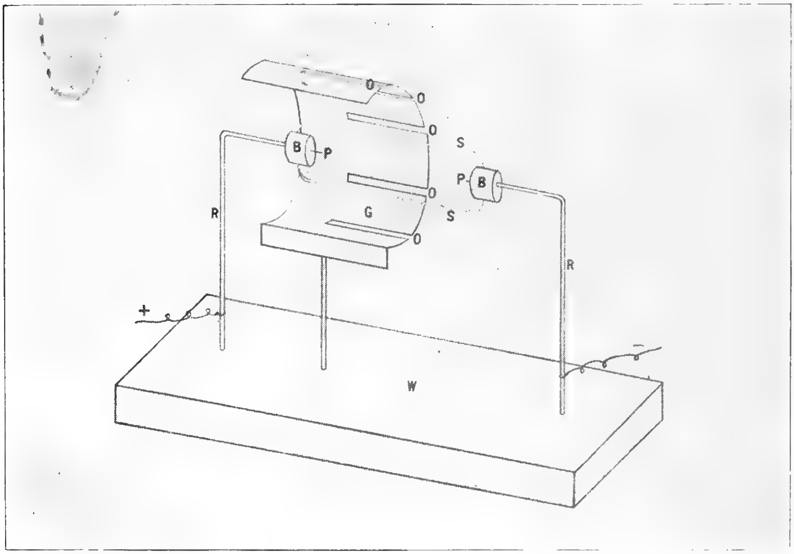
It appears that the first determination of the velocity of sound that can lay claim to any accuracy was made by Cassini, Maraldi, and LaCaille, of the Paris Academy, in 1738. By noting the time interval between seeing the flash of a cannon and hearing the report, with different distances between gun and experimenter, they arrived at the conclusion that the velocity of sound is independent of the intensity. This conclusion seems to have been accepted for more than a century. In 1864 Regnault determined the velocity of sound by firing guns reciprocally and using an electrical device for recording the instant of firing the gun and the arrival of the sound vave at the distant station. He found a small difference, about six parts in three thousand, in the velocities measured when the stations were 1,280 meters apart and when they were 2,445 meters apart, the former being the greater. The difference he attributed to the fact that the average intensity of the sound when the stations were nearest was much greater than when farthest apart, thus reaching the conclusion that the velocity of sound is a function of its intensity.

Regnault's conclusion accords with theory and with experimental results obtained by several later experimenters. Among these may be named Jacques at Watertown, Mass., 1879, who obtained velocities of 1,076 feet per second, and 1,267 feet per second, at points 20 feet and 80 feet respectively to the rear of a cannon fired with a charge of one and one-half pounds of powder. Wolfe and others have found varying velocities for explosion waves, a wave from an electric spark being of this nature. A fuller consideration of these experiments will be given when the writer has completed his experimental work on this subject.

The apparatus in use in this investigation, which is still in progress, is practically the same as described by the writer in a paper published three years ago under the title "A New Method of Photographing Sound Waves."[1] But three changes have been made in the apparatus there shown. One is the short-circuiting of the capacity by a high resistance and inductance to give better regulation of the time interval between the sound and illuminating

[1]Physical Review, Vol. XXXV, No. 5. Nov., 1912.

sparks, a method described elsewhere in these Proceedings. A second is a considerable increase in the two capacities, to obtain waves of greater intensity. A third is a modification of the sound gap, or rather a disposition of screens about the sound spark in order to obtain waves from the same spark of both great and small intensity. These waves are photographed on the same plate, enabling one to determine their relative velocities. A few of the results are given in this preliminary paper.

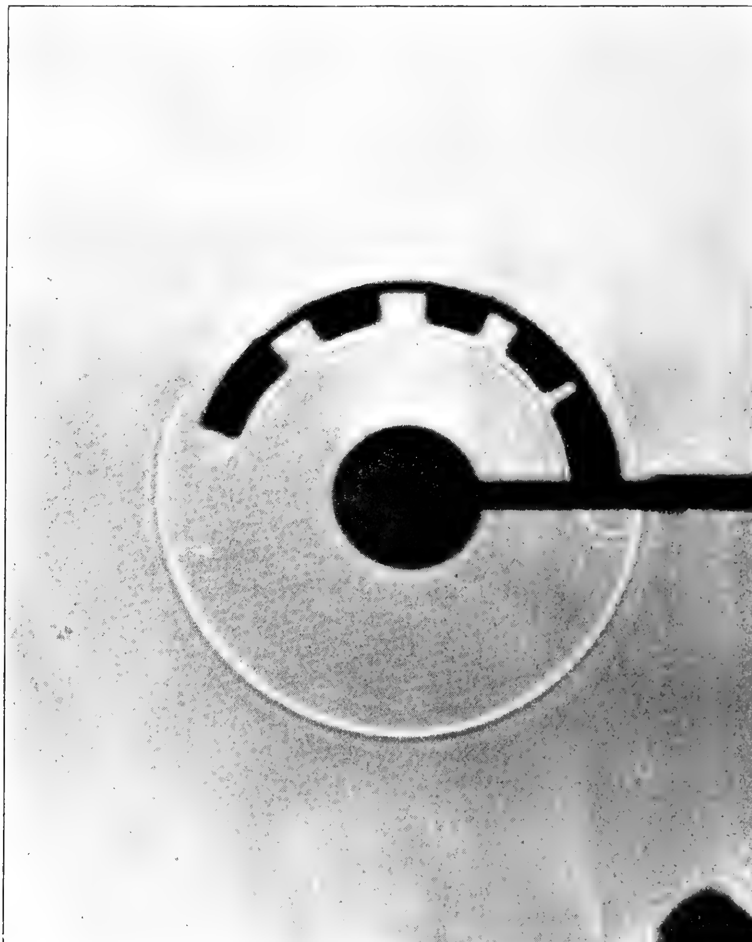


The details of the sound gap and screen are shown in Figure 31. A heavy spark is passed between the platinum terminals P-P. This produces a cylindrical sound wave shown in section at S, S. G is a cylindrical metal screen, which I shall call a grating, concentric with the spark axis, and having longitudinal slits or apertures O, O, cut in it, as shown in the figure, thus forming a sort of grating. The grating is so placed that it intercepts but one end, the left end in the figure, of the cylindrical wave, the right end or half spreading out the same as if the grating were not in use. I shall call this wave the main wave. Some of the energy of the left end of the wave is reflected by the grating, but some of it passes through the apertures which thus become sound sources, the waves spreading out in every direction from these sources. I shall call these waves wavelets.

The energy at any point in the wave front of the wavelets must be small compared to the energy at any point in the main wave, for two reasons. In the first place only a fraction of the energy of the original wave passes through the apertures. In the second place, what does get through spreads out to form the wavelets and thus greatly reduces the energy propagated in a particular direction. If the speed of propagation decreases with the energy of the sound wave, and, therefore, with the intensity, it would seem that our photographs should show two results: the velocity of a wavelet should be less than that of the main wave, and the wave front of a wavelet should not be circular, because the energy at a point in the wavelet falls off rapidly as the distance from the pole of the wave increases. One need not cite Stokes's law, for the pictures clearly indicate a variation in intensity along the front of the wavelets. Yet, taking into consideration the breadth of the apertures the wavelets are circular, showing that the velocity of the pole of the wave is not greater than the velocity tangent to the grating surface. Nor does the breadth of the aperture, and, therefore, the energy passing through, appear to make any difference in the velocity. It will be noted that the photographs show apertures of four different sizes.

The photographs show that the main wave and the poles of all the wavelets are tangent to one another, and since the wavelets are circular, that the velocity of the attenuated wavelet propagated tangent to the grating surface is not less than the velocity of the main wave of much greater intensity.

Physics Laboratory, Indiana University, December, 1915.

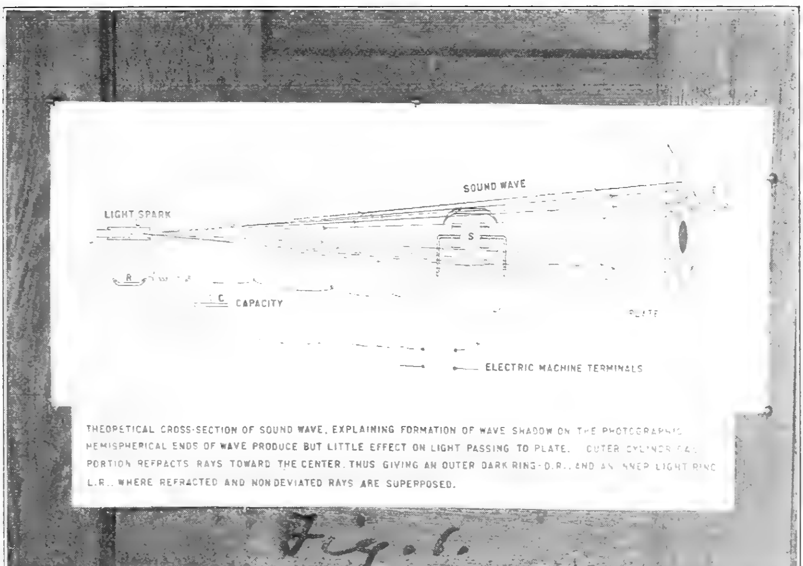


A Simple Method of Harmonizing Leyden Jar Discharges.

Arthur L. Foley, Head of the Department of Physics, Indiana University.

Publication No. 41.

In the photography of sound waves[1] one of the chief difficulties is to secure the proper time interval between the sound producing spark and the illuminating spark which pictures the wave. A spark gap is always apparently more or less erratic. When one places two gaps in series, Figure 1, and en-



deavors to adjust the condenser C to make the spark L, occur at a definite time after the spark S, he finds that the time interval is far from constant. The interval varies, not merely because of variations in the spark gaps themselves, but because of the charge remaining in the capacity C after a spark

[1]A New Method of Photographing Sound Waves. Physical Review, Vol. XXXV, No. 5, November, 1912.

has taken place. This spark is due to two causes. One is the tendency of the Leyden jars forming the capacity C to take on what is known as a residual charge. The other results from the oscillatory character of a Leyden jar discharge, the jars having a charge after each spark depending on the direction of the last oscillation. With a charge on the capacity C varying as to both sign and magnitude, one can not expect a constant time interval between the sparks L and S. In my later experiments I have been able to eliminate much of this trouble by short-circuiting the terminals of the capacity C through a high resistance R and an inductance I. The resistance R is merely a tube of water with wires passing through corks at either end of the tube. The inductance I is an electromagnet of about a thousand turns of wire. The result may be obtained with either a resistance or an inductance, if sufficiently large. Using both one can, without reducing the intensity of the illuminating spark, reduce the resistance R by shortening the water resistance until the jars discharge themselves completely very soon after every spark. Thus the condenser is brought into the same electrical condition before every spark and consequently the time required to charge it to sparking potential is made constant.

The arrangement here described does not completely eliminate all variations in the time interval between the sparks because much of the variation is due to change in the effective resistance of the spark gaps themselves, something the writer has been unable to control. The arrangement does, however, reduce the variation about 50 per cent.

Physics Laboratory, Indiana University; November, 1915.

An Electroscope for Measuring the Radioactivity Soils.

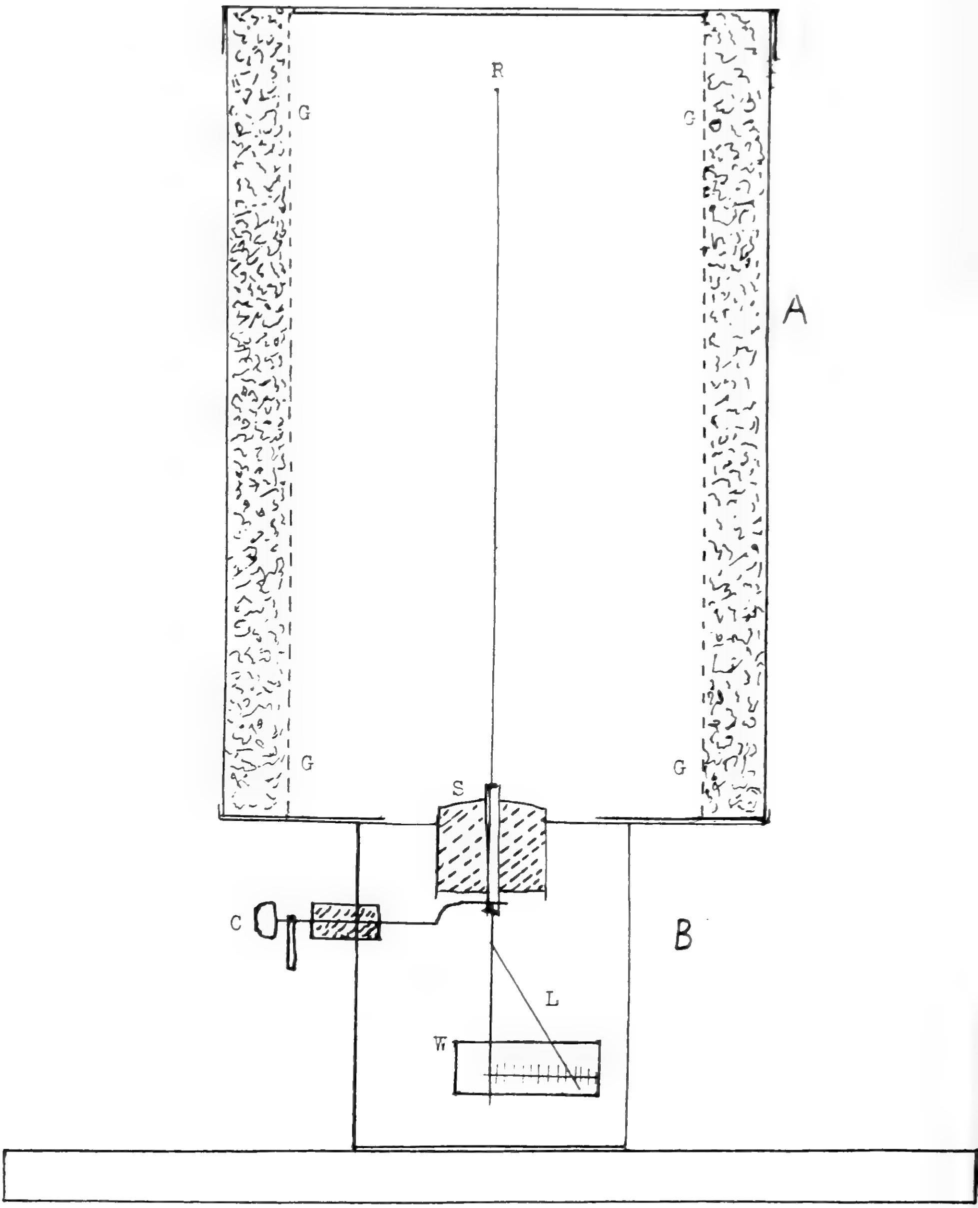
By R. R. Ramsey.

In measuring the radioactivity of soils if extreme accuracy is desired it is necessary to dissolve the sample and then determine the amount of radium or thorium by means of the emanation method. The getting the sample in solution is a long tedious process. For a description of this method I shall refer to Joly's Radioactivity and Geology.

For an approximate determination of the radioactivity one can use an α ray electroscope provided that the sample is fairly active. The standard being uranium oxide, U_3O_8, a "thick" layer, one gram to 10 square centimeters say, gives a current of 5.8×10^{-13} amperes or 17.4×10^{-4} E.S.U. per square centimeter surface if the plates of the electroscope are 4 cm. or more apart. The amount of radium in the oxide may be determined by dissolving it and then determining the amount of emanation in the solution after it has stood 30 days. The sample is placed in the α ray electroscope and compared with the uranium oxide. It will be evident that an assumption is made here that the absorption coefficient of all samples for α rays is the same as the absorption coefficient of uranium oxide for α rays. This assumption is only approximately true.

The radioactivity of soil is very slight and in order to get an appreciable current a large area must be exposed. This necessitates large plates in the ordinary form of α ray electroscope. The large plates increases the capacity of the electroscope and thus diminishes the sensitiveness of the electroscope. Instead of an ionization chamber with plates I have hit upon the plan of using a cylindrical chamber with a central rod. The material to be tested is packed between the wall of the cylinder and an inside cylinder made of wire gauze. The space between the two walls is made as small as the ease of filling will permit. One or two centimeters, say.

In this form of electroscope the amount of surface exposed can be increased at will by increasing the size of the cylinder, and as the diameter of the cylinder is increased the capacity is decreased. Thus the sensitiveness of the electroscope is increased in two ways as the ionization chamber is increased; by increasing the surface exposed and by decreasing the capacity of the instru-



Soil Electroscope.

ment. The size of the chamber will be limited only by the potential of the central rod. The potential must be at least the saturation potential, that is the potential must be great enough to pull out the ions as fast as they are formed. With the usual potential, about 300 volts, the diameter may be made 15 or 20 centimeters. The height may be made as great as is convenient to use.

The general plan of the instrument is shown in the figure. A, is the ionization chamber, B, is the chamber containing the gold leaf. L, is the leaf, W, is the window through which the leaf is read on the scale. C, is the charging system. S, is the sulphur plug and R, is the central rod. For a more detailed description of the method of making and reading an electroscope I will refer to my paper on The Radioactivity of Spring Water. (Ind. Acad. Proc. 1914.)

The top of the chamber, B, has a disc with a flange fastened to it. The diameter of this disc is such as to fit the ionization chamber. The lower end of the chamber, A, is closed and a hole is cut large enough to let the sulphur plug, S, pass. The gause cylinder, G, is soldered to a disc which will fit the inside of the large cylinder and pass the plug, S. A disc of diameter of the gause cylinder is soldered in the top. A lid fits over the top of the large cylinder.

To fill in the material to be tested the chamber A, is removed from off the chamber B, the gause cylinder is placed inside and the material is packed lightly between the two walls. The lid is placed on and the chamber A, is placed on the chamber B.

Correction must be made for the absorption of α rays by the gause. This can be determined by getting the ionization current of uranium nitrate when free and when covered with a sample of the gause, using an ordinary α ray electroscope.

Or the electroscope may be calibrated by filling in a material of known activity between the gause and the outside cylinder. Or uranium nitrate may be mixed with an inactive substance in known proportions and placed in the electroscope.

In testing soils the sample should be allowed to dry for a few days as fresh damp soil contains a large amount of radium emanation which has come up from the lower material.

Indiana University, December 1, 1915.

The Cause of the Variation of the Emanation Content of Spring Water.

By R. R. Ramsey.

Last year at the annual meeting of this Society I presented a paper on "Radioactivity of Spring Water" in which I called attention to the fact that there was a variation of the radioactivity from time to time. During nine months of the past year I have measured the emanation content of two springs once every week. In a short time I discovered that there was a connection between the radioactivity and the flow of the springs. The flow of one of the springs was measured every week during six months.

The springs are about 1.3 miles apart. One isuses out of coarse graval the other issues from a crevice in the solid rock. Both springs are known as never failing springs, however the flow of both are affected by the rain fall. They both vary in the same manner but not to the same degree. The variation of the Ill. Cent. spring, the one measured, is much more then the Hottle spring. The method of measuring the flow was by means of a horizontal weir, the depth being measured and computed according to the usual formula.

The radioctivity was measured by means of the [1]Schmidt shaking method and an emanation electroscope. The electroscope was standardized by means of an emanation standard secured from the Bureau of Standards. The Schmidt shaking method can be carried out at the spring. The accuracy of the method when the measurements are made at the spring in 15 to 30 minutes is about 5 per cent. The observations for the nine months are shown in the table I. The date of observation, the temperature, the flow in gallons per day, and the emanation content of the water is given for each spring.

It will be noted that the radioactivity of the Hottle spring is higher and more constant than the Ill. Cent. spring. In the same manner the flow of the Hottle spring is more constant than the Ill. Cent. spring but it is not always greater than the Ill. Cent. It will be noted that the fluctuations of the radioactivity are in the same general manner for both springs.

This is better shown by means of curves Figure II. The full lines are for the radioactivity the dotted line is for the flow. The curves have a general

[1]Indiana Academy of Science Proceedings, 1914.

fall towards low values and then a rather sudden rise. An increase in flow is accompanied by an increase in radioactivity.

The increase of flow follows the melting of a heavy snow or a heavy rain. Thus the radioactivity of the spring depends upon the rain fall. The radioactivity of rain water is very small compared to the values obtained at the springs. It can not be due to the radioactivity of rain water.

The above results, together with the fact that "wet weather" springs are very radioactive and that one on the campus of Indiana University measured 1920 $x10^{-12}$ a short time after a heavy rain fall, lead to the conclusion that the variation of the emanation content of Indiana springs is due to the rain water percolating through the soil and dissolving and carrying down with it some of the emanation which is continually moving upwards from the interior of the earth to the surface. During dry weather when the flow of the water is not rapid a large per cent of the emanation which was dissolved in the water is transformed into radium A, B, C, and D before the water issues from the ground.

This conclusion is in accord with the observations of Wright & Smith (Phys. Rev. Vol. 5, p. 459, 1915) in which they find that the amount of emanation which issues from the soil is decreased as much as 50 per cent at times after heavy rains.

To recapitulate, the variation of the emanation content of spring water is due to the rain water dissolving emanation as it percolates through the soil.

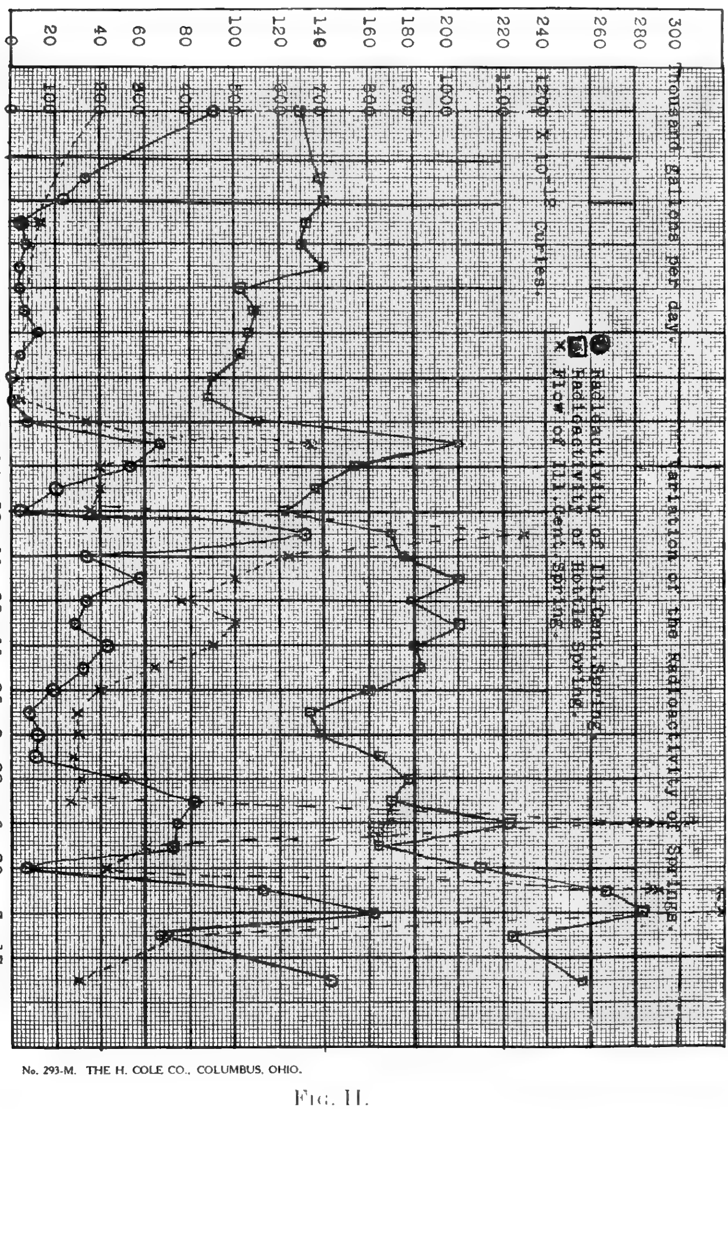
Department of Physics, Indiana University, December 1, 1915.

TABLE I.

Variation of the Emanation Content of Certain Springs near Bloomington Indiana. (Flow given in gallons per day.)

Date.	Hottle Spring. Temp C. °	Hottle Spring. Flow.	Hottle Spring. Curies per Liter.	Illinois Central Spring. Temp. C. °	Illinois Central Spring. Flow.	Illinois Central Spring. Curies per Liter.
1914.						
Sept. 24........	13		$650x10^{-12}$			$445x10^{-12}$
Oct. 16........	13		695	12.8		166
Oct. 23........	13.3		700	13		120
Oct. 30........	13	10000	665	12.7	130000	20
Nov. 6........	13		650	12.6		40

Date.	Hottle Spring. Temp. C.	Flow.	Curies per Liter.	Illinois Central Spring. Temp. C.	Flow.	Curies per Liter.
Nov. 13	13		705	13		20
Nov. 20	13		520	13		20
Nov. 26	13		550	13		30
Dec. 3	13		535	13		60
Dec. 11	13		510	13		20
Dec. 18			450	13		00
Dec. 26	13		445	12.8	5000	00
1915.						
Jan. 1		20000	560		32000	40
Jan. 7	12.6		1020	12	136000	340
Jan. 14	13		770	13	39500	272
Jan. 21	13		680	12.8	40000	100
Jan. 18	12		610	12	32000	20
Feb. 4	12	62000	850	12	250000	750
Feb. 11	12		875	12.6	123000	166
Feb. 18	11.8		915	12	100000	350
Feb. 25	11.3		890	12	75000	170
Mar. 5	11.5		1010	12	100000	143
Mar. 11	11.5		900	12	85000	220
Mar. 18	11.3		920	12	62500	160
Mar. 25	11.3		800	12	40000	90
April 1	11		670	12	30000	45
April 8	11.3		690	12	30000	30
April 15			830	12	28000	60
April 22	12		890	12	30000	6
April 28			750	12.2	25000	410
May 7	11.4		1140	12	410000	365
May 13	11.9		825	12.4	60000	365
May 21	11		1050	12.3	42000	25
May 27	12		1340	12	500000	750
June 3	11.6		1420	12	400000	820
June 10	11.8		1120	12	76000	355
June 25	12		1280	12.5	30000	715



No. 293-M. THE H. COLE CO., COLUMBUS, OHIO.

FIG. 11.

A Standard Condenser of Small Capacity.

By R. R. Ramsey.

In radioactive measurements of substances which are very feebly radioactive it is necessary to have an electroscope which is very sensitive. One of the conditions to obtain this result is, the electroscope must have a very small capacity. A capacity of one to ten centimeters. A sphere has a capacity equal to its radius when far removed from other objects but when brought near to the electroscope its capacity changes to a value which depends upon the position, size and shape of the electroscope.

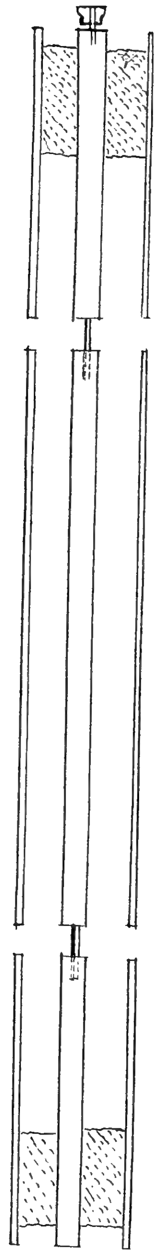
It is customary to use a cylindrical condenser. The capacity of a cylindrical condenser is

$$C = \frac{L}{2 \log_e R_1/R_2}$$

where C is the capacity; L is the length; R_1 is the inside radius of the outside cylinder; R_2 is the radius of the inside cylinder. This formula gives the capacity if the effect of the ends can be neglected. This requires that the length should be great compared to the difference of the two radii. When these conditions are met the capacity will be 100 cm. or more.

In order to correct for the end effects I have made a condenser in three sections, the construction of which is illustrated in the cross sectional drawing. The middle cylinder is made of a brass rod about 9 millimeters in diameter. The outside cylinder is made of brass tubing whose inside diameter is about 3.6 cm. The diameters are chosen large in order that the accuracy of measurement may be great. The ratio of the diameters is made large in order that the capacity per unit length may be small.

The length of the end sections is 10 cm. The length of the middle section is 20 cm. The middle rod is held in place in the end sections by means of sulphur. This was accomplished by means of two wooden discs which were accurately turned to fit in the ends of the large cylinder and hold the middle rod in the center. These discs were placed in the ends of the end sections. The end section was stood upon the outside end and melted sulphur was poured through a hole in the top disc until the cylinder was about one-third filled. The discs were removed after the sulphur had hardened. Dowel pins are placed on the middle rod to hold the middle section in place.



Standard Condenser.

The capacity of the middle section is calculated by the formula. The electroscope is charged to a potential V_1. The charge on the electroscope is divided with the condenser, all sections being used.

If C_1 is the capacity of the electroscope.

C_2 is the capacity of the end sections.

C_3 is the capacity of the middle section.

V_1 is the initial potential.

V_2 is the final potential.

then since

$$Q = C_1V_1 = (C_1 + C_2 + C_3)V_2$$

$$V_1/V_2 = (C_1 + C_2 + C_3)/C_1 = r_1$$

The electroscope is again charged to a potential V'_1. The charge is again divided with the condenser, the end sections being used.

Then we have

$$V'_1/V'_2 = (C_1 + C_2)/C_1 = r_2$$

combining the two equations involving r_1 and r_2 we get

$$C_1 = C_3/(r_1 - r_2)$$

In case that one has a steady ionization current as in the case of radium emanation in an emanation electroscope after three or four hours, one can allow the electroscope to discharge through a certain potential difference, dV, first with the electroscope alone, then with the ends of the condenser connected to the electroscope, and then with the entire condenser connected. Since $i = C\ dV/t$ and dV is constant, we have,

$$C_1/t_1 = (C_1 + C_2)/t_2 = (C_1 + C_2 + C_3)/t_3 = C_3/(t_3 - t_2)$$

Care must be taken to see that the current is constant during the observations. If the current is due to β or γ rays there is danger of the air inside of the condenser being ionized and thus producing a variable current.

The capacity of the middle section of the condenser which I have is 8.06 cm. The capacity of the end sections is found by experiment to be about 17 cm. Thus, since the combined length of the ends is the same as the middle section, the end effects plus the dielectric effect of the sulphur is about 9 cm.

Department of Physics, Indiana University, December 1, 1915.

Rate of Humification of Manures.

R. H. Carr.

It has been recognized for a long time that organic matter is an important constituent of the soil, but as to just what way it aids in crop production, there seems to be considerable difference of opinion. Some maintain that it is valuable only for the plant food it carries, while others value it more especially for the plant food in the soil which may be made available by its decomposition. The following paragraph from the Iowa Station, found in the September, 1915, Journal of the American Chemical Society expresses the sentiment of many soil investigators as to the value of humus, and the rate of humification. "The organic matter extracted by alkali is of no very different character than the organic matter of the soils as a whole. This together with the fact proved by Fraps and Hammer, Texas Bul. 129, that upon adding organic matter to soil, at the end of a years time there is no more material extracted with diluted ammonia than at the beginning of the period, proves quite conclusively that the determination of the amount of humus as found by the various methods is of no particular value in the study of a soil." This statement seems rather unreasonable to the author of this article, since the elements that are of value as fertilizers are locked up in most farm manures, green manures, cotton seed meal, etc., as complex compounds and hence are unavailable to the growing plant which must have its food supplied in a very simple form. In well rotted manures these complex molecules are largely broken down to simpler substances containing the same elements, but with a different arrangement in the molecule. They are quite soluble in water and if not leached by rains are very effective as a fertilizer compared with fresh manure.

Therefore, since fertility is so closely related to the unlocking of these complex plant molecules in the manures, an effort was made to measure the rate of humification of the more common ones.

Plan of Procedure.

A clay soil was chosen that was very deficient in organic matter and was, therefore, humus-hungry. With this soil were mixed different manures so that each double box, holding about 1 cubic foot, contained the same amount of organic matter. The contents of the boxes were as follows:

TABLE I.

Box 1 contained 2 lbs. hen manure + 50 gr. $CaCO_3$.
Box 2 contained 3.2 lbs. sheep manure.
Box 3 contained 2.4 lbs. hog manure.
Box 4 contained 3.0 lbs. horse manure.
Box 5 contained 6.6 lbs. steer manure + 50 gr. $CaCO_3$.
Box 6 contained 6.0 lbs. cow manure + 50 gr. $CaCO_3$.
Box 7 contained 4.0 lbs. horse manure + 101 gr. CaO, MgO.
Box 8 contained 4.0 lbs. horse manure + 171 gr. CaO.
Box 9 contained 4.0 lbs. horse manure + 179 $CaCO_3$, $MgCO_2$.
Box 10 contained 4.0 lbs. horse manure + 175 gr. $CaCO_3$.
Box 11 contained no treatment.

On May 30, 1914, the manure, limestone and soil were well mixed and the boxes were placed in the ground out of doors in order to approximate field conditions. At the same time samples of the mixed soil were taken for humus determinations. Other samples were taken on the following dates: November 25, 1914; February 16, 1915, after winter freeze; April 13, 1915, after a period of quite warm weather; June 1, 1915, October 15 and November 22, 1915.

Humus Determination.

Effort was made to follow the course of changes brought about by bacteria and the weathering agencies, etc., by determining the amount of humus present at the various periods. The term *humus*, as used by American soil investigators, does not refer to the total organic matter present in a soil, but only to that which is soluble in 4 per cent NH_4OH, the calcium and magnesium having been removed. The Official Method as modified by Smith was used in all the determinations. The following tables give averages for the different periods:

TABLE II.

