Proceedings of the

Indiana Academy of Science

1901

PROCEEDINGS

OF THE

Indiana Academy of Science

1901.

EDITOR, - - DONALDSON BODINE.

ASSOCIATE EDITORS:

C. A. WALDO,
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THOMAS GRAY,
JOHN S. WRIGHT.

INDIANAPOLIS, IND.
1902.

INDIANAPOLIS:
Wm. B. Burford, Printer.
1902.

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

[Approved March 11, 1895.]

Preamble.

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 body, 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,

Publication of the Reports of the Indiana Academy of Science.

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.

Editing Reports.

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 services, 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

Number of printed Reports.

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.

Proviso.

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 Indiana 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.

Disposition of Reports.

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.

Emergency.

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

[Approved March 5, 1891.]

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana,* That it shall be unlawful for any person to kill any wild bird other than a game bird, or purchase, offer for sale any such wild bird after it has been killed, or to destroy the nests or the eggs of any wild bird. Birds.

SEC. 2. For the purpose of this act the following shall be considered game birds: the Anatidæ, commonly called swans, geese, brant, and river and sea ducks; the Rallidæ, commonly known as rails, coots, mudhens, and gallinules; the Limicolæ, commonly known as shore birds, plovers, surf birds, snipe, woodcock and sandpipers, tattlers and curlews; the Gallinæ, commonly known as wild turkeys, grouse, prairie chickens, quail, and pheasants, all of which are not intended to be affected by this act. Game birds.

SEC. 3. Any person violating the provisions of Section 1 of this act shall, upon conviction, be fined in a sum not less than ten nor more than fifty dollars, to which may be added imprisonment for not less than five days nor more than thirty days. Penalty.

SEC. 4. Sections 1 and 2 of this act shall not apply to any person holding a permit giving the right to take birds or their nests and eggs for scientific purposes, as provided in Section 5 of this act. Permits.

SEC. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science 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 said Board written testimonials from two well-known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege and pay to said Board one dollar to defray the necessary expenses attending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of such permit has killed Permits to Science. Bond. Bond forfeited.

any bird or taken the nests or eggs of any bird for any other purpose than that named in this section and shall further be subject for each offense to the penalties provided in this act.

Two years.

SEC. 6. The permits authorized by this act shall be in force for two years only from the date of their issue, and shall not be transferable.

Birds of prey.

SEC. 7. The English or European House Sparrow (Passer domesticus), crows, hawks, and other birds of prey are not included among the birds protected by this act.

Acts repealed.

SEC. 8. All acts or parts of acts heretofore passed in conflict with the provisions of this act are hereby repealed.

Emergency.

SEC. 9. An emergency is declared to exist for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

OFFICERS, 1901-1902.

President,

HARVEY W. WILEY.

Vice-President,

W. S. BLATCHLEY.

Secretary,

JOHN S. WRIGHT.

Assistant Secretary,

DONALDSON BODINE.

Press Secretary,

GEORGE W. BENTON.

Treasurer,

J. T. SCOVELL.

EXECUTIVE COMMITTEE.

Harvey W. Wiley,
W. S. Blatchley,
John S. Wright,
Donaldson Bodine,
G. W. Benton,
J. T. Scovell,
M. B. Thomas,
D. W. Dennis,
C. H. Eigenmann,
C. A. Waldo,
Thomas Gray,
Stanley Coulter,
Amos W. Butler,
W. A. Noyes,
J. C. Arthur,
J. L. Campbell,
O. P. Hay,
T. C. Mendenhall,
John C. Branner,
J. P. D. John,
John M. Coulter,
David S. Jordan.

CURATORS.

BOTANY	J. C. Arthur.
ICHTHYOLOGY	C. H. Eigenmann.
HERPETOLOGY, MAMMALOGY, ORNITHOLOGY	Amos W. Butler.
ENTOMOLOGY	W. S. Blatchley.

COMMITTEES, 1901-1902.

PROGRAM.

M. B. Thomas, M. E. Crowell.

MEMBERSHIP.

M. J. Golden, W. A. McBeth, Glenn Culbertson.

NOMINATIONS.

C. A. Waldo, W. A. Noyes, A. J. Bigney.

AUDITING.

W. K. Hatt, W. S. Blatchley.

STATE LIBRARY.

A. W. Butler, Stanley Coulter, C. A. Waldo, J. S. Wright.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

Stanley Coulter, John S. Wright, M. B. Thomas.

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, W. S. Blatchley.

EDITOR.

Donaldson Bodine, Wabash College, Crawfordsville.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, Donaldson Bodine, M. B. Thomas, J. C. Arthur, Stanley Coulter.

RELATIONS OF THE ACADEMY TO THE STATE.

D. W. Dennis, A. W. Butler, R. W. McBride, G. W. Benton.

GRANTING PERMITS FOR COLLECTING BIRDS AND FISHES.

A. W. Butler, Stanley Coulter, W. S. Blatchley.

DISTRIBUTION OF THE PROCEEDINGS.

A. W. Butler, J. S. Wright, G. W. Benton.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885-6	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886-7	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887-8	J. P. D. John	Amos W. Butler			O. P. Jenkins.
1888-9	John C. Branner	Amos W. Butler			O. P. Jenkins.
1889-90	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890-1	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891-2	J. L. Campbell	Amos W. Butler			C. A. Waldo.
1892-3	J. C. Arthur	Amos W. Butler	Stanley Coulter. W. W. Norman.		C. A. Waldo.
1893-4	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894-5	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895-6	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896-7	Thomas Gray	John S. Wright	A. J. Bigney		W. P. Shannon.
1897-8	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.
1898-9	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.

In Memoriam.

PHILIP SCHAFFNER BAKER,

Born, Evansville, Indiana, 1851.

Died, Asheville, North Carolina, September Second, 1901.

Vice-President

of the

Indiana Academy of Science, 1901.

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 of 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 there-after 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. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

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

ARTICLE III.

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

SEC. 2. The annual meeting of this Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the

Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past Presidents, together with the officers and Executive Committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not specially 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.

MEMBERS.

FELLOWS.

R. J. Aley	*1898	Bloomington.
J. C. Arthur	1893	Lafayette.
George W. Benton	1896	Indianapolis.
A. J. Bigney	1897	Moore's Hill.
A. W. Bitting	1897	Lafayette.
Donaldson Bodine	1899	Crawfordsville.
W. S. Blatchley	1893	Indianapolis.
H. L. Bruner	1899	Irvington.
Severance Burrage	1898	Lafayette.
A. W. Butler	1893	Indianapolis.
J. L. Campbell	1893	Crawfordsville.
John M. Coulter	1893	Chicago, Ill.
Stanley Coulter	1893	Lafayette.
Glenn Culbertson	1899	Hanover.
D. W. Dennis	1895	Richmond.
C. R. Dryer	1897	Terre Haute.
C. H. Eigenmann	1893	Bloomington.
Percy Norton Evans	1901	Lafayette.
A. L. Foley	1897	Bloomington.
Katherine E. Golden	1895	Lafayette.
M. J. Golden	1899	Lafayette.
W. F. M. Goss	1893	Lafayette.
Thomas Gray	1893	Terre Haute.
A. S. Hathaway	1895	Terre Haute.
Robert Hessler	1899	Logansport.
H. A. Huston	1893	Lafayette.
Arthur Kendrick	1898	Terre Haute.
Robert E. Lyons	1896	Bloomington.
V. F. Marsters	1893	Bloomington.
C. L. Mees	1894	Terre Haute.
W. J. Moenkhaus	1901	Bloomington.
Joseph Moore	1896	Richmond.
D. M. Mottier	1893	Bloomington.
W. A. Noyes	1893	Terre Haute.
L. J. Rettger	1896	Terre Haute.
J. T. Scovell	1894	Terre Haute.
Alex. Smith	1893	Chicago, Ill.
W. E. Stone	1893	Lafayette.

*Date of election.

Joseph Swain	*1898	Bloomington.
M. B. Thomas	1893	Crawfordsville.
C. A. Waldo	1893	Lafayette.
F. M. Webster	1894	Wooster, Ohio.
H. W. Wiley	1895	Washington, D. C.
John S. Wright	1894	Indianapolis.

NON-RESIDENT MEMBERS.

George H. Ashley .... Charleston, S. C.
M. A. Brannon .... Grand Forks, N. D.
J. C. Branner .... Stanford University, Cal.
D. H. Campbell .... Stanford University, Cal.
A. Wilmer Duff .... Worcester, Mass.
B. W. Evermann .... Washington, D. C.
Charles H. Gilbert .... Stanford University, Cal.
C. W. Green .... Stanford University, Cal.
C. W. Hargitt .... Syracuse, N. Y.
O. P. Hay .... Washington, D. C.
Edward Hughes .... Stockton, Cal.
O. P. Jenkins .... Stanford University, Cal.
D. S. Jordan .... Stanford University, Cal.
J. S. Kingsley .... Tufts College, Mass.
D. T. MacDougal .... Bronx Park, New York City
T. C. Mendenhall .... Worcester, Mass.
Alfred Springer .... Cincinnati, Ohio.
L. M. Underwood .... New York City.
Robert B. Warder .... Washington, D. C.
Ernest Walker .... Clemson College, S. C.

ACTIVE MEMBERS.

G. A Abbott .... Indianapolis.
Frederick W. Andrews .... Bloomington.
George C. Ashman .... Frankfort.
Edward Ayres .... Lafayette.
Edwin M. Blake .... Lafayette.
Lee F. Bennett .... Valparaiso.
Charles S. Bond .... Richmond.
Fred. J. Breeze .... Pittsburg.

* Date of election.

E. M. Bruce ....
A. Hugh Bryan ....Indianapolis.
E. J. Chansler ....Bicknell.
Howard W. Clark ....Culver.
George Clements ....Peru.
Charles Clickener ....Tangier.
Mel T. Cook ....Greencastle.
U. O. Cox ....Mankato, Minn.
William Clifford Cox ....Columbus.
J. A Cragwall ....Crawfordsville.
Albert B. Crowe................................Ft. Wayne.
M. E. Crowell................................Franklin.
Edward Roscoe Cumings ....Bloomington.
Alida M. Cunningham ....Alexandria.
Lorenzo E. Daniels................................Laporte.
H. J. Davidson ....Baltimore, Md.
Charles C. Deam ....Bluffton.
Martha Doan ....Westfield.
J. P. Dolan......................... ....Syracuse.
Herman B. Dorner ....Lafayette.
Hans Duden ....Indianapolis.
Joseph Eastman................................Indianapolis.
E. G. Eberhardt ....Indianapolis.
M. N. Elrod ....Columbus.
Samuel G. Evans................................Evansville.
Carlton G. Ferris................................Big Rapids, Mich.
E. M. Fisher................................Urmeyville.
Wilbur A. Fiske ....Richmond.
W. B. Fletcher................................Indianapolis.
Austin Funk................................New Albany.
Charles W. Garrett ....Logansport.
Robert G. Gillum........................... .....Terre Haute.
Vernon Gould ....Rochester.
Victor K. Hendricks ....Logansport.
Mary A. Hickman................................Greencastle.
John E. Higdon................................Indianapolis.
Frank R. Higgins ....Terre Haute.
John J. Hildebrandt...................... ....Logansport.
J. D. Hoffman ....Lafayette.
Allen D. Hole................................Richmond.
Lucius M. Hubbard ....South Bend.
Alex. Johnson ....Ft. Wayne.
Edwin S. Johonnott, Jr. ....Terre Haute.
Ernest E. Jones ....Kokomo.
Chancey Juday................................Madison, Wis.

O. L. Kelso	Terre Haute.
Charles T. Knipp	Bloomington.
V. H. Lockwood	Indianapolis.
William A. McBeth	Terre Haute.
Robert Wesley McBride	Indianapolis.
Rousseau McClellan	Indianapolis.
Richard C. McClaskey	Terre Haute.
Lynn B. McMullen	Indianapolis.
James E. Manchester	Vincennes.
W. G. Middleton	Richmond.
John A. Miller	Bloomington.
H. T. Montgomery	South Bend.
Walter P. Morgan	Terre Haute.
Fred. Mutchler	Terre Haute.
J. P. Naylor	Greencastle.
Charles E. Newlin	Irvington.
John Newlin	West Lafayette.
John F. Newsom	Stanford University, Cal.
R. W. Noble	Chicago, Ill.
D. A. Owen	Franklin.
Rollo J. Peirce	Logansport.
Ralph B. Polk	Greenwood.
James A. Price	Ft. Wayne.
Frank A. Preston	Indianapolis.
A. H. Purdue	Fayetteville, Ark.
J. H. Ransom	Lafayette.
Ryland Ratliff	Bloomington.
Claude Riddle	Lafayette.
Giles E. Ripley	Decorah, Iowa.
George L. Roberts	Greensburg.
D. A. Rothrock	Bloomington.
John F. Schnaible	Lafayette.
E. A. Schultze	Ft. Wayne.
John W. Shepherd	Terre Haute.
Claude Siebenthal	Indianapolis.
J. R. Slonaker	Bloomington.
Richard A. Smart	Lafayette.
Lillian Snyder	Rockville.
Retta E. Spears	Elkhart.
William Stewart	Lafayette.
J. M. Stoddard	Crawfordsville.
Charles F. Stegmaier	Greensburg.
William B. Streeter	Indianapolis.
Frank B. Taylor	Ft. Wayne.
J. F. Thompson	Richmond.

A. L. Treadwell	Oxford, Ohio.
Daniel J. Troyer	Goshen.
A. B. Ulrey	North Mancheste
W. B. Van Gorder	Worthington.
Arthur C. Veatch	Rockport.
H. S. Voorhees	Ft. Wayne.
J. H. Voris	Huntington.
B. C. Waldemaier	West Lafayette.
Jacob Westlund	Lafayette.
Fred C. Whitcomb	Delphi.
William M. Whitten	South Bend.
Neil H. Williams	Indianapolis.
William Watson Woollen	Indianapolis.
J. F. Woolsey	Indianapolis.

Fellows	44
Non-resident members	20
Active members	112
Total	176

LIST OF FOREIGN CORRESPONDENTS.