GRAMS OF HUMUS AND ASH IN 1 GRAM SOIL.

	Hen + 50 $CaCO_3$ 1		Sheep + 50 $CaCO_3$ 2		Pig + 50 $CaCO_3$ 3		Horse + 50 $CaCO_3$ 4		Steer + 50 $CaCO_3$ 5		Cow + 50 $CaCO_3$ 6	
	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.
Soils, manures unexposed.	.0057	.0083	.0068	.0080	.0051	.0088	.0058	.0087	.0092	.0076	.0079	.0087
May 30-Feb. 16	.0069	.0080	.0078	.0065	.0081	.0060	.0061	.0065	.0093	.0076	.0092	.0074
Feb. 16-April 13	.0073	.0112	.0072	0.100	.0083	.0107	.0063	.0101	.0094	.0100	.0096	.0115
April 13-June 1	.0078	.0096	.0066	.0096	.0073	.0096	.0068	.0088	.0097	.0098	.0097	.0102
June 1-Oct. 15	.0071	.0073	.0075	.0087	.0064	.0083	.0089	.0080	.0092	.0094	.0091	.0086
Oct. 15-Nov. 22												
Check	.0049	.0097					No treatment.					

TABLE 3.

	Horse — 101 CaO. MgO 7		Horse — 171 CaO 8		Horse — 179 $CaCO_3$. $MgCO_3$ 9		Horse — 175 $CaCO_3$ 10	
	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.	Humus.	Ash.
Soil, manure unexposed...	.0055	.0085	.0048	.0078	.0055	.0075	.0055	.0072
May 30 to Feb. 16.......	.0064	.0084	.0051	.0065	.0067	.0087	.0051	.0065
Feb. 16 to April 13.......	.0070	.0090	.0061	.0096	.0066	.0099	.0061	.0103
April 13 to June 1........	.0072	.0094	.0058	.0093	.0123	.0062	.0069	.0096
June 1 to Oct. 15.........	.0090	.0072	.0081	.0083	.0093	.0087	.0074	.0090
Oct. 15 to Nov. 22.......	......	......	......	......	......	......	......	......
Check..................	.0049	.0097			No treatment			

TABLE 4.

PERCENT OF INCREASE OR DECREASE IN HUMUS.

Hen. 1	Sheep. 2	Pig. 3	Horse. 4	Steer. 5	Cow. 6	
.08	.20	.02	.09	.43	.30	NH_4OH soluble humus—before exposure. Over check.
.12	.09	.30	.03	.01	.13	May 30 to Feb. 16.
.04	—.06	.02	.02	.01	.04	Feb. 16 to April 13.
.05	—.06	—.10	.05	.03	.01	April 13 to June 1.
—.07	......	—.09	.15	—.05	—.06	June 1 to Oct. 15.
......	..			......	......	Oct. 15 to Nov. 22.
601 9	443	1174	165 9	928	620 9	Grams of corn and stalks produced 1915
456	401	281	222	260	249	produced 1916

TABLE 5.

PERCENT OF INCREASE OR DECREASE IN HUMUS.

Horse 7 CaO, MgO	Horse 8 CaO	Horse 9 $CaCO_3$, $MgCO_3$	Horse 10 $CaCO_3$	
.06	—.01	.06	.06	NH_4OH soluble humus before exposure. Over check.
.09	.03	.12	—.04	May 30 to Feb. 16.
.06	.10	—.01	.10	Feb. 16 to April 13.
.02	—.03	.57	.04	April 13 to June 1.
.18	.23	—.30	.05	June 1 to Oct. 15.
....	....	....	....	Oct. 15 to Nov. 22.
123.1	46.6	637.6	386	Grams of corn and stalks produced 1915
308	392	347	320	produced 1916
Check box 145.4....	....	....	....	Grams of corn and stalks produced 1915
151......	....	....	....	produced 1916

It will be noticed in Table 4 that fresh steer manure is quite soluble in NH_4OH and the solubility is not increased appreciably on exposure in the soil. The same is true to a large extent of cow manure, but less of pig manure while horse manure is only broken down after about 12 to 18 months' exposure, except in the case of Box 9 which was treated with dolomitic limestone. It will also be noticed in Table 5 that when the acidity was corrected with 171 grams of CaO in Box 8 and 101 grams of CaO, MgO in Box 7, the rate of humification was retarded—the CaO and CaO, MgO both having an antiseptic action when more is added than is needed to correct the soil acidity. Chemically equivalent amounts of Ca and Mg (in neutralizing power) were added to Boxes 7, 9 and 10. It would seem that the growth of corn obtained in Box 9 was due to the early humifying of the manure (June 1). While in Boxes 4, 7 and 8 the humification came too late to benefit this year's crop. The yields in Boxes 3 and 5 were the largest of all but it is probable that the higher nitrogen content was the main cause.

Conclusions.

1. Growth of corn, other factors being constant, seems to be proportional to the rate of humification of manures.

2. The ammonia soluble matter in cow and steer manure is not appreciably increased on 18 months' exposure, but hog, sheep and horse manure humify less rapidly and in the order named.

The Food of Nestling Birds.

Howard E. Enders and Will Scott.

The surprisingly rapid growth of fledgling birds is a matter of common observation but the activities of the parents in the collection of food and the care of the young is scarcely realized by persons who have not carried on observations throughout the whole of a bird's working-day.

It has been the practice of the authors, each summer, for a period of years,* to assign students in groups of four to the work of observing the activities of birds and their fledgling young from dawn until nightfall. The work was carried on in relays such that two persons were at the nest at all times, one to make the observations at close range with the aid of field-glasses, and the other to make the notes. By this method it was possible to observe, time and note in considerable detail, the activities of the birds, also the character and number of pieces of food brought at each trip to the nest.

Observations, many in duplicate, have thus been made upon seventeen different species of the birds common to Winona Lake, Indiana. In the several instances, the birds were under observation for a period of several consecutive days, and we have reason to believe, without markedly modifying their activities after the first hour or two.

The object of the present paper is to indicate the nature, quality and *quantity* of food brought to the young throughout a bird's full working-day. A transcript of a single example is given in full while others are given in summaries to indicate the number of feeds, number of pieces. Both "soft" and "hard" food are fed to the young birds in proportions which change somewhat with the age of the nestlings.

It is contended that the stomach contents afford the only accurate and reliable method of study of the food of birds. We believe that this method is not applicable to the food of nestling birds for two reasons: first, the food is soft and not readily identifiable; and the second and more important reason is that the food is digested very rapidly. The stomach contents do not serve as a criterion of the *quantity* of food that is eaten in the course of a day.

*Biological Station of Indiana University at Winona Lake, Ind.

Observations on the Brown Thrasher.

Toxostoma rufum.

There were four young in the nest. They remained in the same position throughout the day and were, therefore, indicated $\left(\frac{1-2}{3-4}\right)$. The nest was on the ground in a clump of weeds. The day was bright, warm and calm.

4:00 A. M. Parents off the nest.
25 Female fed (unidentified)—cleaned the nest.
26 Male fed (unidentified).
39 Male fed apparently a caterpillar.
55 Male and female fed apparently caterpillars.
57 Male fed caterpiller.
59 Male fed (unidentified)—brooded until 5:11.
(7 feeds during the hour.)

5:27 Female and male fed—earthworm.
27 to :40 female brooded.
40 Male fed—earthworm.
45 Female fed—earthworm.
47 Male fed (unidentified.)
(5 feeds during the hour.)

6:05 Male fed.
6:05 Male fed.*
06 Female fed.
09 Female fed.
17 Male fed—earthworm.
17 to :40 the male brooded.
40 Female fed and carried away excrement.
50 Female fed.
50 to :53 the female brooded.
55 Male fed and carried away excrement.
(7 feeds during the hour.)

7:03 Male fed—brooded till :26.
26 Female fed.

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*Food not identified where name is not given.

30 Female and male fed insects.
37 Female fed.
38 Female fed—caterpiller.
44 Male fed—brooded till :56.
56 Female fed and carried away excrement.
(8 feeds during the hour.)

8:01 Female fed.
12 Male fed—worms.
14 Female fed—worms.
15 Male fed—worms.
24 Male fed—large green larva.
26 Female fed.
28 Male fed.
32 Female fed and brooded till :53.
53 Male fed—insects and brooded till :58.
58 Female fed—caterpillar.
59 Male fed—caterpillar.
(11 feeds during the hour.)

9:08 Female fed—caterpillar.
09 Male fed—caterpillar.
18 Female fed—worm.
20 Male fed—worm.
25 Female fed—grasshopper, and brooded till :47.
52 Male fed and brooded till 10:19.
(6 feeds during the hour.)

10:19 to 10:29 the nest was vacant.
29 Male fed—caterpillar.
30 Female fed—insect.
33 Female fed—dragonfly.
33 Male fed—worm.
36 Female fed—worm.
42 Female fed—cutworm.
53 Male fed—cutworm and ate the excrement.
59 Male fed—cutworm and ate the excrement.
(8 feeds during the hour.)

11:02 Female fed—worm and beetle—carried away excrement.
03 Male fed—cutworm.
05 Male fed—dragonfly.
14 Male fed—caterpillar.
20 Female fed—caterpillar.
27 Male fed—caterpillar to bird No. 3.
33 Female fed—caterpillar to bird No. 1.
34 Male fed—caterpillar to bird No. 2, and brooded till :39.
43 Female fed—caterpillar to bird No. 2.
44 Male fed—caterpillar to bird No. 2.
47 Male fed—caterpillar to bird No. 2—ate excrement.
52 Female fed—caterpillar to bird No. 3.
53 Male fed—2 insects to bird No. 1.
58 Female fed—caterpillar to bird No. 4.
58 Male fed—caterpillar to bird No. 4.
(15 feeds during the hour.)

12:04 Male came but did not feed—brooded till :11.
12 Female fed—caterpillar to No. 1.
21 Male fed—caterpillar to No. 2 brooded till :30.
30 Female fed—cut-worm to No. 1.
40 Male fed green larvae to No. 2 and No. 3.
40 to :45, the nest was vacated.
45 Female fed larvae to No. 3 and No. 4, and ate excrement.
46 Chased blackbirds away from the tree; flicker and other birds.
48 Male fed—dragonfly to No. 2.
(6 feeds during the hour.)

1:00 Female fed—dragonfly to No. 2.
08 Male fed—larvae to No. 1 and No. 3—carried away excrement.
09 Female fed—larvae to No. 2.
11 Female fed—larvae to No. 2.
16 Female fed—larvae to No. 3.
21 Female fed—cut-worm to No. 2.
25 Female fed—cut-worm to No. 4.
29 Male fed—cut-worm to No. 3 and No. 4.
43 Female fed—cutworm to No. 2.
44 Male fed—larva to No. 2.

47 Male fed—larva to No. 3.

50 Male fed—larva.

51 Male fed—larva.

58 Male fed—larva.

(14 feeds during the hour.)

2:02 Female fed—larva to No. 1.

14 Male fed—larva to No. 2.

14 Female fed—larvae to No. 1 and No. 3.

23 Female fed—beetle to No. 4.

24 Male fed—beetle to No. 3 and No. 4.

24 Female fed—to No. 1 and No. 2.

37 Male fed—larva to No. 4—ate the excrement.

40 to :45 male brooded, and ate the excrement.

45 Male fed—larva to No. 4.

46 Female fed—larva to No. 3.

51 Male fed—larva to No. 1.

54 Female fed—larva to No. 1.

57 Female fed—beetle to No. 1.

58 Female fed—cut-worm to No. 2.

(13 feeds during the hour.)

3:00 Female fed—cut-worm to No. 2, No. 3, and No. 4.

05 Female fed—cut-worm to No. 3 and ate the excrement.

10 Male fed insect to No. 1.

15 to :25 Male fed—cut-worm, rested, ate excrement.

26 Male fed—insect to No. 2.

28 Male fed—2 insects to No. 4.

37 Female fed—to No. 3, and ate excrement.

38 Male fed—to No. 2, and ate excrement.

51 Male fed—cut-worm to No. 2.

52 Female fed—cut-worm to No. 1.

56 Female fed—cut-worm to No. 4.

57 Female fed—cut-worm to No. 3 and No. 4.

(12 feeds during the hour.)

4:01 Male fed—cut-worm to No. 4 and ate excrement.

09 Female fed—cut-worm to No. 1.

17 Male fed—cut-worm to No. 2.
20 Female fed—cut-worm to No. 4 and ate excrement.
21 Female fed—dragonfly to No. 1, and ate excrement.
28 Male fed—insect to No. 4.
32 Male fed—cut-worm to No. 3.
36 Female fed—dragonfly to No. 3.
37 Female fed—dragonfly to No. 1.
42 Female fed—cut-worm to No. 4.
44 Male fed—dragonfly to No. 3.
50 Female fed—beetle to No. 3.
51 Male fed—dragonfly to No. 3.
51 to 54, rested at the nest.

(13 feeds during the hour.)

5:02 Female fed—dragonfly to No. 3.
03 Female fed—dragonfly to No. 3.
05 Male fed—cut-worm to No. 3.
09 Female fed—winged ant to No. 1.
10 Female fed—beetle to No. 2.
11 Female fed—cut-worm to No. 1.
14 Female fed—cut-worm to No. 2 and No. 3.
16 Female fed—ants to No. 1 and No. 3; ate excrement.
20 Male fed—ants to No. 1.
25 Female fed—ants to No. 4.
26 Female fed—ants to No. 1.
27 Male fed—ants to No. 1 and No. 4.
32 Female fed—ants to No. 2, rested till :40 at nest.
43 Female fed—ants to No. 3.
49 Male fed—ant to No. 4.

(15 feeds during the hour.)

6:02 Male fed—beetle to No. 2.
07 Female fed—three ants to No. 1.
17 Female fed—beetle to No. 2, and ate excrement.
24 Male fed—cut-worm to No. 4.
24 Female fed—ants to No. 3.
29 Male fed—moth to No. 3; brooded till :33.
35 Male fed—ants to No. 3.

42 Female fed—cut-worm to No. 3.
42 Male fed—cut-worm to No. 3; brooded till 7:00.
(9 feeds during the hour.)

7:04 Male fed—cut-worm to No. 1 and No. 3.
13 Male fed—beetle to No. 2.
25 Female fed—cut-worm to No. 3.
27 Female fed—beetle to No. 4.
30 Female fed—worm to No. 1; carried away excrement.
35 Male fed—cut-worm to No. 1; ate excrement.
42 Male fed.
47 Male returns without feed: broods.
(7 feeds during the hour.)

8:00 Still brooding on the nest for the night.

The young were weighed onthe following day, as indicated below. The weight of the young was 40 grams.

The weight of { 1 beetle, 7 ants, 1 dragonfly } is 1 gram.

Weight of 308 pieces (estimated number of pieces), 35 grams. Approximately this weight of food was consumed by four birds in a single day. Thus each bird consumed approximately one-fourth its weight of insects and worms.

Total number of feeds, 156.

Average number of feeds per hour, 9 5-8.

Individual feeds during the day:

To No. 1, 43 feeds (about).
To No. 2, 42 feeds (about).
To No. 3, 48 feeds (about).
To No. 4, 40 feeds (about).
Feeds by the male........................78 times.
Feeds by the female........................78 times.

Age of young not determined.

Classified list of food:

150 cutworms.

9	"worms."
5	earthworms.
11	dragonflies.
10	beetles.
50	ants.
1	grasshopper.
72	or more other insects.
308	or more.

Summaries of Activities of American Robins

Merula migratoria (Ten Nests.)

	Number of Visits to the Nest by Parent Birds.	Number Young in the Nest.	Total Number Feeds.	Total Number Pieces.	Number of Feeds.		List of Food: Classified.	Enemies Driven Away.
					Male.	Female.		
July 3, 1912	136	4	130	130	51	79	35 earthworms 1 caterpillar 2 grasshoppers 42 other insects 27 berries (blackberries, raspberries, gooseberry) 1 bread 22 unidentified	None.
July 10, 1913	140	2 (4-days) old	140	140	60	72	86 earthworms 6 caterpillars 10 grasshoppers and crickets 21 other insects 5 berries 12 unidentified	Other robin. Cowbird.
July 10, 1913	105	2 (8-days)	101	126	....	101	21 earthworms 12 caterpillars 7 grasshoppers and crickets 43 other insects 40 berries 1 cherry 1 seed 1 unidentified Water three times	Chased sparrows twice.

Summaries of Activities of American Robins—Continued.

	Number of Visits to the Nest by Parent Birds.	Number Young in the Nest.	Total Number Feeds.	Total Number Pieces.	Number of Feeds. Male.	Number of Feeds. Female.	List of Food: Classified.	Enemies Driven Away.
July 10, 1914	202	4	211	211	200	1	101 earthworms. 7 caterpillars. 9 grasshoppers and crickets. 42 other insects. 6 berries. 46 unidentified.	Domestic difficulties; male *drove female from the nest*; did not permit her to return. He drove blackbirds and also other unidentified bird away.
July 10, 1914	77	2 (left nest before end of the day)	77	77	48	29	25 earthworms. 1 caterpillar. 5 grasshoppers and crickets. 11 other insects. 20 berries. 15 unidentified. Water one time.	Purple grackle three times.
July 10, 1914	60	2	52	53	31	21	38 earthworms. 4 grasshoppers. 11 other insects.	None.
July 10, 1911	110	2 (5-days) about	107	107	57	50	58 earthworms. 6 grasshoppers. 18 other insects. 25 berries (chiefly mulberries). Water two times.	None.

July 7, 1915	70	2	57	63	54	3	45 earthworms 3 caterpillars 3 grasshoppers and crickets 1 other insect 5 mulberries 6 unidentified Several flies and a few seeds	Young robin; red squirrels period of fifteen minutes.
Showe	rs during the	morning. Very	heavy rain dur	ing last half of	the afterno	on		
	Male covers wings hang drains rain	young. His over nest; from tne nest						
July 7, 1915	96	2 (5-days) old	84	87	56	28	54 earthworms 1 centipede 5 grasshoppers 15 other insects 1 berry 10 cherries 1 bread	None.
Showe	rs during the	morning. Very	heavy rain dur	ing last half of	the afterno	on		
July 6, 1915	205	Not recorded	196	188	85	91	26 earthworms 18 caterpillars 3 grasshoppers 53 other insects 2 spiders 84 berries (77 mulberries)	Drove yellow hammer 4 times, flickers twice, red squirrel once, 3 robins, sparrow once.

SUMMARY OF THE ACTIVITIES OF TWO WOOD PEWEES.

(*Contopus virens.*)

	Number of Visits to Nest by Parent Birds.	Number Young in the Nest.	Total Number of Feeds and Pieces.		List of Food Classified.	Enemies Driven Away.
Clear Day. July 3, 1912.....	477	3 (age?)	369	369 +	2 caterpillars............. 3 butterflies.............. 1 fly..................... 7 dragonflies.............. 1 winged ant............... 1 grasshopper.............. 354 + unidentified insects.......	2 Cowbirds. Blackbird 4 times. Six Blackbirds at one time. Nuthatch, Woodpecker. Downy Woodpecker. Blue Jay. Yellow Hammer. Cowbird again. 2 Flickers. Squirrel twice.
Rainy Day. July 7, 1915.....	670	3	65	65 +	7 caterpillars............. 1 butterfly................ 9 flies.................... 5 dragonflies.............. 1 beetle................... 1 black wasp............... 41 + other insects..............	None.

Summary of the Activities of a Kingbird.

Tyrannus tyrannus.

The same nest, with *two* young, was under observation for a period of six days beginning with the morning on which the eggs hatched. The data of the first day were imperfectly recorded and are, therefore, not included in the summary. The data cover the 3rd, 4th, 6th, 7th, and 8th day after the hatching of the eggs.

SUMMARY OF THE ACTIVITIES OF A KINGBIRD

	Number of Visits to the Nest by Parent Birds.	Total Feeds.	Number of Feeds		List of Food.	Enemies Driven Away.
			By Male.	By Female.		
July 12, 1913. 3rd day	102	60	37	23	2 earthworms 2 caterpillars 1 white grub 2 damselflies 2 dragonflies 1 moth 6 grasshoppers 8 beetles 2 other insects 14 seeds 20 unidentified	Woodpecker.
July 13, 1913. 4th day	102	92	69	23	7 earthworms 16 caterpillars 2 grubs 12 grasshoppers 2 crickets 2 katydids 2 damselflies 12 dragonflies 1 bee 2 beetles 12 other insects 19 unidentified	None.
July 14, 1913					Rain. No observations	

July 15, 1913. 6th day.....	78	74	40	34	10 earthworms 1 caterpillar 2 grubs 3 grasshoppers 1 cricket 2 damselflies 12 dragonflies 1 beetle 20 other insects 1 seed 21 unidentified	Robin. Blue jay.
July 16, 1913. 7th day.....	74	61	39	22	2 earthworms 9 grubs 1 damselfly 18 dragonflies 1 moth 13 other insects 19 unidentified	None.
July 17, 1913. 8th day.....	111	100	40	60	16 earthworms 8 grubs 3 damselfiies 15 dragonflies 1 moth 1 beetle 1 grasshopper 38 other insects 1 c ntipede 17 unidentified	Blackbird. Sparrow. 3 Blackbirds.

Howard E. Enders, Purdue University, West Lafayette, Indiana.
Will Scott, Indiana University, Bloomington, Indiana.

On the Change that Takes Place in the Chromosome in Mutating Stocks.

Roscoe R. Hyde.

Two new eye mutations, tinged and blood have appeared in my cultures of the fruit fly that throw light upon the question as to the nature of the change that takes place in the chromosome when a new character appears. Both mutations show typical sex-linked inheritance, consequently they are expressions of changes in the X chromosome. Both mutants give the same linkage values when measured with other sex-linked characters. When measured with yellow body color a linkage of 1.2 results; with miniature wings 33; with bar eyes 44. Morgan has described three sex-linked eye mutants, white, eosin and cherry, which give the same linkage values. Consequently, we now have five sex-linked eye mutants, namely, white, tinged, eosin, cherry and blood, which give an increasing color series from white to the bright red of the wild fly. A study of their linkage relations shows that they either lie very closely together on the X chromosome or that they are but different modifications of the same gene. The two possibilities involve the question of the origin of mutations as well as the fundamental make-up of an hereditary factor.

Mendel evidently thought of something in the germ cell that stood for round (R) and something that stood for wrinkled (W) and that these two things could not coexist in the same gamete. That is, (W) is allelomorphic to (R).

The origin of mutation in the light of the above assumption would seem to depend upon the splitting up of more complex hybrids—the bringing to the surface of units already created. Evolution in the light of such a conception would seem to depend upon the shifting together of desirable units.

Bateson viewed the matter in a different light. He knew of the origin of new forms by mutation. He postulated a definite something in the germ cell that stands for the character, as for example (T) which stands for the tallness in peas, which when lacking makes the pea a dwarf (t). In other words, instead of two separate factors he regards the tallness and dwarfishness merely as an expression of the two possible states of the same factor,—

its presence and its absence. Hence his well-known Presence and Absence theory. In this case (T) is allelomorphic to its absence (t). The inheritance of combs in chickens is a beautiful application of such a conception. Mutations according to this theory appear as the result of losses.

Bateson pushed this idea to its logical conclusion in his Melbourne address where he speculates on the possibility that evolution has come about by the loss of something. These somethings he assumes to be inhibitors. (Science, August 28, 1914).

" . . . As I have said already, this is no time for devising theories of evolution, and I propound none. But as we have got to recognize that there has been an evolution, that somehow or other the forms of life have arisen from fewer forms, we may as well see whether we are limited to the old view that evolutionary progress is from the simple to the complex, and whether after all it is conceivable that the process was the other way about.

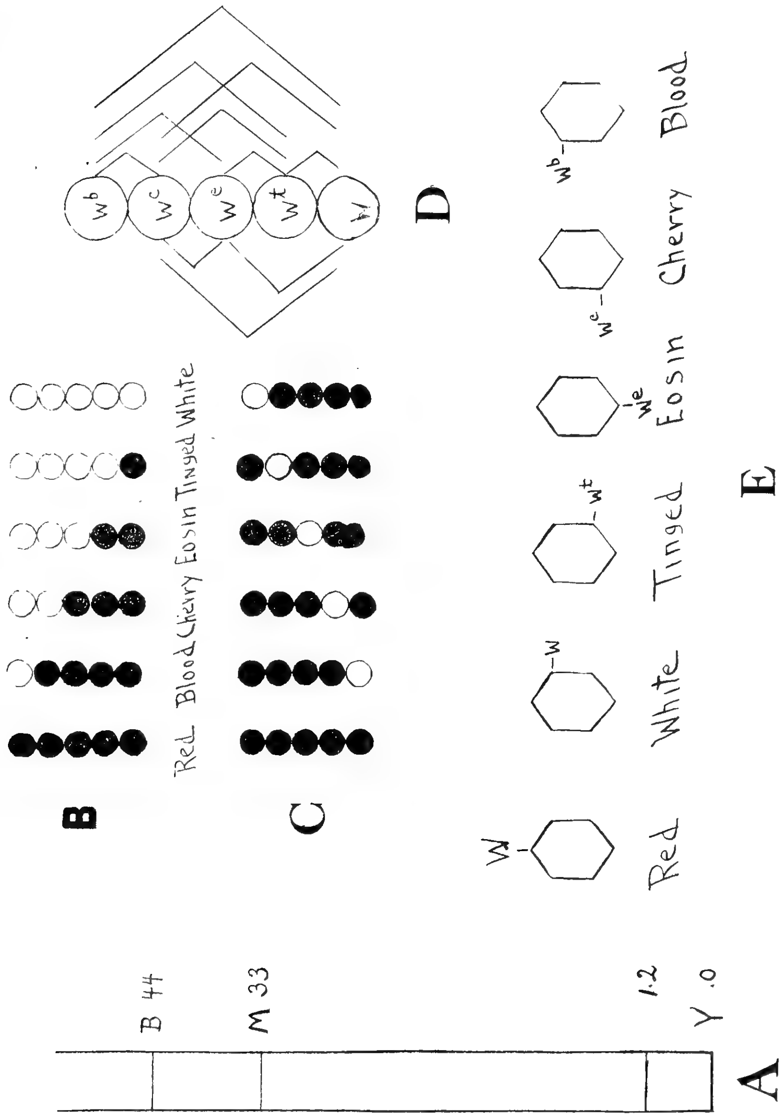
" . . . At first it may seem rank absurdity to suppose that the primordial form or forms of protoplasm could have contained complexity enough to produce the divers types of life.

" . . . Let us consider how far we can get by the process of removal of what we call "epistatic" factors, in other words those that control, mask, or suppress underlying powers and faculties.

" . . . I have confidence that the artistic gifts of mankind will prove to be due not to something added to the make-up of an ordinary man, but to the absence of factors which in the normal person inhibit the development of these gifts. They are almost beyond doubt to be looked upon as *releases* of powers normally suppressed. The instrument is there, but it is "stopped down." The scents of flowers or fruits, the finely repeated divisions that give its quality to the wool of the merino, or in an analogous case the multiplicity of quills to the tail of the fantail pigeon, are in all probability other examples of such releases.

" . . . In spite of seeming perversity, therefore, we have to admit that there is no evolutionary change which in the present state of our knowledge we can positively declare to be not due to loss. When this has been conceded it is natural to ask whether the removal of inhibiting factors may not be invoked in alleviation of the necessity which has driven students of the domestic breeds to refer their diversities to multiple origins."

Another idea as to the way these factors may find expression in the germ cells has been advanced by Morgan under the heading of Multiple Allelo-



FIGURES A, B, C, and E.—Explanation given in Text.

morphs. According to this conception there is a definite something (W) located at point 1.2 on the X chromosome which stands for the red eye of the wild fly. (Fig. A.) This gene underwent some kind of change and gave rise to white eyes (w). In another stock the same particle mutated and gave rise to eosin (w^e). In still another stock the same particle changed and gave rise to cherry (w^c). (W) is allelomorphic to (w), to (w^e) and to (w^c). each of these in turn is allelomorphic to each other; hence they form a system of Multiple Allelomorphs. This view is supported by a large amount of experimental data by Morgan and his co-workers, but strange as it may seem the numerical results can be interpreted in terms of the Presence and Absence theory provided the mutants are the result of losses of several factors that stand for red in a completely linked chain of loci.

The assumption that these three mutants are the result of changes in loci lying very closely together on the chromosome as demanded by the Presence and Absence theory has been tested by Morgan and others by means of their linkage relations in three possible combinations as given in Fig. D. (Shown by the broken lines on the left.) The discovery of the two new mutants has made it possible to carry out the test in eight additional ways. The evidence which involves data from something like a half-million animals weighs heavily against the Presence and Absence theory and is entirely in accord with the assumption that something analogous to isomerism may change an hereditary factor resulting in the production of a new form. I have attempted to visualize this in Fig. E. If this is the correct interpretation the possibilities locked in a small amount of chromatin may be almost infinite, for a great many different arrangements are possible from a few things.

There are some points worthy of consideration as tending to give weight to the Multiple Allelomorph theory.

1. On the Presence and Absence theory it is necessary to assume that in the region of 1.2 on the X chromosome there is a chain of five completely linked loci (very close together) upon which the color of the red eye of the wild fly depends. Multiple Allelomorphs accounts for all of the facts while postulating but one locus.

2. Gratuitous to the Presence and Absence theory let us assume that the loci are in jutaposition. If we assume that blood, cherry, eosin, tinged and white have appeared as a result of successive losses as shown in Fig. C, we encounter a difficulty. When any two of these mutants are crossed the

two chromosomes are brought together in the female, each restores the missing part to the other and a red-eyed female should result in the F_1 generation. As a matter of fact no red-eyed female appears. She is invariably a compound, that is, in each case she is intermediate between the eye colors of the two stocks used as parents.

Again the evidence is fairly conclusive that when the two X chromosomes are brought together in the female they break and reunite at apparently all levels on the chromosome. Accordingly, it would seem that a break and reunion would occasionally take place between the members of this chain of loci. If such a phenomena should occur a complete chain of loci would result like the chain in Fig. C (on the extreme left), which would express itself in the F_2 generation in the production of a red-eyed male. But in all the possible attempts to break up such a line, as shown in Fig. D, no such a red-eyed male has been found. To be sure the loci may be so close together that crossing over would take place infrequently, but the evidence from such large counts as have been made in which the red-eyed male has been specifically looked for would weigh heavily against its ever taking place.

3. The mutations may be due to losses according to the scheme represented in Fig. B., one loss produced blood, two losses produced cherry, and so on. Such an assumption would seem to accord with the fact that when any two of these stocks are crossed no red females are produced in the F_1 generation. On the other hand it should be expected that the chromosome in which the least number of losses had occurred would act as a dominant. For example, when blood and tinged are crossed, the females should be like blood. But no such result is obtained. The female is intermediate in color.

Again we should expect from the phenomena of crossing-over that, in a cross for example between blood and white occasionally a cherry, or an eosin, or a tinged male would appear in the F_2 generation, but none has been observed.

4. The history of the appearance of the members of this multiple allelomorph system shows that they are rare phenomena. Careful observation by Morgan, Sturtevant, Muller, Bridges, myself and others show these mutants to have appeared but a few times. It would be safe to say, I think, that only one has occurred in five million times. I have represented blood by one loss from the chromosome. Tinged is the result of four losses in this completely linked chain of loci. The possibility of such mutants appearing involves so many simultaneous losses that there would be one chance

in millions. It seems almost impossible to believe that we should have ever found such a mutant.

5. The experimental evidence shows there are many factors arranged in a linear series on the X chromosome. Some affect wings, some body colors, others the shape of the eye, and so forth. Sturtevant has pointed out the significance of the fact in light of the above statement that the characters which behave as members of a multiple allelomorph system are closely related physiologically.

6. If the mutants are the result of changes as shown in Fig. D it would seem as if a mutated stock would more readily give rise to subsequent mutations, since fewer simultaneous losses are necessary. As a matter of fact four of the members mutated directly from red while eosin came from white.

7. Morgan has emphasized the idea that it is difficult to account for reverse mutations on the assumption of losses from a completely linked chain of loci, as the Presence and Absence theory postulates. On the other hand it is conceivable how such a reaction could come about if the mutant is the result of an expression of something analogous to an isometric change.

8. Is chromatin such simple material that the only change conceivable is a loss?

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Some Preliminary Observations on the Oxygenless Region of Center Lake, Kosciusko Co., Ind.

Herbert Glenn Imel.

It has been found that some of our lakes contain no free oxygen during the summer months.

Birge and Juday ('11) found that Beasley and Mendota Lakes not only had such oxygenless regions but that animal life existed in these regions. They report sixteen genera of living, active protozoa, three of worms, two rotifers, two crustacea and one mollusc.

Scott found in his studies of lakes of northern Indiana that Center Lake, Kosciusko county, had such a region, and under his direction the writer undertook, during the summer of 1915 to find out what forms of animal and plant life existed in this region.

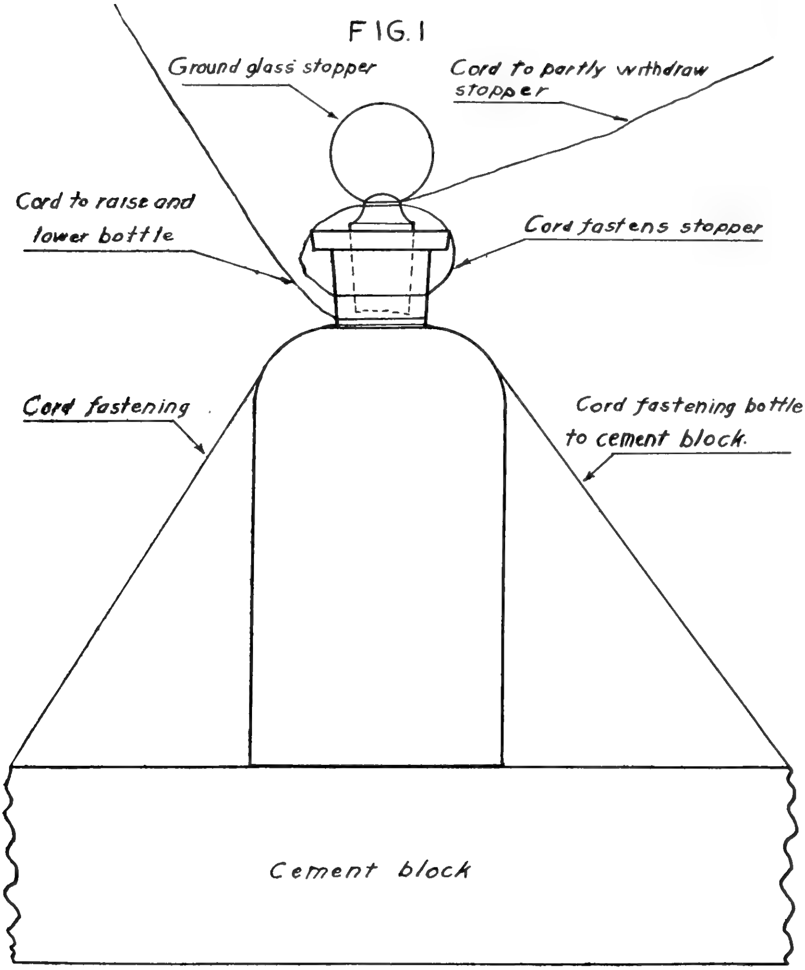
According to Birge and Juday ('11), after the autumnal overturn, during the winter, and until the approach of spring, the gas conditions are very nearly uniform throughout the lake, but with the approach of spring, and through the spring and summer, the oxygen content becomes less and less in the lower strata while the carbon dioxide, both free and fixed, becomes greater and greater until by July 15 or August 1, the free oxygen is zero while the carbon dioxide is very great. (See Figs. 6, 7, 8.)

This condition is brought about in three ways: (1) by the respiration of the plants and animals in it; (2) lack of surface contact with the air; (3) decomposition of the dead organisms in it.

Determinations of the temperature, free oxygen, free and fixed carbon dioxide, were made at the beginning and the end of the observation period, July 28 and August 26. The oxygen was determined by the Winkler method and the temperature was read by means of a thermophone. The results of these readings are shown on graphs attached hereto. (See Fig. 5.)

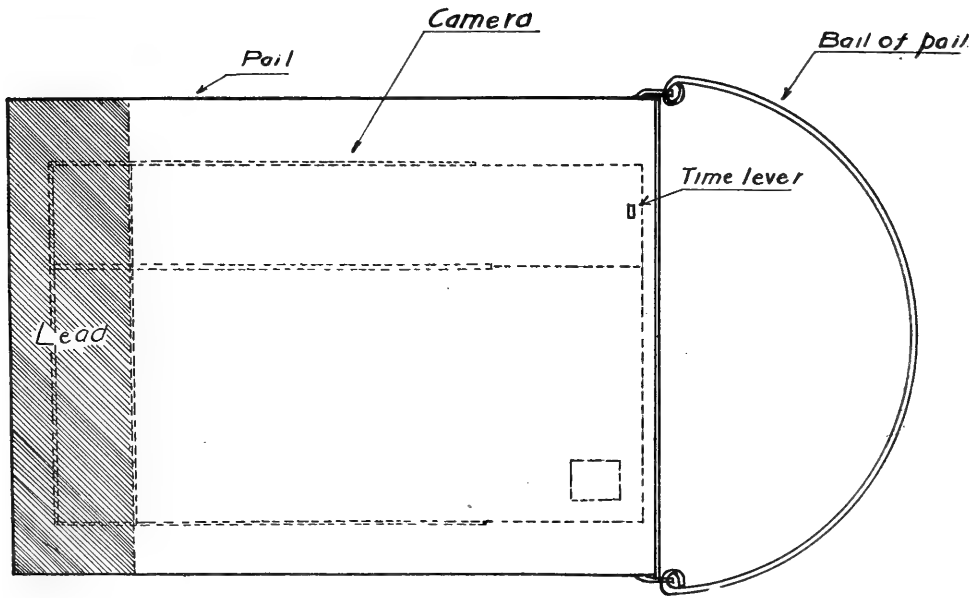
A pump, with a hose marked off in meters, was used in the collection of the water. The samples of plankton were collected by pumping a quantity of water through a plankton net at the desired depth and then rinsing off with the last stroke into a collecting bottle. This method was used for

FIG. 1



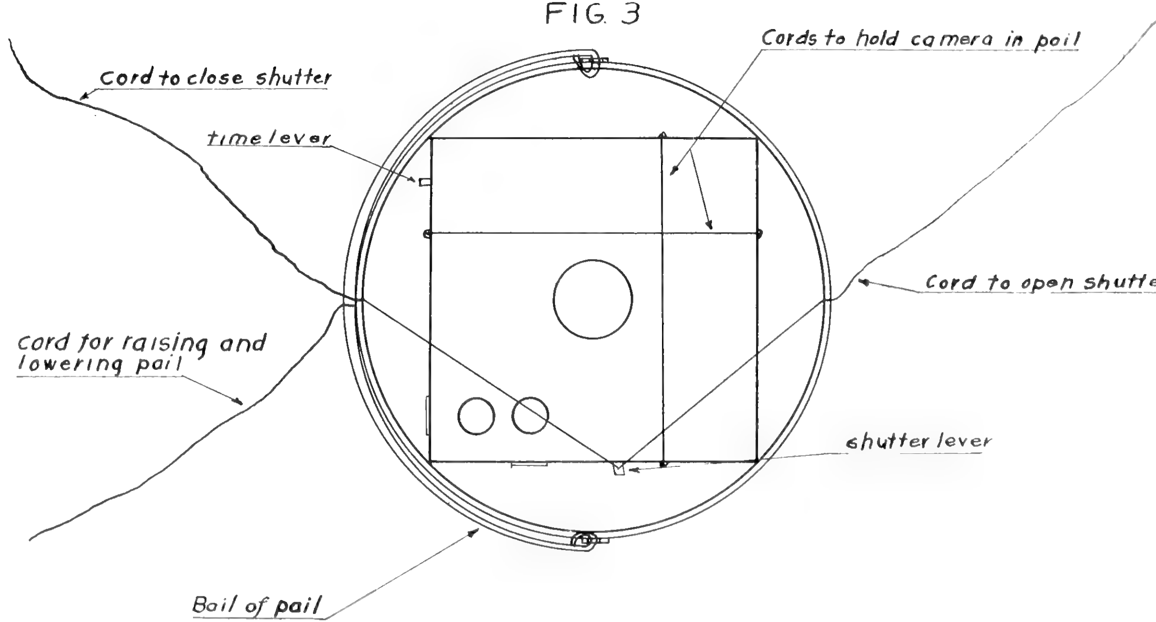
BOTTOM COLLECTING OUTFIT

FIG 2



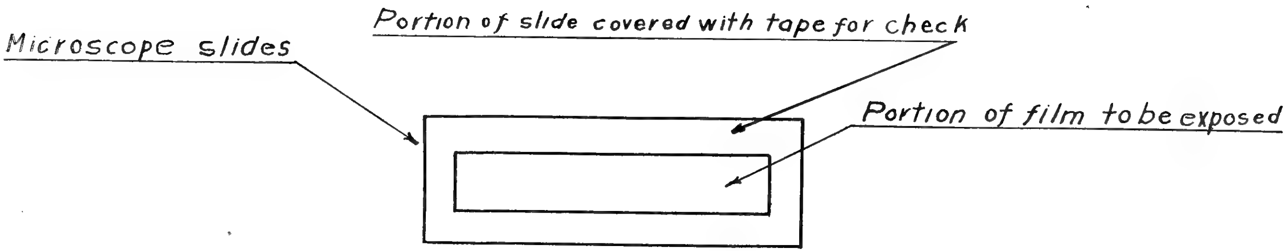
Side view of under water camera apparatus showing camera in position and means of operating.

FIG. 3



Top view of under water camera apparatus showing camera in position and means of operating.

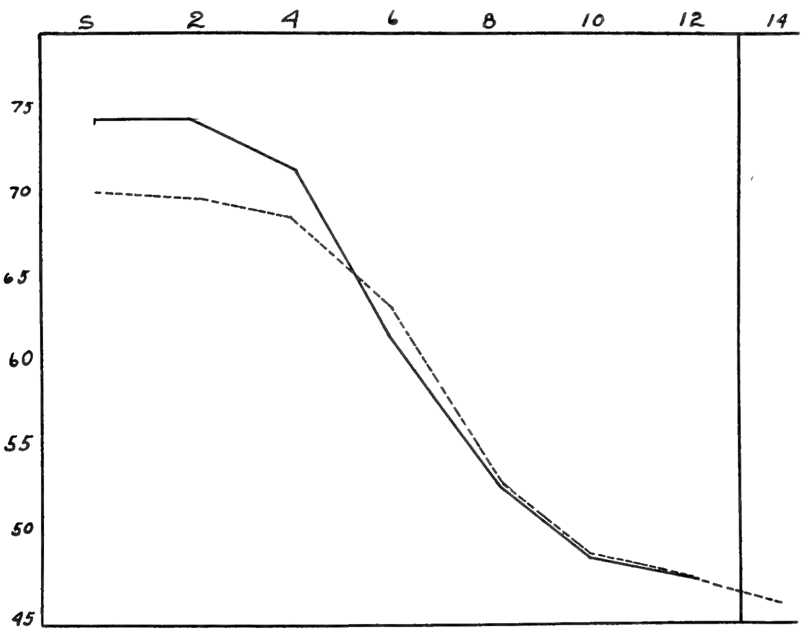
FIG. 4.



Camera plate made of two microscope slides with film of same size between Edges taped to prevemt wetting and act as a check

FIG 5

TEMPERATURE CURVE



———— READING JULY, 28.

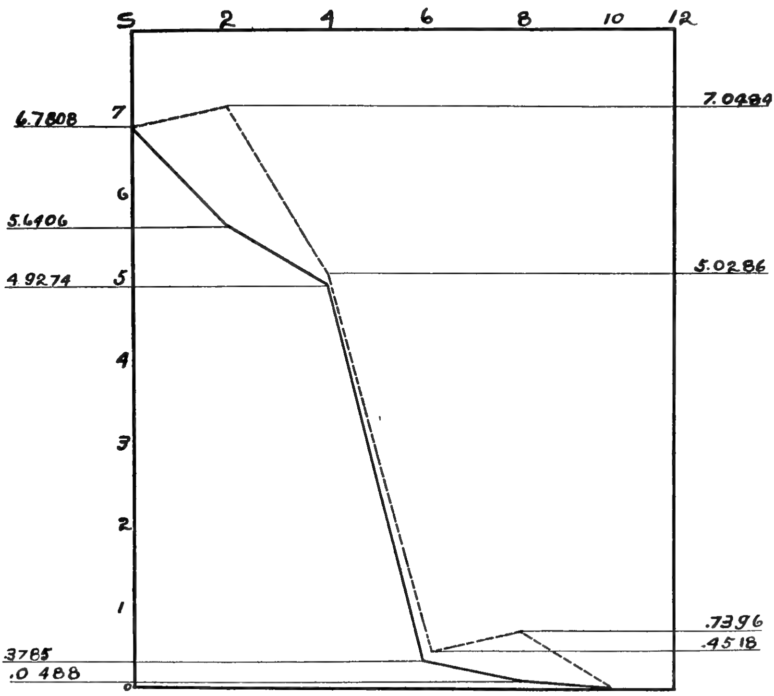
- - - - - READING AUG. 26

READ DEGREES FROM TOP TO BOTTOM.

READ METERS FROM LEFT TO RIGHT.

FIG. 6

FREE OXYGEN CURVE



________ READING JULY, 28
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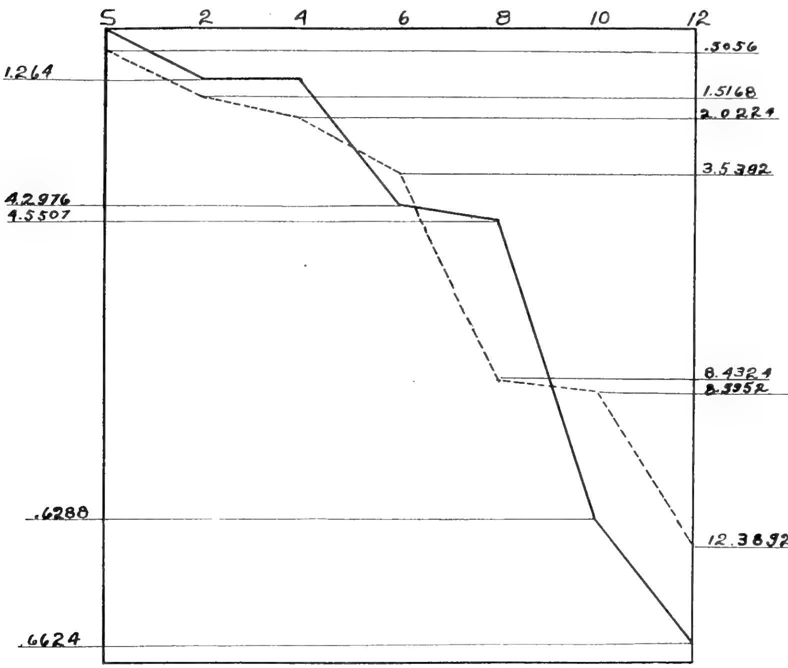
FIGURES AT TOP REPRESENT METERS DEEP.
FIGURES AT SIDE REPRESENT C C FREE O. PER LITER

FIG 7

FREE CO_2 CURVE



———— READING JULY, 28.

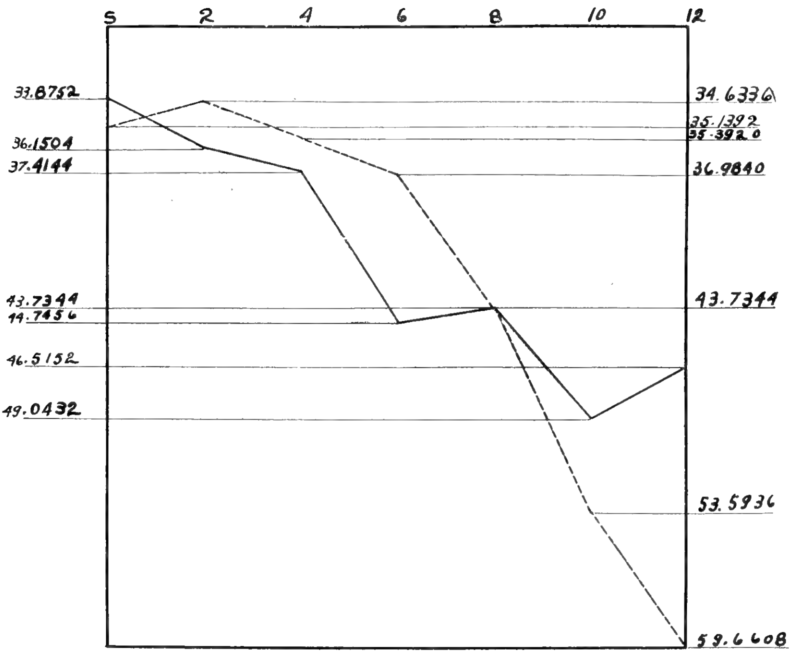
- - - - - - READING AUG 26

FIGURES AT TOP REPRESENT METERS DEEP

FIGURES AT SIDES REPRESENT CC FREE CO_2 PER LITER

FIG 8

FIXED CO_2 CURVES



———— READING TAKEN JULY, 28
-------- READING TAKEN AUG. 26
FIGURES AT TOP REPRESENT METERS DEEP
FIGURES AT SIDES REPRESENT C C

all but the bottom collection, which was taken in the manner described below and as illustrated by the figures.

A sixteen-ounce reagent bottle (see Fig. 1) with a ground glass stopper was securely fastened to a block of cement weighing approximately 30 lbs. The stopper was so tied that it could be partly pulled out. A strong cord was attached to the neck of the bottle to permit raising and lowering the bottle. A second cord was attached to the stopper so that when the empty bottle was at the bottom the stopper could be pulled as far as its fastenings would permit, allowing the bottle to be filled with the bottom ooze. When the bottle was filled the cord attached to the stopper was loosened, thus allowing it to snap back in place and securely close the bottle, and with the cord around the neck the bottle was drawn to the surface. The stopper and neck of the collecting bottle were rinsed off first with alcohol, then distilled water. The contents were then transferred to smaller reagent bottles, corked and sealed with paraffin to insure their being air tight.

The contents of the collections, especially the bottom collection, were examined microscopically and the plants and animals that seemed alive were listed. As a check, some bottles of the same collection were kept fifteen days in darkness and at approximately the same temperature as the lake bottom. Their contents were then examined and the plants and animals found therein were apparently as active as when first collected. The animals were all seen moving with more or less rapidity, the protozoans quite rapidly, the higher forms not so much so. Their activity increased with exposure to light and air.

From the total examinations made, the following were found, demonstrated to be alive and classified. Nine protozoa, one rotifer, one crustacea, twenty algae and fourteen diatoms.

Animals Classified after Conn and Webster.

Protozoa:

Dactylasphaerium radiosum Ehr.

Difflugia globostoma Leidy.

Amoeba proteus Ehr.

Helizoa:

Actinosphaerium eichornii.

Mastigophora-flagellata:

Peranema sp.(?)

Ciliata:
- Colpidium sp.(?)
- Paramoecium Bursaria Ehr.
- Stentor coerulus Ehr.
- Vorticella sp.(?)

Gastotricha: One form belonging to this group was abundant.

Crustaceae:
- Copepoda—
  - Cyclops biënspidatus.
  - Algae—classified after Conn and Webster.

Cyanophyceae (Blue-green):
- Oscillatoria subtilissima Kütz.
- Oscillatoria aeruginoso caerulea.
- Merismopedia nagelii.
- Microcystis aeruginoso Kütz.
- Nostoc rupestre Kütz.
- Nostoc rupestre sp.(?)

Chlorophyceae (Green Algae):
- Scenodesmus caudatus.
- Pediastrum pertusum var. clarthratum A. Br.
- Pediastrum Boryanum Turp. (two types).
- Pediastrum Boryanum Turp. var. granulatum Kütz.
- Ulthorix sp.(?)
- Zygnemeae stellium var. genuinum Kirch.
- Spirogyra variens (Hass) Kütz.

Heterokontae (Yellow green):
- Tribonema minus (Wille) Raz.

Bacillarieae (Diatomaceae) classified after Wolle:
- Navicula Sillimanorum Ehrb.
- Navicula Tabellaria.
- Navicula Tabellaria var. Macilenta.
- Gomphonema Geminatum (two types).
- Asterionella Formosa.
- Asterionella Formosa var. Ralfsii (two types)
- Asterionella Formosa var. Bleakeleyi.
- Asterionella Formosa var. Gracillima.
- Fragalaria Capucina Desmaz.
- Stephanodiscus Niagara Ehr. (two types).

Thus far we have established the following: (a) Center Lake, during part of the year, has a region devoid of free oxygen. (b) A number of living organisms are found in it during this time.

Many of these organisms are chlorophyl bearing. This made it desirable to determine, if possible, whether or not any light reached the bottom of this rather turbid lake.

To answer this question a Brownie No. 0 camera, boiled in paraffine to make it impervious to water, was fastened into a pail weighted in the bottom with lead to sink it. (See Fig. 2.) The lever of the shutter was arranged with strings running through opposite sides of the top of the pail (see Fig. 3) so that when the camera was sunk to the desired depth the shutter could be opened, exposing a bit of film arranged between two microscopic slides which were taped around the edges, serving the double purpose of keeping the film dry and acting as a check. (See Fig. 4.)

After an exposure of five minutes, the shutter was closed by means of the other cord and the camera raised to the surface. The film was developed. The exposed part of the film was distinctly darkened, showing that there is some light at the bottom of the lake. The intensity and quality of this light remains to be determined.

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The Occurrence of More Than One Leaf in Ophioglossum.

It is usually stated that in the Ophioglossales one leaf develops each year. In collecting material of Ophioglossum vulgatum near Gary, Ind., during the summer of 1914, it was observed that there was a large proportion of plants with more than one leaf, so a count was made. Of a total of two hundred plants, selected at random, ninety-one had one leaf above ground, one hundred and five had two leaves, and four had three leaves. A similar proportion was found the same year in plants collected in a wood adjoining the Earlham College campus. Material collected during the summers of 1913 and 1915 showed few plants with more than one leaf.

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The Phytecology of Peat Bogs Near Richmond, Indiana.

M. S. Markle.

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While the peat bog is a common feature of the landscape in northerly latitudes, the presence of a bog as far south as Central Indiana or Ohio excites considerable interest. It is the belief of modern botanists (1), that these bogs originated during the period immediately following the glacial period, when the area abutting on the edge of the ice approximated arctic conditions, and gradually emerged from this condition after the recession of the ice. Since the retreat of the ice began at its southern border, areas retaining any of the primitive conditions incident to the original arctic climate increase in rarity southward. In Indiana and Ohio, the Ohio river formed the approximate southern boundary of the ice sheet at the time of its greatest extension; so these bogs are within sixty or seventy miles of the southernmost limit of glacial action and even nearer the edge of the most recent ice sheet. No doubt many bogs formerly existed in central Indiana and Ohio, but, with changed conditions, practically all have disappeared.

The principal features of interest involved in an ecological study of the vegetation of peat bogs are, first, the presence of a large number of xerophytic forms, a situation not to be inferred from the well-watered condition of the habitat; second, the existence of many plants characteristic of arctic and subarctic regions. Little study was made of the anatomy of these xerophytic forms, as they are not nearly so well represented here as in the northern bogs.

The presence of boreal forms may be accounted for as follows: During the glacial period, the flora of the area bordering on the ice was arctic, such a flora having been able to retreat southward before the slowly-advancing ice, and consisted of such forms as were able to withstand the many north-

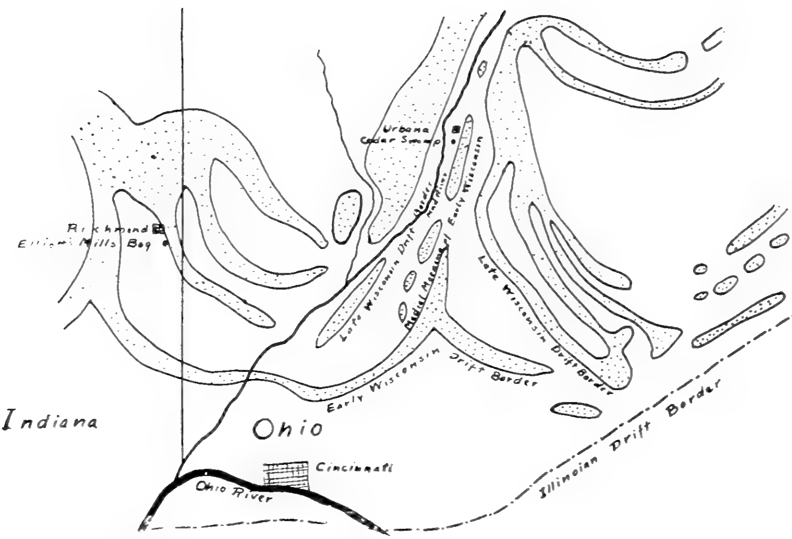

FIG. 1. Map of part of southeastern Indiana and southwestern Ohio, showing glacial moraines of the Early and Late Wisconsin Ice Sheets and the boundary of the Illinoian drift: also the location of the bogs near Richmond, Indiana and Urbana, Ohio. Adapted from Leverett and supplemented by observation.

and-south oscillations of the ice. When the ice finally retreated, the plants followed. As any area became warmer and drier, some species perished. The southern flora, long held in check by the glacier, began to crowd in and where conditions were favorable for its growth, replaced the arctic flora, which remained only in such situations as were unsuitable for the growth of the southern plants, such as bogs and cool, shady ravines. Such places as these are islands of northern plants left in our now southern and south-eastern flora.

The physiographic cycle of a bog differs from that of an ordinary swamp in several particulars; while both are ephemeral features of the landscape, soon being destroyed by sedimentation or by drainage, they differ in the manner in which they are filled; a swamp fills up from the bottom by the gradual accumulation of sediment deposited by incoming streams and that formed by decaying plant and animal matter; while a bog fills largely from the top by the formation, beginning at the edge, of a gradually thickening and settling floating mat of partially decayed vegetation, which is finally capable of supporting a rich flora. Bogs are more likely to develop in undrained or poorly drained depressions, though there are partially drained bogs and undrained swamps.

The glacial age was not a unit, but was characterized by alternate advances and recessions of the ice, repeated no one knows how often. The last few advances were, in general, less extensive than their predecessors, so the terminal moraine of each was not, in every case, destroyed by its successor. The moraines of three of these successive advances of the ice can be distinguished in Ohio (2). The oldest, the Illinoian, extended almost to the Ohio river. The second, the Early Wisconsin, extended nearly as far, and was divided by an elevation of land into two lobes, the Scioto on the east and the Maumee-Miami on the west. The Late Wisconsin sheet followed the same course as did its predecessor. The terminal moraines of the two sheets are roughly parallel. The medial moraine of the two lobes of the Early Wisconsin Sheet was not destroyed by the Late Wisconsin, and the outwash plain between the medial moraine of the Early Wisconsin and the lateral moraine of the Late Wisconsin formed a broad valley, now drained by the Mad river. In this valley is located a bog, known locally as the Cedar Swamp. See accompanying map, Fig. 1.

Cedar Swamp is in Champaign county, Ohio, about five miles south of Urbana. It is between the river and the east bluff of the valley. There is

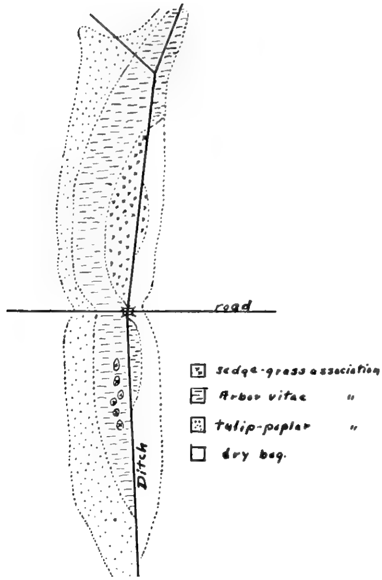

Fig. 2. Map of Cedar Swamp, showing relation of the plant associations. The birch-alder association is not shown.

Fig. 3. Panoramic view of Cedar Swamp, looking northward from near the road. Made from two photographs. Sedge-grass association in foreground, arbor vitae association in background, with birch-alder association between. The sedge-grass association had recently been burned over.

no evidence that it occupies a former bed of the stream. The bog probably occupies what was originally a small lake on the valley floor, fed by springs in the underlying gravel. The former area of the bog was no doubt much greater than its present area, as is shown by extensive outlying deposits of peaty soil. The area of the bog has been greatly reduced during the last few years by artificial means. From natives of the vicinity, it was learned that the bog was formerly much wetter and more impenetrable. A story is told of an "herb-doctor" who entered the bog on a collecting expedition and never returned. A skeleton recently unearthed was supposed to be that of the unfortunate doctor.

The bog is now artificially drained by a large ditch, but the natural drainage was evidently very sluggish.

The bog in its present condition throws no light on the question of the origin of the floating mat of plants characteristic of the earlier stages. Four rather distinct plant associations, representing four stages in the plant succession in a bog formation, are represented here. These are the sedge-grass association, the birch-alder association, the arbor vitae association and the maple-tulip association.

The quaking mat, occupied by the sedge-grass association, has almost disappeared, and exists only in isolated patches, the largest of which is shown on the accompanying map, Fig. 2. One of the smaller patches appears in a photograph, Fig. 7. The areas that are left are quite typical. Walking about over the mat is to be conducted with some caution, especially in the wetter seasons. By jumping on the mat, one can shake it for many feet around. A stick can be thrust down with little resistance to a depth of four to six feet. The burning over of the largest of these areas has destroyed many of the typical plants. The principal species found in the association are as follows:

Drosera rotundifolia.
Parnassia caroliniana.
Carex spp.
Lophiola aurea.
Solidago ohioensis.
Solidago Riddellii.
Calopogon pulchellus.
Liparis Loeselii.
Habenaria peramoena.

FIG. 4. Arbor vitae trees two feet in diameter with the logs upon which they germinated still remaining. The ends of the logs near the trees do not show. The hatchet is stuck in the nearer log. Cedar Swamp.

Equisetum arvense.
Typha latifolia.
Utricularia minor.
Lobelia Canbyi.
Cardamine bulbosa.
Scirpus americanus.
Geum rivale.
Aspidium thelypteris.

The birch-alder association occupies the smallest area of any of the associations, since it forms merely a narrow fringe between the areas of quaking mat and the areas occupied by the arbor vitae association. Some of the same plants are found intermingled with the trees and others on the mat. The tendency is for these bordering shrubs gradually to close in upon the mat areas they enclose until the mat is covered. The shrubs may gain a foothold upon higher points in the mat association from which they spread outward. The principal plants of the birch-alder association are as follows:

Potentilla fruticosa.
Aldus incana.
Betula pumila.
Hypericum prolificum.
Salix cordata.
Physocarpus opulifolius.
Cephalanthus occidentalis.
Steironema quadrifolia.
Silphium terebinthinaceum.
Ulmaria rubra.
Phlox glaberrima.

By far the largest part of the bog is occupied by the arbor vitae association. The association is noticeable from a distance, on account of the presence of these trees of arbor vitae, or white cedar, which gave the bog its name. Trees two feet in diameter are common. A stump, oblong in cross-section, was found to be twenty feet in circumference and five by eight feet in diameter. The stump was hollow, so that its age could not be determined, but the outer six inches showed about one hundred growth rings, so the tree must have been several hundred years old. Under natural conditions, this association would probably persist for a very long time, as invasion from without goes on very slowly. The Thuyas have very com-

Fig. 5. Stump of an arbor vitae tree 40 years old, and the log upon which it germinated. Cedar Swamp.

plete possession of the habitat. Shade conditions are such as to exclude light-demanding forms. First attempts at photography under the arbor vitaes resulted in failures, on account of uniform under exposures. The vegetation of the forest floor is not abundant, except in early spring. The herbs are largely shade-enduring species. The mat of roots and fallen branches and leaves is another factor that deters invasion from without. If the toxicity of the substratum is a factor, it exerts its maximum influence here, under present conditions. Then, too, the plants of the association are reproducing themselves very efficiently, all stages of seedlings and saplings being found. Nearly all the Thuyas germinate on stumps and logs. A specimen four or five inches in diameter and twenty-five feet in height was found growing on a stump four feet high. Even the oldest trees, which must be hundreds of years old, are still grasping in their roots the partially decayed remains of the logs upon which they germinated. The fact that the logs are lying in a position that subjects them to the greatest exposure to decay shows the resistant qualities of arbor vitae wood. The logs shown in the photograph (Fig. 4) are still fairly sound, though the trees which grew upon them are two feet in diameter.

One of the commonest undergrowth shrubs is Taxus canadensis, which is here a prostrate, creeping shrub, seldom more than one or two feet in height. No traces of seed formation were observed, but the plant reproduces abundantly by layering. What at first glance seems to be a group of plants is found to be a series of layered branches from a common central plant. This habit is of considerable ecological importance here, since it seems to be the only means of reproduction of the species.

As the accompanying list shows, the arbor vitae association is the habitat of a large number of species of ferns, which form a prominent part of the flora of the association. Camptosorus was found in four widely-separated situations, growing luxuriantly upon fallen logs. Plants of Pteris more than four feet in height are rather common. Osmunda cinnamomea is common, but only two specimens of O. regalis were seen. Botrychium virginianum is abundant. Prothallia of O. cinnamomea are common.

A single plant of Lycopodium lucidulum, probably the last representative of its species, was found. The disappearance of this species is indicative of what has occurred in the case of many other northern forms and of the eventual fate of those that remain. Another disappearing species is

FIG. 6. A fallen arbor vitae tree, showing shallow rooting. Trees are frequently uprooted. Cedar Swamp.

Vaccinium corymbosum, only one specimen of which was seen. The principal species of the association are as follows:

*Thuya occidentalis.
*Taxus canadensis.
*Alnus incana.
Populus deltoides.
*Populus tremuloides.
Rhus vernix.
Rhus cotinus.
Rhus glabra.
Lindera benzoin.
Ribes Cynosbati.
Rubus idaeus.
*Rubus triflorus.
*Vaccinium corymbosum.
Cornus paniculata.
Cornus alternifolia.
Acer rubrum
Pyrus arbutifolia.
Ampatiens biflora.
Laportea canadensis.
Asclepias incarnata.
Caltha palustris.
Symplocarpus foetidus.
Cypripedium parviflorus.
Cypripedium hirsutum.
Aralia racemosa.
Polygonatum biflorum.
Dioscorea villosa.
Polymnia canadensis.
Mitchella repens.
Anemonella thalictroides.
Anemone quinquefolia.
Pedicularis lanceolata.
Polemonium reptans.
Uvalaria perfoliata.
Mitella diphylla.