AFRICA.

Dr. J. Medley Wood, Natal Botanical Gardens, Berea Durban, South Africa.

South African Philosophical Society, Cape Town, South Africa.

ASIA.

China Branch Royal Asiatic Society, Shanghai, China.

Asiatic Society of Bengal, Calcutta, India.

Geological Survey of India, Calcutta, India.

Indian Museum of India, Calcutta, India.

India Survey Department of India, Calcutta, India.

Deutsche Gesellschaft, für Natur- und Völkerkunde Ostasiens, Tokio, Japan.

Imperial University, Tokio, Japan.

Koninklijke Naturkundige Vereeniging in Nederlandsch-Indie, Batavia Java.

Hon. D. D. Baldwin, Honolulu, Hawaiian Islands.

EUROPE.

V. R. Tschusizu Schmidhoffen, Villa Tannenhof, Halle in Salzburg, Austria.

Herman von Vilas, Innsbruck, Austria.

Ethnologische Mittheilungen aus Ungarn, Budapest, Austro-Hungary.

Mathematische und Naturwissenschaftliche Berichte aus Ungarn, Budapest, Austro-Hungary.

K. K. Geologische Reichsanstalt, Vienna (Wien), Austro-Hungary.

K. U. Naturwissenschaftliche Gesellschaft, Budapest, Austro-Hungary.

Naturwissenschaftlich-Medizinischer Verein in Innsbruck (Tyrol), Austro-Hungary.

Editors "Termeszetrajzi Fuzetk," Hungarian National Museum, Budapest, Austro-Hungary.

Dr. Eugen Dadai, Adj. am. Nat. Mus., Budapest, Austro-Hungary.

Dr. Julius von Madarasz, Budapest, Austro-Hungary.

K. K. Naturhistorisches Hofmuseum, Vienna (Wien), Austro-Hungary.

Ornithological Society of Vienna (Wien), Austro-Hungary.

Zoologische-Botanische Gesellschaft in Wien (Vienna), Austro-Hungary.

Dr. J. von Csato, Nagy Enyed, Austro-Hungary.

Botanic Garden, K. K. Universitat, Wien (Vienna), Austro-Hungary.

Malacological Society of Belgium, Brussels, Belgium.

Royal Academy of Science, Letters and Fine Arts, Brussels, Belgium.

Royal Linnean Society, Brussels, Belgium.

Societé Belge de Geologie, de Paleontologié et Hydrologie, Brussels, Belgium.

Societé Royale de Botanique, Brussels, Belgium.

Societé Geologique de Belgique, Liège, Belgium.

Royal Botanical Gardens, Brussels, Belgium.

Bristol Naturalists' Society, Bristol, England.

Geological Society of London, London, England.

Dr. E. M. Holmes, British Pharm. Soc'y, Bloomsbury Sq., London, W. C., England.

Jenner Institute of Preventive Medicine, London, England.

The Librarian, Linnean Society, Burlington House, Piccadilly, London W., England.

Liverpool Geological Society, Liverpool, England.

Manchester Literary and Philosophical Society, Manchester, England.

"Nature," London, England.

Royal Botanical Society, London, England.

Royal Kew Gardens, London, England.
Royal Geological Society of Cornwall, Penzance, England.
Royal Microscopical Society, London, England.
Zoölogical Society, London, England.
Lieut.-Col. John Biddulph, 43 Charing Cross, London, England.
Dr. G. A. Boulenger, British Mus. (Nat. Hist.), London, England.
F. DuCane Godman, 10 Chandos St., Cavendish Sq., London, England.
Mr. Howard Saunders, 7 Radnor Place, Hyde Park, London W., England.
Phillip L. Sclater, 3 Hanover Sq., London W., England.
Dr. Richard Bowlder Sharpe, British Mus. (Nat. Hist.), London, England.
Prof. Alfred Russell Wallace, Corfe View, Parkstone, Dorset, England.

Botanical Society of France, Paris, France.
Ministérie de l'Agriculture, Paris, France.
Societé Entomologique de France, Paris, France.
L'Institut Grand Ducal de Luxembourg, Luxembourg, Lux., France.
Soc. de Horticulture et de Botan. de Marseille, Marseilles, France.
Societé Linneenne de Bordeaux, Bordeaux, France.
La Soc. Linneenne de Normandie, Caen, France.
Soc. des Naturelles, etc., Nantes, France.
Zoölogical Society of France, Paris, France.
Baron Louis d'Hamonville, Meurthe et Moselle, France.
Pasteur Institute, Lille, France.
Museum d'Histoire Naturelle, Paris, France.

Bontanischer Verein der Provinz Brandenburg, Berlin, Germany.
Deutsche Geologische Gesellschaft, Berlin, Germany.
Entomologischer Verein in Berlin, Berlin, Germany.
Journal für Ornithologie, Berlin, Germany.
Prof. Dr. Jean Cabanis, Alte Jacob Strasse, 103 A., Berlin, Germany.
Augsburger Naturhistorischer Verein, Augsburg, Germany.
Count Hans von Berlspsen, Münden, Germany.
Braunschweiger Verein für Naturwissenschaft, Braunschweig, Germany.
Bremer Naturwissenschaftlicher Verein, Bremen, Germany.
Ornithologischer Verein München, Thierschstrasse, 37½, München, Germany.

Royal Botanical Gardens, Berlin W., Germany.

Kaiserliche Leopoldische-Carolinische Deutsche Akademie der Naturforscher, Halle a Saale, Wilhemstrasse 37, Germany.

Königlich-Sächsische Gesellschaft der Wissenschaften, Mathematisch-Physische Classe, Leipzig, Saxony, Germany.

Naturhistorische Gesellschaft zu Hanover, Hanover, Prussia, Germany.

Naturwissenschaftlicher Verein in Hamburg, Hamburg, Germany.

Verein für Erdkunde, Leipzig, Germany.

Verein für Naturkunde, Wiesbaden, Prussia.

Belfast Natural History and Philosophical Society, Belfast, Ireland.

Royal Dublin Society, Dublin.

Royal Botanic Gardens, Glasnevin, County Dublin, Ireland.

Societa Entomologica Italiana, Florence, Italy.

Prof. H. H. Giglioli, Museum Vertebrate Zoölogy, Florence, Italy.

Dr. Alberto Perugia, Museo Civico di Storia Naturale, Genoa, Italy.

Societa Italiana de Scienze Naturali, Milan, Italy.

Societa Africana d' Italia, Naples, Italy.

Dell 'Academia Pontifico de Nuovi Lincei, Rome, Italy.

Minister of Agriculture, Industry and Commerce, Rome, Italy.

Rassegna della Scienze Geologiche in Italia, Rome, Italy.

R. Comitato Geologico d' Italia, Rome, Italy.

Prof. Count Tomasso Salvadori, Zoölog. Museum, Turin, Italy.

Royal Norwegian Society of Sciences, Throndhjem, Norway.

Dr. Robert Collett, Kongl. Frederiks Univ. Christiana, Norway.

Academia Real des Sciencias de Lisboa (Lisbon), Portugal.

Comité Geologique de Russie, St. Petersburg, Russia.

Imperial Academy of Sciences, St. Petersburg, Russia.

Imperial Society of Naturalists, Moscow, Russia.

Jardin Imperial de Botanique, St. Petersburg, Russia.

The Botanical Society of Edinburgh, Edinburgh, Scotland.
John J. Dalgleish, Brankston Grange, Bogside Sta., Sterling, Scotland.
Edinburgh Geological Society, Edinburgh, Scotland.
Geological Society of Glasgow, Scotland.
John A. Harvie-Brown, Duniplace House, Larbert, Stirlingshire, Scotland.
Natural History Society, Glasgow, Scotland.
Philosophical Society of Glasgow, Glasgow, Scotland.
Royal Society of Edinburgh, Edinburgh, Scotland.
Royal Physical Society, Edinburgh, Scotland.
Royal Botanic Garden, Edinburgh, Scotland.

Barcelona Academia de Ciencias y Artes, Barcelona, Spain.
Royal Academy of Sciences, Madrid, Spain.

Institut Royal Geologique de Suède, Stockholm, Sweden.
Societé Entomologique a Stockholm, Stockholm, Sweden.
Royal Swedish Academy of Science, Stockholm, Sweden.

Naturforschende Gesellschaft, Basel, Switzerland.
Naturforschende Gesellschaft in Berne, Berne, Switzerland.
La Societé Botanique Suisse, Geneva, Switzerland.
Societé Helvetique de Sciences Naturelles, Geneva, Switzerland.
Societé de Physique et d' Historie Naturelle de Geneva, Geneva, Switzerland.
Concilium Bibliographicum, Zürich-Oberstrasse, Switzerland.
Naturforschende Gesellschaft, Zürich, Switzerland.
Schweizerische Botanische Gesellschaft, Zürich, Switzerland.
Prof. Herbert H. Field, Zürich, Switzerland.

AUSTRALIA.

Linnean Society of New South Wales, Sidney, New South Wales.
Royal Society of New South Wales, Sidney, New South Wales.
Prof. Liveridge, F. R. S., Sidney, New South Wales.
Hon. Minister of Mines, Sidney, New South Wales.

Mr. E. P. Ramsey, Sidney, New South Wales.
Royal Society of Queensland, Brisbane, Queensland.
Royal Society of South Australia, Adelaide, South Australia.
Victoria Pub. Library, Museum and Nat. Gallery, Melbourne, Victoria.
Prof. W. L. Buller, Wellington, New Zealand.

NORTH AMERICA.

Natural Hist. Society of British Columbia, Victoria, British Columbia.
Canadian Record of Science, Montreal, Canada.
McGill University, Montreal, Canada.
Natural Society, Montreal, Canada.
Natural History Society, St. Johns. New Brunswick.
Nova Scotia Institute of Science, Halifax, N. S.
Manitoba Historical and Scientific Society, Winnipeg, Manitoba.
Dr. T. McIlwraith, Cairnbrae, Hamilton, Ontario.
The Royal Society of Canada, Ottawa, Ontario.
Natural History Society, Toronto, Ontario.
Hamilton Association Library, Hamilton, Ontario.
Canadian Entomologist, Ottawa, Ontario.
Department of Marine and Fisheries, Ottawa, Ontario.
Ontario Agricultural College, Guelph, Ontario.
Canadian Institute, Toronto.
Ottawa Field Naturalists' Club, Ottawa, Ontario.
University of Toronto, Toronto.
Geological Survey of Canada, Ottawa, Ontario.
La Naturaliste Canadian, Chicontini, Quebec.

La Naturale Za, City of Mexico.
Mexican Society of Natural History, City of Mexico.
Museo Nacional, City of Mexico.
Sociedad Cientifica Antonio Alzate, City of Mexico.
Sociedad Mexicana de Geographia y Estadistica de la Republica Mexicana, City of Mexico.

WEST INDIES.

Botanical Department, Port of Spain, Trinidad, British West Indies.
Victoria Institute, Trinidad, British West Indies.
Museo Nacional, San Jose, Costa Rica, Central America.
Dr. Anastasia Alfaro, Secy. National Museum, San Jose, Costa Rica.
Rafael Arango, Havana, Cuba.
Jamaica Institute, Kingston, Jamaica, West Indies.
The Hope Gardens, Kingston, Jamaica, West Indies.

SOUTH AMERICA.

Argentina Historia Natural Florentine Amegline, Buenos Ayres, Argentine Republic.
Musée de la Plata, Argentine Republic.
Nacional Academia des Ciencias, Cordoba, Argentine Republic.
Sociedad Cientifica Argentina, Buenos Ayres.
Museo Nacional, Rio de Janeiro, Brazil.
Sociedad de Geographia, Rio de Janeiro, Brazil.
Dr. Herman von Jhering, Dir. Zoöl. Sec. Con. Geog. e Geol. de Sao Paulo, Rio Grande do Sul, Brazil.

Deutscher Wissenschaftlicher Verein in Santiago, Santiago, Chili.
Societé Scientifique du Chili, Santiago, Chili.
Sociedad Guatemalteca de Ciencias, Guatemala, Guatemala.

. . . PROGRAM . . .

OF THE

SEVENTEENTH ANNUAL MEETING

OF THE

INDIANA ACADEMY OF SCIENCE,

STATE HOUSE, INDIANAPOLIS,

December 26, 27 and 28, 1901.

EXECUTIVE COMMITTEE.

MASON B. THOMAS, President. P. S. BAKER, Vice-President. JOHN S. WRIGHT, Secretary.
E. A. SCHULTZE, Asst. Secretary. G. W. BENTON, Press Secretary.
J. T. SCOVELL, Treasurer.

D. W. DENNIS,	STANLEY COULTER,	J. L. CAMPBELL,	J. P. D. JOHN,
C. H. EIGENMANN,	AMOS W. BUTLER,	O. P. HAY,	JOHN M. COULTER,
C. A. WALDO,	W. A. NOYES,	T. C. MENDENHALL,	DAVID S. JORDAN.
THOMAS GRAY,	J. C. ARTHUR,	JOHN C. BRANNER,	

The sessions of the Academy will be held in the State House, in the rooms of the State Board of Agriculture.

Headquarters will be at the Hotel English. A rate of $2.00 and up per day will be made to all persons who make it known at the time of registering that they are members of the Academy.

Reduced railroad rates for the members can not be obtained under the present ruling of the Traffic Association. Many of the colleges can secure special rates on the various roads. Those who can not do this could join the State Teachers' Association and thus secure a one and one-third round trip fare.

ROBT. J. ALEY,
KATHERINE GOLDEN,
Committee.

GENERAL PROGRAM.

THURSDAY, DECEMBER 26.

Meeting of the Executive Committee at Hotel Headquarters .... 8 p. m.

FRIDAY, DECEMBER 27.

General Session .... 9 a. m. to 12 m.
Sectional Meetings .... 2 p. m. to 5 p. m.

SATURDAY, DECEMBER 28.

General Session, followed by Sectional Meetings .... 9 a. m. to 12 m.

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

PROFESSOR M. B. THOMAS,

At 11 o'clock Friday morning.

Subject: "Forestry in Indiana."