Fig. 7. One of the small areas occupied by the sedge-grass association, with Silphium and Typha in the foreground, and Thuya in the background. The birch-alder association is not well developed here. Cedar Swamp.

Hydrophyllum appendiculatum.
Hydrophyllum virginianum.
Arisema diphylla.
Trillium grandiflorum.
Trillium cernuum.
*Trientalis americana.
*Maianthomum canadense.
Senecio aureus.
Botrychium virginianum.
Osmunda regalis.
Osmunda cinnamomea.
Pteris aquilina.
Cystopteris fragilis.
Aspidium spinulosum.
Aspidium cristatum.
Aspidium thelypteris.
Adiantum pedatum.
Anoclea sensibilis.
Camptosorus rhizophyllus.
Asplenium acrosticoides.
*Lycopodium lucidulum.

On the west side of the arbor vitae association is an almost undisturbed tree association, differing greatly in composition from that just described. The arbor vitae zone is made up largely of plants of northern origin or plants characteristic of bogs, while the plants of the other group, called the maple-tulip association, are those typical of the climax mesophytic forest of the region and are distinctly southern in their origin. A comparison of the distribution of the more distinctly boreal forms of the arbor vitae associatiln, indicated thus (*) in the list, with those given below for the maple-tulip association, will make the difference in origin very striking. Practically all these boreal forms occur outside the limits of distribution given by the best manuals. The beech is usually a member of the climax mesophytic forest of this region, but since for some reason it is absent from all the forests of this vicinity for several miles around, it is also absent in the bog. The principal trees of the maple-tulip association follow:

Liriodendron tulipifera.
Acer saccharinum.
Acer rubrum.
Fraxinus nigra.
Fraxinus americana.
Juglans cinera.
Ulmus americana.
Ulmus racemosa.
Platanus occidentalis.
Lindera benzoin.
Xanthoxylum americanum.
Pilea pumila.
Urticastrum sp.
Thalictrum dasycarpum.

We have in the cedar swamp a formation of plants of a decidedly boreal aspect, maintaining itself, but for the influence of man, in the midst of a flora predominantly southern. Ability to maintain itself in the struggle with the southern flora was probably due originally to differences in the habitat. Just what the factors are that make bog conditions unsuitable for the growth of most plants have not been fully determined; but some combination of edaphic conditions permitted the northern plants to remain and removed them very largely from competition with the southern forms. In the later stages of the development of the bog, many of these conditions have probably been modified or removed. Many of the southern plants could undoubtedly maintain themselves under the present conditions; but the bog plants have such complete possession of the habitat that invasion is practically precluded. But for the influence of man, the formation would no doubt have been able to maintain itself for many centuries to come.

About two miles southeast of Richmond, Ind., lies a small remnant of a formerly much more extensive peat bog. It is known as the Elliott's Mills bog and is in such an advanced state in the physiographic cycle of bogs that little resemblance to a typical bog remains. But the characteristic peat soil and the presence of certain bog and boreal plants indicate its former character. The bog lies in a broad, shallow valley between morainic hills. It evidently occupies a shallow, undrained depression scooped out in a softer part of the underlying Niagara limestone. The bog is crossed by a public highway and is now drained by the roadside ditch. It was necessary to blast through rock in order to get an outlet for the bog, showing that it is a rockbound depression. Tile drains from the bog carry streams of cold water throughout the year. Galleries supplying part of the water for the city of Richmond occupy a drier part of the bog.

The very advanced state of the bog is due, no doubt, to its nearness to the southern limit of glaciation and its consequent great age. Few typical bog plants remain. The following, however, are more or less characteristic of bogs: Rhus vernix, Salix pedicellaris, Hypericum prolificum, Parnassia caroliniana, Potentilla fruticosa. Only one specimen of Rhus vernix remains and it is dying—a fate typical of that of many bog plants which must formerly have existed here.

Nearly all boreal forms have likewise disappeared. The following species have a range reaching far into the north: Potentilla fruticosa, Salix rostrata, Populus tremuloides. Only one specimen of Salix rostrata was found. No other specimen is known in the region. Populus tremuloides occurs sparingly thru central Indiana, but is common in the bog.

A very striking fact is the presence of a large number of species characteristic of prairies. This is somewhat strange when it is remembered that the prairie is a formation not at all characteristic of eastern Indiana, which was originally heavily forested. Eastern Indiana is, however, not far from the tension line between the forest formation characteristic of the east and southeast and the prarie formation characteristic of the west and southwest. No doubt after the retreat of the glacial ice there was a migration of plants of both of these formations and a consequent struggle between them for the possession of the new territory. In some instances the pond-swamp-prairie succession or the pond-bog-prairie succession may have occurred, while in other cases the pond-swamp-forest or the pond-bog-forest succession may have taken place. The last named is the succession that occurred at Cedar Swamp. In Eastern Indiana, the condition that finally prevailed over the entire area was the mesophytic forest, but it is not likely that the patches that may have followed the succession toward the prairie would have entirely disappeared. This hypothesis would account for such islands of prairie plants in a forested area as we find in this bog. This is not an isolated case, for other such situations are found in eastern Indiana and western Ohio and are known locally as "quaking prairies." The writer hopes to make further studies of these areas.

The following plants occur in the Elliott's Mills bog:

Rhus vernix.
Cornus stolonifera.
Potentilla fruticosa.
Parnassia caroliniana.
Hypericum prolificum.
Salix pedicellaris.
Salix rostrata.
Gerardia paupercula.
Populus tremuloides.
Aster Nova-Angliae.
Aster oblongifolius.
Phlox glaberrima.
Physostegia virginica.
Ulmaria rubra.
Solidago ohioensis.
Solidago Ridellii.
Solidago stricta.
Solidago rugosa.
Rudbeckia hirta.
Desmodium paniculata.
Monarda fistulosa.
Rosa setigera.
Koellia virginica.
Chelone glabra.
Cirsium muticum.
Salix nigra.
Salix cordata.
Lobelia syphilitica.
Lobelia Kalmii.
Aspidium thelypteris.
Selaginella apus.
Physocarpus opulifolius.
Inula Helenium.
Geum canadense.
Symplocarpus foetidus.
Eupatorium perfoliatum.

Eupotorium purpureum.
Sagittaria latifolia.
Alisma plantago.
Carex spp.
Cuscuta sp.
Ludwigia palustris.
Bidens trichosperma.
Oxypolis rigidior.
Campanula americana.

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A Report on the Lakes of the Tippecanoe Basin.*

Will Scott.

This paper presents the first section of the results of the survey of the Indiana lakes. The lakes herein described all lie in the Tippecanoe basin. This basin contains 1,890 square miles. The plan of the survey has been to construct a hydrographic map of the lakes; and to determine at critical levels the temperature together with the amount of oxygen, free carbon-dioxide, carbonates and plankton.

The following lakes have been mapped: Manitou, Yellow Creek, Beaver Dam, Silver, Plew, Sawmill, Irish, Kuhn, Hammon, Dan Kuhn and Ridinger.

Gas determinations and plankton collections have been made in the following lakes: Manitou, Yellow Creek, Pike, Eagle (Winona), Little Eagle (Chapman), Tippecanoe, Plew, Hammon (Big Barbee).

All of the lakes in this basin have been caused by irregularities in the great Erie-Saginaw interlobate moraine which was formed by the Erie and Huron-Saginaw lobes of the Wisconsin ice sheet. The basins are either kettle holes, irregulatities in the ground moraine, channel lakes, or a combination of these.

In the lakes that we have mapped the area varies from 85,084 sq. M. in Sawmill lake to 3,265,607 sq. M. in Manitou. The volume varies from 284,716 cu. M.in the former to 9,787,024 cu. M. in the latter. Their maximum depth varies from 7.9 M. in Dan Kuhn lake to 22 M. in Yellow Creek lake. The average depth of Dan Kuhn lake is 2.588 M. and that of Yellow Creek lake is 10 M. These are the maximum and the minimum for the lakes mapped.

The bottom temperatures vary from 5.3° C. in Tippecanoe lake to 15° C. in Little Eagle (Chapman). The amount of wind distributed heat (i. e. in excess of 4° C.) has been calculated in gram calories per square centimeter of surface. This varies from 5,361 gram calories in Manitou to 10,563 calories in Yellow Creek lake.

The oxygen is always abundant in the epilimnion. In six observations it was found to exceed the saturation point at one or more levels. The

*A complete report of this work, with maps, tables, and other data, will be published as the July number of the Indiana University Studies for 1916.

oxygen is always reduced in the hypolimnion. The following lakes have no free oxygen in their lower levels: Hammon, Lingle, Little Eagle, Pike, Center and Webster.

All lakes that have been examined are hard water lakes. The maximum amount of carbondioxide as carbonates varies in the different lakes from 27 cc. per liter to 60 cc. per liter. They are all increasingly acid in their lower levels, but in the epilimnion they are sometimes alkaline. This is due to photosynthesis.

The above statements in this discussion apply only to summer conditions.

No very general correlation has been found between the plankton and the dissolved gases. Some of the lakes are much richer in plankton than others. It seems probable at the present stage of the investigation that this is related to, and possibly caused by the varying amount of phanerogams that are produced in their littoral region.

A List of Plant Diseases of Economic Importance in Indiana with Bibliography.

F. J. Pipal.

INTRODUCTION.

Plant diseases cost Indiana considerably more every year than the maintenance of all public schools in the State. In other words, they exact an annual tax of over $15,000,000. The loss on the grain crops alone amounts to about $11,000,000. The above estimates are based upon the results of the experimental and demonstrational work conducted for a number of years with grain smuts over a large section of the state, upon special reports from coöperators in plant disease survey, general correspondence, and personal investigations and observations by the members of the Botanical and other departments of the Agricultural Experiment Station.

A considerable proportion of this damage to growing crops can be readily and cheaply prevented by employing certain well-established, precautionary measures. This has been clearly demonstrated in the disinfection of seed grain by the formaldehydge treatment and in the spraying of fruit trees. Other effective sanitary measures and methods of control are available, which, if put into practice, will save yearly a neat sum of money.

It is highly desirable, therefore, that Indiana farmers realize these facts and avail themselves of the knowledge regarding plant diseases and their control. A greater interest of the farmer in this phase of work will also add stimulus to further and more extensive investigations of plant diseases so that new and more practical measures of prevention and control can be evolved and made available for general practice.

In order to bring together the accumulated information regarding the plant diseases that occur within the State the writer has made an attempt in this paper to present a list and a bibliography of plant diseases in Indiana. It is far from complete, however, and when a thorough survey is completed many additions will be made to it. This list is merely intended to serve as a foundation for plant disease surveys to be made in the future.

With a few exceptions the list includes all plant diseases that have been reported heretofore in various publications, and other diseases of which specimens have been collected or received from correspondents by former and present members of the Department of Botany, Indiana Agricultural Experimental Station, or by Professor G. N. Hoffer, of the School of Science, Purdue University. Unless otherwise stated in the list the specimens are in the phytopathological collection of the Station Department of Botany, or in the collection of Professor Hoffer. The distribution of the diseases is given either by counties, together with the dates of collections when known; or by sections of the State in which they are prevalent. If they occur generally over the State they are mentioned as common.

The bibliography includes articles written by Indiana workers and pertaining to Indiana plant diseases, published mostly in the bulletins and reports of the Indiana Agricultural Experiment Station, Proceedings of the Indiana Academy of Science, Transactions of the Indiana Horticultural Society, and the Annual Reports of the State Entomologist. It also includes several papers presented at meetings by out-of-state scientists, but pertaining to diseases common to Indiana and printed in the State publications. References to the articles dealing with the diseases mentioned in the following list are given by number, in the chronological order in which they were published.

In order to make the plant disease survey as complete as possible, co-operation is solicited, and the Department of Botany, Agricultural Experiment Station, Lafayette, will be pleased to receive specimens, especially of the less common or unreported diseases. Any valuable information as to the prevalence of such diseases, the extent of damage caused, relation to weather conditions, etc., will also be appreciated.

The writer wishes to express his gratitude to Prof. H. S. Jackson, Chief of the Department of Botany, Indiana Agricultural Experiment Station, for valuable advice and assistance in the preparation of this list.

LIST OF DISEASES.

Alfalfa (*Medicago sativa* L.)

Downey Mildew, *Peronospora Trifoliorum* DeB. Tippecanoe, 1915.

Leaf Spot, *Pseudopeziza Medicaginis* (Lib.) Sacc. Common. 78.

Rust, *Uromyces Medicaginis* Pass. Putnam, 1907.

Violet Root Rot, *Rhizoctonia Crocorum* (Pers.) DC. Referred to formerly as *R. Medicaginis* D.C. St. Joseph, 1915. County agent, J. S. Bordner, reported a number of affected spots in one field, each spot being as much as 10 feet across and enlarging at the rate of 1 foot every 30 days during the growing season. So far as known to the writer this disease has been reported on alfalfa only from Nebraska, Kansas and Virginia.

Wilt, *Sclerotinia Trifoliorum* Eriks. Clark, Fulton and Henry, 1914. Especially prevalent in Clark county.

Apple (*Pyrus Malus* L.)

Bitter Pit (cause physiological). Common on Baldwin variety. Baldwin Fruit Spot, caused by *Cylindrosporium Pomi*, has been reported but no definite determination of it has yet been made. References to Baldwin Fruit Spot: **58, 59, 84, 36.**

Bitter Rot, *Glomerella rufomaculans* (Berk.) Spaul. and von Schr. Prevalent in the southern half of the State. **46, 76, 78, 57, 58, 84, 100, 36, 40.**

Black Rot, *Sphaeropsis Malorum* Peck. Shear's studies indicate genetic connection with Melanops. Prevalent in the southern half of the State. **78, 58, 59, 84, 100, 67, 36, 40, 117.**

Blister Canker, *Nummularia discreta* (Schw.) Tul. Becoming serious in the southern part of the State. **36, 40, 39, 117, 86.**

Blotch, *Phyllosticta solitaria* E. & E. Common. **78, 58, 59, 84, 37, 40.**

Brown Rot, *Sclerotinia cinerea* (Bon.) Wor. Common. **58, 59, 84.**

Crown Gall, *Pseudomonas tumefaciens* E. F. Smith & Towns. Reported serious occasionally on nursery stock. **57, 59, 84, 36.**

European Canker, *Nectria ditissima* Tul. Found injurious to nursery stock. **57, 58, 59.**

Fire Blight, *Bacillus amylovorus* (Burr.) DeToni. Common. **76, 78, 57, 58, 59, 34, 36, 38, 117, 62.** See also under Pear.

Fly Speck, *Leptothyrium Pomi.* (Mont. & Fr.) Sacc. Usually found together with sooty blotch. **78, 58, 84, 36, 40.**

Jonathan Fruit Spot (cause unknown). Serious on Jonathan apples in storage.

Leaf Spot, *Phyllosticta limitata* Pk. Tippecanoe, 1915.

Pestalozzia concentrica B. & Br. Monroe, Franklin and Martin, 1912.

Mildew, *Podosphaera oxyacanthae* (D.C.) DeB. Floyd, 1906, and *Podosphaera leucotrichia* (E. & E.) Salm. Sullivan, 1915. **84.**

Pink Rot, *Cephalothecium roseum* Cda. Common. **58, 84.**

Root Rot, *Clitocybe parasitica* Wilcox and *Armillaria mellea* (Vahl.) Qual. Serious in some orchards in the southern counties.

Rust, *Gymnosporangium Juniperi-virginianae* Schw. Common. **133, 94, 78, 57, 58, 84, 100, 36, 40, 39, 117.**

Scab, *Venturia inaequalis* (Fr.) Wint. Common. **76, 78, 57, 58, 84, 59, 100, 36, 40, 39.**

Soft Rot, *Penicillium* spp. Common. **58, 59, 84.**

Sooty Blotch, *Phyllachora pomigena* (Schw.) Sacc. Most abundant in unusually moist seasons and in damp situations. **78, 58, 84, 36, 40.**

Trunk Rot, *Fomes applanatus* (Pers.) Wallr. Kosciusko, 1914.

Ash (*Fraxinus* spp.)

Mildew, *Phyllactinia corylea* (Pers.) Karst. Johnson, 1890. Montgomery and Putnam, 1893. **132.**

White Heart Rot, *Fomes fraxinophilus* Peck. **132, 71.**

Asparagus (*Asparagus* sp.)

Rust, *Puccinia Asparagi* D.C. Rather common. **110, 21, 142, 76, 77, 136, 25.**

Aster, Chinese (*Callistephus hortensis* Cass.)

Fusarium Wilt, *Fusarium* sp. Tippecanoe, 1912; Clinton, 1914; Allen and Marion, 1915.

Rust, *Coleosporium Solidaginis* (Schw.) Thum. Jefferson, 1914.

Barley (*Hordeum* sp.)

Black Stem Rust, *Puccinia poculiformis* (Pers.) Wettst. Common.

Covered Smut, *Ustilago Hordei* (Pers.) Kell. & Sw. Rather common. **132, 42.**

Loose Smut, *Ustilago nuda* (Jens.) Kell. & Sw. Rather common.

Stripe Disease, *Helminthosporium gramineum* (Rag.) Erik. Tippecanoe, 1910.

Bean (*Phaseolus vulgaris* L.)

Anthracnose, *Colletotrichum Lindemuthianum* (Sacc. & Magn.) Bri. & Cav. Common. **78, 128.**

Rust, *Uromyces appendiculatus* (Pers.) Lev. Common. **132, 142, 78.**

Stem Rot, *Corticium vagum* B. & C. *var. Solani* Burt. Laporte, 1911.

Beech (*Fagus* sp.)

Heart Rot, *Steccherinum septentrionale* (Fr.) Banker. Rather common. **132, 71.**

Leaf Spot, *Phyllosticta faginea* Pk. Monroe, 1909. **137.**

Mildew, *Microsphaera Alni* (D.C.) Wint. Johnson, 1890. **132.**

Beet (*Beta vulgaris* L.)

Bacterial Disease. While the cause of this disease has been ascribed to a bacterial origin, the matter has not been definitely settled. The general characteristics of the diseased plants are similar to those caused by the curly top disease described by Townsend (U. S. Dept. of Agr. B. P. I. Bul. 122). The curly top disease, however, appears to be caused, as indicated by Shaw (U. S. Dept. of Agr. B. P. I. Bul. 181) and Ball (U. S. Dept. of Agr. Bur. Ent. Bul. 66), by the beet leafhopper (*Eutettix tenella*). As this insect is claimed to be confined to the southern states and therefore is not likely to be found in Indiana, it is doubtful if the Indiana disease is the same as the curly top. **65, 31, 55.**

Leaf Blight, *Cercospora beticola* Sacc. Probably common. **128, 78.**

Leaf Spot, *Septoria Betae* West. Tippecanoe, 1896.

Scab, *Oospora scabies* Thaxter. Common. **65, 31.**

Birch, Yellow (*Betula lutea* Michx. f.)

Rust, *Melampsoridium betulinum* (Pers.) Kleb. Steuben, 1913. **25.**

Blackberry (*Rubus* spp.)

Anthracnose, *Gloeosporium venetum* Speg. Burkholder reported genetic connection with Plectodiscella. Common. **128, 78, 57, 36, 40.**

Crown Gall, *Pseudomonas tumefaciens* E. F. Smith and Townsend. Rather serious in some localities. **76, 57, 40.**

Leaf Spot, *Septoria Rubi* West. Common. **78, 40.**

Rust, *Gymnoconia interstitialis* (Schlecht.) Lagh. Common. **64, 128, 142, 78, 57, 36.** *Puccinia Peckiana* Howe. Tippecanoe, 1895. *Kuehneola Uredinis* (Link) Arthur. Common.

Blue-grass (*Poa pratensis* L.)

Anthracnose, *Colletotrichum cereale* Manns. Tippecanoe, 1914.

Leaf Spot, *Scoletotrichum graminus* Fckl. Johnson, 1890. **132.**

Mildew, *Erysiphe graminis* D.C. Common in wet seasons. **132.**

Rust, *Puccinia epiphylla* (L.) Wettst. Common. **132.**

Slime Mold, *Physarum cinereum* (Batsch) Pers. Tippecanoe, 1913. Marion, 1915.

Cabbage (*Brassica oleracea* L.)

Black Leg, *Phoma oleracea* Sacc. Elkhart, 1915. Large percentage of the crop in two fields was severely affected.

Black Rot, *Pseudomonas campestris* (Pammel) E. F. Smith. Common. **108, 76, 78, 42.**

Club-root, *Plasmodiophora Brassicae* Wor. Rather common. **77.**

Drop, *Sclerotinia libertiana* Fckl. Tippecanoe, 1915. No specimen preserved.

Leaf Blight, *Alternaria Brassicae* (Berk.) Sacc. Clark, 1908. One field almost ruined. No specimen preserved.

Wilt or Yellows, *Fusarium conglutinans* Wr. Pike and Decatur, 1914.

Canteloupe (*Cucumis Melo* L.)

Anthracnose, *Colletotrichum Lagenarium* (Pass.) Ell. & Halls. Becoming common. **78.**

Leaf Blight, *Alternaria Brassicae* (Berk.) Sacc. Common. **128, 78, 144.**

Wilt, *Bacillus tracheiphilus* E. F. Smith. Very serious in many localities. **76, 78, 144.**

Carnation (***Dianthus Caryophyllus*** L.)

Bacteriosis, *Bacterium Dianthi* Arth. & Boll. Serious in greenhouses. **30.**

Bud Rot, *Sporotrichum anthophilum* Peck. Marion, 1909. **58.**

Leaf Spot, *Alternatia Dianthi* S. & H. Monroe, 1912. **138.**

Rust, *Uromyces caryophyllinus* (Schrank) Wint. Common. **132, 138.**

Catalpa (***Catalpa*** spp.)

Heart Rot, *Collybia velutipes* Fr. and *Polyporus versicolor* Fr. Tippecanoe, 1913. **71.**

Leaf Spot, *Cladosporium* sp. Common. **58.** *Macrosporium Catalpae* Ell. & Mart., Kosciusko, 1914, and *Phyllosticta Catalpae* Ell. & Mart., Kosciusko, 1914. **71.**

Mildew, *Microsphaera vaccinii* (Schw.) Salm. Reported as *Microsphaera elevata* Burrill. Putnam, 1891. Owen, 1893. Tippecanoe, 1890. *Phyllactinia suffulata* (Reb.) Sacc. Montgomery, 1893. **132.**

Cauliflower (***Brassica oleracea*** L. ***var. botrytis*** D. C.)

Black Rot, *Pseudomonas campestris* (Pammel) E. F. Smith. No locality mentioned. **77.**

Celery (***Apium graveolens*** L.)

Leaf Spot, *Septoria Petroselini* Desm. var. Apii. Br. & Cav. Tippecanoe, 1915. *Cercospora Apii* Fr. Marshall and St. Joseph, 1915.

Cherry (***Prunus*** spp.)

Black Knot, *Plowrightia morbosa* (Schw.) Sacc. Common. **127, 10, 130, 57, 36, 40, 117.**

Brown Rot, *Sclerotinia cinerea* (Bon.) Wor. Common. **57, 58, 36, 40.**

Leaf Spot, *Cylindrosporium Padi* Karst. Higgins has reported genetic relation with *Coccomyces hiemalis* Higgins. Common. **78, 57, 36, 38, 40.**

Powdery Mildew, *Podosphaera oxyacanthae* (D.C.) DeB. Common.

Scab. *Venturia cerasi* Aderh. Kosciusko, 1913.

Chestnut (*Castanea* spp.)

Blight, *Endothia parasitica* (Murrill) Anders. Marion and Benton, 1915.
Leaf Spot, *Mycosphaerella maculiformis* (Pers.) Schw. Martin, 1915.

Chrysanthemum (*Chrysanthemum* spp.)

Rust, *Puccinia Chrysanthemi* Roze. Tippecanoe, 1900. **24.**

Clover (*Trifolium* spp.)

Anthracnose, *Colletotrichum Trifolii* Bain. Monroe, 1908, on red clover. **137.** *Gloeosporium caulivorum* Kirchner. Tippecanoe, 1915, on red clover.

Black Mold, *Phyllachora Trifolii* (Pers.) Fckl. Johnson, 1890, on red clover. **132.**

Rust, *Uromyces fallens* (Desm.) Kern and *Uromyces Trifolii* (Hedw.) Lev. Common. **132, 25, 142, 98.**

Sooty Spot, *Polythryncium Trifolii* Kze. Franklin, 1912, on red and white clover.

Wilt, *Sclerotinia Trifoliorum* Eriks. Gibson, 1915, on red and crimson clover.

Corn (*Zea Mays* L.)

Dry Rot, *Fusarium* sp. Common. **77, 78.**

Rust, *Puccinia Sorghi* Schw. Common. **132, 142.**

Smut, *Ustilago Zeae* (Beckm.) Ung. Common. **49, 12, 56, 107, 33, 111, 113, 45, 76, 78.**

Cucumber (*Cucumis sativus* L.)

Angular Leaf Spot, *Bacterium lachrymans.* E. F. Smith & Bryan. Pulaski, Marshall and Fulton, 1915.

Anthracnose, *Colletotrichum Lagenarium* (Pass.) Ell. & Hals. Marshall, Laporte, St. Joseph, Starke, Pulaski and Fulton, 1915.

Bacterial Wilt, *Bacillus tracheiphilus* E. F. Smith. Marshall, Tippecanoe, Laporte, Fulton, Starke, Pulaski and St. Joseph, 1915.

Downy Mildew, *Peronoplasmopara cubensis* (B. & C.) Clinton. Marshall, 1915.

Powdery Mildew, *Erysiphe Cichoracearum* D.C. Marshall, 1915.

White Pickle or Mosaic Disease (cause not known). Marshall, Laporte, Tippecanoe, Fulton, Pulaski, St. Joseph and Starke. 1915.

Currant (*Ribes* spp.)

Anthracnose, *Pseudopeziza Ribis* Kleb. Rather common. **138, 40.**

Leaf Spot, *Septoria Ribis* Desm. Common. **78, 40.**

Powdery Mildew, *Sphaerotheca Mors-uvae* (Schwein.) Berk. & Curt. Common. **40.**

Eggplant (*Solanum Melongena* L.)

Leaf Spot, *Ascochyta Lycopersici* Brun. Tippecanoe, 1915.

Elm (*Ulmus* spp.)

Leaf Spot, *Mycosphaerella Ulmi* Kleb. Johnson, 1890. *Dothidella ulmea* (Schw.) E. & E. Montgomery, 1893. Kosciusko, 1912. **132, 135, 71.**

Mildew, *Uncinula macrospora* Pk. Rather common. **132.**

Rot, *Pleurotus ulmarius* Bull. Common. **71.**

Ginseng (*Panax quinquefolium* L.)

Wilt, *Acrostalagmus albus* Preuss. Brown, 1909. **58.**

Gooseberry (*Ribes grossularia* L.)

Anthracnose, *Pseudopeziza Ribis* Kleb. Becoming common. **40.**

Leaf Spot, *Septoria Ribis* Desm. Common. **78, 138, 40.**

Mildew, *Sphaerotheca Mors-uvae* (Schw.) Berk. & Curt. Common. **128, 78, 40.**

Grape (*Vitis* spp.)

Anthracnose, *Gloeosporium ampelophagum* Sacc. Rather common. **58, 60, 36, 40.**

Black Rot, *Guignardia Bidwellii* (Ell.) Viala & Ravaz. Common. **8, 128, 78, 60, 36, 40.**

Crown Gall, *Pseudomonas tumefaciens* E. F. Smith & Towns. No locality mentioned. **38.**

Downy Mildew, *Plasmopara viticola* (B. & C.) Berl. & DeToni. Common. **132, 58, 60, 36, 40.**

Powdery Mildew, *Uncinula necator* (Schw.) Bull. Common. **8, 127, 36, 40.**

Necrosis, *Fusicoccum viticolum* Red. Tipton, 1907. **60.**

Hickory (***Hicoria*** spp.)

Leaf Spot, *Bacterium* sp. Common. **71.**

Marsonia sp. Kosciusko, 1913.

Mildew, *Microsphaera Alni* (D.C.) Wint. Johnson, 1890; Marshall, 1893. **132.**

Root Rot, *Armillaria mellea* Vahl. Tippecanoe, 1915. **71.**

Hollyhock (***Althaea rosea*** Cav.)

Rust, *Puccinia malvacearum* Mont. St. Joseph, Montgomery, Marshall, Huntington, Marion, and Tippecanoe, 1915.

Horse Chesnut (***Aesculus Hippocastanum*** L.)

Mildew, *Uncinula flexuosa* Pk. Johnson, 1890; Montgomery. **132.**

Japanese Ivy (***Ampelopsis tricuspidata*** Sieb. & Zucc.)

Cladosporium Wilt, *Cladosporium herbarum* Link. Tippecanoe, 1914.

Lettuce (***Lactuca sativa*** L.)

Downy Mildew, *Bremia Lactucae* Regel. Found frequently in greenhouses. **143.**

Drop, *Sclerotinia libertiana* Fckl. Common in greenhouses.

Leaf Spot, *Septoria Lactucae* Pass. Johnson, 1890. Kosciusko, 1913. **132.**

Lilac (***Syringa vulgaris*** L.)

Mildew, *Microsphaera Alni* (Wollr.) Wint. Common. **102.**

Linden (***Tilia americana*** L.)

Mildew, *Uncinula Clintonii* Peck. Montgomery, 1890; Putnam, 1893. **132.**

Locust, Black (*Robinia Pseudacacia* L.)

Yellow Heart Rot, *Fomes rimosus* Berk. Rather common. **71.**

Locust, Honey (*Gleditsia* triacanthos L.)

Leaf Spot, *Melasmia hypophylla* Sacc. Marion, 1890; Tippecanoe, 1892; Putnam, 1893. **132.**

Mildew, *Microsphaera Alni* (Wallr.) Wint. Common. **71.**

Maple (*Acer* spp.)

Anthracnose, *Gloeosporium apocryptum* E. & E. Marion, Floyd, Vanderburg and Boone, 1914. **39.**

Bark Canker, *Schizophyllum commune* Fr. Rather common. **71.**

Canker, *Nectria cinnabarina* (Tode) Fr. Carroll, 1913. **71.**

Leaf Spot, *Phleospora Aceris* Lib. Johnson, 1890, on red maple. *Stagonospora collapsa* (C. & E.) Sacc. Putnam, 1893, on soft maple. **132.**

Leaf Tar Spot, *Rhytisma acerina* (Pers.) Fr. Common in some localities. **132, 137, 39, 71.**

Mildew, *Uncinula circinata* C. & P. Montgomery, 1885; Johnson, 1890; Marshall, 1893, on red and soft maple. **132, 102.**

Sun Scald. This trouble, thought to be due to drouth and storm injury has been quite prevalent over the State during the past few seasons. **38, 39.**

White Heart Rot, *Fomes igniarius* (L.) Gillet. Common. **71.**

White Rot, *Polyporus squamosus* (Huds.) Fr. Tippecanoe. **71.**

Millet (*Chaetochloa italica* (L.) Scribn.

Smut, *Ustilago Crameri* Koern. Rather common but not serious. **112.**

Oak (*Quercus* spp.)

Leaf Spot, *Ceratophorum uncinatum* (Cl. & Pk.) Sacc. Johnson, 1890, on bur-oak. *Didymella lephosphora* Sacc. & Speg. Monroe, 1911, on red oak. *Gloeosporium septorioides* Sacc. Montgomery, 1890; Monroe, 1909, on red oak. *Marsonia Martini* Sacc. & Ell. Common on several species. *Phyllosticta Quercus* Sacc. & Speg. Montgomery, 1893, on bur-oak. **132, 137, 71.**

Brown Heart Rot. *Fomes Everhartii* Ell. & Gall. = (*Pyropolyporus Everhartii* (Ell. & Gall.) Murrill). Common in the northern counties. **71.**

Mildew, *Microsphaera Alni* (Wallr.) Wint. Frequently on leaves of coppice growth of red and white oaks. *Phyllactinia suffulta* (Reb.) Sacc. Shelby, 1890; Vigo, 1893, on swamp and red oaks. **132, 71.**

Piped Rot. *Polyporus pilotae* Schw. = (*Aurantiporus pilotae* (Schw.) Murrill). In the southern part of the State. **71.**

Red Heart. *Polyporus sulphureus* (Bull.) Fr. = (*Laetiporus speciosus* Batt.) Murrill). Common. **71.**

Root Rot. *Armillaria mellea* Vahl. Common. *Polyporus Berkeleyi* Fr. = (*Grifolia Berkeleyi* (Fr.) Murrill). Tippecanoe and Monroe. *Polyporus dryadeus* Fr. Tippecanoe and Monroe. **71.**

Speckled Rot. *Stereum frustulosum* Pers. Putnam, 1891. **132.**

Straw-colored Rot. *Polyporus frondosus* Fr. = (*Grifolia frondosa* (Fr.) Murrill.) Common, although it does not frequently attack living trees. **71.**

White Rot or Coral Fungus. *Hydnum erinaceus* Bull. Common. **71.**

Oats (*Avena sativa* L.)

Covered Smut. *Ustilago levis* (Kell. & Sw.) Magn. Common.

Loose Smut. *Ustilago Avenae* (Pers.) Jens. Common. **3, 6, 9, 132, 56, 122, 109, 20, 123, 115, 26, 27, 76, 78, 42, 32, 75, 91.**

Rust, *Puccinia Rhamni* (Pers.) Wettst. Common. **132, 25, 142, 76, 78.**

Ohio Buckeye (*Aesculus glabra* Willd.)

Mildew, *Uncinula flexuosa* Pk. Johnson, 1890; Montgomery. **132.**

Leaf Spot. *Phyllosticta Paviae* Desm. Montgomery and Johnson, 1890; Brown, 1893. **132.**

Onion (*Allium Cepa* L.)

Black Mold. *Macrosporium parasiticum* Thuem. Starke, 1912.

Smut, *Urocystis cepulae* Frost. Becoming serious locally in the north central counties. **135.**

Soft Rot. *Bacillus* sp. Occasionally casues considerable loss in storage.

Pea (*Pisum* sp.)

Blight, *Ascochyta Pisi* Lib. Common. **42, 136.**

Peach (*Amygdalus persica* L.)

Bacterial Leaf Spot, *Bacterium Pruni* E. F. Smith. Vanderburg, 1915.

Blight, *Coryneum Beyerinkii* Oud. Reported in several localities in the peach-growing districts. **61, 40.**

Brown Rot, *Sclerotinia cinerea* (Bon.) Wor. Common. **76, 57, 58, 61.**

Crown Gall, *Pseudomonas tumefaciens* E. F. Smith & Towns. Probably not common. **57, 61.**

Leaf Curl, *Exoascus deformans* (Berk.) Fckl. Common. **132, 128, 17, 76, 78, 57, 61, 40.**

Powdery Mildew, *Sphaerotheca pannosa* (Wallr.) Lev. Common. **58, 61.**

Scab, *Cladosporium carpophilum* Thuem. Common. **2, 98, 58, 61, 40.**

Yellows. Common. **76, 78, 57, 58, 61, 40, 117.**

Pear (*Pyrus communis* L.)

Black Rot, *Sphaeropsis Malorum* Pk. Shear's studies indicate genetic connection with Melanops. Tippecanoe, 1915.

Blight, *Bacillus amylovorus* (Burr.) DeToni. Common. **43, 57, 81, 92, 93, 97, 121, 52, 53, 51, 105, 128, 99, 63, 95, 76, 78, 59, 84, 36, 38, 40, 117, 62.** See also under Apple.

Leaf Blight, *Entomosporium maculatum* Lev. Perfect stage = *Fabrea maculata* (Lev.) Atk. Rather common. **36, 40.**

Leaf Spot, *Septoria pyricola* Desm. Rather common. **135.** *Mycosphaerella sentina* (Fr.) Schw. Kosciusko, 1914.

Scab, *Venturia pyrina* Aderh. Rather common. **128, 78.**

Pepper (*Capsicum annuum* L.)

Black Rot, *Macrosporium Solani* Ell. & Mart. Tippecanoe, 1912.

Plum (*Prunus* spp.)

Black Knot, *Plowrightia morbosa* (Schw.) Sacc. Common. **127, 10, 128, 130, 76, 78, 57, 58, 36, 40, 117.**

Brown Rot, *Sclerotinia cinerea* (Bon.) Wor. Common. **128, 76, 78, 57, 58, 36, 40.**

Leaf Spot, *Cylindrosporium Padi* Karst. Common. **128, 78, 57, 36, 40.**

Plum Pocket, *Exoascus Pruni* Fckl. Common. **17, 38, 117.**

Poplar (*Populus* spp.)

Leaf Spot, *Marsonia Populi* (Lib.) Sacc. Tippecanoe, 1910.
Mildew, *Uncinula Salicis* (D.C.) Wint. Common. **132.**
Rust, *Melampsora Medusae* Thuem. Common. **142, 71.** *Melampsora Abietis-canadensis* (Farl.) Ludwig. Tippecanoe, Jasper, Steuben, Putman.

Potato (*Solanum tuberosum* L.)

Bacterial Wilt, *Bacilus solanacearum* E. F. Smith. Serious locally. **78.**
Early Blight, *Macrosporium Solani* Ell. & Mart. Common. **128, 119, 78.**
Fusarium Rot, *Fusarium* sp. Common.
Late Blight, *Phytophthora infestans* (Mont.) DeB. Common. **128, 119, 78.**
Scab, *Oospora scabies* Thaxter. Common. **11, 13, 14, 15, 20, 76, 78, 54.**
Tipburn. Probably sunscald injury. Tippecanoe, 1907.

Privet (*Ligustrum vulgare* L.)

Anthracnose, *Gloeosporium cingulatum* Atk. Marion, 1908. **58.**

Quince (*Cydonia vulgaris* Pers.)

Black Rot, *Sphaeropsis malorum* Pk. Shear indicates genetic connection with Melanops. Common. **76, 78.**
Blight, *Bacillus amylovorus* (Burr.) DeToni. Common. **76, 78, 36, 40.**
See also under Apple and Pear.
Leaf blight, *Entomosporium maculatum* Lev. Common. **128, 58, 36, 40.** Perfect stage = Fabrea maculata (Lev.) Atk.
Mildew, *Podosphaera oxyacanthae* (D.C.) DeB. Montgomery, 1885. **102.**
Rust, *Gymnosporangium germinale* (Schw.) Kern. Perry, 1914. **77.**

Radish (*Raphanus sativus* L.)

Downy Mildew, *Peronospora parasitica* (Pers.) DeB. **143.**
White Rust, *Albugo candida* (Pers.) Roussel. Common. **132, 143.**

Raspberry (*Rubus* spp.)

Anthracnose, *Gloeosporium venetum* Speg. Burkholder reported genetic connection with Plectodiscella. Common. **128, 76, 78, 58, 36, 40.**

Cane Blight, *Coniothyrium Fuckelii* Sacc. No locality mentioned. **40.**

Crown Gall, *Pseudomonas tumefaciens* E. F. Smith & Towns. Common. **40.**

Leaf Spot, *Septoria Rubi* West. Common. **78, 40.**

Rust, *Gymnoconia interstitialis* (Schlecht.) Lagh. Common. **78, 36.**

Rhubarb (*Rheum Rhaponticum* L.)

Leaf Spot, *Ascochyta Rhei* E. & E. Tippecanoe, 1912 and 1915.

Rose (*Rosa* spp.)

Black Spot, *Actinonema Rosae* (Lib.) Fr. Wolf reported perfect stage, *Diplocarpon Rosae* Wolf.

Leaf Spot, *Dicoccum Rosae* Bon. Howard, 1911.

Mildew, *Sphaerotheca pannosa* Wallr. Common. **132.**

Rust, *Phragmidium americanum* Dietel. Probably common. **132.**

Phragmidium disciflorum (Tod) J. F. James. St. Joseph, 1915.

Phragmidium subcorticium (Schrank) Wint. Tippecanoe, 1915.

Rubber Plant (*Ficus elastica* Roxb.)

Leaf Spot. *Macrosporium* sp. Tippecanoe, 1910.

Rye (*Secale cereale* L.)

Ergot, *Claviceps purpurea* (Fr.) Tul. Common. **132.**

Leaf Rust, *Puccinia asperifolia* (L.) Wettst. Common.

Stem Rust, *Puccinia poculiformis* (Jasq.) Wettst. **25.**

Sorghum (*Sorghum* spp.)

Kernel Smut, *Sphacelotheca Sorghi* (Lk.) Clinton. Common. Collected on several members of the sorghum group.

Snapdragon (*Antirrhinum majus* L.)

Anthracnose, *Colletotrichum Antirrhini* Stew. Tippecanoe, 1915.

Rust, *Puccinia Antirrhini* Diet. & Holw. Montgomery, Lagrange, Hendricks and Wabash, 1915.

Strawberry (*Fragaria* spp.)

Leaf Spot, *Mycosphaerella Fragariae* (Tul.) Linden. Common. **128, 58, 40, 90, 39.**

Mildew, *Sphaerotheca Humuli* (D.C.) Burr. Common. **38, 40.**

Sweet Pea (*Lathyrus* spp.)

Root Rot, *Fusarium Lathyri* Taubenhaus. Tippecanoe, 1912.

Sweet Potato (*Ipomoea Batatas* Lam.)

Black Rot, *Sphaeronema fimbriatum* (Ell. & Hals.) Sacc. Rather common. **77, 83.**

Dry Rot, *Diaporthe batatatis* Harter & Field. Tippecanoe, 1912. **83.**

Fusarium Rot, *Fusarium* sp. Tippecanoe, 1912. **83.**

Stem Rot, *Nectria Ipomoeae* Hals. Tippecanoe, 1912. Monroe. 83.

Swiss Chard (*Beta* sp.)

Leaf Spot, *Cercospora beticola* Sacc. Tippecanoe, 1910.

Sycamore (*Platanus occidentalis* L.)

Leaf Spot, *Stigmina Platani* Fckl. Tippecanoe, 1914. **71.**

Mildew, *Microsphaera Alni* (DC.) Wint. Johnson, 1890; Putnam, 1891; Montgomery, 1893. **132.**

Phyllactinia Corylea (Pers.) Karst. Common. **71.**

Timothy (*Phleum pratense* L.)

Anthracnose, *Colletotrichum cereale* Manns. Hamilton and Bartholomew, 1909.

Leaf Spot, *Scoletotrichum graminis* Fckl. Johnson, 1890. **132.**

Rust, *Puccinia poculiformis* (Jacq.) Wettst. Common. **79, 80, 74.**

Silver Top, *Sporotrichum Poae* Pk. Kosciusko, 1914.

Smut, *Ustilago striaeformis* (West.) Niess. Common. **132.**

Tomato (*Lycopersicum esculentum* Mill.)

Anthracnose, *Colletotrichum phomoides* (Sacc.) Chest. Common.

Bacterial Blight, *Bacillus solanacearum* E. F. Smith. Serious locally. **78, 39.**

Black Rot, *Alternaria* sp. Tippecanoe, 1912.

Blossom End Rot (cause not known). Common, especially during dry weather. **76, 78, 131.**

Fusarium Wilt, *Fusarium Lycopersici* Sacc. Knox, 1913; Tippecanoe, 1914 and 1915.

Leaf Mold, *Cladosporium fulvum* Cke. Wabash, 1915, in greenhouse.

Leaf Spot, *Septoria Lycopersici* Speg. Common. **128, 78, 131.**

Mosaic Disease (cause not definitely known). Common in greenhouses.

Oedema. Cause physiological. Tippecanoe, 1912, in greenhouse.

Walnut, Black (*Juglans nigra* L.)

Leaf Spot, *Marsonia Juglandis* (Lib.) Sacc. Perfect stage = *Gnomonia leptostyla* (Fr.) Ces. & d. Not. Tippecanoe, 1914.

Mildew, *Microsphaera Alni* (D.C.) Wint. Johnson, 1890. Putnam, 1893. **132.**

Walnut, White (*Juglans cinerea* L.)

Mildew, *Phyllactinia Corylea* (Pers.) Karst. Carroll, 1913. **71.**

Watermelon (*Citrullus vulgaris* Schrad.)

Anthracnose, *Colletotrichum Lagenarium* (Pass.) Ell. & Hals. Common. **128, 78.**

Fusarium Wilt, *Fusarium vasinfectum* Atk. *var. niveum* Sm. Common. **78, 144.**

Leaf Blight, *Alternaria Brassicae* (Berk.) Sacc. *var. nigrescens* Pegl. Common.

Wheat (*Triticum vulgare* L.)

Anthracnose, *Colletotrichum cereale* Manns. Posey, 1912.

Ebony Point, *Alternaria* sp. Common.

Fusarium Blight, *Fusarium* sp. Unusual outbreak of Fusarium trouble occurred during the past season (1915) in Orange, Washington, Jefferson and Green counties. The maturing heads had a dull grayish-brown color instead of the normal golden brown. The kernels were small, shrunken, and in many cases covered with mycelial growth. Prof. G. N. Hoffer, who co-operated in the investigation of this disease, found many kernels internally infected with Fusarium.

Leaf Rust, *Puccinia triticina* Eriks & Henn. Common. See under Stem Rust.

Loose Smut, *Ustilago Tritici* (Pers.) Jens. Common. **82, 35, 91a, 132, 19, 109, 23, 116, 76, 78, 42, 32.**

Scab, *Fusarium* sp. Common, **7, 18, 76, 78.**

Septoria Spot, *Septoria graminum* Desm. Common. Another species of Septoria which agrees closely with *S. glumarum* Sacc. was found associated with the Fusarium blight disease. Pycnidia were found in abundance not only on glumes but on sheaths and nodes as well. In one of the fields examined by the writer every wheat plant was severely affected.

Stinking Smut, *Tilletia foetans* (B. & C.) Trel. Common. **82, 3, 5, 91a, 9, 56, 20, 76, 78, 42, 57, 32, 88.** *Tilletia Tritici* (Beij.) Wint. Franklin, 1912.

Stem Rust, *Puccinia poculiformis* (Jacq.) Wettst. Common. **82, 50, 4, 47, 48, 142, 76, 78, 57.**

Willow (*Salix* spp.)

Mildew, *Uncinula Salicis* (D.C.) Karst. Common. **132, 71.**

Rust, *Melampsora Bigelowii* Thuem. Common. **71.**

Wood Rot, *Daedalea confragosa* (Balt.) Pers. Tippecanoe, 1912.

Yellow Poplar (*Liriodendron tulipifera* L.)

Mildew, *Erysiphe Liriodendri* Schw. Putnam, 1891 and 1893; Montgomery 1893. *Phyllactinia suffulta* (Reb.) Sacc. Johnson, 1890; Montgomery, 1893. **132.**

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3. ————

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4. ————

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5. ————

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6. ————

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7. ————

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8. ————

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11. ————

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12. ————

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13. ————

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18. ——————

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19.*——————

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20. ——————

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21. ——————

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22. ——————

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23. ——————

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*Article 19 should be credited to Wm. Stuart.

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1911 What about oat smut this year? Ind. Agr. Exp. Sta. Newsp. Bul. 173. Brief account of the formaldehyde treatment.

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The Olympic Coal Fields of Washington.

By Albert B. Reagan.

The Olympic Peninsula covers an area of about eight thousand square miles. It is approximately a right angle triangle in shape with its hypotenuse on the Pacific side. Its shorter limb faces the "Sound," the longer limb of the triangle faces the Strait of Juan de Fuca. This peninsula consists of a moderately benched area forming a coastal bench surrounding a high central area termed the Olympic Mountains which are situated somewhat southeast of the center of the peninsula. And from this high area there extends northwestward to Cape Flattery a gradual declining ridge. The most commonly heard-of places of the region are LaPush and Quillayute on the Pacific front and Neah Bay, Clallam Bay, Port Angeles, and Port Townsend on the Strait of Fuca side.

The region is much fissured and faulted and much of the strata are tipped at a high angle. The core of the Olympic Mountains is supposed to be pre-Cretaceous in age. The exposed rocks along the Strait of Fuca are Pleistocene and Tertiary. The Pleistocene is the Country rock from Port Townsend to Fresh Water Bay north of Port Angeles. Eocene rocks are exposed at Port Crescent, and from there northward to Cape Flattery and then down the Pacific front as far south as the Point of Arches, the exposed rock is Oligocene-Miocene. The Point of Arches appears to be pre-Cretaceous in age, as do also the rocks at Point Elizabeth, one hundred twenty miles further south, while the intervening coast exposures appear to be Cretaceous in age. The troughs of the Quillayute river and its tributaries are incised in Tertiary strata.

Coal is exposed in the Oligocene-Miocene from Pyscht to Clallam Bay on the Strait of Fuca, a distance of about eight miles. Coal is also found inland near Fresh Water Bay. Small stringers of coal are also exposed in the Hoko Canyon. Small seams of coal were also observed at Strawberry and Johnson Points and near Portage Head on the Pacific Coast. Coal is also found in the Quillayute trough. The three principal coal areas will receive special mention.

The Quillayute River Field. About two miles southeast of Mora P. O. on the east bank of the Quillayute River a coal seam runs in an east and west direction with nearly a vertical dip. A thirty-foot tunnel was driven into this seam some years ago. The coal was found to be good quality of lignite, but the vein being less than a foot in thickness, the work was abandoned.

Another exposure in this field is near the Bogachiel river, about eight miles southwest of Forks P. O. Some years ago a company, said to be the Narrow Gauge Railroad Company, drove a thirty-foot tunnel into the exposed coal seam here. The coal was found to be a good quality of lignite, but as the vein was less than a foot in thickness, the work was abandoned. Below is an analysis of a specimen of coal from the headwaters of the Quillayute river, likely from the above tunnel:[1]

Moisture	5.10 per cent.
Volatile combustible matter	39.15 per cent.
Fixed carbon	47.01 per cent.
Ash	7.77 per cent.
Sulphur	.97 per cent.
Total	100.00 per cent.

The Fresh Water Bay Field. Drilling inland from the bay has exposed several seams of coal, some of workable size. The coal is in the Oligocene-Miocene formation. So far no development work has been done. Below is a drill record from a hole in a deep gulch in a broad synclinal trough about one mile south of the eastern end of Fresh Water Bay:

	Feet.
Dark sandstone	39⅔
Coal	⅓
Gray sandstone	24
Soft white sandstone	17
Sandstone containing oyster shells	10
Sandstone containing green boulders	10
Sandstone	40
Fireclay	20
Gray sandstone	40
Hard blue shale	30

[1] Mines and Minerals of Washington. Ann. Report, First State Geological Survey pp. 15, 16, Olympia, 1891.

	Feet.
Gray sandstone	50
Coal	$2\frac{1}{6}$
Gray sandstone	420
Coal	$4\frac{2}{3}$
Total	$527\frac{5}{6}$

The Clallam Bay Field. This field lies in a synclinal trough between Pillar Point at Pyscht and Slip Point on Clallam Bay on the Strait of Fuca and extends inland about seven miles, but is interrupted on the east and south by sharp faults and is truncated at the north by the Strait of Fuca. The coal is in the Oligocene-Miocene formation. The formation here consists of six hundred feet of coarse, thick-bedded, massive sandstone, interbedded with an occasional bed of conglomerate. In it are also interbedded several workable seams of coal.

This field was discovered in the early 50's of last century. Of a specimen of coal obtained at Slip Point then, Prof. J. S. Newberry gave the following analysis:[2]

Fixed carbon	46.40 per cent.
Volatile matter	50.97 per cent.
Ash	2.63 per cent.
Total	100.00 per cent.

Later, in about 1865, a mine was opened up $2\frac{1}{2}$ miles east of Slip Point, known as the Thorndike Mine. At this place there were six leads of coal, ranging in thickness from one to three feet, all having a dip of ten degrees. The formation was sandstone and the coal seams were found to be from twelve to one hundred feet apart. The coal was one of the best coals found in the State of Washington. Mining at this time was continued till a fault cut off the veins, or they pinched out.

Coal is now being mined from other locations in the sea-front of the same field. The work is being done by the Clallam Bay Coal Company. Prospecting in 1904 discovered veins as follows: One seam exposed along the coast was forty inches in thickness, another eighty feet stratigraphically below this one was twelve inches in thickness, and another, a twenty-two

[2]Pacific Railroad Report, Vol. IV, Part II, p. 67.

inch seam, is about one hundred feet below this one. This was near Slip Point. Other seams have been discovered farther down the sea-cliff to the eastward of these.

A tunnel has been driven more than 600 feet along the line of the 40-inch seam near Slip Point. The mouth of this tunnel is on the beach, so that coal can be loaded right onto ships from it.

The coal of this mine breaks with a conchoidal fracture and shows extreme sharp edges. It is clean, hard, glossy black lignite, with small quantities of pyrite. This pyrite is often included in the coal in veinlets, but not in quantity to damage the coal. The coal leaves no clinkers. Until recently the output of this mine was said to be 200 tons per month. An analysis of a specimen of this coal gave the following:[3]

Moisture	5.55 per cent.
Volatile combustible matter	34.25 per cent.
Fixed carbon	47.80 per cent.
Ash	11.40 per cent.
Total	100.00 per cent.

Thorough prospecting will likely disclose more and large coal seams.

[3]Analysis by Prof. N. W. Lord of the Department of Metallurgy and Mineralogy, Ohio State University, Columbus, Ohio.

The Olymic Forest and Its Potential Possibilities.

By Albert B. Reagan.

The Olympic Peninsula lies west of Puget Sound in the State of Washington. It comprises a wide, somewhat benched coastal strip bordering both the Strait of Juan de Fuca at the north, the Pacific Ocean at the west, and the "Sound" on the east. This coastal strip surrounds a central high area termed the Olympic Mountains. These mountains are wholly isolated. They form an eroded, domed area in the central-northeastern part of the peninsula. From this main mass there extends a western limb in declining altitude to Cape Flattery at the entrance of the Strait of Fuca, Mounts Constance, Meany, and Olympus of the central area approximate 8,150 feet in height, while the immediate region exceeds 6,000 feet in elevation, while the ridge towards the Cape receds to less than 2,000 feet in altitude. As a result of the practically domed area the drainage is radial in all directions, but the larger streams flow into the Pacific.

This peninsula, with its lofty peaks, stands first in the path of the moisture bearing winds from the Pacific. As a result, the precipitation is very heavy; at the coast it is usually rain, in the mountains snow. The precipitation averages about 40 inches east and north of the mountains, as far up the Strait of Fuca side as Port Angeles. West of the mountains at an elevation of 3,000 feet the precipitation averages 80 inches and in Upper-Strait-Flattery region and along the Pacific front 100 to 120 inches annually. The climate, also, is controlled by the prevailing southwesterly winds from the Pacific. Notwithstanding this, however, the valleys of the upper mountain districts are filled with glaciers. At the coast, however, especially on the Pacific front, snow seldom stays on the ground any length of time.

Growing under this equable climate with such an abundance of rainfall (enough in amount to preserve the forest and shrubbery from general destruction by fire), the peninsula, with few exceptions, is the most densely forested region in North America, and smaller plants do also equally well. Of course, as one approaches the mountains, the forest becomes less dense till the timber line is reached; but in the reverse proportion the flowering herbs at the same time increase in number and beauty. The open country at timber line in summer is one of nature's flower gardens. The region in the lower levels is a jungle of trees, shrubs, and entangled vines, which must be seen to be appreciated.

The plants identified in the region to date number 687. The trees and plants most noticeable in the peninsula are fir, cedar, spruce, hemlock, red elder, "Shallon," "Rubes," salal, "Vaccinum," "Ribes," Selaginella ("S. oregona"), crab-apple, devil's club, "usnea," bearded lichens, bearberry, dogwood ("Cornus nuttallii"), and oregon grape. Here Douglas fir, tide-land spruce, and red cedar reach gigantic proportions. The avilable timber per township averages 3,000 feet B. M. per acre amid the high mountains up to 59,000 feet B. M. per acre often in the Quillayute region. There is estimated to be 32,890,717 M. feet B. M. lumber in the region according to the estimate of Henry Gannett, Chief of Division of Forestry (1899).[1] This estimate has been more than doubled by Dodwell and Rixon at a later date; they give 69,000,000 M. feet B. M.[2] And the close measurement now used would likely double that amount. One quarter section in the Quillayute country cruised both by the Lacy Company cruisers and by the Clallam county cruisers for purpose of tax-estimating, aggregated more than 30,000,000 feet B. M. There is enough timber in the region to supply the whole United States' demand for considerable over two years.[3]

The timber by species is approximately as follows: Spruce, 6 per cent.; cedar, 10 per cent.; Lovely fir, 18 per cent.; Red fir, 24 per cent; hemlock, 42 per cent.

Geographically, the Olympic Peninsula is parcelled out in the following county divisions: Chehalis county, Mason county, Jefferson county, and Clallam county. For convenience the area of the timber in each and the timber of same will be considered separately.

Mason County.

This county includes the southeastern part of the Olympic Mountains, from which it extends eastward so as to include much of the Hood Canal country. The portion within the mountains contains but little timber of present merchantable value. the "low country" of the county, however,

[1]Twentieth Annual Report, U. S. G. S. (1898-1899). Part V, pp. 12-37.

[2]Arthur Dodwell and Theodore F. Rickson: Forest Conditions in the Olympic Forest Reserve, Washington. Professional paper, U. S. Geol. Surv., No. 7, 110 pages, 20 plates, 1 map, 1902.

[3]See Reagan: Transactions of the Kansas Acadamy of Science, p. 136, in article, "Some Notes on the Olympic Peninsula, Washington."

with the exception of a few small prairie tracts, was originally heavily timbered, but the timber is now more than half logged.

Area of timbered and other lands in Mason county, Washington.

Total area	996 square miles
Present merchantable timber area	395 square miles
Logged area	493 square miles
Naturally barren area	6 square miles
Burned area	112 square miles

Estimate of timber in Mason county, Washington.[4]

Fir	2,055,648 M. feet B. M.
Spruce	492 M. feet B. M.
Cedar	25,970 M. feet B. M.
Hemlock	8,955 M. feet B. M.
Total	2,091,065 M. feet B. M.

Average per acre of timbered land, 5,600 feet B. M.

Chehalis County.

This county borders upon the Pacific Ocean, and on the north extends far up into the Olympic Mountains. The mountainous part is high and rugged and contains but little merchantable timber, and in other parts there are numerous prairie tracts. Barring these areas, the county was originally heavily forested, mainly with fir in the interior and with spruce and cedar upon the coast. There have been but few fires in this county and the burned area is trifling. The county, however, lies in the Grays Harbor lumber district and an approximate third of it has been denuded of its forests.

Area of timbered and other lands in Chehalis county, Washington.

Total area	2,104 square miles
Present merchantable timber area	1,000 square miles
Logged area	831 square miles
Naturally bare area	47 square miles
Burned area	236 square miles

[4]After Gannett. Loc. cit., p. 28. It is well to add that under the present close cruising of timber, however, Mr. Gannett's figures should be multiplied by 3.

Estimate of timber in Chehalis county, Washington.[5]

Fir	9,799,418 M. feet B. M.
Spruce	3,068,307 M. feet B. M.
Cedar	3,474,350 M. feet B. M.
Hemlock	2,236,983 M. feet B. M.
Total	18,579,058 M. feet B. M.

Average per acre of timbered land, 21,300 feet B. M.

Jefferson County.

This county stretches from Hood's Canal upon the east to the Pacific Ocean. Its central portion, comprising three-fourths of it, lies within the Olympic Mountains. Scattered here and there in this area there are considerable timber in the below-timber-line districts, but on account of the inaccessibleness of the district it is of no value at present for milling purposes. Barring the mountain area, the county was formerly heavily forested, on the west with cedar and spruce, on the east with fir. The timber in the eastern part of the county has been largely destroyed either by ax or fire, mainly the latter. The timber in the western part of the county is yet virgin, being untouched by fire or ax. The most abundant species represented in this county is the cedar.

Area of timbered and other lands in Jefferson county, Washington.

Total area	1,688 square miles
Present merchantable timber area	430 square miles
Logged area	296 square miles
Naturally bare area	100 square miles
Burned area	215 square miles
Non-merchantable timber area	647 square miles

Estimate of timber in Jefferson county, Washington.[6]

Fir	794,232 M. feet B. M.
Spruce	267,427 M. feet B. M.
Cedar	2,124,725 M. feet B. M.
Hemlock	1,043,776 M. feet B. M.
Total	4,230,160 M. feet B. M.

Average per acre of timbered land, 15,300 feet B. M.

[5] Loc. cit., p. 19. Remarks above apply.
[6] Loc. cit., p. 24. Remarks above apply.

Clallam County.

This county extends from the top of the Olympic Mountains north to the Strait of Fuca and from near Dungeness on that strait to a little to the south of LaPush on the Pacific coast, occupying a large area both to the north and to the west of the Olympics. The mountainous part of the county is not regarded as containing any timber of present merchantable value. The remainder of the county is heavily forested; but the ax has made inroads in these forests along the shores of the Strait of Fuca as far west as Crescent Bay, and millions of feet of logs have been cut at Clallam Bay and in the Hoko district on the same side of the peninsula. In addition, fires have extended inland from these cuttings to the mountain districts, destroying large areas of timber. The western part of the county is still in the virgin state. In this county hemlock and fir vie with each other in amount of merchantable log-lumber.

Area of timbered and other lands in Clallam county, Washington.

Total area	1,824 square miles
Present merchantable timber area	1,000 square miles
Logged area	217 square miles
Burned area	181 square miles
Bare and unmerchantable timber area	426 square miles

Estimate of timber in Clallam county, Washington.[7]

Fir	3,045,297 M. feet B. M.
Spruce	1,758,845 M. feet B. M.
Cedar	547,617 M. feet B. M.
Hemlock	3,719,840 M. feet B. M.
Total	9,071,599 M. feet B. M.

Average per acre of timbered land, 15,700 feet B. M.

Below is a description of the merchantable timber species as they occur in the peninsula.

[7]Loc. cit., p. 20. Remarks above apply.

FAMILY PINACEAE: Pine Family.

Genus *Chamaecyparis.*

C. nootkatensis (Lamb) Spach: Alaska Cedar. This tree is found on all the mountain ridges below 3,500 feet elevation. It is a conspicuous tree on the ridges at the headwaters of the Soleduck and Bogachiel rivers and in the vicinity of the Soleduck Hot Springs. It is often called Yellow Cedar. It is also more abundant in the swamp regions near the Pacific coast, bordering the rivers near their mouths. It is a medium tree in height for this region, but exceeds the Red Fir in girth. Its greatest development is usually where it stands the heaviest. It averages about 140 feet in height and 50 inches in diameter. This tree is subject to rot; half of the stand is injured by this disease.[8]

Genus *Thuja.*

T. plicata Donn: Red Cedar; Giant Cedar. This cedar is found in all parts of the peninsula, except in the high mountain districts. It is of larger growth near the coast, where it often measures from 40 to 50 feet in circumference; some trees in the Elwa valley are said to measure even 80 feet in circumference.

This tree differs from *C. nootkatensis* above in its wood being reddish in color, in its larger size in circumference-measurements, and in the scales of its cones being oblong, not pilcate.[9]

[8]The juice of the bark of this tree and that of the Giant Cedar is used by the natives in dyeing basket straw. The other coloring matter used by these Indians is burned yellow clay, black earth, blood, soot and charcoal.

[9]Of this giant cedar the Indians make their dug-out canoes, canoes ranging from the size of a little river canoe to an ocean-whaling canoe that will hold ten whale hunters, or three tons of freight. These canoes are in each case made from a single piece (section) of log and the canoe is in each case one continuous piece when finished, except just the front totem (river-deer) part. In making these canoes in the old time it was a slow process of burning and scraping with clam shells, and a possible chiseling with some wedge-shaped stone. Today they are hewed out with ax and Indian adz. A canoe for ocean use is now worth about $100.

The cedars are used for may purposes by the Indians of the coast. The juice of the green bark is used as medicine, after being boiled. The outer bark is used in making wigwams. In the old times they also shredded the inner bark of these species and wove it into a sort of cloth. Of this cloth they then made skirts for the women, and other wearing apparel both for the men and the women. They also lined their cradles with this bark and wrapped their babies up in it before tying them in the cradles. A peculiar raincoat was made from this bark to be worn by the men while fishing in stormy weather.

Genus *Pinus.*

P. monticola Dougl.: Western White Pine. This tree is found on the western slopes of the Olympics, above 500 feet elevation, usually in swamps and wet places.

Description: Cones oblong-cylindrical; scales of cones unarmed; leaves five in each fascicle.

Genus *Abies.*

A. nobilis Lindl.: Lovely Fir; Noble Fir. This tree is found at considerable elevations; but rarely at elevations less than 1,500 feet.

Description: This is a tall, silvery-barked, noble-looking tree. It differs from the other firs principally in the color of its bark and in its having cones with conspicuous reflexed bracts.

A. lasiocarpa (Hook) Nutt.: Alpine Fir; Subalpine Fir. This tree is found only on the higher parts of the mountains, rarely below 5,000 feet.

Description: A tree of 60 to 80 feet in height; bark pale, thin, smooth, ash-gray in color; leaves dark-green above, with two resin-ducts about equi-distant between the upper and lower face; cones oblong-cylindrical, puberulent, with bracts concealed.

A. amabilis (Dougl.) Forbs.: Lovely Fir; Amabilis Fir. This tree is found only on the high ridges adjacent to the mountains, rarely below 1,200 feet elevation. It is one of the large lumber-producing trees of the region, producing more than 11,000,000 M. feet B. M.

Description: This tree is distinguishable from *A. lasiocarpa* above by its cones not being puberulent and by the greater length of the cones.

A. grandis Lindl.: White Fir. This tree is occasionally met with in the Soleduck Hot Spring region.

Genus *Pseudotsuga.*

P. mucronata (Raf.) Sudw.: Douglas Fir; Red Fir. This tree grows in abundance. It reaches its greatest development in the Quillayute-middle-upland region. In its growth, however, it extends up the mountain slopes to the altitude of 3,500 feet. In the high mountains and in the neighborhood of the Pacific coast, this species is practically entirely wanting. It grows to its greatest dimensions where the stand is heaviest. Throughout the region it averages 240 feet in height; 77 feet clear of limbs, with a diameter of 55 inches. This tree is everywhere free from disease. The stand of timber of this species is estimated to be more than 15,000,000 M. feet B. M.

Description: Tree large; in youth, spruce-like and pyrimidal, more spreading in old age; leaves somewhat two-ranked by a twist at base.

Genus *Tsuga.*

T. heterophylla (Raf.) Sarg.: Western Hemlock. This tree is found throughout the region.

Description: This is a lowland tree, with cones 1 to 2 cm. long.

T. mertensiana (Bong.) Carr: Black Hemlock; Merten's Hemlock. This tree is found almost everywhere in the forest from the shore line up to 4,500 feet elevation. With the Western Hemlock above, it is by far the most abundant tree in the region, being found in every part of it to timber line. It is not so large a tree as the other merchantable trees, either in height or diameter, the amount of clear trunk is also less. In the high mountain regions the tree is greatly affected by disease, but as the shore line is approached the percentage of diseased trees diminish to the minimum. This tree with the Western Hemlock estimate 26,000,000 M. feet B. M.