The following papers will be read in the order in which they appear on the program, except that certain papers will be presented "*pari passu*" in sectional meetings. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another whose time is approximately the same. Where no time is sent with the papers, they have been uniformly assigned ten minutes. Opportunity will be given after the reading of each paper for a brief discussion.

N. B.—By the order of the Academy, no paper can be read until an abstract of its contents or the written paper has been placed in the hands of the Secretary.

GENERAL.

1. Correlation of Forestry and the Sciences, 10 m......W. H. Freeman
2. The Center of Population of the United States, 5 m......J. A. Miller
3. The Relation of Scientific Organizations to Manufacturers, 10 m..R. B. Polk
4. Mounds and Burial Grounds of Bartholomew County, Indiana, 5 m...................................J. J. Edwards
5. Experiments in the Hybridization of Fishes, 15 m..W. J. Moenkhaus
6. Microscopic Organisms Found in the Lafayette, Indiana, Reservoir, 10 m..........................Severance Burrage

MATHEMATICS, PHYSICS AND ASTRONOMY.

7. Investigations in the Electro-deposition of Platinum 8 m., J. A. Cragwall
8. Note on Some Experimental Work with a New Form of Pressure Regulator, 10 m........................Wm. K. Hatt
9. Elastic Changes in Bars of Nickel Steel, 10 m..........Wm. K. Hatt
10. Kirkwood Observatory, 10 m..........................J. A. Miller
11. Daylight Meteors (by title)..........................J. A. Miller
12. Physical Observations of Mars at the Opposition of 1901, 10 m......................................W. A. Cogshall
13. On the Density and Surface Tension of Liquid Air, 10 m..C. T. Knipp

14. A Few Experiments with Liquid Air, 3 m. . . . . C. T. Knipp
15. The Bitangential of the Quintic, 20 m. . . . . U. S. Hanna
16. A Theorem in Geometry, 3 m. . . . . J. C. Gregg
17. A Simple Proof that the Medians of a Triangle Concur, 3 m. . . . . J. C. Gregg
18. Note on an Attempted Angle Trisection, 3 m. . . . . R. J. Aley
19. A Problem in Geometry, 3 m. . . . . J. A. Cragwall

ZOOLOGY.

20. An Aberrant Etheostoma, 3 m. W. J. Moenkhaus
21. The Spinning of the Egg-sac in Lycosa, 5 m. . . . . W. J. Moenkhaus
22. The Culture of Amoeba, 2 m. . . . . A. J. Bigney
23. Protective Coloring of Terns, 5 m. . . . . A. J. Bigney
24. Effect of Pressure on Developing Eggs, 10 m. . . . . A. J. Bigney
25. Zoölogical Survey of Minnesota, 10 m. . . . . U. O. Cox
26. The Eyes of the Rhineura Floridana, the Blind Amphisbaenian from Florida, 10 m. . . . . C. H. Eigenmann
27. The Eyes of the Blind Shrimp from the Artesian Well at San Marcos, Texas, 10 m. . . . . E. M. Neher
28. Report of the Biological Station, under the direction of C. H. Eigenmann
    (a) Maps of Winona, Pike and Center Lakes, 10 m. . . . A. A. Norris
    (b) The Mollusca of Winona Lake, 10 m. . . . . A. A. Norris
    (c) The Dragonflies of Winona Lake, 10 m. . . . . . . E. B. Williamson
    (d) The Flora of Eagle Lake and Vicinity, 10 m. . . . . . H. W. Clark
    (e) Plant Ecology of the Winona Lake Region, 10 m. . Lucy Youse
29. Variation Notes, 5 m. . . . . C. H. Eigenmann and Clarence Kennedy
30. The History of the Eye of Amblyopsis; Abstract, 10 m., C. H. Eigenmann
31. Zoölogical Miscellany, 10 m. . . . . C. H. Eigenmann

GEOLOGY AND GEOGRAPHY.

32. Niagara Group Unconformities in Indiana, 10 m. . . . . M. N. Elrod
33. The Valley of the Lower Tippecanoe River, 10 m. . . . . . F. J. Breeze
34. Concerning a Series of Well-defined Ripple Marks in the Hudson River Group, Richmond, Indiana, 10 m., Joseph Moore and A. D. Hole
35. Variation in the Spires of Seminula Argentia (Shepard) Hall, 10 m. . . . . J. W. Beede

*36. Note on the Changes of Fauna at the Beginning of the Kansas Permian, 5 m. .... J. W. Beede

37. Topography and Geography of Bean Blossom Valley, Monroe County, Indiana, 3 m. .... V. F. Marsters

*38. Note on Cross-bedding in the St. Louis Limestone, Monroe County, Indiana, 5 m. .... V. F. Marsters

39. Wabash River Terraces in Tippecanoe County, Indiana, 12 m. .... Wm. A. McBeth

40. History of Wea Creek, Tippecanoe County, Indiana, 12 m., Wm. A. McBeth

41. Paleontology of Bartholomew County, Indiana, Mammalian Fossils, 5 m. .... J. J. Edwards

CHEMISTRY.

42. Organic Acid Phosphides, 5 m. .... P. N. Evans

43. Adsorption of Dissolved Substances, 10 m. .... P. N. Evans

44. The Determination of Manganese in Iron and Steel, 10 m., W. A. Noyes and G. H. Clay

45. A New Hydroxy-dihydro-alpha-Campholytic Acid, 10 m., W. A. Noyes and A. M. Patterson

BOTANY.

46. Some Drug Adulterations of Note, 10 m. .... John S. Wright

47. Notes on Apple Rusts, 8 m. .... H. Whetzel

48. Notes on the Genus Stemonitis, 8 m. .... H. Whetzel

49. Vegetation of Abandoned Rock Quarries, 10 m. .... Mel T. Cook

*50. The Phytogeographic Regions of Indiana, 10 m. .... Stanley Coulter

51. Contributions to the Flora of Indiana, 5 m. .... Stanley Coulter

52. Germinative Power of Conidia of Aspergillus Oryzae, 10 m., Mary F. Hiller

53. A Study of the Histology of the Wood of Certain Species of Pines, 10 m. .... Katherine E. Golden

54. A Comparison of the Microscopic Structure of Cuban, Mexican and Philippine Mahoganies, 10 m. .... Katherine E. Golden

*55 Some Characteristic Plants of Tennessee, 10 m. .... G. W. Martin

*56. Interesting Phases in the Development of Cypress "Knees," 10 m. .... G. W. Martin

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* Paper not presented.

57. Spore Resistance of Loose Smut of Wheat to Formalin and Hot Water, 10 m. . . . . Wm. Stuart
58. Some Additions to the Flora of Indiana, 3 m. . . . . Wm. Stuart
59. Effect of Composition of Soil Upon the Minute Structure of Plants, 15 m. . . . . Herman B. Dorner
60. A Collection of Myxomycetes, 10 m. . . . . Fred Mutchler

THE SEVENTEENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The seventeenth annual meeting of the Indiana Academy of Science was held in Indianapolis, Friday, December 27, 1901, preceded by a session of the Executive Committee of the Academy, 8:30 p. m., Thursday, December 26th.

At 9:15 a. m., December 27, President Mason B. Thomas called the Academy to order in general session, at which committees were appointed and other routine and miscellaneous business transacted. Following the disposition of the business, papers of general interest were read until 11 o'clock, at which time the retiring President, Mason B. Thomas, made his address; subject, "Forestry in Indiana."

At 2 p. m. the Academy met in two sections—biological and physico-chemical—for the reading and discussion of papers. President Thomas presided over the biological section and Dr. Thomas Gray acted as chairman of the physico-chemical division. Both sections adjourned about 4:30 and the Academy was assembled in general session for the transaction of business.

Adjournment, 5 p. m.

THE FIELD MEETING OF 1901.

The members assembled at Orleans, Orange County, leaving this point in carriages early Friday morning, May 24. They visited the region of Lost River, which is rich in geological, botanical and zoölogical features. From this locality the party went to West Baden, in which district Saturday, May 25, was spent.

PRESIDENT'S ADDRESS.

Mason B. Thomas.

Forestry in Indiana.

It seems strange that while European countries, with their vast tracts of forests, were spending money, energy and time in an effort to secure a conservative and economical management of their timber lands and, in most cases, had brought the whole question to a very practical and wise solution resulting in the maintenance of the steady value of the forest crop and securing by careful and well managed cutting the largest possible yearly production and revenue, the United States did practically nothing to arouse her citizens to some such rational forestry management. It was not until 1873 that the American Association for the Advancement of Science, at its Portland meeting, appointed a committee to urge Congress to some action in connection with our forestry interests. The recommendations of this committee were favorably received, but not until 1876 was the Commissioner of Agriculture required to appoint a man to study our forestry resources, the consumption and exportation of our timber, the extent of our supply, the effects of forests on our climate and the best methods to employ in conserving them. Since that time the work of the Department at Washington has grown under the care of Messrs. F. B. Hough, N. H. Eggleston, B. E. Fernow, and the present Forester, Mr. G. Pinchot, who in the order named have been in charge of it. They have, with very meager appropriations—to 1899 but $247,216.85—collected and published a large amount of valuable information relating to our forests, their use, care and abuse, and have secured the coöperation of many public-spirited men and not a few scientists, who have started, in many States, active campaigns educating the public in forestry matters and securing proper forestry legislation. Our federal government can not obtain the desired results without the active coöperation of the States and the support of its private citizens. Our own fair Indiana has been very remiss in the discharge of her duties in this matter, and the neglect has resulted in a great loss to our timber interests and the consequent injury to its numerous dependencies.

The State of Indiana is a part of the North Central Division of our country and includes 36,350 square miles, with an acreage of 23,264,000.

When the early explorers paddled their birch canoes from the Ohio up the Wabash and its tributaries they passed through a great wilderness of native forests of giant oaks, elms, maples and beeches. From the very banks of the streams where they landed to the tops of the highest hills was one unbroken covering of the forest primeval. The tall sycamores, lining the river banks like sentinels, crowded into the rushing waters the overhanging willows at their feet and guarded the giant elms, hardy soft maples and buckeyes of the rich river bottoms, while from the higher ground looked down the tall and rugged oaks, the mighty beeches and hard maples, walnuts, ashes and hickories, with here and there a towering tulip, all vying with each other for soil and sunshine. The lowlands of the north were clothed to the very water's edge with tamarack, ash and soft maples and the sterile soil of the south supported a thick growth of cedars and scrub oaks. Everywhere trees and shrubs of lesser size struggled with each other and with multitudes of herbaceous plants for every inch of soil and ray of sunshine. The records of the dimensions of some of these giants of our virgin forest seem past belief. A few illustrations will suffice.

Red maple—Height, 108 feet; circumference, 13 feet.

Hickory—Height, 150 feet.

Tulip—Height, 190 feet; circumference, 25 feet.

Sycamore—Height, 120 feet; diameter, 13 feet.

Cottonwood—Height, 150 feet; diameter, 8 feet.

White Oak—Height, 150 feet; circumference, 20 feet.

Basswood—Height, 190 feet; circumference, 17½ feet.

The forest floor was a spongy mass of forest litter that held in its pores the products of many rains and freely gave of its wealth to thirsty soil of open areas and to the multitudes of springs that kept the rivers to a uniform volume. Birds and animals of many kinds and in great numbers found here a suitable home, while the streams were stocked with an abundance of fish whose nearly ideal environment gave no suggestion of future extermination. Such was the picture of the forest primeval.

This condition, contrasted with the one we now see about us, tells of striking changes during a short period. Everywhere level fields of beautiful corn, wheat, and other crops clothe the tracts that were once covered with forests.

In 1870 the State contained 7,189,334 acres of forest, which was one-third ot its era. This acreage placed Indiana well up in the list of forest States. In 1880 this had been reduced to 4,335,161 acres, or one-fifth of the State's area. The records show that up to that time the forests had been removed mostly in the interests of agriculture and that no large bodies of the original tracts remained. At this period Indiana ranked fifth in her lumber manufacturing interests, but the statistician records the warning that, at the present rate of consumption, the forests of the State must soon cease to be commercially important.

In 1890 one-twelfth of our total area remained in forests, and the decade between 1880 and 1890 may be said to mark the greatest real loss to the State. The large decrease before this period was so closely connected with the clearing by settlers for cultivation that little of the timber in tracts not suitable for argiculture had been disturbed.

Between 1870 and 1880 2,854,143 acres of timber were removed and 3,829,459 added to cultivated lands, indicating a great demand for all tracts cleared in the past and also such open areas as might be tillable, while between 1880 and 1890 2,604,005 acres were cleared and but 1,173,744 acres added to cultivated fields. Over 260,000 acres were cleared annually during this period, or an excess of 60,000 acres yearly over what was removed in the most active immigration period just preceding. Timber was cut for revenue, and the demands of the manufacturing and shipping interests caused the owners to forget the relation of forests to our general prosperity. How the statistician's prediction has been fulfilled may be realized by reference to the statement of a well-known forester who, last year in reviewing the forestry interests of each State, says of Indiana that her forests have long since ceased to be of any value commercially. While this is not strictly true, it does illustrate the drift the State is making in this direction, since we now have but 1,227,141 acres, or one-twentieth of our whole area, in forests, and much of this has been cut over and the valuable part removed. The State no longer has any important supplies of valuable timbers, like oak, walnut, poplar, etc.

At present our largest tracts of timber are in the extreme southern part, in Franklin, Harrison, Brown, Jackson, Lawrence, Martin, Perry and Washington counties and a small tract in the north in Allen and Kosciusko counties. A few scattered tracts may be found elsewhere, but in the main these bodies are small and the timber of little consequence. The western border of the State contains but little timber and is the eastern edge of the great treeless region that extended over the north in Benton, Newton and Jasper counties and over much of Lake, Porter, Laporte, Pulaski, White, Tippecanoe and Warren. Some of this is now covered with young forests that will eventually add much to the forest resources of the State.

An examination of the topography of the State shows that the cleared lands include the headwaters of our principal rivers and streams. The entire basin of the Wabash and its tributaries has been more or less denuded, or at least does not contain any considerable area of timber land. The basins of a few small streams, like the Blue and Pigeon Rivers and a part of White River, are still wooded and the influence of the remaining tracts here, as elsewhere, is manifest in the less conspicuous changes in the streams so protected. Truly the problem of securing the proper maintenance and control of the forests of the State is grave and important.