Description: Characteristically, this tree differs from the Western Hemlock above in its having appreciably longer cones.[10]

Genus *Picea.*

Picea sitchensis (Bong.) Traut: Sitka Spruce. This species is found only in the neighborhood of the coast, seldom ever found thirty miles inland. It is densest a little way back from the coast, the immediate coast seeming to be too damp for its best development. The tree averages 225 feet in height, 81 feet of which is often clear of limbs. Its diameter exceeds 5 feet on the average. This tree seems to be less affected by disease than any other merchantable tree in the region. It aggregates over 4,000,000 M. feet B. M. in merchantable timber.

Description: Trees tall, pyrimidal, with soft, white, tough timber; leaves flattened, somewhat two-ranked, and spirally arranged around the branchlets.

P. engelmanni Parry: Engelmann Spruce. This spruce is only scattered

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[10]The Indians use the bark of this tree in tanning hides. Hemlock bark tea is also used as an emetic.

here and there and in too small quantities, usually, to be of much value in a merchantable way.

Description: Tree subalpine, with height averaging about 90 feet; branches horizontal; bark thin, scaly, reddish to purplish brown; branches pubescent; leaves quadrangular.

The Uredinales of Indiana.

By H. S. Jackson.

The first authentic record of the collection of any species of plant rust in Indiana of which we have any knowledge was made by Dr. J. M. Coulter in the Botanical Bulletin (Botanical Gazette) 1:20, 1876. In a short article he noted the common occurrence of *Uromyces lespedezae* Schw. on *Lespedeza violacea*, presumably in the vicinity of Hanover.

The first account of the rusts of the State presented before the Indiana Academy of Science was included in a paper by E. M. Fisher on the Parasitic Fungi of Indiana, which was read at the annual meeting for 1890. This paper listed a considerable number of species of Uredineae, but unfortunately was not published and is unavailable. The specimens on which the paper was based were deposited in the herbarium of the United States Department of Agriculture. A list of the species was, however, obtained by Dr. L. M. Underwood and included in his "List of the Cryptogams at present known to inhabit the State of Indiana," which was printed in the Proceedings for 1893.

The latter list forms the basis of our knowledge of the cryptogamic flora of the State and enumerates 88 species of Uredinales including the unattached aecial and uredinial forms. Supplementary lists by various authors have appeared in the Proceedings from time to time since that date, only the most noteworthy of which need be mentioned.

In 1896 Miss Lillian Snyder presented a list of the rusts of Tippecanoe county, supplementing the work in 1898 with lists from Madison and Noble counties. The rusts of Hamilton and Marion counties were listed by G. W. Wilson in 1905.

Two complete State lists have been presented to the Academy by Dr. J. C. Arthur. The first was read in 1898 and enumerated 80 species; the second was presented in 1903 and included 105 species. Both these lists were prepared in such form as to illustrate the latest developments in revised nomenclature. The unattached aecial and uredinial forms were omitted.

The present list is based on the information contained in all the preceding ones which have appeared in the Proceedings of the Academy, together with the wealth of material collected in all parts of the State contained in the

Arthur herbarium at the Purdue Experiment Station. An attempt has been made to show the distribution within the State by counties. Under each host is given a list of the counties within which the species has been collected, together with the name of the person making the *first* collection and the year in which the collection was made. A considerable number of the collections which have been recorded in the first lists were not available to the writer. These have been included in the distribution only when there seemed to be no chance of mistaking their identity. A few species evidently wrongly determined of which no specimens were available, have been omitted.

The nomenclature followed is that of Dr. J. C. Arthur as used in the N. Am. Flora, volume 7, in so far as that admirable work has been completed, or as proposed for the unpublished portion. The nomenclature of the hosts in general conform to that of Britton & Brown, Illustrated Flora, 2nd edition.

For convenience in consulting the list, the species not previously recorded are marked *. Hosts not previously recorded are printed in black-faced type. References are inserted following the host name to the year and page of preceding volumes of the Proceedings, where additional information may be obtained. Wherever Indiana rusts have appeared in published sets of exsiccati reference is made following the collector's name. Reference by number is made to the rusts included in the set of Parasitic Fungi distributed by the Indiana Biological Survey. December, 1894. Series 1. (See Proceedings 1894:154-156. 1895.)

It is the plan of the writer to submit additions and corrections to this list as material is collected. It would be greatly appreciated if collectors would send duplicates of their collections to the writer.

The writer wishes to acknowledge his indebtedness to Dr. J. C. Arthur for the unrestricted use of his herbarium and notes in the preparation of this list without which any approach to completeness would have been impossible. Dr. Arthur has also kindly read the manuscript and offered many helpful suggestions.

COLEOSPORIACEAE.

*1. COLEOSPORIUM CAMPANULAE *(Pers.) Lev.*

On **Campanula americana** L.

Delaware, 1915 (Jackson); Hamilton, 1907 (Wilson); Tippecanoe, 1907 (Arthur & Kern).

*2. COLEOSPORIUM DELICATULUM *(Arth. & Kern) Hedg. & Long*

On **Euthamia graminifolia** (L.) Nutt.

Harrison, 1915 (Fogal); Jefferson, 1914 (Demaree); Johnson, 1915 (Pipal); Orange, 1915 (Jackson).

*3. COLEOSPORIUM ELEPHANTOPODIS *(Schw.) Thum.*

On **Elephantopus carolinianus** Willd.

Gibson, 1915 (Hoffer); Jefferson, 1915 (Demaree); Orange, 1915 (Jackson).

*4. COLEOSPORIUM HELIANTHI *Schw.*

On **Helianthus decapetalus** L.

Owen, 1893 (Underwood); Tippecanoe, 1915 (Ludwig).

On **Helianthus hirsutus** Raf.

Orange, 1915 (Jackson).

5. COLEOSPORIUM IPOMOEAE *(Schw.) Burrill.*

On Ipomoea pandurata (L.) Mey. 1896:171, 218.

Tippecanoe, 1895 (Arthur); 1896 (Snyder); 1914 (Ludwig in Barth. Fungi Col. 4519).

6. COLEOSPORIUM SOLIDAGINIS *(Schw.) Thum.* 1908:89.

On Aster azureus Lindl. 1893:50.

Montgomery, 1890 (Fisher), 1893 (Olive).

On Aster cordifolius L. 1893:51.

Montgomery, 1890 (Fisher); Tippecanoe, 1896 (Snyder).

On **Aster Drummondii** Lindl.

Tippecanoe, 1904 (Arthur).

On Aster ericoides L. 1905:179.

Delaware, 1915 (Jackson); Hamilton, 1905 (Wilson); Orange, 1915 (Jackson); Tippecanoe, 1915 (Mrs. Emily Arthur).

On **Aster longifolius** Lam.

Putnam, 1907 (Wilson).

On Aster Novae-angliae L. 1893:51.

Johnson, 1890 (Fisher); Montgomery, 1890 (Fisher); Tippecanoe, 1904 (Arthur).

On Aster paniculatus Lam. 1893:51, 1905:179.

Franklin, 1912 (Ludwig); Hamilton, 1905 (Wilson); Montgomery, 1890 (Fisher); Tippecanoe, 1896 (Snyder).

On Aster puniceus L. 1893:51.

Henry, 1915 (Jackson); Johnson, 1890 (Fisher); Steuben, 1903 (Kellerman); Tippecanoe, 1896 (Snyder).

On Aster sagittifolius Willd. 1893:51.

Delaware, 1915 (Jackson); Johnson, 1890 (Fisher); Tippecanoe, 1896 (Snyder).

On Aster salicifolius Lam. 1893:51.

Henry, 1915 (Jackson); Johnson, 1890 (Fisher).

On Aster Shortii Hook. 1893:51.

Montgomery, 1890 (Fisher).

On Aster Tradescanti L. 1893:51.

Johnson, 1890 (Fisher).

On **Callistephus hortensis** Cass.

Jefferson, 1914 (Demaree).

On Solidago arguta Ait. 1893:51.

Montgomery, 1890 (Fisher).

On Solidago caesia L. 1893:51.

Johnson, 1890 (Fisher); Montgomery, 1890 (Fisher); Tippecanoe, 1912 (Pipal).

On Solidago canadensis L. 1893:51. 1905:179.

Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Marion, 1905 (Wilson); Montgomery, 1890 (Fisher); Orange, 1915 (Jackson); Tippecanoe, 1915 (Jackson); Tipton, 1915 (Pipal); Wabash, 1890 (Miller).

On Solidago flexicaulis L. (*S. latifolia* L.) 1893:51 1896:218.

Montgomery, 1890 (Fisher); Owen, 1893 (Underwood Ind. Biol. Survey No. 54); Tippecanoe, 1896 (Snyder).

On Solidago patula Muhl. 1893:51.

Montgomery, 1890 (Fisher); Tippecanoe, 1906 (Kern).

On Solidago rugosa Mill. 1893:51.

Johnson, 1890 (Fisher); St. Joseph, 1904 (Cunningham); Tippecanoe, 1904 (Arthur).

On Solidago serotina Ait. 1893:51.

Johnson, 1890 (Fisher); Owen, 1893 (Underwood Ind. Biol. Survey, 54 in part); Steuben, 1903 (Kellerman).

On **Solidago ulmifolia** Muhl.

Montgomery, 1907 (Fitzpatrick); Tippecanoe, 1896 (Snyder).

Following the usage of earlier American authors this species has often erroneously been referred to the European *C. Sonchi-arvensis* (Pers.) Lev.

*7. COLEOSPORIUM TEREBINTHINACEAE *(Schw.) Arth.*

On **Silphium integrifolium** Michx.

Tippecanoe, 1915 (Ludwig).

On **Silphium terbinthinaceum** Jacq.

Tippecanoe, 1912 (Hoffer); 1914 (Ludwig, in Barth. N.Am. Ured. 1109).

8. COLEOSPORIUM VERNONIAE *B. & C.*

On Vernonia fasciculata Michx. 1893:51. 1905:179.

Hamilton, 1905 (Wilson); Montgomery, 1893 (Olive); Orange, 1915 (Jackson); Putnam, 1891 (Underwood); Tippecanoe, 1896 (Snyder).

On Vernonia noveboracensis (L.) Willd. 1893:51.

Jefferson, 1915 (Demaree); Johnson, 1890 (Fisher).

On **Vernonia altissima** Nutt.

Delaware, 1915 (Jackson); Hamilton, 1905 (Wilson); Henry, 1915 (Jackson); Orange, 1915 (Jackson); Tippecanoe, 1905 (Kern).

UREDINACEAE.

*9. BUBAKIA CROTONIS *(Cooke) Arth.*

On **Croton monanthogynus** Michx.

Franklin, 1912 (Oskamp); Lawrence, 1915 (Hoffer); Putnam, 1907 (Wilson).

10 HYALOPSORA POLYPODII *(DC.) Magn.*

Uredo polypodii DC.

On Felix fragilis (L.) Underw. (*Cystopteris fragilis* (L.) Bernh. 1893:56. 1903:143.

Putnam, 1893 (Underwood Ind. Biol. Survey 53).

*11. MELAMPSORA ABIETIS-CANADENSIS *(Farl.) Ludwig.*

On **Populus deltoides** Marsh.

Jasper, 1913 (Arthur & Fromme).

On Populus grandidentata Michx. 1893:51.

Putnam, 1893 (Underwood Ind. Biol. Sur. 50).

On **Populus heterophylla** L.

Tippecanoe, 1914 (Ludwig).

On **Populus tremuloides** Michx.

Steuben, 1903 (Kellerman).

Some of above collections were previously recorded in the Proceedings as *M. Medusae* Thüm.

12. MELAMPSORA BIGELOWII *Thüm.* 1908:89.

On Salix amygdaloides Anders. 1903:143.

Lagrange, 1907 (Arthur); Steuben, 1903 (Kellerman).

On Salix cordata Muhl. 1893:51. 1905:180.

Hamilton, 1905 (Wilson); Montgomery, 1893 (Olive); Tippecanoe, 1904 (Arthur).

On Salix discolor Muhl. 1893:51. 1896:218.

Montgomery, 1890 (Fisher); Tippecanoe, 1896 (Snyder).

On Salix interior Rowlee (*S. longifolia* Muhl.) 1893:51. 1905:180.

Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Montgomery, 1893 (Olive); Marion, 1905 (Wilson); Owen, 1893 (Underwood Ind. Biol. Sur. 49); St. Joseph, 1904 (Cunningham); Steuben, 1903 (Kellerman); Tippecanoe, 1898 (Stuart).

On Salix nigra Marsh. 1893:51.

Henry, 1915 (Jackson); Montgomery, 1890 (Fisher); Tippecanoe, 1887 (Arthur).

On **Salix Wardii** *Bebb.* (1893:51 as *S. nigra* Marsh.)

Johnson, 1890 (Fisher).

Following frequent usage of American authors this species has been variously referred to in the Proceedings as *Melampsora*

Salicina Lev., *M. farinosa* (Pers.) Schroet. and *M. Salicis-cupreae* (Pers.) Wint., all of which apply to European species.

13. MELAMPSORA MEDUSAE *Thüm.* 1908:89.

On Populus balsamifera L. 1893:51.

Montgomery, 1890 (Fisher).

On Populus deltoides Marsh. (*P. monilifera* Ait.) 1893:51. 1896: 218. 1905:180.

Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Marion, 1905 (Wilson); Montgomery, 1893 (Olive); Putnam, 1891 (Underwood); Tippecanoe, 1914 (Ludwig, in Barth. Fungi Col. 4737 and in Barth. N.Am. Ured. 1122); 1888 (Bolley), 1896 (Snyder); Warren, 1909 (Kern & Johnson).

On Populus grandidentata Michx. 1893:51.

Montgomery, 1890 (Fisher); Putnam, 1890 (Underwood).

On Populus tremuloides Michx. 1893:51. 1898:188.

Marshall, 1893 (Underwood); Noble, 1897 (King).

This species has occasionally been erroneously referred in the Proceedings to *M. populina* (Jacq.) Lev., a European species.

14. MELAMPSORIDIUM BETULAE (*Schum.*) *Arth.*

Melampsoridium betulinum (Pers.) Kleb.

On Betula lutea Michx. 1903:143. 1908:89.

Steuben, 1903 (Kellerman).

15. PUCCINIASTRUM AGRIMONIAE (*Schw.*) *Tranz.*

Caeoma Agrimoniae Schw.

On Agrimonia hirsuta (Muhl.) Bickn. (*A. Eupatoria* Am. Auct.) 1893:50.

Montgomery (Rose); Owen, 1893 (Underwood); Putnam, 1891 (Underwood); 1907 (Wilson).

On Agrimonia mollis (T. & G.) Britton. 1893:50. 1896:218. 1905:180.

Delaware, 1915 (Jackson); Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Orange, 1915 (Jackson); Tippecanoe, 1896 (Snyder).

On Agrimonia parviflora Soland. 1893:50.

Jefferson, 1915 (Demaree); Marshall, 1893 (Underwood); Putnam, 1893 (Underwood, Biol. Surv. 51); Tippecanoe, 1913 (Travelbee).

16. PUCCINIASTRUM HYDRANGEAE *(B. & C.) Arth.*

Uredo Hydrangeae B. & C.

Coleosporium Hydrangeae (B. & C.) Snyder.

Thecopsora Hydrangeae (B. & C.) Magn.

On Hydrangea arborescens L. 1893:56. 1896:218. 1903:143.

Marion, 1890 (Tracy); Montgomery, 1890 (Fisher); Putnam, 1891 (Underwood); Tippecanoe, 1896 (Snyder).

AECIDIACEAE.

17. ALLODUS AMBIGUA *(A. & S.) Arth.*

Puccinia ambigua (A. & S.) Lagerh.

Dicaeoma ambigua (A. & S.) Kuntze.

On Galium Aparine L. 1896:172. 1903:146.

Jefferson, 1903 (Arthur); Tippecanoe, 1896 (Snyder).

*18. ALLODUS CLAYTONIATA *(Schw.) Arth.*

Caeoma (Aecidium) Claytoniatum Schw.

Puccinia Mariae-Wilsoni G. W. Clinton.

On **Claytonia virginica** L.

St. Joseph, 1904 (Cunningham).

19. ALLODUS PODYPHYLLI *(Schw.) Arth.*

Puccinia Podyphylli Schw.

Dicaeoma Podyphylli (Schw.) Kuntze.

On Podyphyllum peltatum L. 1893:54. 1896:221. 1898:184, 189. 1905:182.

Brown, 1893 (Underwood); Dearborn, 1889 (Bolley); Fayette, 1914 (Ludwig in Barth. N. Am. Ured. 1166 and in Barth. Fungi Col. 4760); Franklin, 1912 (Ludwig); Hamilton, 1905 (Wilson); Jasper, 1915 (Arthur); Jefferson, 1910 (Johnson); Johnson, 1890 (Fisher); Montgomery, 1893 (Olive); Monroe, 1893 (Underwood); Noble, 1897 (King); Owen, 1893 (Underwood); Posey, 1906 (Arthur & Kern); Putnam, 1892; 1893

(Underwood, Ind. Biol. Sur. 15); St. Joseph, 1905 (Cunningham); Tippecanoe, 1896 (Snyder); Wabash, 1890 (Miller); Vigo, 1893 (Underwood).

20. ALLODUS TENUIS (*Schw.*) *Arth.*

Caeoma (*Aecidium*) *tenue* Schw.

Puccinia tenuis Burr.

Dicaeoma tenue (Burr.) Kuntze.

On Eupatorium urticaefolium Reich. (*E. ageratoides* L.) 1893:55. 1896:221. 1903:151.

Putnam, 1893 (Underwood); Tippecanoe, 1896 (Snyder).

*21. BULLARIA BARDANAE (*Cda.*) *Arth.*

Puccinia Bardanae Corda.

On **Arctium Lappa** L.

Carroll, 1915 (Hoffer); Delaware, 1915 (Jackson); Henry, 1915 (Jackson); Tippecanoe, 1915 (Jackson).

*22. BULLARIA BULLATA (*Pers.*) *Arth.*

Puccinia bullata (Pers.) Wint.

On **Taenida integerrima** (L.) Drude.

Tippecanoe, 1915 (Ludwig).

23. BULLARIA CHRYSANTHEMI (*Roze*) *Arth.*

Puccinia Chrysanthemi Roze.

Dicaeoma Chrysanthemi (Roze) Arth.

On Chrysanthemum Sinense Sabine. 1903:147.

Tippecanoe, 1899 (Dorner); 1900 (Arthur).

*24. **BULLARIA GLOBOSIPES** (*Pk.*) *comb. nov.*

Puccinia globosipes Pk.

Uredo similis Ell.

On **Lycium halimifolium** Mill.

Shelby, 1890 (Fisher); Type of *Uredo similis* Ell. Jour. Myc. 7:275. 1893.

*25. BULLARIA HIERACII (*Schum.*) *Arth.*

Puccinia Hieracii (Schum.) Mart.

On **Hieracium scabrum** Michx.

Montgomery, 1913 (Arthur).

26. **BULLARIA KUHNIAE** *(Schw.) comb. nov.*

Puccinia Kuhniae Schw.

Dicaeoma Kuhniae (Schw.) Kuntze.

On Kuhnia eupatorioides L. 1893:54. 1896:220.

Harrison, 1915 (Fogal); Tippecanoe, 1888 (Bolley); 1900 (Arthur).

27. BULLARIA TARAXACI *(Reb.) Arth.*

Puccinia Taraxaci (Reb.) Plowr.

Dicaeoma Taraxaci (Reb.) Kuntze.

On Leontodon Taraxacum L. (*Taraxacum Taraxacum* (L.) Karst. 1893:53. 1896:219. 1898:188. 1903:51. 1905:182.

Franklin, 1915 (Ludwig); Henry, 1915 (Jackson); Hamilton, 1905 (Wilson); Jefferson, 1910 (Johnson); Johnson, 1890 (Fisher); Marion, 1905 (Wilson); Miami, 1915 (Ludwig); Montgomery, 1893 (Olive); Noble, 1897 (King); Putnam, 1893 (Underwood); Tippecanoe, 1888 (Bolley), 1896 (Snyder); Vigo, 1893 (Arthur).

On **Leontodon erythrospermum** (Andrz.) Britton (*Taraxacum erythrospermum* Andrz.)

Hamilton, 1909 (Kern & Johnson); Jefferson, 1910 (Johnson); Tippecanoe, 1907 (Arthur).

Reported erroneously in the Proceedings as *Puccinia flosculosorum* (A. & S.) Wint. and *Dicaeoma flosculosorum* (A. & S.) Martins.

28. DASYSPORA ANEMONES-VIRGINIANAE *(Schw.) Arth.*

Puccinia Anemones-virginianae Schw.

Dicaeoma Anemones-virginianae (Schw.) Arth.

On Anemone cylindrica A. Gray. 1896:219.

Tippecanoe, 1892 (Arthur).

On Anemone virginiana L. 1903:146.

Steuben, 1903 (Kellerman); Tippecanoe, 1903 (Arthur).

29. DASYSPORA ASTERIS *(Duby) Arth.*

Puccinia Asteris Duby.

Dicaeoma Asteris (Duby) Kuntze.

On **Aster azureus** Lindl.

Tippecanoe, 1896 (Stuart).

On Aster cordifolius L. 1893:52.
Montgomery, 1890 (Fisher).

On **Aster longifolius** Lam.
Putnam, 1907 (Wilson); Tippecanoe, 1905 (Wilson).

On **Aster Novae-angliae** L.
Tippecanoe, 1910 (Johnson & Orton).

On Aster paniculatus Lam. 1893:52. 1896:219. 1905:181.
Hamilton, 1905 (Wilson); Montgomery, 1890 (Fisher); Tippecanoe, 1896 (Snyder).

On **Aster punicens** L.
Tippecanoe, 1905 (Kern).

On **Aster sagittifolius** Willd.
Delaware, 1915 (Jackson).

30. DASYSPORA CIRCAEAE (*Pers.*) *Arth.*

Puccinia Circaeae Pers.
Dicaeoma Circaeae (Pers.) Kuntze.

On Circaea Lutetiana L. 1893:53. 1896:219. 1905:181.
Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Putnam, 1893 (Underwood, Ind. Biol. Sur. 28); Tippecanoe, 1896 (Snyder); Wabash, 1886 (Miller).

31. DASYSPORA DAYI (*Clint.*) *Arth.*

Puccinia Dayi Clinton.
Dicaeoma Dayi (Clint.) Kuntze.

On Steironema ciliatum (L.) Raf. 1893:53. 1905:181.
Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Kosciusko, 1913 (Hoffer); Putnam, 1893 (Underwood, Ind. Biol. Sur. 25).

32. DASYSPORA GLECOMATIS (*DC.*) *Arth.*

Puccinia verrucosa (Schultz) Lk.

On Agastache nepetoides (L.) Kuntze. 1905:181.
Hamilton, 1905 (Wilson); Johnson, 1915 (Pipal); Sullivan (Hoffer); Tippecanoe, 1910 (Johnson).

33. DASYSPORA LOBELIAE (*Ger.*) *Arth.*

Puccinia Lobeliae Ger.
Dicaeoma Lobeliae (Ger.) Arth.

On Lobelia syphilitica L. 1893:54. 1896:220.

Fulton, 1893 (Underwood); Johnson, 1890 (Fisher); Putnam, 1893 (Underwood, Ind. Biol. Sur. 20); Tippecanoe, 1883 (Arthur); Vermillion, 1889 (Arthur) Vigo, 1893 (Underwood).

*34. DASYSPORA MALVACEARUM *(Bert.) Arth.*

Puccinia malvacearum Bert.

Dicaeoma malvacearum (Bert.) Kuntze.

On **Althaea rosea** L.

Huntington, 1915 (Miller); Marion, 1915 (Dietz); Marshall, 1915 (Arthur); Montgomery, 1915 (Anderson); St. Joseph, 1915 (Bordner).

On **Malva rotundifolia** L.

Marshall, 1915 (Arthur); St. Joseph, 1914 (Anderson).

35. **DASYSPORA PHYSOSTEGIAE** *(P. & C.) comb. nov.*

Puccinia Physostegiae P. & C.

Dicaeoma Physostegiae (P. & C.) Kuntze.

On Dracocephalum virginianum L. (*Physostegia virginiana* (L.) Benth.) 1894:151. 1896:220.

Marshall, 1893 (Underwood, Ind. Biol. Sur. 13); Tippecanoe, 1895 (Arthur).

36. DASYSPORA RANUNCULI *(Seymour) Arth.*

Puccinia Ranunculi Seymour.

Dicaeoma Ranunculi (Seym.) Kuntze.

On Ranunculus septentrionalis Poir. 1893:55.

Montgomery, 1893 (Olive); 1903 (Hughart).

*37. DASYSPORA SAXIFRAGAE *(Schlecht.) Arth.*

Puccinia Saxifargae Schlecht.

On **Micranthes pennsylvanica** (L.) Han. (*Saxifraga pennsylvanica* L.)

Porter, 1913 (Deam).

*38. DASYSPORA SEYMERIAE *(Burr.) Arth.*

Puccinia Seymeriae Burr.

On **Afzelia macrophylla** (Nutt.) Kuntze.

Tippecanoe, 1907 (Dorner).

The combination *D. Seymeriae* (Burr.) Arthur was made in Result. Sci. Congr. Bot. Vienne 347. 1906. By a typographical error the specific name was written "Seymouriae." *Puccinia Seymeriae* Burr. not *Puccinia Seymourii* Lindl. was clearly intended. The latter is probably not a Dasyspora and in any case is a synonym of *P. musenii* E. & E.

39. DASYSPORA SILPHII (*Schw.*) *Arth.*

Puccinia Silphii Schw.

Dicaeoma Silphii (Schw.) Kuntze.

On Silphium integrifolium Michx. 1903:151.

Tippecanoe, 1901 (Dorner).

On **Silphium perfoliatum** L.

Tippecanoe, 1906 (Wilson, Olive, Kern).

On Silphium sp. 1893:55.

Putnam, 1891 (Underwood).

40. DASYSPORA XANTHII (*Schw.*) *Arth.*

Puccinia Xanthii Schw.

Dicaeoma Xanthii (Schw.) Kuntze.

On Ambrosia trifida L. 1896:222. 1905:182.

Gibson, 1915 (Hoffer); Hamilton, 1905 (Wilson); Tippecanoe, 1896 (Snyder).

On Xanthium americanum Walt. 1893:56.

Johnson, 1890 (Underwood); Montgomery, 1893 (Olive); Orange, 1913 (Arthur & Ludwig); Putnam, 1891 (Underwood); Tippecanoe, 1905 (Wilson).

On **Xanthium communis** Britton.

Allen, 1911 (Orton); Montgomery, 1910 (Jennison); Tippecanoe, 1914 (Travelbee).

On Xanthium pennsylvanica Wallr. 1893:56. 1896:222. 1905:182.

Fountain, 1914 (Arthur); Hamilton, 1905 (Wilson); Marion, 1905 (Wilson); Montgomery, 1890 (Fisher); Putnam, 1893 (Underwood); Tippecanoe, 1896 (Snyder).

On **Xanthium spinosum** L.

Tippecanoe, 1895 (Arthur).

The earlier collections recorded in the Proceedings were mainly referred to as occurring on *Xanthium canadense* Mill. and *X. strumarium* L. The exact identity of the host can not now be determined and the collections so referred are here placed under *X. pennsylvanicum* and *X. americanum* respectively.

41. DICAEOMA(?) ALETRIDIS *(B. & C.) Kuntze.*

Puccinia Aletridis B. & C.

On Aletris farinosa L. 1903:146.

Lake, 1884 (Hill).

42. DICAEOMA ANDROPOGONIS *(Schw.) Kuntze.*

Aecidium Penstemonis Schw.

Puccinia Andropogi Schw.

I. On Penstemon hirsutus (L.) Willd. 1896:217. 1908:90.

Tippecanoe, 1896 (Stuart in Arth. & Holw. Ured. Exsicc. et Icones, 39a).

III. On Andropogon furcatus Muhl. 1896:219.

Tippecanoe, 1896 (Stuart, Snyder).

On Schizachyrium scoparium (Michx.) Nash (*Andropogon scoparius* Michx.) 1896:219.

Tippecanoe, 1896 (Snyder in Arth. & Holw. Ured. Excicc. et Icones, 39f); 1898 (Stuart in Arth. & Holw. Ured. Exsicc. et Icones, 39e).

43. DICAEOMA ANGUSTATUM *(Pk.) Kuntze.*

Puccinia angustata Peck.

Aecidium Lycopi Gerard.

I. On Lycopus americanus Muhl. (*L. sinuatus* Ell.) 1893:50. 1898:189; 1908:91.

Jasper, 1903 (Arthur); Tippecanoe, 1898 (Snyder); Vigo, 1893 (Underwood).

On **Lycopus uniflorus** Michx.

Jasper, 1903 (Arthur); Tippecanoe, 1908 (Johnson).

III. On Scirpus atrovirens Muhl. 1893:52. 1896:219. 1905:181.

Hamilton, 1905 (Wilson); Jefferson, 1914 (Demaree); Johnson, 1890 (Fisher); Putnam, 1891 (Underwood); Owen, 1911 (Pipal); Tippecanoe, 1889 (Bolley); 1896 (Snyder).

On Scirpus cyperinus (L.) Kunth. 1893:52.

Fulton, 1893 (Underwood); Putnam, 1891, 1893 (Underwood, in Ind. Biol. Sur. 32); Steuben, 1903 (Kellerman).

*44. **DICAEOMA**(?) **ANTIRRHINII** *(D. & H.) comb. nov.*

Puccinia Antirrhinii Diet. & Holw.

On **Antirrhinum majus** L.

Hendricks, 1915 (Miller); Lagrange, 1915 (Hissong); Montgomery 1914 (Rees).

45. DICAEOMA ASPARAGI *(DC.) Kuntze.*

Puccinia Asparagi DC.

On Asparagus officinalis L. 1903:146. 1905:181.

Fountain, 1900 (Beatty); Franklin, 1913 (Ludwig, in Barth. Fungi Col. 4255); Hamilton, 1905 (Wilson); Jefferson, 1914 (Demaree); Lake, 1899 (Breyfogle); Steuben, 1903 (Kellerman); St. Joseph, 1915 (Balzer); Tippecanoe, 1900, 1901 (Arthur)

46. DICAEOMA ASPERIFOLII *(Pers.) Kuntze.* 1908:91.

Aecidium Asperifolii Pers.

Puccinia rubigo-vera (DC.) Wint. p.p.

On Secale cereale L. 1896:221.

Carroll, 1913 (Pipal); Marion, 1896 (Chapman); Posey, 1910 (Johnson); Tippecanoe, 1889 (Arthur); Vigo, 1914 (Cox.)

*47. DICAEOMA CALTHAE *(Grev.) Kuntze.*

Aecidium Calthae Grev.

Puccinia Calthae (Grev.) Link.

On **Caltha palustris** L.

Tippecanoe, 1914 (Hoffer).

48. DICAEOMA CANALICULATUM *(Schw.) Kuntze.*

Sphaeria canaliculata Schw.

Puccinia Cyperi Arth.

Puccinia nigrovelata Ell. & Tracy.

Dicaeoma Cyperi (Arth.) Kuntze.

I. On **Ambrosia trifida** L.

Tippecanoe, 1896 (Snyder).

On **Xanthium americanum** Walt.

Tippecanoe, 1903 (Arthur).

On **Xanthium commune** Britton.
Montgomery, 1899 (Arthur); Tippecanoe, 1895 (Arthur).

III. On **Cyperus Engelmannii** Steud.
Newton, 1913 (Arthur & Fromme).

On **Cyperus esculentus** L. 1896:220 (as *C. strigosus* L.)
Tippecanoe, 1896 (Snyder).

On **Cyperus filiculmis** Vahl. 1896:219 (as *C. strigosus* L.)
Tippecanoe, 1896 (Snyder).

On Cyperus strigosus L. 1893:53, 54. 1894:154, 157. 1905:181. 1908:94.

Hamilton, 1905 (Wilson); Marion, 1890 (Earle); Putnam, 1893 (Underwood); Tippecanoe, 1904 (Arthur).

On **Cyperus Schweinitzii** Torr.
Montgomery, 1893 (Underwood).

*49. **DICAEOMA CEPHALANTHI** (*Seym.*) *comb. nov.*

Aecidium Cephalanthi Seymour.
Puccinia Seymouriana Arth.

I. On **Cephalanthus occidentalis** L.
Jasper, 1915 (Arthur).

III. On **Spartina Michauxiana** Hitchc.
Jasper, 1913 (Arthur & Fromme); Starke, 1903 (Arthur).

50. DICAEOMA CNICI (*Mart.*) *Arth.*

Puccinia Cnici Mart.
Puccinia Cirsii-lanceolati Schroet.
Jackya Cirsii-lanceolati (Schroet.) Bub. 1898:182.

On Cirsium lanceolatum (L.) Hill (*Carduus lanceolatus* L.) 1893: 53. 1898:182. 1903:152.

Marion, 1890 (Bolley); Marshall, 1893 (Underwood); Putnam, 1893 (Underwood); Steuben, 1903 (Kellerman); Tippecanoe, 1904 (Arthur).

Previously reported in the Proceedings (1893:53; 1898:182) as *P. flosculosorum* (A. & S.) Roehl and *Dicaeoma flosculosorum* (A. & S.) Mart.