In order to appreciate fully the real value of our forests to our State let us consider their general influence upon some of our natural conditions and industries affecting the general prosperity of our commonwealth.

One of the most important assertions made by those who advocate rational forestry management is that the forests exercise a very large influence on our climate and rainfall. So great have been the claims of these zealous advocates that I sometimes feel that the whole cause of forest care is seriously injured by claims for which no convincing proof is forthcoming and which do not appeal to educated people accustomed to think for themselves. In fact, too often scientific men have indulged in pleasant contemplations on this subject and made statements that were not founded on sufficient data to satisfy a man who did not believe things because he wished them to be so. For the thorough examination of this problem we must have accurate data of climatic conditions for many years and in connection with these careful records of forestry changes for the same territory. In the study of these it should be kept in mind that general climatic variations occur in all countries even where no changes have been made in forestry matters and it accordingly becomes difficult to determine the exact relation of the forest changes to climatic variations in other countries where marked changes have taken place in the forests. Notwithstanding the fact that different climatologists maintain exactly opposite views regarding forest influences on the climate, there are certain facts that are hardly controvertible. It is doubtful if the forest tract influences very largely the climatic conditions or total rainfall of a country except in a very few favorably located regions, but the important thing for us to consider is the value of Indiana forests to our own commonwealth and if possible the extent to which we would be justified in devoting time and money to secure certain forestry regulations.

The soil of a forest is less susceptible to sudden variations in temperature than that of the fields outside, and consequently warms more slowly in summer and its cooling is delayed in the winter. The summer effect is much more marked than the winter effect. The mean annual temperature of the forest soil is about 21 degrees lower than that outside. In the summer this cool soil will temper the air above it, start currents in the direction of adjoining fields and lower their temperature.

The average annual evaporation within the forest is but fifty per cent. of that in the open, and the difference between the two is greatest in the summer when the saving for the forest is the largest and most needed. About twelve per cent. of the precipitated water is evaporated in the year from forest soil and forty per cent. from open fields, the presence of the forest litter effecting a saving in some cases of seven-eighths of what would otherwise evaporate directly. Much of this difference is due to the looseness of forest soil and its poor capillarity that fails to draw the water to the surface. That the forest serves as a windbreak, in preventing currents of air from rushing over adjoining fields and depriving them of their moisture, is obvious to all.

The extent to which the forest influences affect the adjoining fields, and the distance to which this may be felt, depends on the nature of the forest, its size, composition, age, exposure, underbrush, elevation, proximity of streams, etc.

A collection of all of the published records of temperature and rainfall taken in the State has been studied, but they do not furnish such data as would in any way bear on the problem in hand. The earliest records were made in 1867 at but two points in the State. The central office at Indianapolis was not organized until 1882 and its first publication was in 1884. In a half dozen places records were kept from 1872 to 1881 and then discontinued. All of these stations were cities or towns and do not afford data for the forests about. Certain it is that statistics to support our claims are not forthcoming in Indiana, but our conditions are not unlike those of other States from which these facts were gathered, and the results are applicable to our own territory.

The influence of the forests on the fertility or productiveness of our land has been discussed from may points of view and it is hardly safe to generalize in a matter so dependent on the controlling influences of local conditions. The forests do affect climatic conditions in their immediate vicinity, and further, their influence is along the line of those changes that would act most beneficially to agricultural crops. The preservation of the rainfall by the forests is also of great advantage to our agricultural interests. These beneficial influences in Indiana are, in my judgment, evident only in the immediate vicinity of forests, and their removal has not, as far as statistics show, affected the production of certain crops in the whole State in any prejudicial way. The general disastrous effect will not be evident for some years. The great richness of our soil and its general suitableness for agriculture delays the certain penalty, but it is sure to come, and then the restoration will be a long and difficult process.

The annual yield of corn per acre has been gradually increasing in the whole State during the last thirty years, as the averages for these five-year periods will show:

1876—1880	23.55 bushels per acre
1881—1885	23.48 bushels per acre
1886—1890	29.77 bushels per acre
1891—1895	30.4 bushels per acre
1896—1900	37.2 bushels per acre

While it is doubtless true that some of this increase may be due to better methods of cultivation, yet it is hardly likely that this has produced any appreciable change during the last ten years, while during that period we have removed 509,045 acres of our forests, or more than one-third of the whole amount that remained. The average yield for each of the last three years is larger than for any previous year in the history of the State. Practically the same is true of our wheat, as these records will show:

1880—1884	12.3 bushels per acre
1885—1889	13.2 bushels per acre
1890—1894	15.8 bushels per acre
1895—1900	12.46 bushels per acre

This nearly steady increase is interrupted by the very low acreage of 1895 and 1896, when the yield per acre was below that of any previous year for which records exist, and certainly this falling off could not be due to deforestation since the three succeeding years returned to the normal yield per acre. The year 1891 produced the largest yield in the history of the State, 20.9 bushels per acre. With oats the records show practically the same:

1878—1880	19.3 bushels per acre
1881—1885	30.56 bushels per acre
1886—1890	27.39 bushels per acre
1891—1895	26.26 bushels per acre
1896—1900	29.99 bushels per acre

These fluctuations do not indicate the constant deleterious influences of deforestation, and in 1899 and 1900 the yield per acre reached its maximum.

The same general conditions are found to exist in the case of other cereals.

While these things are true for the whole State, in those localities that have suffered most from deforestation the amount of wheat and other grains produced on an acre has fallen off with the steady decline of the forests. These local losses seem to be made good by the heavy yields of newly cleared ground which has not yet felt the full effect of cutting away its adjoining timber, but the time must certainly come when what has been true in so many countries will be found true here. The world is full of examples of barren and sterile areas that were once verdant and productive, and the change has been brought about as the result of deforestation.

The whole Mediterranean country was once the garden of the world, but with the ruthless destruction of the forests came the blight of drought, cruel winds, storms and snows, that ruined rich plantations, made vine-clad slopes unproductive and impoverished the entire basin. Parts of Germany, France and Spain have taken alarm at the approach of similar conditions and, at great expense, have restored to the lands their covering of trees and the return of prosperity has demonstrated the necessity of forests to the fertility of the soil.

One of the direct results of the destruction of our forests has been the disappearance of our springs, the consequent failure of our domestic water supply and the variation in volume and regularity of our streams. The annual rainfall has varied but little during the last fifty years, but the method of its disposal has materially changed. The great water capacity of forest soil and litter, the rapidity with which water percolates through it, the irregularity of the forest floor and the general absence of ditches and gullies, decreases surface drainage during precipitation. The uniform covering of snow in winter prevents the soil from freezing and when the snow melts this body of water is retained. The great mass of water formerly held by the forest and gradually given out to the streams as they carried off the more immediate supply now flows from unprotected fields like rain from gravel streets, washing away the best of the upland, inundating the lowlands, and making agriculture along the banks of many streams most uncertain.

Then, too, the navigability of our streams has been seriously affected. The headwaters no longer contain sufficient water to float even the old-time flatboat, and farther down the stream the channel is simply a labyrinth of bars and shoals, products of denuded fields above, making navigation impracticable. The failure of our streams to compete as formerly in the commerce of our State increases the cost of living and destroys what otherwise might be a great industry.

The Wabash River, extending northward from the Ohio, receives tributaries from almost every section and drains four-fifths of our commonwealth. The central and southern parts are reached by the north and east branches of the White River and the north and north central parts by the Wabash and Tippecanoe. The records of the early navigation of these streams is full of interest. The head of navigation for boats of small draught was Monticello on the Tippecanoe, Logansport on the Wabash, Indianapolis on the White River, and on the east fork of the White and Muscatatuck rivers, as far east as Scott County. On the southeast the White River was navigable to Brookville.

Some of these early boats had really a large carrying capacity. One built at Terre Haute for the navigation of the Wabash was one hundred and thirty feet long and twenty-nine feet wide, with a carrying capacity of three hundred and fifty tons.

From the heads of navigation and below, and from the smaller tributaries of all of Indiana's streams from many miles in the interior, flat boats carried lumber, pork, poultry, corn, wheat, oats, fruits and hoop-poles down the Mississippi to New Orleans and the returning river steamers distributed great quantities of freight up many of these streams into the State. To some extent the smaller tributaries of the Ohio that reached into the State through one or two counties were factors in our transportation system. But all of this has passed away and from only a few places on the lower Wabash do we receive any practical advantage from our waterways. It would be unreasonable to claim that deforestation has been the cause of all this, for cultivation of open fields and the extensive underdrainage of level areas has contributed very materially to these results.

Our lumber interests are of sufficient importance to demand our very careful protection. They represent the second largest industry in the State and with the disappearance of the supply of raw material our very large income from them will be seriously curtailed. For many years our timber industries have drawn raw material from the best of our timber resources at a comparatively low price, but now the quality of this material is decreasing and the price increasing. Both of these factors make it difficult for our manufactures to compete with corresponding establishments located in timbered districts. To be sure, much of the raw material could be shipped in, and indeed about eighty per cent. of it is now imported, but this additional cost makes it impossible for our manufacturers to compete successfully and they are compelled to move to other States. We have already lost some of our important plants to Kentucky, Missouri and Arkansas.

In 1840 our lumber production (raw material for our factories) amounted to $420,791, in 1877 to $10,791,428, and in 1893 to $18,403,267.

The last ten years has seen an almost phenomenal increase both in number and variety of wood industries. More than fifty different kinds of establishments are using wood as their raw material, and to supply this demand timber has been cut without reference to its effect on the land or the State.

Some interesting and striking facts are discovered from an examination of our fruit crops in connection with the deforestation of our lands. The discoveries are certainly suggestive of a very close relation between the two.

In 1880 the eleven counties producing the largest yield of apples were as follows:

Counties.	Bushels of Apples.	Acres of Forest.
Allen	1,007,576	108,132
Crawford	608,043	50,005
Harrison	610,500	81,807
Kosciusko	602,462	52,275
Laporte	617,353	33,457

Counties.	Bushels of Apples.	Acres of Forest.
Ripley	650,735	69,183
St. Joseph	780.243	43,958
Steuben	655.843	47,973
Sullivan	1,059,149	46,867
Washington	888.421	80,852
Wayne	607.377	47,265

Several of these counties are among the most heavily wooded of any in the State and, with the possible exception of Laporte, they all contain a very large acreage of forest. The history of the apple crops in connection with the history of the removal of the timber in these counties helps to substantiate our claim for their importance. In 1897 these counties made the following showing:

Counties.	Bushels of Apples.	Acres of Forest.
Allen	6,170	29,876
Crawford	9,894	22,374
Harrison	57.241	40,125
Kosciusko	721	24,052
Laporte	1,304	17,490
Ripley	7,630	27,079
St. Joseph	980	9,463
Steuben	432	1,746
Sullivan	13,123	9,718
Washington	8,202	42,381
Wayne	3,863	7,718

From these figures it appears that the counties now exhibiting the largest falling off in their apple crops show nearly corresponding reduction in their forest areas (Allen, Sullivan, Steuben, Kosciusko, St. Joseph). Similar conditions are not found all over the State, but it is certainly suggestive that those counties that formerly produced the largest apple crops and have suffered most from deforestation have fallen to the end of the list in their yield of apples (Steuben, Sullivan, St. Joseph, Allen), and the importance of the forest becomes the more significant when we discover that of the counties formerly producing the largest crops those have fallen off the least that have removed the smallest amount of timber (Crawford, Harrison, Laporte, Ripley, Washington).

These relations are too significant and constant to be simply coincident, and in my judgment do demonstrate a very close relation between the forests and the fruit crops.

It is true that many counties like Tipton, Vigo, Putnam and Hendricks, that are not now largely covered with timber, are among our best producers of apples, but in these places investigation shows that the raising of apples is attended with great difficulty and spraying and other precautions are required that twenty years ago were not necessary. I do not insist that the presence of large tracts of forests in Indiana are absolutely necessary for the production of a successful fruit crop, but the facts seem to show that such tracts are conducive to its best development. It is more than a coincidence that Harrison County, with the largest acreage of forest of any county in the State, stands second in the size of its apple crop and first in its peach crop.

The influence of the forest is manifested in their moderating effects that prevent sudden changes and extremes of temperature that would be injurious to fruit trees; also the retention of the snow in winter prevents the ground from freezing and imperiling their roots. The removal of the forests in the vicinity of orchards has caused the disappearance of the large number of birds that formerly made their homes near but are now driven to distant forests for nesting and seldom appear in the orchard. These birds formerly destroyed large numbers of insect pests that now so seriously affect both trees and fruit. The general absence of these insects in heavily timbered counties is doubtless due to the birds. It is not likely that the presence of new insect pests, introduced into the State in nursery stock and in other ways, would account for the decline in many counties since any such pest would soon be generally distributed over the State and affect all regions alike. The raising of perfect apples is attended with difficulty and yields such poor financial returns that the number of trees in the State has decreased twenty-five per cent. during the last twenty years, but the decline in the yield has been fifty-five per cent. for the same period.

There can be no question as to the influence of the forests on the abundance and condition of the fish in our streams. The presence of fish depends largely on the constancy and character of the water in the stream and this is so directly connected with the size and location of our forests that the relation is easily recognized.

Early records show that our fishing industry was very important and the source of no little revenue that provided the sole support of many of our citizens. Nearly all of this has passed away, fishing is not now an established business and the food fishes are gradually disappearing from our streams. It is true that seining, dynamiting, and other methods of illegal fishing and stream pollution are responsible for much of this, but the complete disappearance of many streams and the steady reduction of others, with the uncertainty of their volume, has been by far the largest factor in the decline. This uncertain flow and decrease in volume prevents the stream from clearing itself particularly in the summer when the danger from its pollution is greatest. Such waters are not suitable either for the homes of fish or their spawning and we must change the character of our streams if we expect to return to our former conditions.

The present condition of the forests in the State as they appear from a general examination makes us realize the magnitude of the problem we are facing. Nothing succeeds like success, and to this might be added nothing fails like failure. This is exemplified in studying the large tracts of partially cleared and neglected timber land all over our State. A great portion of this area is covered with old and ill-shapen trees of valuable woods not removed in lumbering and many thrifty trees of wood that is not now considered valuable and, in addition to this, many thrifty trees of good timber not yet large enough to be marketable, growing without any care or attention, too isolated to secure for the valuable trees the benefits of natural pruning that would result in clear stems, or to secure for the vicinity the natural advantages of a forest in retaining the forest litter or influencing the soil, water supply, and to some extent the climatic conditions. At the same time the trees are too close and afford too much shade to permit the growth of good grass. The problem is too complex for the average owner, the whole area grows steadily worse and soon ceases to excite a desire for improvement in the mind of the holder.

The causes of this decline in our forests, beyond the legitimate clearing for cultivation, have been many, but the most important of all has been man's greed and the desire for immediate realization of his heritage. This desire has not been curbed by an appreciation of the importance of our forests to our prosperity. For this educated people, who are conscious of the many important consequences resulting from the decline of our forests, are more or less responsible.

Some of the other causes of the forest's decline may be properly considered in turn.

The greatest foe that attacks our forests is fire. No other destructive agent leaves us with so little in our hands to mourn over or to form the incentive for future care and protection. The great destroyer engulfs everything it reaches and we are left with ruined and blackened fields that indicate the cost of its visit. The loss and danger is two fold: First, the destruction of old and marketable standing timber that could soon be converted into cash, and the stunting and scarring of many young trees that never recover or make at most an insufficient growth, in the end to be discarded as poor or unsound timber; second, the loss of forest humus and of young sprouts and seedlings that represent the working capital of the farmer or forester. Upon this the hopes of his future profits depend, and while the loss seems difficult to estimate at the occurrence, it becomes more manifest as time passes and the fields become simply waste land covered with herbaceous and shrubby vegetation, scattering noxious weeds over all the region and bringing no returns to the owner.

The extent to which Indiana has suffered from forest fires can hardly be discovered. We have had no historic fires, such as those of Michigan or Wisconsin, to use as a suitable text for vigorous protestations against carelessness on the part of farmers, hunters and railroads, but careful estimates show that we are annually losing large sums in this way, and a little care and foresight would relieve us of this useless waste. In 1880 90,427 acres of timber were burned over, resulting in an estimated loss of $130,335, and during that year no unusual fires occurred. This indicates approximately our annual loss. We should take immediate steps to check this waste.

Something must be done to secure immunity from the great loss we suffer from browsing animals, which now prevent the reforesting of many tracts that would otherwise soon naturally grow up to young trees. The pasturing of our wood lots prevents the possibility of natural increase in the forest acreage and deprives the forest soil of much of its value from the destruction of its litter by the stamping of cattle. This can be more efficiently remedied by securing the coöperation of the owner than by legislation.

The State also loses much from destructive lumbering. A visit to any of our large timber tracts shows the reckless waste from this cause. Without any thought of the future a tract is cleared of its timber and only the best of the logs are drawn out. Frequently large tops with their limbs that might be utilized in many ways are left. Small trees or saplings are removed for wood or are cut down in making roads and in clearing and the possibility of early reforestation is destroyed. The debris of such reckless logging operations remains on the ground to invite destructive fungi and insects and furnish fuel for fires that otherwise might run out if the ground was clear or covered with a thrifty growth of young trees.

The marked increase in the number of concerns using small and second growth timber makes it important that we watch the development of our young forests lest they, too, fall a victim to man's greed before they are of sufficient size to be profitably marketed or before plans for systematic cutting are inaugurated.

Insect ravages are a source of very serious loss to our forests in many parts of the State. Our records show occasional outbreaks in various localities and whole forests are frequently denuded. While in the majority of cases this does not at once result in the death of the tree, it does produce serious loss in its effect on the reduced growth and diminution in thickness of the annual ring, that valuable increment that represents practically the only return to the owner. Frequently deformations and abortions of various parts result from the attack of borers and other insects. In most cases it is hardly practicable to inaugurate exterminative measures when any considerable area is affected because of the great cost and difficulties in treatment, but where local outbreaks occur, due to particularly dangerous pests like the San José scale, and the whole region is threatened, the State can well afford to coöperate and promptly back such measures as will result in wiping out the cause of the danger.

A most important and practical precaution to prevent the increase in insects and fungi is to remove, as far as possible, old stumps and logs, cut down and convert into wood or lumber dead trees, or remove their bark, and thus decrease the possibility of the multiplication of the pests by destroying their usual and most frequent breeding places.

As far as I have been able to observe, our State has suffered little in the way of extensive outbreaks in any particular locality from parasitic fungi, and while a goodly number of species of these destroying agents may be found in the State, yet they are of the kind that attack very old or dead timber and could be readily controlled by proper attention to the destruction of their usual breeding places, as was suggested in the case of the insect pests. The marketing of timber deteriorating from the presence of fungi would preclude serious loss.

Of other forest enemies, storms, lightning, snow, gnawing animals, etc., we have our occasional outbreaks, but none of sufficient magnitude in recent years to cause serious loss. The destruction frequently resulting from the first agent could usually be very much reduced if prompt measures were taken to market, as soon as possible, all timber that had in any way been irreparably injured.

We should carefully guard every avenue of waste. Our inexhaustible fuel beds should be made, as far as possible, to take the place of the more valuable timber that is now being used for wood. Many so-called worthless and cheap woods could doubtless be substituted for valuable kinds now generally used and a more accurate knowledge of the properties of our various woods by our wood workers would effect a great saving. More up-to-date methods of sawing, happily now being largely used, would also increase our resources.

The importance of our forests to our State should now be apparent. Their influence on the rainfall secures in time and place results of greatest benefit to all. They likewise influence in a beneficial way the immediate climatic conditions, the value of our soil for agricultural purposes and the production of a satisfactory fruit crop. They determine very largely the number and character of our streams, their importance as water-ways, and the abundance of food fishes. They are indispensable to flourishing manufacturing and commercial industries, thus affecting the distribution of population. I may also add, we owe something to them for the maintenance of good sanitation and low mortality.

The very much depleted condition of our forests and the danger of their complete destruction from the forces just enumerated calls for immediate and vigorous action. This should be along two well defined lines: education and legislation. The land owners of the State can be forced to do but little, but by judicious and united efforts a public sentiment can be created in favor of the movement and the majority of the forest owners will join in the efforts to secure practical results.

The State, county and township agricultural associations at all public gatherings should present forestry topics for discussion, and here, as elsewhere, competent persons should present the facts applicable to local conditions, giving to the farmers simple and practical directions for the care of their forests and the most economical methods for increasing their acreage. At fairs and meetings of associations opportunity is nearly always afforded for such work. Our teachers should be urged to give at their gatherings frequent opportunity for the presentation of such forestry matters as would be appropriate to the occasion. At our agricultural college and in connection with several of our public educational institutions courses in forestry should be given so that our coming generation of agriculturists, teachers and professional men may deal with our problems in an intelligent way. We need in every community men trained in forestry matters who, even though they may not be actively engaged in forestry work, will be the leaders of public sentiment and the organizers of movements in the direction of forest care. Some of these men may in time be encouraged to supplement the work of the State by securing control, at tax sales or in other ways, of suitable forest lands and managing them in a manner to obtain a permanent investment, that could be made to yield a reasonable return to their posterity. In some countries large estates have been left in this way, protected by proper conditions that would prevent subsequent holders from depreciating the value of the investment, that, well managed, would yield a very liberal return.

Although the State does not own forest lands, she should educate her citizens in this subject for the same reason that she now does in agricultural matters, even though she is not engaged in agriculture.

It is also important that the public schools lend their influence to this cause in devoting some part of their time to the general study of our trees and the value of our forests. This need not be introduced into the curriculum as a regular subject, but in connection with the nature work in the grades some few matters might be presented and in the high school a few talks to the whole student body each term would accomplish very much, indeed a simple recognition of the importance of the subject would greatly assist in securing a hearing with the young. A German proverb says, "Whatever you would have appear in the nation's life you must introduce into the public school, and in not doing this we are missing one of the most important means of bettering our forestry conditions."

Fortunately one day has been set apart for the consideration of our forest interests, and the proper observance of arbor day in our State affords one of the very best methods of presenting this subject to the people. This day should be carefully observed in every school district in the State as a holiday and appropriate exercises should be prepared for the occasion. In these exercises the pupils of our public schools should take as prominent a part as possible by reading suitable poems or presenting essays on various subjects connected with our trees and forests.

In addition to this there should be presented to the people at these gatherings a thoroughly practical talk by some one trained in forestry matters on subjects that will reach the farmers, who own ninety-seven per cent. of the forests, and direct them in improvements and work that will result in a betterment of our forestry conditions. An effort should be made to correct the prevailing impression that forestry means the hoarding of trees. It should be clearly explained that the application of proper methods would result in inaugurating a system of intelligent cutting that would bring to the owner the largest yearly returns without impairing his investment. It should be further explained that there is no desire to re-forest land well adapted for cultivation, but rather to cover with forests the vast areas of brush and waste land, that in 1893 represented thirty-five per cent. of our total acreage, and that only in this way can these tracts be made profitable.

The thoroughness with which the State is settled makes it likely that this land is unfit for cultivation, and if this could be added to our permanent forests, and these properly managed, our condition would be almost satisfactory. This waste land is well scattered throughout the State, but several large tracts are located in Harrison, Parke, Perry, Jackson and Crawford counties, and these should, if possible, be secured by the State. No other line of activity offers as large returns with so little labor as the reclaiming of these waste tracts. A little tree planting, pruning, and clearing of worthless stock for wood to pay the cost of the work, and the protection of these trees from forest enemies would soon secure a forest that would become, if properly managed, a permanent and paying investment. An especial effort should be made to reclaim all of this land that is located in any way to influence our streams and if possible restore to the State these important factors in our prosperity.

In some States the results from the work of arbor day have been very important. In New York, last year, the day was observed in 10,251 school districts, and in twelve years 229,616 trees have been planted. Our State should not be behind in this matter.

The next important means by which we hope to secure a betterment of our forestry conditions is through legislation. The history of forestry legislation in Indiana at the opening of the last legislature was summed up by an eminent botanist who, in discussing the forestry laws of several States, said of Indiana that she had nothing to offer in this direction. While this does represent the main facts in the case it does by no means tell the whole story. A law passed in 1899 exempted from taxation permanent forest land containing not less than 170 trees per acre and also any areas that might be planted to the same number or more, cultivated a few years and protected from cattle for a stated time. A like exemption could be secured by bringing land containing 100 or more trees to the same standard and maintaining it as a forest.

This law has in it much that is good, but the results of its operation demonstrate the difficulty of accomplishing much by legislation without provision for education. This law was intended to induce owners to secure a compactness that would make their timber lands forests in all that this term means to the forester and thus prevent the clearing of land below the point where it ceased to be a forest and became a woods pasture. The financial consideration was not enough to attract any very large number of people and the farmer was not made to see the beneficial effects of the forest so preserved or the possibility of their management to secure profitable returns. Further no attempt was made to direct the owner in his efforts to bring his depleted forests to the standard where exemption could be secured and consequently the total acreage was not increased. But 284 exemptions, including 5,312 acres, have been secured in the whole State.

The law passed by the last legislature seems to be a wise one in that it places the forestry matters of the State in charge of a properly organized board with authority to make all desirable recommendations for the regulation of our forests. The last legislature deserves our special commendation in its taking the first official step and establishing a board of forestry. I am certain that this board will receive the hearty support and co-operation of the Academy of Science and of the public spirited citizens who have for many years persistently urged attention to our forestry interests and thus have opened the way for forestry legislation. To secure any permanent benefits additional laws must be enacted, whenever such as are suitable to our local conditions are suggested, and the campaign of education inaugurated must be pushed by all friends of forestry. Had the State adopted any radical legislation without the thorough study of the situation within our borders it might have resulted in a misfit, since only those forestry laws are really effective that are based on the exact needs of a locality. Additional legislation must follow investigation and not precede it.

What it is possible to accomplish by forestry legislation may be discovered by an examination of the legislation in those States that have done most in forestry matters. A few of these States have worked out problems very similar to those that now confront us and from them we may learn much. In New York, as the pioneer in this country, the legislation has developed as the result of experiment and investigation with the single purpose of preserving to the State its valuable forests. The State first, in 1885, secured control of certain large tracts of virgin forest and placed the management of these in the hands of a forestry commission. This commission was given charge of all forestry matters, including the collection and dissemination of information, the care of forest fires, the reforestation of new lands, and, in fact, was the custodian of the State's forests. This board has been several times reorganized, until the men who compose it are each charged with the responsibility of a certain part of the State's work. The remuneration is sufficient to obtain thoroughly competent persons for each department and thus secure a businesslike service. This board has expended more than $3,000,000 in the purchase of forest lands of the Adirondacks. With it all they have wisely guided public sentiment until the people are wholly in sympathy with the work and are proud of their foresight in saving to the State so much that is vitally connected with its prosperity. In addition to this New York has established a school of forestry that has already accomplished much toward solving many problems peculiar to American forests. It is fortunate that New York has been so generous in conducting her experiments on such a large scale, for the outcome of this will be of incalculable aid to other States which have the same problems to face. We can not copy European forest methods and hope to secure the greatest efficiency in our forest work. Principles are valuable but the methods of their application must vary.

In Pennsylvania the history of forest legislation shows the usual results. Failure to fix responsibility and to arouse public sentiment made the law inoperative, but in 1897 the people were stirred to action, forest fires were promptly put out and the State has established forest reserves by retaining the land that came to it from the nonpayment of taxes and in condemning for that purpose suitable tracts at the headwaters of her principal streams. Laws relieving forest land owned by farmers from taxation has done much to encourage tree planting, and what was missed in our own law has been secured here by educating the people to a realization of the importance of immediate action.