51. DICAEOMA CLEMATIDIS (*DC.*) *Arth.*

Aecidium Clematidis DC.
Aecidium Aquilegiae Pers.
Puccinia tomipara Lagerh.
Puccinia Agropyri E. & E.
Puccinia Panicularíae Arth.

I. On Aquilegia sp. 1893:49.
Tippecanoe, 1889 (Bolley).

On **Clematis virginiana** L.
Tippecanoe, 1907 (Arthur).

On Syndesmon thalictroides (L.) Hoffmg. 1894:151.
Montgomery, 1894. (Olive).

III. On **Agropyron repens** (L.) Beauv.
Miami, 1912 (Holman); Tippecanoe, 1898 (Arthur, Stuart).

On **Bromus ciliatus** L.
Tippecanoe, 1898 (Stuart).

On **Bromus japonicus** Thunb.
Tippecanoe, 1914 (Roberts).

On **Bromus purgans** L.
Tippecanoe, 1903 (Arthur).

On **Bromus secalinus** L.
Franklin, 1912 (Ludwig).

On **Hordeum jubatum** L.
Tippecanoe, 1910 (Johnson).

On **Panicularia grandis** (S. Wats.) Nash.
Jasper, 1913 (Arthur & Fromme).

*52. DICAEOMA CONOCLINII (*Seymour*) *Kuntze.*

Puccinia Conoclinii Seymour.

On **Eupatorium coelestinum** L.
Orange, 1915 (Jackson & Pipal).

53. DICAEOMA CONVOLVULI (*Pers.*) *Kuntze.*

Puccinia Convolvuli (Pers.) Cast.

On Convolvulus sepium L. 1893:53. 1896:219. 1905:181.
Carroll, 1912 (Ludwig); Hamilton, 1905 (Wilson); Marion, 1905 (Wilson); Montgomery, 1899, Putnam, 1891, 1893 (Underwood, Ind. Biol. Sur. 21); Tippecanoe, 1895 (Stuart); Tipton, 1915 (Pipal).

*54. DICAEOMA(?) CYPRIPEDII *(Arth.) Kuntze.*

Puccinia Cypripedii Arth.

On **Limodorum tuberosum** L.

Kosciusko, 1914 (Hoffer).

55. DICAEOMA EATONIAE *Arth.*

Aecidium Ranunculi Schw.

Puccinia Eatoniae Arth.

I. On Ranunculus abortivus L. 1893:50. 1908:91.

Brown, 1893 (Underwood); Decatur, 1889 (Arthur); Putnam, 1892, 1893, 1894 (Underwood, Ind. Biol. Sur. 55); St. Joseph, 1904 (Cunningham); Tippecanoe, 1894 (Golden).

III. On Sphenopholis pallens (Spreng.) Scribn. (*Eatonia pennsylvanica* A. Gray). 1903:148.

Jasper, 1915 (Arthur); Tippecanoe, 1903 (Arthur).

56. DICAEOMA ELEOCHARIDIS *(Arth.) Kuntze.*

Puccinia Eleocharidis Arth.

I. On **Eupatorium maculatum** L.

Tippecanoe, 1908 (Johnson).

On Eupatorium perfoliatum L. 1894:151. 1896:217. 1908:91.

Jasper, 1903 (Arthur); Montgomery, 1894 (Olive); Tippecanoe, 1896 (Snyder).

On **Eupatorium purpureum** L.

Tippecanoe, 1899 (Arthur).

III. On Eleocharis palustris (L.) R. & S. 1893:53. 1896:219. 1908:91.

Lagrange, 1907 (Arthur); Montgomery, 1907 (Dorner); Tippecanoe, 1888 (Bolley), 1896 (Snyder).

57. DICAEOMA ELLISIANUM *(Thum.) Kuntze.*

Puccinia Ellisiana Thum.

I. On **Viola papilionacea** Pursh.

Tippecanoe, 1897 (Arthur).

III. On Schizachyrium scoparium (Michx.) Nash (*Andropogon scoparius* Michx.) 1903:148.

Tippecanoe, 1898 (Stuart).

58. DICAEOMA EMACULATUM (*Schw.*) *Kuntze.*

Puccinia emaculata Schw.

On Panicum capillare L. 1893:53. 1896:220. 1905:181.

Fayette, 1912 (Ludwig); Franklin, 1913 (Ludwig); Grant, 1915 (Pipal); Hamilton, 1905 (Wilson); Henry, 1897 (Pleas); Jasper, 1903 (Arthur); Montgomery, 1893 (Olive); Noble, 1906 (Whetzel); Putnam, 1892 (Underwood, Ind. Biol. Sur. 29); Tippecanoe, 1896 (Snyder).

On **Panicum miliaceum** L.

Tippecanoe, 1910 (Orton).

59. DICAEOMA EPIPHYLLUM (*L.*) *Kuntze.*

Puccinia Poarum Niels.

On Poa pratensis L. 1893:57. 1898:189. 1908:91.

Fayette, 1912 (Ludwig); Franklin, 1912 (Ludwig); Hamilton, 1909 (Kern & Johnson); Henry, 1915 (Jackson); Johnson, 1890 (Fisher); Owen, 1911 (Pipal); Putnam, St. Joseph, 1904 (Cunningham); Tippecanoe, 1896 (Snyder).

On **Alopecurus geniculatus** L.

Clinton, 1910 (Maish).

Reported erroneously in the Proceedings (1893:57) as *Uromyces dactyloides* Otth.

60. DICAEOMA ERIOPHORI (*Thum.*) *Kuntze.*

Puccinia Eriophori Thüm.

On Eriophorum angustifolium Roth. (*E. polystachyon* L.) 1903:146.

Noble, 1884 (Van Gorder).

On Eriophorum virginicum L. 1903:146.

Lake, 1914 (Hoffer); Noble, 1884 (Van Gorder); Wells, 1905 (Deam).

61. DICAEOMA EXTENSICOLA (*Plowr.*) *Kuntze.* 1908:92.

Puccinia extensicola Plowr.

Puccinia Dulichii Syd.

Puccinia vulpinoidis D. & H.

Dicaeoma Caricis-erigerontis Arth.

Dicaeoma Caricis-asteris Arth.

Dicaeoma Caricis-solidaginis Arth.

Dicaeoma Dulichii (Syd.) Arth.

I. On Aster cordifolius L. 1893:49.
Montgomery, 1893 (Olive); Tippecanoe, 1897 (Arthur).
On Aster Drummondii Lindl. 1903:147.
Tippecanoe, 1901 (Arthur).
On Aster paniculatus Lam. 1903:147. 1905:181.
Hamilton, 1905 (Wilson); Tippecanoe, 1901 (Arthur).
On Aster sagittifolius Willd. 1893:49.
Montgomery, 1893 (Olive).
On **Aster salicifolius** Lam.
Tippecanoe, 1901 (Arthur).
On **Doellingeria umbellata** (Mill.) Nees.
Jasper, 1903 (Arthur).
On Erigeron annuus (L.) Pers. 1894:151.
Montgomery, 1889 (Arthur), 1894 (Olive); Posey, 1906 (Arthur); Tippecanoe, 1899 (Arthur).
On Erigeron ramosus (Walt.) B. S. P. 1903:147.
Jasper, 1903 (Arthur).
On Leptilon canadense (L.) Britt. 1903:147.
Jasper, 1903 (Arthur).
On Solidago caesia L. 1893:49.
Montgomery, 1893 (Olive).
On Solidago canadensis L. 1893:49.
Jasper, 1915 (Mrs. J. C. Arthur); Laporte, 1893 (Arthur); Tippecanoe, 1896 (Snyder).
On Solidago flexicaulis L. (*S. latifolia* L.) 1893:49.
Putnam, 1893 (Underwood); Tippecanoe, 1894 (Golden).
On Solidago patula Muhl. 1903:147.
Tippecanoe, 1902 (Arthur).
On **Solidago serotina** Ait.
Vigo, 1899 (Arthur).
On **Solidago ulmifolia** Muhl.
Putnam, 1896 (Wilson); Tippecanoe, 1894 (Golden).
III. On Carex cephalophora Muhl. 1903:147.
Newton, 1913 (Arthur & Fromme); Tippecanoe, 1898 (Snyder); 1902 (Arthur).
On **Carex cephaloidea** Dewey(?)
Tippecanoe, 1898 (Snyder).

On Carex conoidea Schk. 1905:181.
Hamilton, 1905 (Wilson); Tippecanoe, 1900 (Stuart).

On Carex festucacea Schk. 1903:147.
Marion, 1913 (Overholtz & Young); Tippecanoe, 1899, 1901 (Arthur).

On Carex foenea Willd. 1903:147.
Lagrange, 1912 (Arthur); Tippecanoe, 1901 (Arthur).

On Carex nebraskensis Dewey (*Carex Jamesii* Torr.) 1903:147.
Fayette, 1913 (Ludwig); Jefferson, 1913 (Arthur); Tippecanoe, 1902 (Arthur).

On **Carex oligocarpa** Schk.
Fayette, 1915 (Ludwig).

On **Carex Pennsylvanica** Lam.
Tippecanoe, 1906 (Kern & Olive).

On **Carex sparganioides** Muhl.
Lagrange, 1907 (Arthur); Tippecanoe, 1897 (Arthur).

On Carex straminea Willd. 1893:52.
Johnson, 1890 (Fisher).

On Carex tetanica Schk. 1903:147.
Tippecanoe, 1899 (Arthur).

On Carex vulpinoidea Michx. 1893:56. 1896:221.
Fayette, 1912 (Ludwig); Lagrange, 1907 (Arthur); Orange, 1913 (Arthur & Ludwig); Tippecanoe, 1888 (Bolley); 1896 (Snyder).:

On Dulichium arundinaceum (L.) Britt. 1893:52.
Jasper, 1915 (Arthur & Ford); Marshall, 1893 (Underwood).

*62. DICAEOMA FRAXINI (*Schw.*) *Arth.*

Aecidium Fraxini Schw.
Puccinia peridermiospora Arth.

On **Spartina Michauxiana** Hitchc.
Lagrange, 1907 (Arthur); Jasper, 1913 (Arthur & Fromme).

63. **DICAEOMA GROSSULARIAE** (*Schum.*) *comb. nov.* 1908:92.

Aecidium Grossulariae Schum.
Puccinia albiperidia Arth.
Puccinia quadriporula Arth.
Puccinia uniporula Orton.

I. On Grossularia Cynosbati (L.) Mill. (*Ribes Cynosbati* L.) 1893-50. 1898:188.

Montgomery, 1893 (Olive); Noble, 1897 (King); Putnam, 1892 (Underwood); Tippecanoe, 1906 (Kern).

On **Grossularia missouriensis** (Nutt.) Cov. & Britt. (*Ribes gracile* Pursh).

Tippecanoe, 1906 (Kern).

On **Grossularia oxyacanthoides** (L.) Mill. (*Ribes oxyacanthoides* L.)
Montgomery, 1899 (Arthur).

On Grossularia rotundifolia (Michx.) Cov. & Britt. (*Ribes rotundifolium* Michx.) 1893:50.

Putnam, 1893 (Underwood, Ind. Biol. Sur. 58).

On **Grossularia setosa** (Lindl.) Cov. & Britt. (*Ribes setosum* Lindl.)

Tippecanoe, 1909 (Johnson).

III. On **Carex crinita** Lam.

Jasper, 1915 (Arthur & Ford); Tippecanoe, 1904 (Arthur).

On **Carex digitalis** Willd.

Franklin, 1912 (Ludwig).

On Carex hirtifolia MacKenzie (*C. pubescens* Muhl.) 1903:145.

Tippecanoe, 1901 (Arthur).

On **Carex Hitchcockiana** Dewey.

Fayette, 1912 (Ludwig).

On **Carex laxiflora** Lam.

Fayette, 1915 (Ludwig); Tippecanoe, 1897 (Arthur).

On **Carex squarrosa** L.

Tippecanoe, 1906 (Kern).

On **Carex stricta** Lam.

Lagrange, 1912 (Arthur).

On **Carex tetanica** Schk.

Tippecanoe, 1899 (Arthur).

64. DICAEOMA HELIANTHI *(Schw.) Kuntze.*

Puccinia Helianthi Schw.

On Helianthus annuus L. 1893:55. 1905:181.

Delaware, 1915 (Jackson); Hamilton, 1905 (Wilson); Henry, 1915 (Jackson); Jefferson, 1914 (Demaree); Johnson, 1890

(Fisher); Marion, 1905 (Wilson); Montgomery, 1893 (Olive); Putnam, 1891, 1892 (Underwood); Tippecanoe, 1906 (Kern).

On Helianthus divericatus L. 1893:55.

Jasper, 1903 (Arthur); Montgomery, 1890 (Fisher); Steuben, 1903 (Kellerman); Tippecanoe, 1905 (Kern).

On Helianthus giganteus L. 1903:148.

Steuben, 1903 (Kellerman); Tippecanoe, 1907 (Arthur).

On Helianthus grosse-serratus Mart. 1893:55. 1896:221.

Montgomery, 1893 (Olive); Steuben, 1903 (Kellerman); Tippecanoe, 1906 (Snyder).

On **Helianthus hirsutus** Raf.

Harrison, 1915 (Fogal); Orange, 1915 (Jackson).

On Helianthus mollis Lam. 1903:148.

Jasper, 1903 (Arthur); Tippecanoe, 1896 (Snyder).

On **Helianthus occidentalis** Riddle.

Harrison, 1915 (Fogal).

On **Helianthus petiolaris** Nutt.

Tippecanoe, 1905 (Wilson).

On Helianthus strumosus L. 1893:55.

Johnson, 1890 (Fisher); Putnam, 1903 (Underwood); Tippecanoe, 1888 (Bolley); 1894 (Golden).

On Helianthus tuberosus L. 1905:181.

Jefferson, 1914 (Demaree); Marion, 1905 (Wilson).

On Helianthus trachelifolius Mill. 1893:55.

Montgomery, 1890 (Fisher); Shelby, 1890 (Fisher).

65. DICAEOMA HELIOPSIDIS (*Schw.*) *Kuntze.*

Puccinia Heliopsidis Schw.

On Heliopsis helianthoides (L.) Sweet. 1893:54.

Johnson, 1890 (Fisher); Tippecanoe, 1901 (Stuart).

66. DICAEOMA HIBISCIATUM (*Schw.*) *Arth.*

Caeoma Hibisciatum Schw.

Aecidium Napaeae Arth. & Holw.

Puccinia Muhlenbergiae Arth.

I. On Napaea dioica L. 1894:151.

Tippecanoe, 1889 (Arthur).

III. On Muhlenbergia mexicana (L.) Trin.

Henry, 1915 (Jackson); Johnson, 1915 (Pipal); Lake, 1913 (Pipal); Lawrence, 1905; Tippecanoe, 1896 (Stuart, Snyder).

On Muhlenbergia Schreberi Gmel. (*M. diffusa* Schreb.) 1893:53, 55. 1905:181.

Delaware, 1915 (Jackson); Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Owen, 1911 (Pipal); Tippecanoe, 1896 (Snyder in Arth. & Holw. Exsic. et Icon. 50a).

On **Muhlenbergia tenuiflora** (Willd.) B. S. P.

Montgomery, 1915 (Mrs. J. C. Arthur).

On Muhlenbergia umbrosa Schreb. (*M. sylvatica* Torr.) 1896. 221.

Johnson, 1915 (Pipal); Tippecanoe, 1896 (Snyder).

67. DICAEOMA IMPATIENTIS (*Schw.*) *Arth.*

Aecidium Impatientis Schw.

Puccinia perminuta Arth.

I. On Impatiens biflora Walt. (*I. fulva* Nutt.) 1893:50.

Jefferson, 1915 (Demaree); Johnson, 1890 (Fisher); Montgomery (Rose); Putnam, 1893 (Underwood); Tippecanoe, 1914 (Ludwig in Barth. Fungi Columb. 4757, and Barth N. Am. Ured. 1254).

On Impatiens pallida Nutt. (*I. aurea* S. Wats.) 1896:217.

Carroll, 1910 (Hoffer); Fayette, 1913 (Ludwig); Putnam, 1903. (Wilson); Tippecanoe, 1896 (Snyder).

III. On **Agrostis perennans** (Walt.) Tuckerm.

Delaware, 1915 (Jackson); Fayette, 1912 (Ludwig); Johnson 1890 (Fisher).

On **Elymus canadensis** L.

Tippecanoe, 1896 (Snyder).

On **Elymus striatus** Willd.

Jefferson, 1903 (Arthur); Tippecanoe, 1902 (Arthur).

On Elymus virginicus L. 1893:55. 1896:221. 1908:91.

Tippecanoe, 1888 (Bolley), 1900 (Arthur).

On Hystrix Hystrix (L.) Millsp. 1893:52.

Jefferson, 1914 (Demaree); Johnson, 1890 (Fisher).

*68. DICAEOMA IRIDIS (*DC.*) *Kuntze.*

Uredo Iridis DC.

On Iris versicolor L.

Marshall, 1893 (Underwood. Ind. Biol. Sur. 52).

69. DICAEOMA MAJANTHAE (*Schum.*) *Arth.*

Aecidium Majanthae Schum.

On Phalaris arundinacea L. 1903:149. 1909:90.

Tippecanoe, 1899 (Stuart).

70. DICAEOMA MELICAE (*Syd.*) *Arth.*

On Melica mutica Walt. 1903:149.

Tippecanoe, 1899 (Stuart).

71. DICAEOMA MENTHAE (*Pers.*) *S. F. Gray.*

Puccinia Menthae Pers.

On **Blephila ciliata** (L.) Raf.

Hamilton, 1905 (Wilson).

On Blephilia hirsuta (Pursh) Torr. 1893:54. 1896:220. 1905:181.

Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Montgomery, 1890 (Fisher); Posey, 1906 (Arthur); Tippecanoe, 1899, 1901 (Arthur), 1896 (Snyder); Vermillion, 1889 (Arthur).

On Cunila origanoides (L.) Britton (*C. mariana* L.) 1893:54.

Martin, 1915 (Hoffer); Monroe, 1886 (Blatchley).

On Koellia pilosa (Nutt.) Britton (*Pycnanthenum muticum pilosum* A. Gray). 1893:54.

Vigo, 1893 (Underwood).

On Koellia virginiana (L.) MacM. (*Pycnanthemum lanceolatum* Pursh). 1893:54. 1896:220.

Marshall, 1893 (Underwood); Tippecanoe, 1896 (Snyder).

On Mentha canadensis L. 1893:54. 1905:181.

Grant, 1915 (Pipal); Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Marshall, 1893 (Underwood. Ind. Biol. Sur. 11); Steuben, 1903 (Kellerman); Tippecanoe, 1883 (Arthur).

On **Mentha spicata** L.

Hamilton, 1915 (Pipal).

On Monarda fistulosa L. 1893:54. 1896:220. 1905:181.

Carroll, 1912 (Ludwig); Hamilton, 1905 (Wilson); Jefferson, 1914 (Demaree); Marion, 1905 (Wilson); Marshall, 1893 (Underwood); Montgomery, 1890 (Fisher); Steuben, 1903 (Kellerman); Tippecanoe, 1894 (Golden); 1896 (Snyder); Vigo, 1893 (Underwood).

*72. **DICAEOMA MINUTISSIMUM** *(Arth.) comb. nov.*

Aecidium Nesaeae Ger.

Puccinia minutissima Arth.

I. On **Decodon verticillatus** (L.) Ell.

Jasper, 1915 (Arthur).

III. On **Carex lasiocarpa** Ehrh. (*C. filiformis* Good).

Fulton, 1893 (Underwood); Jasper, 1913 (Arthur & Fromme).

*73. DICAEOMA MONTANENSE *(Ellis) Kuntze.*

Puccinia montanensis Ellis.

On **Elymus canadensis** L.

Tippecanoe, 1896 (Arthur).

74. DICAEOMA ARGENTATUM *(Schultz) Kuntze.*

Puccinia nolitangeris Corda.

Uredo Impatientis Rebh.

Puccinia argentata (Schultz) Wint.

III. On Impatiens biflora Walt. (*I. fulva* Nutt.) 1893:52. 1896:220. 1903:146.

Johnson, 1890 (Fisher); Tippecanoe, 1896 (Snyder).

*75. DICAEOMA OBSCURUM *(Schroet.) Kuntze.*

Puccinia obscura Schroet.

On **Juncoides campestre** (L.) Kuntze (*Luzula campestris* DC.)

Montgomery, 1913 (Arthur).

76. DICAEOMA OBTECTUM *(Pk.) Kuntze.* 1908:91.

Puccinia obtecta Pk.

On Scirpus americanus Pers. 1894:151.

Marshall, 1893 (Underwood, Ind. Biol. Sur. 12); Tippecanoe, 1906 (Kern).

On Scirpus validus Vahl. (*S. lacustris* L.) 1894:151.

Montgomery, 1893 (Olive); Vermillion, 1889 (Wright).

77. DICAEOMA ORBICULA (*Peck & Clinton*) *Kuntze.*

Puccinia orbicula Peck & Clinton.

On Nabalus albus (L.) Hook. 1893:55. 1896:221.

Putnam, 1890 (Arthur); Tippecanoe, 1895 (Golden); Vigo, 1893 (Arthur).

Erroneously reported in the Proceedings as *P. Prenanthes* (Pers.) Fckl., which is a Brachy-form (Bullaria) not recorded for Indiana.

78. DICAEOMA PAMMELII (*Trel.*) *Arth.*

Aecidium Pammelii Trel.

Puccinia Panici Diet.

I. On Tithymalopsis corollata (L.) Kl. & Garcke (*Euphorbia corollata* L.) 1893:49. 1901:284. 1903:149. 1908:90.

Johnson, 1890 (Fisher); Tippecanoe, 1901 (Stuart).

III. On Panicum virgatum L. 1901:283. 1903:149. 1908:90.

Jasper, 1903 (Arthur); Lake, 1910 (Johnson); Newton, 1913 (Arthur & Fromme); Starke, 1905 (Arthur); Tippecanoe, 1901 (Stuart).

79. **DIAECOMA PATRUELIS** (*Arth.*) *comb. nov.*

Accidium compositarum lactucae Burrill.

Puccinia patruelis Arth.

I. On Lactuca canadensis L. 1894:151.

Jasper, 1906 (Arthur); Lagrange, 1912 (Arthur): Montgomery, 1894 (Olive); Tippecanoe, 1903 (Seaver).

On **Lactuca floridana** (L.) Gaertn.

Tippecanoe, 1906 (Olive).

On **Lactuca sativa** L.

Tippecanoe, 1902 (Burrage).

On **Lactuca virosa** L. (*L. scariola* L.)

Jasper, 1910 (Kern & Billings).

III. On Carex sp.

Jasper, 1903 (Arthur).

80. DICAEOMA PECKII (*DeT.*) *Arth.*

Aecidium Peckii DeToni.

Puccinia ludibunda Ell. & Ev.

I. On Oenothera biennis L. 1893:50. 1896:217. 1908:92.
Jasper, 1910 (Kern & Billings); Laporte, 1883 (Arthur); Putnam, 1896 (Wilson); Tippecanoe, 1896 (Snyder), 1902 (Arthur); Vigo, 1893 (Underwood).

III. On **Carex lanuginosa** Michx.
Lagrange, 1912 (Arthur); Tippecanoe, 1911 (Johnson).

On **Carex sparganioides** Muhl.
Lagrange, 1907 (Wilson).

On Carex stipata Muhl. 1903:149.
Tippecanoe, 1902 (Arthur), 1912 (Overholts & Orton).

On Carex trichocarpa Muhl. 1903:149.
Hamilton, 1909 (Kern & Johnson); Jasper, 1906 (Arthur & Kern); Madison, 1898 (Snyder); Tippecanoe, 1901 (Arthur).

81. DICAEOMA POCULIFORME (*Jacq.*) *Kuntze.*

Aecidium Berberidis Pers.
Puccinia graminis Pers.
Puccinia phlei-pratensis Erikss. & Henn.

I. On Berberis vulgaris L. 1893:49. 1908:92.
Lagrange, 1889 (Arthur).

III. On Agrostis alba L. 1893:53. 1903:150. 1905:182.
Hamilton, 1905 (Wilson); Jasper, 1906 (Arthur); Jefferson, 1914 (Demaree); Marshall, 1893 (Underwood, Ind. Biol. Sur. 14); Putnam, 1893 (Underwood); Steuben, 1903 (Kellerman); Tippecanoe, 1898 (Stuart); Wayne, 1910 (Johnson).

On **Arrhenatherum elatium** (L.) Beauv.
Tippecanoe, 1898 (Stuart).

On Avena sativa L. 1893:53. 1896:220. 1905:182.
Hamilton, 1905 (Wilson); Montgomery, 1893 (Olive); Putnam, 1893 (Underwood); Steuben, 1903 (Kellerman); Tippecanoe, 1888 (Bolley), 1896 (Snyder).

On **Bromus secalinus** L.
Franklin, 1912 (Ludwig).

On Cinna arundicacea L. 1903:150.
Tippecanoe, 1899 (Stuart); 1901 (Arthur).

On Dactylis glomerata L. 1896:220, 223.
Franklin, 1912 (Ludwig); Tippecanoe, 1896 (Snyder).

On Hordeum jubatum L. 1896:220, 224.

Tippecanoe, 1896 (Snyder); 1898 (Arthur).

On **Hordeum vulgare** L.

Tippecanoe, 1898 (Stuart).

On Phleum pratense L. 1909:417. 1910:203.

Bartholomew, 1909 (Hunter); Cass, 1910 (Johnson); Delaware, 1915 (Jackson); Franklin, 1912 (Ludwig); Hamilton, 1910 (Wilson); Henry, 1915 (Jackson); Jefferson, 1910 (Johnson); Posey, 1910 (Johnson); Spencer, 1910 (Johnson); Tippecanoe, 1910 (Johnson); Tipton, 1915 (Pipal); Wayne, 1910 (Johnson); Wabash, 1910 (Johnson); Whitley, 1910 (Johnson).

On **Secale cereale** L.

Clay, 1910 (Ringo).

On Triticum vulgare Vill. 1893:54. 1898:188. 1905:182.

Carroll, 1912 (Pipal); Decatur, 1912 (Moor); Franklin, 1912 (Ludwig); Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Marion, 1914 (Hameisen); Noble, 1897 (King); Posey, 1912 (Pipal); Putnam, 1893 (Underwood); Tippecanoe, 1890 (Arthur); Wayne, 1910 (Johnson).

82. DICAEOMA POLYGONI-AMPHIBII (*Pers.*) *Arth.*

Puccinia Polygoni-amphibii Pers.

Aecidium sanguinolentum Lindr.

I. On Geranium maculatum L. 1893:40. 1896:217. 1898:188. 1908:92.

Laporte, 1915 (Cotton); Noble, 1893 (King); Tippecanoe, 1894 (Golden); Vigo, 1893 (Underwood, Arthur).

III. On Persicaria amphibia (L.) S. F. Gray (*Polygonum Hartwrightii* A. Gray). 1903:150.

Steuben, 1903 (Kellerman).

On Persicaria hydropiperoides (Michx.) Small (*Polygonum hydropiperoides* Macouni). 1898:184. 1898:189.

Noble, 1897 (King); Tippecanoe, 1898 (Stuart).

On Persicaria lapathifolia (L.) S. F. Gray (*Polygonum lapathifolium* L.) 1898:184.

Tippecanoe, 1898 (Arthur).

On Persicaria Muhlenbergii (S. Wats.) Small (*Polygonum Muhlenbergii* S. Wats., *P. emersum* Britt.) 1893:55. 1905:182.

Fulton, 1893 (Underwood); Hamilton, 1905 (Wilson); Huntington, 1915 (Troop); Jasper, 1903 (Arthur); Lagrange, 1907 (Arthur); Tippecanoe, 1904 (Arthur); Wabash, 1890 (Miller).

On Persicaria pennsylvanica (L.) Small (*Polygonum pennsylvanicum* L.) 1898:184.

Henry, 1915 (Jackson); Putnam, 1893 (Underwood, Ind. Biol. Sur. 26); Tippecanoe, 1898 (Arthur); Tipton, 1915 (Pipal).

On Persicaria punctata (Ell.) Small (*Polygonum punctatum* Ell., *P. acre* H. B. K.) 1893:55, 57.

Johnson, 1890 (Fisher); Putnam, 1891 (Underwood).

83. DICAEOMA POLYGONI-CONVOLVULI (*Hedw.*) *Arth.*

Puccinia Polygoni-convolvuli Hedw.

On Tiniaria Convolvulus (L.) Webb. & Moq. (*Polygonum convolvulus* L.) 1898:184. 1905:182.

Delaware, 1915 (Jackson); Hamilton, 1905 (Wilson); Marion, 1905 (Wilson); Tippecanoe, 1898 (Arthur).

On Tiniaria scandens (L.) Small (*Polygonum scandens* L.) 1896:223.

Putnam, 1907 (Wilson); Tippecanoe, 1900 (Arthur).

84. DICAEMOA PUNCTATUM (*Link*) *Kuntze.*

Puccinia punctata Link.

Dicaeoma Galiorum (Lk.) Arth.

On Galium asprellum Michx. 1893:53.

Johnson, 1890 (Fisher).

On Galium concinnum Torr. & Gray. 1893:53. 1905:182.

Delaware, 1915 (Jackson); Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Montgomery, 1893 (Olive); Owen, 1893 (Underwood. Ind. Biol. Sur. 17); Steuben, 1903 (Kellerman); Tippecanoe, 1909 (Arthur).

On Galium tinctorum L. 1905:182.

Hamilton, 1905 (Wilson).

On Galium triflorum Michx. 1893:53.

Montgomery, 1893 (Underwood); Putnam, 1891 (Underwood).

85. DICAEOMA PUSTULATUM (*Curtis*) *Arth.*

Aecidium pustulatum Curtis.

Puccinia pustulata (Curtis) Arth.

I. On Comandra umbellata (L.) Nutt. 1893:50. 1908:90.

St. Joseph, 1914 (Arthur); Montgomery, 1893 (Olive); Tippecanoe, 1897 (Arthur); Vigo, 1893 (Underwood, Ind. Biol. Sur. 57).

III. On Andropogon furcatus Muhl. 1903:150.

Jasper, 1903 (Arthur); Lagrange, 1907 (Arthur); Starke, 1905 (Arthur); Tippecanoe, 1896 (Snyder in Arth. & Holw. Ured. et Icones 39h); Vigo, 1893 (Underwood, Ind. Biol. Sur. 33).

On Schizachyrium scoparium (Michx.) Nash (*Andropogon scoparius* Michx.) 1903:150.

Tippecanoe, 1902 (Arthur).

86. DICAEOMA RHAMNI *(Gmel.) Kuntze.*

Aecidium Rhamni Pers.

Puccinia coronata Corda.

Puccinia Lolii Niels.

I. On **Rhamnus caroliniana** Walt.

Tippecanoe, 1904 (Arthur).

On Rhamnus lanceolata Pursh. 1898:184. 1908:90.

Tippecanoe, 1897 (Arthur).

III. On Avena sativa L. 1893:55. 1896:219. 1898:188. 1905:182.

Clay, 1910 (Ringo); Delaware, 1915 (Jackson); Fayette, 1912 (Ludwig); Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Noble, 1897 (King); Tippecanoe, 1896 (Stuart); Wayne, 1910 (Johnson).

On **Cinna arundinacea** L.

Tippecanoe, 1901 (Arthur).

On Calamagrostis canadensis (Mx.) Beauv. 1893:53.

Tippecanoe, 1888 (Bolley).

87. DICAEOMA RUELLIAE *(B. & Br.) Kuntze.*

Uredo Ruelliae B. & Br.

Diorchidium lateripes (B. & Rav.) Magn.

Dicaeoma lateripes (B. & Rav.) Kuntze.

On **Ruellia ciliosa** Pursh.

Tippecanoe, 1904 (Marquis).

On Ruellia strepens L. 1893:54. 1896:218. 1905:181.

Delaware, 1915 (Jackson); Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Owen, 1893 (Underwood, Ind. Biol. Sur. 31); Tippecanoe, 1895 (Stuart), 1896 (Snyder); Wabash, 1887 (Miller).

88. DICAEOMA SAMBUCI *(Schw.) Arth.*

Aecidium Sambuci Schw.

Puccinia Bolleyana Sacc.

Puccinia Atkinsoniana Diet.

I. Sambuscus canadensis L. 1895:50.

Brown, 1893 (Underwood); Fayette, 1913 (Ludwig); Franklin, 1914 (Ludwig); Johnson, 1890 (Fisher); Montgomery, 1893 (Olive); Putnam, 1892, 1893 (Underwood, Ind. Biol. Sur. 56); Tippecanoe, 1899 (Arthur); Vigo, 1893 (Underwood).

III. On Carex Frankii Kunth. 1893:55. 1898:187.

Boone, 1891 (Arthur); Franklin, 1912 (Ludwig); Fulton, 1893 (Underwood); Hamilton, 1909 (Kern & Johnson); Johnson, 1890 (Fisher); Madison, 1898 (Snyder); Orange, 1913 (Arthur & Ludwig); Owen, 1911 (Pipal); Parke, 1900 (Snyder); Putnam, 1893 (Underwood).

On **Carex lupulina** Muhl.

Noble, 1904 (Whetzel).

On Carex lurida Wahl. 1893:52.

Lagrange, 1907 (Arthur); Marion, 1890 (Arthur); Orange, 1913 (Arthur & Ludwig); Tippecanoe, 1896 (Snyder).

On Carex trichocarpa Muhl. 1893:52. 1896:219.

Bartholomew, 1909 (Kern); Jasper, 1906 (Arthur & Kern); Tippecanoe, 1889 (Bolley).