The States of New York, Pennsylvania, Wisconsin, Minnesota and Michigan, representing the most advanced position in forestry matters and in accord with the best judgment of the foremost forestry experts in the United States, have recognized the importance of the State in the control of her forests and the dangers of leaving an industry so vitally connected with the prosperity of her people wholly in the hands of private parties. The aim of the most rational forestry legislation should be to permit the State to obtain control of large tracts, located suitably to influence the head waters of our streams and our agricultural interests and secure permanency to our lumber industries, and then place the management of these in the hands of trained foresters who would secure from them a financial profit to the State in addition to maintaining their highest efficiency as forests. Then the maintenance of smaller tracts that may be acquired from the nonpayment of taxes and adding to these, as occasion presents, lands not especially suited for agricultural purposes. This policy, in those States where its effects have been observed, has received the universal support of the people. Depredations interfering with the best development of the State reserves can be controlled by positive legislation that will fix responsibility and punish the guilty. Forest thieves, fires, browsing on public lands, etc., could all be controlled with ease. In whatever is done the State must take its citizens into its confidence and be prepared to defend each policy or line of action by careful figures based on facts secured from the local conditions. The State should likewise avoid anything that savors of a monopoly in this enterprise and should in every way encourage private capital to coöperate in the work.

It would doubtless be out of place at this time to make suggestions for radical legislation since the present forestry board will no doubt soon have plans along this line based on the very careful study of the local conditions. I wish, however, to commend to the consideration of our legislators the very comprehensive and rational law before the Michigan legislature last winter. This in my judgment is the most perfect plan of forestry legislation that has been presented in this country. This bill was prepared by a forestry commission appointed in 1899, and was based on the needs as discovered from a study of the conditions.

The organization of the fire warden force is most complete: it places responsibility carefully and makes the expense of fighting fires fall largely upon the counties in which it exists, and if any negligence on the part of the warden is discovered the whole burden falls on the county in which he is shown to be remiss. A series of State reserves are to be established in suitable localities where land can be secured from that which has come to the State because of the nonpayment of taxes. The entire management of these forests is placed in the hands of the commission, and they are empowered to appoint a trained forest warden, with assistants, who will have the immediate management of these lands and be responsible to the commission. Appropriations are made for the work, and every phase of it seems to be covered by carefully drawn and very comprehensive legislation. While the laws are based largely on those of New York, they contain a few improvements, and in some respects they might be safely adopted by our own State as more applicable to our conditions. Certain details of the laws in many States are very valuable, but the aim of our State should be toward practical results and not to experiment with any plan unless it has proven to be applicable to many cases and might be effective in our own. The people must be shown the wisdom of each step and this will make our forestry work easy.

A word of caution in connection with the subject of legislation may not be out of place. Great care should be exercised against the possibility of excessive exemption from taxation or the raising by tax of money to pay premiums on forest plantations, else the burden will fall too heavily on our agricultural regions that are not fortunately located for forests, and result in a prejudice against any forestry legislation. While such legislation is a great incentive to forest attention and does stimulate a healthy interest in forest matters, it must not be too liberal or continued beyond a period when its educational effect is desirable, since practical forestry is a profitable occupation and should stand on its own merits. True some farmers have tried it and failed, so have they tried farming and not met with success, but long experience with forests under many and varied conditions has demonstrated the success of the plans, and there can be no question as to its outcome in our State. The problems that confront us in Indiana may be briefly stated as follows:

1. Preservation of our forests now located on lands that are not suitable for agriculture and the management of these tracts so that their productiveness will be permanent.

2. The reforestation in the most economical way of similar lands, now denuded, and securing for them the very best management possible.

3. The maintenance of such other tracts as may be necessary to secure the proper protection to our agricultural, commercial, and sanitary interests.

4. The securing of all needed legislation that will place our forestry interests in the hands of competent persons and supporting them by all authority necessary to secure wise management and permanency to the proper conditions.

As bearing upon the direct solution of these problems I may be permitted to make some specific recommendations. The State should establish forest reserves in different sections where at the public expense peculiar problems connected with each locality could be worked out by experts in charge and plans presented that would be sufficiently profitable to induce private capital to engage in the undertaking. It is further desirable that the State follow the plan already inaugurated in this country and establish in connection with one of our State institutions a school of forestry where our people could be trained in this branch of industrial activity and where the forestry interests of the State could be centered.

But in all of these matters the intelligent support of Indiana's best citizens is solicited and it is only with the hearty coöperation of every one that anything worthy of our great State can be accomplished.

Many fascinating fields for work and investigation along these lines are opening in Indiana, and it is hoped that our scientific friends may be induced to coöperate with our State board in these matters.

Correlation of Forestry and the Sciences.

W. H. Freeman.

Forestry as the science of promoting and fostering the forest area by preservation and cultivation has a significant correlation with the more prominent sciences of geography, zoölogy, engineering, manufacture and government.

This as a fact is beyond questioning, but the ways, manner and extent of the correlation are not generally known, nor have educators, especially in the United States, given it merited consideration. There are excuses for this. Educators and the people generally are not to be censured for this lack of attention in the preservation and cultivation of forests, even for their own good aside from the good of science. Forestry is a subject of very recent agitation in America and especially is it so in Indiana, but it is growing steadily.

President Roosevelt voices this condition of the knowledge of forestry in the opening sentence of his message bearing on the subject. He says, "Public opinion throughout the United States has moved steadily toward a just appreciation of the value of forests." Trusting that you all are familiar with what he says about forestry in his message, I shall, expressing my appreciation for such eminent recognition of it, pass to the discussion of the connective phases mentioned at the beginning.

Forestry as a science issue, it seems to me, is far-reaching in its influences. I think with consistent reason it can be shown that there is scarcely an industrial or intellectual life which forestry does not affect directly or indirectly.

Geography and forestry are closely connected in matters of climate, drainage and surface contour. Forests by their presence have marked influences on climate in governing the phenomena of temperature, moisture and storms. It is asserted by students of the subject that the denudation of forests is the cause of the growing extremes of temperature, violent atmospheric changes, changed precipitation, moisture waste through heightened evaporation and the unhindered flow over the surface to the streams.

The arguments are: First, the forest foliage, as a transpiratory agent, is a great source of moisture to the atmosphere; second, the foliage by its shade prevents the sun's rays from striking the earth's surface and thus prevents evaporation; third, the forest litter, humus and roots, collect, hold and store the rainfall for the gradual and constant resource of water for streams and springs; fourth, the lack of forest litter, humus and roots permits the rainfall to flow quickly over the surface to the streams and away, thus facilitating the drying up of springs and streams and restricting the climatic agents.

In addition to the facts stated above, deforestation means the uninterrupted sway of the winds to carry destruction with them and allows the sun's rays unbroken to overheat the surface and cause abnormal atmospheric conditions resulting in violent storms.

I need only to remind you that the climatic equilibrium is different from ten years ago. The temperature extremes for the year 1886 were

101 and 25. In 1896 they were 103 and 22. More frequent storms of destructive character occur throughout the summer, and the fall and lay of snow is not so constant as formerly. I am not prepared to say that the annual precipitation is much less than before deforestation, but believe the almost certain annual drouth is heightened because the rainfall is not conserved to the soil because of the conditions before mentioned.

Forestry and drainage are reciprocal. The surface drainage is changed. No one rationally doubts it. It is contracted generally, more quickly spasmodic in overflow and becoming more intermittent. The streams in former times under conditions of dense woods contained water all the year round. The rivers dammed by fallen trees and drift prevented the hasty escape of the water from their beds. But now the drifts are gone and for the greater part of the year the streams are stagnant and dead. This is true, especially of the Pigeon, Eel and Wabash rivers. Many of the lakes have shrunken in area and the small creeks and streams no longer exist.

The same causes answer for these conditions as for the climate: lessened transpiratory agents, increased facilities for evaporation, aided escape of the rainfall and destroyed storage conditions.

The unhindered flow of the rainfall over the surface correlates forestry and erosion. Erosion is altering in many places, to a considerable extent, the contour of the State and resulting in serious damage to the streams. The surface is being gullied and the soil carried into the streams and springs, thereby clogging and filling them up.

This devastation of the streams relates forestry and zoölogy. The congestion of the streams with the erosive sediment filling up the deep holes and the intermittent flow are destructive to the propagation of many of the fishes. The drying up of the deeper sloughs and swamps is exterminating the mollusks and crustaceans. The same may be said of every other water-inhabiting species.

It may be argued that in many instances it is well such is the case, but for science it is not good.

Forestry and ornithology are mutually related. The destruction of the forests means the destruction and extinction of many of the birds. Trees are the natural homes of most of our beautiful birds. It is in the forest that they nest and hatch their young. The larger food birds of both land and water habitations are almost entirely extinct in this State. The same is true of many of the finest species of plumage and song birds.

All these facts so far given, you may say, are not because of forestry, but from the lack of it. It is sadly true, and forestry at best can not hope to retrieve, but it can, if properly conducted, nourish the neglected condition and foster the remnants. The science of engineering and forestry are mutually affected, as is also manufacture and construction. "Timber physics" is the term applied to these relations. Forestry in its most complete development should strive to make known the properties of all timbers used for purposes of engineering, manufacture and construction. This knowledge should be extended to cover the properties of timber structure, physical conditions of growth and mechanical qualities. To be of value the tests made should be of the largest number, specimen and physical limitations. A definite knowledge of these and their relation to the mechanical properties will be of inestimable value to users of wood in the lines of work mentioned.

Since we are beginning to plant forests, the production of wood merely is of the smallest consideration, but to produce at the same time quality of wood is the thing to be considered. It is the endless variability in timber physics that has kept it in the background, but I believe with the thorough inauguration of systematic forestry it must come to the front.

It is a well-known fact by all who have to handle wood in constructive connections that our knowledge, technically, of wood properties is very unsatisfactory and has resulted in untold loss in every conceivable manner.

In matters of forestry and government there are to be found at the present time some of the most scientific problems for legislation and control. The management and control of the United States forest reserves against depredations of cutting, grazing, cultivation and fires, and the problem of irrigation and irrigation reservoirs for the reclamation of the arid sections of the Middle West from regions of desolation to areas of life, industry and prosperity involve difficulties of interstate significance and large public interest.

In closing, I say it seems to me the points discussed are some of the ways in which forestry and the sciences are related. As "scientific, like spiritual truth, has ever from the beginning been descending from Heaven to man," so let it continue, and remain for science to substitute facts for appearances and demonstrations for impressions.

Facts in all these, definitely ascertained and generally disseminated and taught in the schools, will rebound in lasting good to an energetic people. This means for Indiana. The saying, "We hail science as man's truest friend and noble helper" was never more applicable than now and at home. I appeal to you as men of science to lend a helping hand and bring forth the truth to a receptive humanity.

Relation of Scientific Organizations to Manufacturers.

R. B. Polk.

In looking over the constitution and by-laws of this organization, I find stated among its objects the following: "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."

Being identified with the manufacture of certain food products, and being a member of this organization, has induced me to give some thought to the results which might be produced if there could be consummated a closer relationship between this society and manufacturers. In suggesting that a movement of this kind be inaugurated, I am taking it for granted that the paramount motives of this organization are for the enlightenment of the public at large, and the advancement of science in general.

It is a fact that there is a certain amount of prejudice on the part of manufacturers against scientists, which I believe to be directly due to a lack of understanding and coöperation. There is, in fact, too much antagonism between manufacturers and our health officers. This is, perhaps, due, to some extent, to impractical and incompetent men being placed in these positions. It may, indeed, be laid in some cases to the fault of the laws they are trying to enforce. And, though I whisper it, it may be due to a desire on the part of some manufacturers to use fraudulent methods in the sale of their goods.

It is a belief too primary to question that science in the hands of men of genius has been directly responsible for nearly all great improvements in the production of pure foods. We have to but mention such names as Appert, Pasteur, Liebig, Hansen, Jorgensen and others and investigate their works to substantiate this assertion.

There have recently been some efforts made on the part of organized manufacturers of food products to utilize the services of some chemists and bacteriologists to solve certain scientific problems bearing on processes for canned goods. All such efforts have, however, been spasmodic and have been dropped; the results thus being minimized. I believe that what is needed to produce real results is quiet, persistent effort, and I think necessarily on the part of an organization.

There are three ways in which manufacturers have need of organized scientific aid: First, in the practical work of production; second, regulating our food laws; third, in educating the public to the use of pure foods, and to the fact that such goods can not be produced as cheaply as adulterated ones.

While it is necessary for the manufacturer to understand the mechanical details and general processes of his factory, it is impracticable for him to become an authority on the obscure scientific details. The ordinary farmer will not leave his work to investigate the mineral constituents of certain plant cells, however great the scientific value. The brewer does not care to know whether or not the bacteria which sours his product is spore forming, so he has a method of keeping clear of them. The baker does not care what particular variety of yeast he uses if he has the right one, and it is pure enough for practical uses. Yet, the foundation ot his business depends upon the separation and purity of the yeast he employs. The canner will not investigate what action sulphite of soda will have on tin until it has cost him $60,000 in one year, as was experienced by a packer a few years ago. Thousands upon thousands of dollars have been lost because such facts as these have been unknown. In fact, the field is so broad that work in many departments of an organization would be necessary.

There is, and has been, great need in our States of a source of unprejudiced authority on the subject of foods which could be referred to in framing laws. Legislatures are fickle. Health officers are subject to political change, which makes the interpretation of the law subject to "change without notice." I am not presuming that it is the scope of this society to become a political factor, but had it been operating on the lines I have suggested it would only be a natural sequence for it to become an advisory authority for lawmakers as well as manufacturers.

In order to show some of the uncertainty the manufacturers have to deal with, I will read extracts from two different letters. One from the

Food Commissioner of Pennsylvania, the other from the Chief Chemist of the Agricultural Department, which is in answer to an inquiry made by a chemical house in New York. The following is from the Food Commissioner of Pennsylvania:

"A number of manufacturers of 'catsup' have represented that the strict enforcement, at this time, of rule No. 12, of the decisions published in Bulletin No. 30, by this department, so far as it relates to catsup, will seriously injure their business. They state that the catsup for next year's trade was manufactured before the rule referred to was issued and that the goods now contain a preservative, known as benzoate of soda, the use of which is prohibited under the law. Whilst rule No. 12 does not absolutely prohibit the use of preservatives in food, it does fix the responsibility upon the manufacturers of showing that a preservative is necessary, and in case of doubt as to its effect upon the health of the consumer, of showing that it is not injurious. Before strictly enforcing any new law, or new ruling, the Dairy and Food Commissioner has always given manufacturers and dealers reasonable time in which to be heard, and, if necessary, to get rid of adulterated goods already on the market, and this is in recognition of the fact that all reputable manufacturers and dealers desire to comply with every lawful regulation of trade for the protection of the public health, and only need to know what the law is, and be given reasonable time to adjust their business to its requirements. In order, therefore, to give time for the proper settlement of the points at issue, the enforcement of rule No. 12, so far as it relates to the use of a moderate quantity of benzoate of soda in catsup, is suspended until opportunity shall be given manufacturers to make clear the fact that its use is necessary and not injurious to health. A meeting will be arranged for in the near future, at which all who are interested can have opportunity to be heard."

It seems that the theory of the law has been reversed in this case by holding a thing wrong until it is proven right. This letter is practically a retraction, and it is very evident the law was passed without fair investigation.

The following is from a chemist, which was written in answer to a letter from a chemical house which manufactures carmine:

"I am in receipt of your letter of the 3d inst. relating to the classification of carmine. I appreciate the position in which you are placed, but do not consider that it would be permissible to class carmine with vegetable colors. Of course, it is not a coal tar derivative and has never been alleged to be injurious except when used in the form of a tin lake. Strictly speaking, however, as I said before, it is not a vegetable color and I should not be inclined to class it as such. It is unfortunate that there is so large an element who regard all vegetable colors as harmless and all others as objectionable."

You will notice from these letters that it is almost impossible for the manufacturer to get definite lines to work to.

To kill an evil we must get at its head. The greatest excuse for adulterated goods is that the public wants something that looks nice, and, above all, something that is cheap. As long as this demand exists, it will be satisfied. It is true we have laws requiring adulterated goods to be labeled as such, but they are juggled with to such an extent that they confuse the public all the more. While these requirements are in force concerning the labeling of adulterated goods, there is no stamp of approval provided for the pure food, and, the consuming public being unacquainted with the label requirement, has to take the manufacturer's word for it.

Laws regarding adulterated foods are necessarily technical. Technicalities can not reach the spirit of a manufacturer, though he may comply with their literal requirements. Foods may be and are prepared under the most filthy and unsanitary conditions, yet fill the technical requirements of the law.

How much greater the incentive to a manufacturer if he could have his goods and methods inspected and receive suggestions from an unprejudiced organization, which, by its researches, had become thoroughly competent.

I believe the State of Indiana could not make a greater move in favor of pure foods and benefit the public more than by delegating power to the Indiana Academy of Science, if it were willing, to place on goods which had passed its inspection, its stamp of approval. While the public should be protected, the manufacturer should be encouraged. In conclusion I wish to say that the needs which I have tried to present are real and not imaginary. While there would probably be considerable apathy on the part of some manufacturers in coöperating with this movement, those who are really interested in the quality of their products will greet a movement of this kind with their enthusiastic support.

Mounds and Burial Grounds of Bartholomew County, Indiana.

J. J. Edwards, M. D.

It has repeatedly been stated that there are no artificial earthworks or mounds within the county which may be ascribed to a prehistoric race. After investigation and numerous inquiries we sum up the data thus obtained and offer it for what it is worth to the student of archaeology:

1. A circular mound sixty feet in diameter and about three feet high, but by cultivation now almost level with the surface of the field, is situated on the farm of Henry Blessing, in Wayne township, section 1, township 8, north, range 5 east. Some years ago it was explored and five skeletons were found, besides numerous stone implements. Many articles of stone, together with fragments of bones, have since been obtained. A man named Sam. Clark found an entire skull, which he used as a "drinking gourd." This mound is one and a half miles northeast of Wailesboro.
2. There is a small circular mound on the Lloyd Moulridge farm, two miles west of Cox's Crossing, in Columbus township, in section 34, township 9, north, range 5 east. Mr. Oscar Lowe informs me that several skeletons and relics have been unearthed here. It has not been systematically explored.
3. There is a small circular mound just north of the Jackson and Bartholomew county line and south of the farm of Eli Marquette. It is situated in a strip of woodland east of the highway which runs southeast from Jonesville, and is in section 16, township 7, north, range 6, east. I do not know if it has been explored.
4. While opening the Wailesboro railroad gravel pit a large skeleton was exhumed. Beside him were buried several relics of stone, among which was a beautiful gorget of polished striped slate, now in my possession. It is different from, but more nearly resembles, the gorget figured as 130, page 118, of the thirteenth annual report of the Bureau of Ethnology (Washington, D. C., 1891-92, published 1896,) than any I have seen figured.
5. In 1901, on opening a gravel pit just north of Wailesboro, in section 12, in the angle formed by the pike and railroad and north of the crossing, a human skeleton was unearthed, but no relics were obtained. This was about one hundred yards north of the place where the large skeleton above referred to was exhumed.

6. There is a mound located on the Pence farm, on Flatrock River, Flatrock township, two miles northeast of Clifford; explored by Dr. Arwine in 1898. Bones, ashes and arrow-points were found.
7. There is a mound one and one-half miles east of the last mentioned (No. 6) on James Hagar's farm. Never explored.
8. Burial place on farm of James Remy, near Burnsville. See eleventh Geological Report, 1881, page 204.
9. Bones have been taken from the Remy gravel bed, near Burnsville. *Ibid.*
10. Bones have been taken from the Hacker burial place. *Ibid.*

Microscopical Organisms Found in the LaFayette (Ind.) Reservoir.

Severance Burrage.

The reservoir of the city of LaFayette is located in a park on Oakland Hill, the highest point of land east of the city, with an altitude of about two hundred feet above the level of the Wabash River. The reservoir itself is built up above the surrounding land level, and the survey head of the reservoir is given as two hundred and thirty-two feet. The reservoir is not quite two hundred feet square, has a depth of twenty-eight feet, and a capacity of four million two hundred thousand gallons. The water with which this reservoir is supplied is obtained from the regular city supply wells, which are driven forty or more feet into the bed of the Wabash River. The water from these wells is remarkably pure and free from organisms. A recent bacteriological analysis showed but one germ to a cubic centimeter, and a microscopical examination was a complete blank. Of course, this remarkable purity is at once lost when this water is pumped up to the reservoir and exposed to the air and sunlight.

It is the purpose of this paper to give a census of the micro-organisms, exclusive of the bacteria, found in this reservoir water, the figures being obtained from twenty microscopical analyses, covering a period of five years:

Diatoms—	Maximum number in any one sample.	Average in all samples.	Percentage of occurrence.
Asterionella	8,700	271.8	60
Cyclotella	2,500	129.5	50
Diatoma	600	10.9	30
Navicula	3,100	108.6	75
Synedra	135,400	18,766.6	100
Pinularia	200	3.8	25
Cocconeis	600	15.4	25
Gomphonema	100	0.9	5
Meridion	100	0.9	5
Cocconema	300	8.1	20
Melosira	4,200	47.2	10
Fragilaria	300	4.4	15
Nitzschia	50	0.4	5
Tabellaria	50	0.7	10
Algae—			
Chaetophora	100	5	5
Oedogonium	100	5	10
Raphidium	50	0.4	5
Protococcus	100	5	5
Scenedesmus	2,800	671.4	20
Fungi—			
Crenothrix	4,400	106.4	35
Beggiatoa	1,200	90	10
Infusoria—			
Dinobryon	64,000	6,546.6	90
Peridinium	28,900	1,031.8	50
Uroglena	800	75.3	25
Rotatoria—			
Anurea	500	126	25
Polyarthra	100	5	5
Crustacea—			
Cyclops	10	0.6	15

Total number of species represented, 27.

Particular attention is called to the three forms, Uroglena, Asterionella and Dinobryon.

The colony-building infusorial form *Uroglena* has appeared in the water of the LaFayette reservoir rather regularly in the summer months since 1896, and has been the cause of much annoyance to the water works officials. At such times it has imparted a very disagreeable odor and taste to the water, leading many consumers to complain that there were dead fish or eels in the pipes. In the summer of 1898 it became necessary to have the water completely drawn off from the reservoir in order to thoroughly cleanse it and get rid of the Uroglena. There has been no serious trouble since that time.

The star-shaped diatom *Asterionella*, although occurring in considerable numbers, has not, as far as known, caused any noticeable effect on the odor or taste of the water. Yet this is the organism which has so often given the characteristic geranium taste to many eastern water supplies.

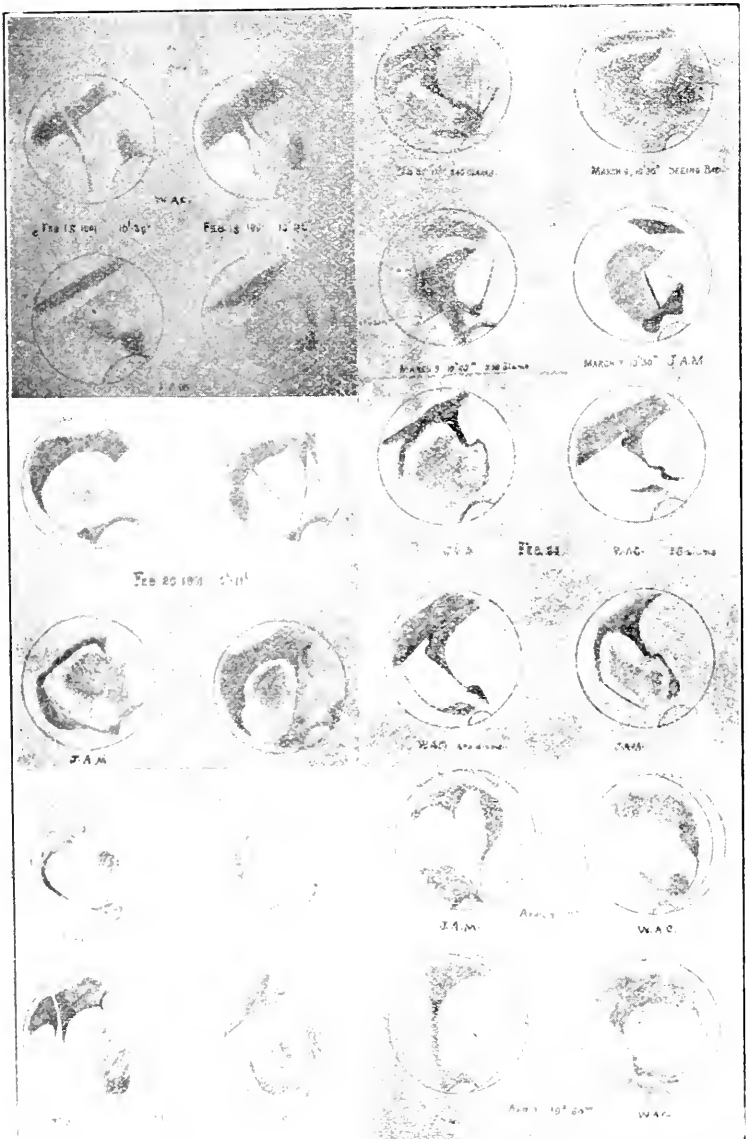
Another infusorial form, *Dinobryon*, is present in the water of the reservoir in large numbers at the present time. Should this number increase to any great extent, we may expect to have a fishy odor and taste imparted to the water.

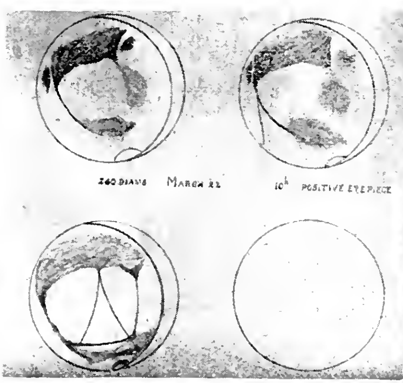
Aside from these three above mentioned forms, the organisms found in the reservoir have practically no effect on the odor or taste of the water.

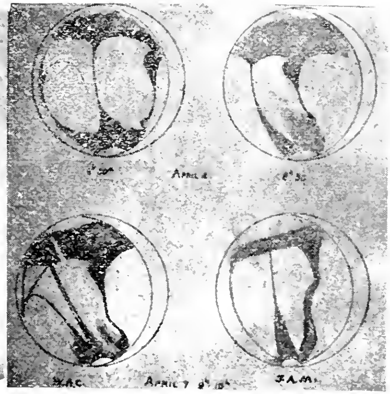
Physical Observations of the Planet Mars at the Opposition of 1901.

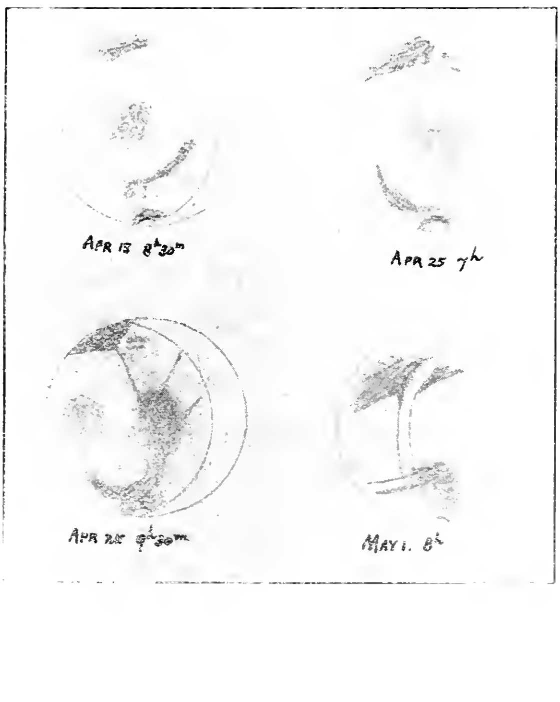
W. A. Cogshall.