89. DICAEOMA SANICULAE *(Grev.) Kuntze.*

Puccinia Saniculae Grev.

On Sanicula canadensis L. 1893:55.

Montgomery (Rose).

*90 DICAEOMA SMILACIS *(Schw.) Kuntze.*

Aecidium Smilacis Schw.

Puccinia Smilacis Schw.

On **Smilax glauca** Walt.

Lawrence, 1915 (Hoffer); Orange, 1913 (Ludwig)

91. DICAEOMA SORGHI (*Schw.*) *Kuntze.*

Puccinia Sorghi Schw.

Puccinia Maydis Bereng.

I. On **Xanthoxalis cymosa** Small (Oxalis cymosa Small).
Tippecanoe, 1904 (Arthur).

III. On Zea Mays L. 1893:54. 1898:188. 1905:182. 1908:90.
Dearborn, 1889 (Bolley); Delaware, 1915 (Jackson); Franklin, 1913 (Ludwig); Hamilton, 1905 (Wilson); Henry 1915 (Jackson); Marion, 1905 (Wilson); Montgomery, 1893 (Olive); Noble, 1897 (King); Putnam, 1893 (Underwood, Ind. Biol. Sur. 23); Tipton, 1912 (Ludwig); Tippecanoe, 1887 (Arthur).

92. **DICAEOMA TRITICINUM** (*Erikss.*) *comb. nov.*

Puccinia triticina Eriksson.

On Triticum vulgare Vill.
Carroll, 1913 (Pipal); Decatur, 1912 (Moor); Franklin, 1912 (Ludwig); Jefferson, 1910 (Johnson); Laporte, 1910 (G. C. Cook); Orange, 1915 (Pipal); Posey, 1906 (Arthur & Kern); Pulaski, 1898 (Arthur); Putnam, 1896 (Wilson); Tippecanoe, 1890 (Arthur); Vigo, 1899 (Arthur); Wayne, 1906 (Hiatt).

93. **DICAEOMA** (?) **TROGLODYTES** (*Lindr.*) *comb. nov.*

Puccinia troglodytes Lidr.

On **Galium triflorum** Michx.
Hamilton, 1905 (Wilson).

94. DICAEOMA URTICAE (*Schum.*) *Kuntze.*

Aecidium Urticae Schum.

Puccinia Caricis Schröt. not Reb.

I. On Urtica gracilis Ait. (U. Lyallii S. Wats.) 1898:185. 1908:92.
St. Joseph, 1904 (Cunningham); Lagrange, 1912 (Arthur); Tippecanoe, 1905 (Kern).

III. On Carex lacustris Willd. (C. riparia Muhl.) 1903:151.
Jasper, 1903 (Arthur); Steuben, 1903 (Kellerman).

On **Carex stipata** Muhl.
Tippecanoe, 1905 (Arthur);

On Carex stricta Lam. 1903:151.

Jasper, 1906 (Arthur & Kern); Steuben, 1903 (Kellerman); Tippecanoe, 1896 (Snyder).

Many of the collections reported in previous lists of Indiana rusts as belonging to this species are now included elsewhere.

95. DICAEOMA VERBENICOLUM *(Ell. & Kell.) Arth.*

Aecidium verbenicolum Ellis & Kellerman.

Puccinia Vilfae Arth. & Holw.

Dicaeoma Vilfae (A. & H.) Arth.

I. On Verbena stricta Vent. 1896:218. 1908:90.

Tippecanoe, 1896 (Snyder).

III. On Sporobolus asper (Michx.) Kunth. 1896:221.

Tippecanoe, 1896 (Snyder).

Erroneously reported in Proceedings for 1896:221 as *Puccinia Sporoboli* Arth.

96. DICAEOMA (?) VERNONIAE *(Scw.) Kuntze.*

Puccinia Vernoniae Schw.

On Vernoniae fasciculata Michx. 1893:55.

Putnam, 1893 (Underwood).

This collection is on the stems and has been distributed in the following exsiccati: Ind. Biol. Sur. 30; Barth. N. Am. Ured. 578; Ell. & Ev. N. Am. Fungi 2988; Seymour & Earle Economic Fungi Supl. B20.

97. DICAEOMA VEXANS *(Farl.) Kuntze.*

Puccinia vexans Farl.

On Atheropogon curtipendulus (Michx.) Fourn. (*Bouteloua curtipendula* (Michx.) Torr.) 1901:283.

Tippecanoe (Stuart).

No specimens of this collection are now available and the determination is somewhat doubtful. Since the species is represented in the Arthur herbarium only from the western plains.

98. DICAEOMA VIOLAE *(Schum.) Kuntze.*

Puccinia Violae (Schum.) DC.

On Viola eriocarpa Schwein. 1903:152.

Decatur, 1889 (Arthur); Montgomery, 1906 (Olive).

On Viola papilionacea Pursh (V. obliqua Hill) 1893:56.

Johnson, 1890 (Fisher); Montgomery, 1893 (Olive); Putnam, 1890 (Arthur); Tippecanoe, 1898 (Arthur); Vigo, 1893 (Arthur)

On Viola pubescens Ait. 1903:152.

Fayette, 1915 (Ludwig); Tippecanoe, 1898 (Arthur).

On **Viola sororia** Willd.

Tippecanoe, 1906 (Kern).

On Viola striata Ait. 1893:56.

Montgomery, 1890 (Fisher); Owen, 1893 (Underwood, Ind. Biol. Sur. 18); Putnam, 1893 (Underwood); Tippecanoe, 1912 (Pipal).

99. DICAEOMA WINDSORIAE (*Schw.*) *Kuntze.*

Puccinia Windsoriae Schw.

Aecidium Pteleae Berk. & Curt.

I. On Ptelea trifoliata L. 1893:50. 1896:217. 1908:90.

Montgomery, 1893 (Olive); Tippecanoe, 1896 (Snyder).

III. On Tridens flava (L.) Hitchc. (*Sieglingia seslerioides* (Mx.) Schrib. 1894:154, 1896:221.

Harrison, 1915 (Kopp); Orange, 1915 (Jackson); Owen, 1911 (Pipal); Tippecanoe, 1896 (Snyder).

100. EARLEA SPECIOSA (*Fr.*) *Arth.*

Aregma speciosa Fr.

Phragmidium speciosum (Fr.) Cooke.

On Rosa carolina L. 1896:219.

Tippecanoe, 1895 (Arthur).

On Rosa virginiana Mill. (*Rosa humilis* Marsh). 1898:179.

Fulton, 1894 (Arthur); Putnam, 1900 (Wilson); Tippecanoe, 1898 (Arthur).

101. GYMNOCONIA INTERSTITIALIS (*Schlect.*) *Lagerh.*

Aecidium nitens Schw.

Puccinia interstitialis (Schlecht.) Tranz.

On Rubus alleghaniensis Porter. 1893:54.

Jefferson, 1910 (Johnson); Marion, 1901 (Dickey); Putnam, 1893 (Underwood, Ind. Biol. Sur. 19); St. Joseph, 1909 (Cunningham); Tippecanoe, 1894 (Golden); 1896 (Snyder); Vigo, 1893 (Underwood).

On Rubus occidentalis L. 1893:54.

Montgomery, 1893 (Olive).

On Rubus procumbens Muhl. (*R. villosus* Ait.) 1893:54. 1896: 220. 1898:188.

Montgomery, 1893 (Olive); Noble, 1897 (King); Tippecanoe, 1899 (Stuart); 1896 (Snyder).

On Rubus strigosus Michx. 1893:54.

Marshall, 1889 (Parks).

*102. GYMNOSPORANGIUM GERMINALE (*Schw.*) *Kern.*

On **Crataegus mollis** (T. & G.) Scheele.

Shelby (Brezze).

On **Cydonia vulgaris** L.

Perry, 1914 (Odell).

103. GYMNOSPORANGIUM GLOBOSUM *Farl.*

Roestelia lacerata (Sow.) Fr. (in part).

Puccinia globosa (Farl.) Kuntze.

Aecidium globosum (Farl.) Arth.

I. On Crataegus coccinea L. 1893:56.

Montgomery, 1893 (Olive); Henry, 1909 (Gardner).

On Crataegus Crus-galli L. 1894:153.

Montgomery, 1894 (Olive).

On Crataegus mollis (T. & G.) Scheele (*C. subvillosa* T. & G.) 1898: 186, 188.

Allen, 1911 (Orton); Clay, 1910 (Ringo); Marion, 1896 (B. M. Davis); Noble, 1897 (King); Tippecanoe, 1898 (Arthur).

On Crataegus punctata Jacq. 1893:56. 1896:222. 1905:182.

Hamilton, 1905 (Wilson); Montgomery, 1893 (Olive); Putnam, 1893 (Underwood, Ind. Biol. Sur. 60); Tippecanoe, 1896 (Snyder).

On **Crataegus Pringlei** Sarg.

Tippecanoe, 1898 (Arthur).

III. On Juniperus virginiana L. 1893:51. 1908:89.

Clinton, 1907 (Kern); Jefferson, 1903 (Arthur); Owen, 1893 (Underwood); Putnam, 1893 (Underwood Ind. Biol. Sur. 45); Tippecanoe, 1888 (Arthur).

104. GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE *Schw.*

Roestelia pyrata Thax.

Gymnosporangium macropus Lk.

Puccinia Juniperi-virginianae (Schw.) Arth.

Aecidium Juniperi-virginianae (Schw.) Arth.

I. On Malus coronaria (L.) Mill. 1893:56. 1896:218.

Hamilton, 1907 (Wilson); Henry, 1909 (Gardner); Marion, 1907 (Shell); Putnam, 1907 (Wilson); Spencer, 1910 (Johnson); Tippecanoe, 1896 (Snyder); Wabash, 1891 (Miller).

On **Malus Ionensis** (Wood) Britton.

Tippecanoe, 1892 (Arthur).

On Malus Malus (L.) Britt. 1898:186. 1901:255.

Carroll, 1913 (Kerlin); Clark, 1912 (Richards); Fayette, 1912 Richards); Floyd, 1890 (Latta); Franklin, 1903 (Kleim), Greene, 1912 (Richards); Howard, 1902 (Armstrong); Jasper, 1913 (Coe); Jackson, 1912 (Richards); Jefferson, 1914 (Demaree); Martin, 1912 (Richards); Montgomery, 1901 (Whetzell); Morgan, 1911 (Lewis); Newton, 1898 (Griggs); Orange, 1912 (Brown); Putnam, 1907 (Wilson); Ripley, 1902 (Ferris); Rush, 1911 (Smiley); Spencer, 1900 (Johnson); Wayne, 1904 (Helms); Wabash, 1911 (Fisher); Warrick, 1912 (Alltz); White, 1913 (Pipal); Whitley, 1911 (More).

III. On Juniperus virginiana L. 1893:51. 1896:218. 1901:255. 1908:89.

Clay, 1910 (Ringo); Franklin, 1912 (Ludwig); Henry, 1914 (Travelbee); Monroe, 1898 (Arthur); Montgomery, 1893 (Olive); Orange, 1915 (Jackson); Owen, 1893 (Underwood); Putnam, 1892, 1893 (Underwood Ind. Biol. Sur. 46); Tippecanoe, 1889 (Bolley), 1898 (Arthur); Warren, 1908 (Davis).

105. KUEHNEOLA OBTUSA *(Strauss) Arth.*

On Potentilla canadensis L. 1893-52. 1896:218. 1898:179.

Delaware, 1915 (Jackson); Fulton, 1893 (Underwood, Ind. Biol. Sur. 47); Jefferson, 1914 (Demaree); Johnson, 1890 (Fisher); Marshall, 1893 (Underwood); Orange, 1913 (Arthur); Owen, 1893 (Underwood); Tippecanoe, 1889 (Bolley), 1896 (Snyder);

1901 (Arth. in Barth. N. Am. Ured. 313); Vigo, 1893 (Arthur, Underwood).

Previously reported in the Proceedings as *Phragmidium Fragariae* (DC.) Wint. and *Aregma Fragariae* (DC.) Arth.

106. KUEHNEOLA UREDINIS (*Link*) *Arth.*

Chrysomyxa albida Kuhn.

Coleosporium Rubi E. & H.

On **Rubus allegheniensis** Porter.

Delaware, 1915 (Jackson); Hamilton, 1907 (Wilson); Montgomery, 1913 (Kern); Warrick, 1906 (Heim).

On Rubus cuneifolius Pursh. 1893:50.

Johnson, 1890 (Fisher).

On **Rubus hispidus** L.

Jasper, 1913 (Arthur & Fromme).

On Rubus procumbens Muhl. (Rubus villosus Ait.) 1893:50.

Johnson, 1890 (Fisher).

107. NIGREDO AMPHIDYMA (*Sydow*) *Arthur.*

Uromyces glyceriae Arth.

On Panicularia septentrionalis (Hitch.) Bicknell. 1893:57. 1898: 180.

Johnson, 1890 (Fisher).

Previously reported as *Uromyces graminicola* Burr. on *Panicum virgatum* L.

108. NIGREDO APPENDICULATA (*Pers.*) *Arth.*

Uromyces appendiculata (Pers.) Lev.)

Caeomurus Phaseoli (Pers.) Arth.

On Phaseolus vulgaris L. 1893:56 in part. 1905:180.

Hamilton, 1905 (Wilson); Henry, 1915 (Jackson); Putnam, 1892 (Underwood Ind. Biol. Sur. 40); Tippecanoe, 1905 (Wilson); Tipton, 1915 (Pipal).

On Stropostyles helvolva (L.) Britt. (*Phaseolus angulosus* Ell., *P. diversifolius Pers.*) 1893:56. 1896:172. 222. 1905:180.

Franklin, 1914 (Roy Allen); Laporte, 1915 (L. B. Clore); Marion, 1905 (Wilson); Montgomery, 1893 (Olive); Putnam, 1907 (Wilson); Tippecanoe, 1895 (Arthur), 1896 (Snyder).

On **Strophostyles pauciflora** (Benth.) S. Wats.
Putnam, 1896 (Cook).

On **Strophostyles umbellata** (Muhl.) Britton.
Sullivan, 1915 (Hoffer).

On Vigna sinensis (L.) Endl. 1903:145.
Tippecanoe, 1902, 1903 (Arthur in Barth. N. Am. Ured. 381).

109. NIGREDO CALADII (*Schw.*) *Arth.*

Uromyces Caladii (Schw.) Farl.

Caeomurus Caladii (Schw.) Kuntze.

On Arisaema Dracontium (L.) Schott. 1893:56. 1896:222. 1905: 180.
Brown, 1893 (Underwood); Fayette, 1913 (Ludwig); Hamilton, 1905 (Wilson); Jasper, 1915 (Arthur); Kosciusko, 1915 (Hoffer); Montgomery, 1893 (Olive); Putnam, 1897 (Cook); Tippecanoe, 1896 (Snyder); Vigo, 1893 (Underwood).

On Arisaema triphyllum (L.) Torr. 1893:56. 1896:222. 1898: 189. 1905:180.
Fayette, 1913 (Ludwig); Hamilton, 1905 (Wilson); Jasper, 1915 (Arthur); Johnson, 1890 (Fisher); Monroe, 1893 (Underwood); Montgomery, 1893 (Olive); Noble, 1897 (King); Owen, 1893 (Underwood); Posey, 1906 (Arthur & Kern); Putnam, 1893 (Underwood); Tippecanoe, 1894 (Golden), 1896 (Snyder); St. Joseph, 1904 (Cunningham); Vigo, 1893 (Underwood, Arthur).

On **Peltandra virginica** (L.) Kunth.
Jasper, 1915 (Arthur); Lake, 1881 (A. B. Seymour).

110. NIGREDO CARYOPHYLLINA (*Schrank.*) *Arth.*

Uromyces Caryophyllinus (Schrank.) Wint.

Caeomurus Caryophyllinus (Schrank.) Kuntze.

On Dianthus caryophyllus L. 1893:56. 1898:180. 1912:99.
Marion, 1892 (Arthur); Monroe, 1912 (Von Hook); Tippecanoe, 1898 (Arthur).

111. NIGREDO FABAE (*Pers.*) *Arth.*

Uromyces Fabae (Pers.) DeBy.

On Lathyrus venosus Muhl. 1896:222. 1898:181. 1903:145.
Tippecanoe, 1896 (Snyder).

Previously reported in the Proceedings as on *Vicia americana* Muhl. and erroneously referred to *Uromyces Orobi* (Pers.) Wint., *Caeomurus Pisi* (Pers.) Gray, *Caeomurus Orobi* (Pers.) Arth., which refer to European species not yet recorded in America.

*112. NIGREDO FALLENS *(Desmaz.) Arth.*

Uromyces fallens (Desmaz.) Kern.

On Trifolium pratense L. 1893:58. 1896:223. 1898:187, 189.

Delaware, 1915 (Jackson); Franklin, 1912 (Ludwig); Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Kosciusko, 1913 (Hoffer); Madison, 1898 (Snyder), Marion, 1905 (Wilson); Miami, 1915 (Ludwig); Montgomery, 1890 (Fisher), 1893 (Underwood Ind. Biol. Sur. 38); Noble, 1897 (King); Owen, 1911 (Pipal); Putnam, 1891 (Underwood); Steuben, 1903 (Kellerman); Tipton, 1912 (Ludwig); Tippecanoe, 1891 (Arthur), 1896 (Snyder); Wabash, 1891 (Miller);.

113. NIGREDO HEDYSARI-PANICULATI *(Schw.) Arth.*

Uromyces Hedysari-paniculati (Schw.) Farl.

Caeomurus Hedysari-paniculati (Schw.) Arth.

On **Meibomia bracteosa** (Michx.) Kuntze.

Delaware, 1915 (Jackson).

On Meibomia canescens (L.) Kuntze. 1893:57. 1903:144.

Johnson, 1890 (Fisher); Montgomery, 1893 (Olive); Tippecanoe, 1907 (Dorner).

On Meibomia Dillenii (Darl.) Kuntze. 1893:57. 1896:222. 1903:144. 1905:180.

Hamilton, 1905 (Wilson, reported as on *M. sessilifolia* (Torr) Kuntze); Martin, 1915 (Hoffer); Montgomery, 1893 (Underwood Ind. Biol. Sur. 35); Tippecanoe, 1896 (Snyder), 1914 (Ludwig in Barth. Fungi Columb. 4592).

On Meibomia laevigata (Nutt.) Kuntze. 1893:57.

Montgomery, 1890 (Fisher).

On Meibomia paniculata (L.) Kuntze. 1893:57. 1896:222.

Hamilton, 1905 (Wilson); Johnson, 1890 (Fisher); Jefferson, 1914 (Demaree); Tippecanoe, 1896 (Snyder, reported as on *Desmodium canadense* DC.)

On Meibomia viridiflora (L.) Kuntze. 1893:57. 1905:180.

Hamilton, 1905 (Wilson); Marion, 1905 (Wilson); Putnam, 1893 (Underwood); Tippecanoe, 1904 (J. C. Marquis).

114. NIGREDO HOWEI *(Pk.) Arth.*

Uromyces Howei Pk.

Caeomurus Howei (Pk.) Kuntze.

On Asclepias incarnata L. 1893:57. 1896:222.

Montgomery, 1893 (Olive); Tippecanoe, 1896 (Snyder).

On Asclepias purpurascens L. 1893:57.

Montgomery, 1890 (Fisher).

On Asclepias Syriaca L. (*A. cornuti* Dec.) 1893:57. 1896:222. 1898:187. 1905:180.

Dearborn, 1888 (Bolley); Delaware, 1890 (Arthur); Hamilton, 1905 (Wilson); Henry, 1915 (Jackson); Johnson, 1890 (Fisher); Madison, 1898 (Snyder); Marion, 1890 (S. M. Tracy), 1905 Wilson); Montgomery, 1890 (Fisher), 1893 (Underwood Ind. Biol. Sur. 36); Putnam, 1891 (Underwood); Steuben, 1903 (Kellerman); Tippecanoe, 1887 (Arthur), 1896 (Snyder); Tipton, 1915 (Pipal); Wabash, 1891 (Miller).

On **Vincetoxicum Shortii** (A. Gray) Britton.

Crawford, 1915 (C. C. Deam).

115. NIGREDO HYPERICI-FRONDOSI *(Schw.) Arth.*

Uromyces Hyperici (Schw.) M. A. Curtis.

Caeomurus Hyperici-frondosi (Schw.) Arth.

On Hypericum canadense L. 1893:57.

Johnson, 1890 (Fisher).

On Hypericum mutilum L. 1893:57.

Marshall, 1893 (Underwood); Putnam, 1891, 1893 (Underwood Ind. Biol. Sur. 42); Spencer, 1910 (Johnson).

On Triadenum virginicum (L.) Raf. (*Elodea camoanulata* Pursh). 1893:57.

Marshall, 1893 (Underwood).

116. NIGREDO LESPEDEZAE-PROCUMBENTIS *(Schw.) Arth.*

Uromyces Lespedezae (Schw.) Pk.

Caeomurus Lespedezae-procumbentis (Schw.) Arth.

On Lespedeza capitata Michx. 1903:145.

Jasper, 1903 (Arthur); Tippecanoe, 1903 (Arthur).

On **Lespedeza frutescens** (L.) Britton.
Lagrange, 1907 (Arthur).

On Lespedeza hirta (L.) Hornem. 1903:145.
Jasper, 1913 (Arthur & Fromme); Marshall, 1893 (Underwood) Ind. Biol. Sur. 39); Martin, 1915 (Hoffer); Orange, 1915 (Jackson).

On Lespedeza procumbens Michx. 1893:57.
Montgomery, 1890 (Fisher).

On Lespedeza repens (L.) Bart. 1896:222.
Tippecanoe, 1894 (Snyder).

On **Lespedeza Stuvei** Nutt.
Harrison, 1915 (Fogal).

On Lespedeza virginica (L.) Britton (*L. reticulata S. Wats.*) 1893:57.
Lagrange, 1907 (Arthur); Montgomery, 1910 (Fisher).

*117. NIGREDO MEDICAGINIS (*Pass.*) *Arthur.*

On **Medicago lupulina** L.
Grant, 1915 (Pipal); Tipton, 1915 (Pipal).

On **Medicago sativa** L.
Putnam, 1907 (Wilson).

*118. NIGREDO MINUTA (*Diet.*) *Arth.*

On Carex lanuginosa Michx. 1903:144.
Jasper, 1903 (Arthur).

On Carex virescens Muhl. 1893:57.
Putnam, 1890 (Arthur).

The former collection erroneously reported as *Caeomurus Solidagini-caricis* Arth. in Proceedings (1903:144) and the latter (1893:57) as *Uromyces perigynius* Hals. on *C. virescens.*

119. NIGREDO PERIGYNIA (*Halst.*) *Arth.*

Uromyces perigynius Halsted.
Caeomurus perigynius (Halst.) Kuntze.
Caeomurus Solidagini-Caricis Arth.

On **Carex tribuloides** Wahl.
Newton, 1913 (Arthur & Fromme).

On Carex varia Muhl. 1903:144.
Jasper, 1903 (Arthur, type of *Uromyces Solidagini-Caricis* Arth.); Lake, 1899 (Hill).

120. NIGREDO PLUMBARIA (*Pk,*) *Arth.*

Uromyces gaurina (Pk.) Snyder.

Caeomurus plumbarius (Pk.) Kuntze.

Caeomurus gaurinus (Pk.) Arth.

On Gaura biennis L. 1896:222. 1898:180. 1903:145.

Hamilton, 1907 (Wilson); Tippecanoe, 1896 (Snyder).

On **Oenothera biennis** L.

Tippecanoe, 1912 (Orton).

121. NIGREDO POLYGONI (*Pers.*) *Arth.*

Uromyces polygoni (Pers.) Fuckel.

Caeomurus Polygoni (Pers.) Kuntze.

On Polygonum aviculare L. 1893:57. 1896:223. 1905:181.

Franklin, 1912, 1914 (Ludwig, in Barth. N. Am. Ured. 1196); Hamilton, 1905 (Wilson); Kosciusko, 1909 (Funk); Montgomery, 1893 (Olive); Putnam, 1893 (Underwood); Tippecanoe, 1888 (Bolley); 1896 (Snyder).

On Polygonum erectum L. 1893:58.

Boone, 1911 (Miller); Henry, 1915 (Jackson); Johnson, 1890 (Fisher); Putnam, 1893 (Underwood Ind. Biol. Sur. 41); Tippecanoe, 1888 (Bolley); 1895 (Snyder).

122. NIGREDO POLEMONII (*Pk.*) *Arth.*

Aecidium Polemonii Pk.

Uromyces acuminatus Arth.

Caeomurus acuminatus (Arth.) Kuntze.

I. On **Polemonium reptans** L.

Tippecanoe, 1901 (Arthur).

III. On Spartina Michauxiana Hitch. (*S. cynosuroides* (L.) Roth). 1903:144. 1908:89.

Jasper, 1903, 1915 (Arthur); Lake, 1913 (Arthur); Starke, 1905 (Arthur); Steuben, 1903 (Kellerman).

123. NIGREDO PROEMINENS (*DC.*) *Arth.*

Uromyces Euphorbiae (Schw.) C. & P.

Caeomurus Euphorbiae (Schw.) Kuntze.

On Chamaesyce humistrata (Engelm.) Small (*Euphorbia humistrata* Engelm.) 1903:144. 1905:180.

Hamilton, 1905 (Wilson); Montgomery, 1906 (Thomas); Putnam, 1911 (Banker); Tippecanoe, 1902 (Arthur).

On Chamaesyce maculata (L.) Small (*Euphorbia maculata* L.) 1893:49. 1896:217. 1905:180.

Hamilton, 1905 (Wilson); Marion, 1905 (Wilson); Montgomery, (Rose); Tippecanoe, 1887 (Arthur).

On Chamaesyce Preslii (Guss.) Arth. (*Euphorbia Preslii* Guss., *E. hypericifolia* A. Gray). 1893:57. 1896:222. 1898:187. 1905:180.

Franklin, 1913 (Ludwig); Fulton, 1909 (Kern); Hamilton, 1905 (Wilson); Henry, 1915 (Jackson); Jefferson, 1914 (Demaree); Johnson, 1890 (Fisher); Madison, 1898 (Snyder); Marion, 1905 (Wilson); Putnam, 1891 (Underwood); Tippecanoe, 1888 (Bolley), 1896 (Snyder), 1914 (Ludwig in Barth. Fungi Col. 4594, 4595).

On Poinsettia dentata (Michx.) Small (*Euphorbia dentata* Michx.) 1893:49, 57. 1896:217, 222. 1905:180.

Franklin, 1914 (Alley); Hamilton, 1905 (Wilson); Marion, 1905 (Wilson); Putnam, 1891, 1893 (Underwood, Ind. Biol. Sur. 43, 59); Tippecanoe, 1896 (Snyder).

On **Poinsettia heterophylla** (L.) Kl. & Garke (*Euphorbia heterophylla* L.)

Tippecanoe, 1904 (Arthur).

124. NIGREDO RHYNCOSPORAE (*Ellis*) *Arth.*

Uromyces Rhyncosporae Ellis.

Caeomurus Rhyncosporae (Ellis) Kuntze.

On Rynchospora alba (L.) Vahl. 1903:145.

Tippecanoe, 1894 (King).

*125. NIGREDO SCIRPI (*Cast.*) *Arth.*

Uromyces Scirpi (Cast.) Burrill.

Aecidium sii-latifolii Wint.

I. On **Cicuta maculata** L.

Tippecanoe, 1903 (Arthur).

III. On **Scirpus americanus** Pers.

Jasper, 1913 (Arthur & Fromme); Montgomery, 1895 (Olive).

On **Scirpus validus** Vahl.

Jasper, 1913 (Arthur & Fromme).

126. NIGREDO SILPHII (*Burr.*) *Arthur.*

Aeicidium compositarum Silphii Burr.

Uromyces Junci-tenuis Sydow.

I. On **Silphium perfoliatum** L.

Vigo, 1899 (Arthur).

III. On **Juncus Dudleyi** Wieg.

Posey, 1910 (Johnson); Steuben, 1903 (Kellerman).

On Juncus tenuis Willd. 1896:222. 1898:187. 1905:180. 1908: 90.

Fayette, 1914 (Ludwig); Franklin, 1912 (Ludwig); Hamilton, 1905 (Wilson); Jefferson, 1914 (Demaree); Madison, 1898 (Snyder); Marion, 1905 (Wilson); Marshall, 1893 (Underwood, Ind. Biol. Sur. 37); Newton, 1913 (Arthur); Orange, 1913 (Arthur); Owen, 1911 (Pipal); Pulaski, 1912 (Ludwig); Starke, 1905 (Arthur); Tippecanoe, 1896 (Snyder).

*127. NIGREDO SPERMACOCES (*Schw.*) *Arth.*

Uromyces Spermacoces (Schw.) M. A. Curtis.

On **Diodia teres** Walt.

Harrison, 1915 (Fogal).

128. NIGREDO TRIFOLII (*Hedw.f.*) *Arth.*

Uromyces Trifolii (Hedw.f.) Lev.

Caeomurus Trifolii (Hedw.f.) Gray).

On Trifolium hybridum L. 1893:58. 1905:181.

Hamilton, 1905 (Wilson); Wabash, 1886 (Miller).

On Trifolium medium L. 1893:58.

Johnson, 1890 (Fisher).

On Trifolium repens L. 1893:58.

Montgomery, 1893 (Olive); Tippecanoe, 1888 (Bolley), 1893 (Golden).

*129. NIGREDO VALENS (*Kern*) *Arth.*

Uromyces valens Kern.

On Carex lupulina Muhl. 1893:58.

Johnson, 1890 (Fisher).

On Carex rostrata Stokes (Carex utriculata Boot.) 1905:180.
Hamilton, 1905 (Wilson, type collection of *Uromyces valens* Kern).

*130. PHRAGMIDIUM AMERICANUM *Diet.*

On Rosa sp. cult. 1893:52.
Putnam, 1892 (Uuderwood, Ind. Biol. Sur. 48).
On Rosa virginiana Mill. (*R. lucida* Ehrh.) 1893:52.
Johnson, 1890 (Fisher).

131. PHRAGMIDIUM DISCIFLORUM (*Tode*) *J. F. James.*

Aregma disciflora (Tode) Arth.
On Rosa sp. cult.
St. Joseph, 1915 (Emery).

*132. PHRAGMIDIUM ROSAE-SETIGERAE *Diet.*

On Rosa carolina L. (?) 1893:52.
Putnam, 1893 (Underwood).
On **Rosa rubiginosa** L.
Monroe, 1914 (Van Hook).
On Rosa setigera Michx. 1893:52.
Hamilton, 1907 (Wilson); Jefferson, 1914 (Demaree); Johnson, 1890 (Fisher); Madison, 1907 (Wilson); Tippecanoe, 1896 (Snyder).

133. PHRAGMIDIUM SUBCORTICIUM (*Schrank.*) *Wint.*

On Rosa sp. cult.
Tippecanoe, 1897 (Arthur).

134. PILEOLARIA TOXICODENDRI (*Berk. & Rav.*) *Arth.*

Pileolaria brevipes Berk. & Rav.
On Toxicodendron radicans (L.) Kuntze (*Rhus radicans* L.) 1893:58. 1896:223. 1898:181.
Laporte, 1883 (Arthur); Jefferson, 1915 (Demaree); Montgomery, 1890 (Fisher); Owen, 1893 (Underwood); Putnam, 1893 (Underwood, Ind. Biol. Sur. 34); Tippecanoe, 1893 (Golden); 1896 (Snyder).
Commonly but erroneously referred to *Uromyces Terebinthi* DC. by American authors.

135. POLYTHELIS FUSCA (*Pers.*) *Arth.*
Puccinia fusca (Pers.) Wint.
Dicaeoma fuscum (Pers.) Kuntze.
Dicaeoma Anemones (Pers.) Arth.
On Anemone quinquefolia L. 1894:151. 1898:181.
Fulton, 1894 (Arthur).

136. POLYTHELIS THALICTRI (*Chev.*) *Arth.*
Puccinia Thalictri Chev.
Dicaeoma Thalictri (Chev.) Kuntze.
On Thalictrum dioicum L. 1893:55.
Montgomery, 1893 (Olive); Tippecanoe, 1912 (Hoffer).

*137. RAVENELIA EPIPHYLLA (*Schw.*) *Diet.*
On Cracca virginiana L.
Harrison, 1915 (Kopp); White, 1911 (Bushnell).

138. TELEOSPORA RUDBECKIAE (*A. & H.*) *Arth.*
Uromyces Rudbeckiae Arth. & Holw.
Caeomurus Rudbeckiae (A. & H.) Kuntze.
On Rudbeckia laciniata L. 1894:152. 1898:187. 1903:145.
Madison, 1898 (Snyder); Montgomery, 1894 (Olive).

139. TRANZSCHELIA PUNCTATA (*Pers.*) *Arth.*
Aecidium punctatum Pers.
Aecidium hepaticatum Schw.
Puccinia Pruni-spinosae Pers.
On Hepatica acutiloba DC. 1893:50.
Jennings, 1912 (C. C. Deam); Montgomery, 1892, 1893 (Thomas); Tippecanoe, 1898 (Arthur).

140. TRIPHRAGMIUM ULMARIAE (*Schum.*) *Link.*
On Filipendula rubra (Hill) Robinson (*Ulmaria rubra* Hill). 1903:43.
Tippecanoe, 1899 (Arthur, in Barth. N. Am. Ured. 83).

141. UROPYXIS AMORPHAE (*M. A. Curtis*) *Schröt.*
On Amorpha canescens Pursh. 1893:58.
Marshall, 1893 (Underwood, Ind. Biol. Sur. 44).

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