Observations of the last opposition of Mars were made at the Kirkwood Observatory of Indiana University from the time the twelve-inch telescope was in place, early in February, till late in May. The observations consisted mainly in drawing the surface markings and were carried on nearly every good night between the dates mentioned. The drawings submitted herewith were all made between February 15 and May 1. Drawings of two different observers are included in the series, part being by Professor J. A. Miller, and part by the writer. Where the drawings of both for the same night are placed together they are generally marked by the proper initials. In all this work the drawing was done as independently as possible, neither looking at the other's drawing until both were complete. It will be seen that in every case the markings drawn are essentially the same, although the drawings vary slightly both in detail and in the location of the dark areas. Dr. Miller almost always placing the dark regions of the southern hemisphere somewhat farther to the south than did the writer.


W.A.C.
Feb 13 1891 10h 30m
Feb 13 1891 10h 20m
March 6, 10h 30m Seeing Bad
March 7 10h 30m J.A.M.
Feb 25 1891
J.A.M.
J.A.M.
W.A.C.
W.A.C.


240 DIAMS MARCH 22
10h POSITIVE EYEPIECE




APR 13 8h30m
APR 25 7h
MAY 1. 8h

This opposition was not nearly so favorable to the observation of surface characteristics as some in the past, as Mars and the earth were so situated that at the time of opposition Mars was at his greatest distance from the sun, while the earth was at its least distance, thus making the distance between Mars and the earth almost a maximum. So great is the eccentricity of the planet's orbit that this distance at opposition may vary from thirty-five million miles to over sixty-two million miles. In this case it was near the latter limit, the nearest approach being on the 22d of February.

This opposition was also somewhat unfavorable if we compare results with those obtained in 1892 and 1894, in that the southern pole of the planet which was at that time turned toward us, at this opposition was turned away from us.

The large dark areas on the planet are mainly in the southern hemisphere and are the most easily seen of anything on the surface except the polar cap. It will be observed that there are also large dark areas in the northern hemisphere, but these, for the most part, are very changeable, both in size and shape and intensity, indicating probably that they are really water and that the change is purely seasonal in character. One of the most conspicuous markings on the planet at the time of opposition was the great polar ice cap. It will be observed that the early drawings all represent this feature as large, and the brilliant white color made it stand out in a very conspicuous manner against the yellow and red of the rest of the surface, while, toward the end of the series, the cap has diminished in size so as to be easily overlooked altogether. It will also be observed that the ice cap is represented with a dark fringe surrounding it, that this fringe follows the edge of the cap as it melts away, and that at the same time the dark areas near this pole become much enlarged and much more intense in contrast with the bright yellow of the disk. This tends to show that these dark patches are really water and as the polar snows melt, the water runs out over the comparatively level surface in great pools.

A few of the numerous so-called canals are shown. As to just the character and origin of these objects there has been a great deal of discussion. Their reality was even questioned for some time after their discovery, but of that there can now be no doubt at all. These canals were first seen by Schiaparelli in 1877, and from that time till the present they have been a constant source of perplexity. The same observer shortly afterward announced that at certain seasons these canals appeared to be doubled, and the same thing has been seen many times since, although as yet there is no really probable explanation offered. It has been supposed to be an optical effect by some, and due to atmospheric causes by others, and by some it is thought that the canal is really double. This doubling is shown in the drawing made on April 7.

As the rotation period of Mars is about thirty-nine minutes longer than our day, by looking at the planet at the same hour on successive nights we will see any particular marking shifted to the right from the center by about 10 degrees Martian longitude for each night. We are therefore able, in the course of about thirty-eight days, to view the whole surface by looking for a short time each night, and the rotation is sufficiently rapid so that even in the course of three or four hours the amount of new detail brought into view is large.

In the drawings of February 15 the most conspicuous part of the whole disk is the great northern ice cap with a large dark area bordering it. The dark band of color across the southern part of the planet is a portion of that great area, supposed at one time to be water, and near the center of the disk are two of the so-called canals, which, on this night, could be followed only for a short distance.

In all these drawings the contrast between the light and dark parts of the planet has been drawn greater than it really appears, so that the drawing would reproduce better. The outlines have been made distinct or hazy as they appeared, but the dark parts of the planet are not so dark generally as shown here.

By comparing the drawings of February 15 and those of February 20, the eastward drift of about ten degrees per day, mentioned above, has brought into view a very dark and conspicuous marking which will be found a number of times in the drawings of later date and which was always connected with the dark area about the pole by a well defined but irregular dark mark best shown in the drawings of the early part of April. This was the first real detail ever seen on the planet and was drawn by Huyghens in 1659. It has probably received more attention from observers than any other part of the planet. This dark line, with many more, from the polar seas leading toward the equator naturally suggests that the so-called canals do really carry away the water resulting from the melting snow. As they are about thirty miles wide, it has been suggested as more probable that they are really strips of vegetation bordering the canal proper, and it is also probable that much of the dark belt covering the greater part of the southern hemisphere is due mainly to vegetation. These areas deepen in color very decidedly at about the time the water would reach them if it were really conducted from the poles to the equatorial regions in the canals, and after the ice cap is all melted and no evidence of other water supply is visible, these areas again turn lighter in color as if the vegetation dried up or died.

Some of those who have done the most in the observation of the planet are of the opinion that the extreme regularity and geometric exactness of the canal system indicate that it is artificial in its origin and it is only fair to say that this is the appearance of the planet when seen to the best advantage. While this idea leads to the conclusion that there is or has been some sort of intelligent life on Mars, yet the canal system (be they real canals or something else) has as yet no other explanation which we can consider at all possible. If we assume the existence on the planet of some sort of intelligent life, a canal system such as we see would be essential, as we can see no storms and but very few clouds, the whole water supply being apparently the melting polar cap.

On the other hand, it is possible that the polar caps are not ice, but some other material which will vaporize in the Martian sunlight and solidify during the long polar night. Unless Mars has some source of heat which the earth has not, the temperature, even at the best, must be far below that experienced at the same latitude on the earth; and as the atmosphere is not more than one-half as dense as ours this difference in temperature is greatly intensified. It has been suggested that the caps are solidified carbon dioxide and we can not say that they are not. The most that can be said for this theory is that carbon dioxide will act that way at a low enough temperature, but it fails to explain in any degree the seasonal changes in color, and suggests no use or origin for the marks called canals. The ice theory accounts for everything but the temperature to melt it.

Consequently, the climatic conditions on Mars, the physical characteristics of its surface, its habitability and inhabitants are still open questions upon which much time and labor must be expended before we can say much about them with certainty.

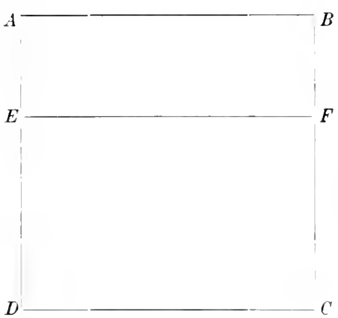
A Problem in Geometry.

J. A. Cragwall.

TO CONSTRUCT A SQUARE THAT SHALL BE $\frac{M}{N}$ OF A GIVEN SQUARE.

The method given below can not be new, nor does it involve any new processes or discoveries; but in all the textbooks examined by the writer no mention has been made of such method.

It is here given because of its simplicity and directness, in the hope that some teacher will consent to lighten the work of the pupil in geometry to that extent. The construction is as follows:



Let ABCD be the given square. Lay off on one side of the square, as AD a distance DE equal to $\frac{M}{N}$ of AD. Then, CDEF is a rectangle with base equal to a side of the square and altitude $\frac{M}{N}$ of it. Then CDEF is $\frac{M}{N}$ of the square Now construct a square equivalent to this rectangle and we have a square that is $\frac{M}{N}$ of the given square.

Some Investigations in the Electro-Deposition of Platinum.

J. A. Cragwall.

When the work for this paper was begun, it was with no intention of making any study of the deposition of platinum, but to obtain a foil that could be used to separate an electrolyte into two compartments and at the same time to set up no barriers to the passage of a current of electricity; it was thought that in this way some new light might be thrown on the subject of the migration of ions. Not being able to secure platinum leaf thin enough for the purpose, an effort was made to make it by depositing platinum electrolytically on some metal that could afterwards be dissolved and leave the platinum intact. The work proved of greater proportions than was anticipated, so that the limited amount of time would only permit a partial investigation into the action of the electrolyte and the character of deposit. The available literature on the subject was very meager, the bibliography of the deposition of metals giving very little light.

Dr. William H. Wahl, of Philadelphia, has written a pamphlet which deals with the subject qualitatively and in a rather indefinite manner. In the investigation several problems presented themselves for solution, among them being the following:

I. The metal that shall be used for the cathode;

II. The solution of platinum to use for electrolyte;

III. The current density that gives the best character of deposit at the most rapid rate;

IV. The concentration of solution that gives best results;

V. The temperature that gives highest efficiency and best character of deposit;

VI. If the foil is porous or granular, the way to treat it so as to remedy the defect and get a dense, tough deposit;

VII. The liquid that will dissolve the metal of the cathode and leave the platinum foil intact.

Most of these problems are very closely related, so that results for several were sometimes obtained from the same set of experiments.

I.

On account of the smooth surface it will take, the ease with which it may be dissolved, that it will take a deposit of another metal so readily, and that it can be rolled into thin sheets, copper seems the best metal for the cathode. The anode, of course, should be platinum, carbon or other substance that will not be acted on by the nascent gas set free in the reaction.

II AND III.

The salt of platinum used must be such that it is easily dissolved and will start up no harmful secondary action during the passage of the current. Platinic chloride will not serve on account of this last restriction. Platinic hydrate, however, is almost ideal and was used in all experiments.

At first an effort was made to use platinic hydrate dissolved in oxalic acid, forming oxalate of platinum, the proportions used being—

1 oz. platinic hydrate,
4 oz. oxalic acid.
4000 c.c. distilled water.

Experiments gave the highest current density that could be used without the appearance of platinum black, as being about .0001 amperes per square centimeter, and even then there was a slight appearance of gas at the cathode. The liquid was of a clear straw color when warm, becoming purple on cooling; but, after allowing the current to run for about 15 minutes, a dark cloudy appearance was noticed at the anode that gradually spread to the whole liquid. No chemical analysis was made to determine the composition of this, though it is very likely that it was platinous hydrate. The liquid was then tightly stoppered and left for about two months, when it was found that all the platinum had been reduced to the form of spongy platinum. This was due to the fact that oxalic acid is an active reducing agent.

Taken as a whole, the experiments with oxalate of platinum were very unsatisfactory, the current being low, the solution unstable and the deposit dark, as if some of the dark precipitate was occluded in the deposit.

Mention is made of these trials for the reason that the results are contrary to the statements of Dr. Wahl.

The next solution tried was made by dissolving platinic hydrate in caustic potash in the proportions—

1 oz. platinic hydrate.
4 oz. caustic potash.
2000 c.c. distilled water.

It was possible to use a current density of .003 amperes per square centimeter and get a bright smooth deposit, when the liquid was held at a temperature of 65 F. When the deposit was made comparatively thick, however, there was some appearance of crystallization. Trial showed a current density of .002 to be about as high as it was best to go with this particular solution at the above temperature.

IV.

Tests were now made to determine the effect of varying the concentrations of the liquid. As above noted, when the proportions were—

1 oz. platinic hydrate.
4 oz. caustic potash.
2000 c.c. distilled water,

the maximum current density that could be used and get a clear, bright deposit was .0035 amperes per square centimeter.

With a solution in the proportions of

2 oz. platinic hydrate,
4 oz. caustic potash,
2000 c.c. distilled water,

it was found possible to run the current density up to .006 amperes.

With another solution in which the proportions were

5 oz. platinic hydrate,
8 oz. caustic potash,
4000 c.c. distilled water,

the current reached .012 amperes before the appearance of platinum black.

Increasing the platinic hydrate in the above so as to have 6 oz. platinic hydrate, increased the current density to .015 amperes per square centimeter. The amount of caustic potash was increased so as to make a solution having the proportions—

2 oz. platinic hydrate,
1 oz. caustic potash,
4000 c.c. distilled water,

when it was found that .002 amperes was as high as the current density could be carried. Increasing the amount of caustic potash still further decreased the amount of current that could be used.

From the results given it may be concluded that the greater the per cent. of platinum in the solution, the higher the current density that can be used. Any increase in the amount of caustic potash lessens the maximum current density.

V.

In regard to the temperature that gives the best results, the experiments showed that any increase in the temperature raised the maximum current density that could be used. Thus, at 65 F. .0035 amperes per square centimeter was the maximum, while a temperature of 100 F. permitted the use of a current as high as .008 amperes per square centimeter, with corresponding changes for intermediate points.

VI.

Burnishing the foil with a smooth bent glass rod, or with a piece of hard wood, made the platinum denser. Lightly beating the foil between chamois skins was of some assistance, though for the purpose in view great care had to be exercised to prevent getting the deposit of unequal thickness over the foil.

VII.

There are many liquids that will dissolve the copper—notably, nitric acid, but, on account of the formation of gas during the reaction and the consequent tearing of the foil, it and several others had to be discarded. Ammonium chloride was found to be the best, though its action is very slow. The result may be hastened, however, by first making this foil of copper, the anode in a copper sulphate electrolyte and dissolving away a large part of the copper before putting the foil in the bath of ammonium chloride.

There is one serious difficulty that is met in dissolving the copper. After all the copper has been dissolved, it is extremely difficult to remove the foil from the liquid on account of the cohesion being sufficient to add enough weight of water to the foil to tear it as it is taken from the liquid or roll it up so that it is useless.

This can only be overcome by placing the foil where it is to go when completed, and then dissolve away the copper.

Although some very fair foils were made in these experiments, it is hardly fair to say that they were wholly successful. But the work opens up another avenue that may lead to something very useful—the electroplating with platinum of delicate surgical instruments, etc., to take the place of nickel. It is well known that many efforts have been made to use platinum for such purposes, but, as far as the writer knows, with very indifferent success on account of the great trouble and consequent cost of the work. Using an electrolyte of platinate of potassium, it is possible to keep it constantly saturated by simply keeping a bag of platinic hydrate hanging in the solution; the process is comparatively rapid and needs little attention after once started. The plated article will stand considerable amount of usage, and, of course, will not tarnish under any ordinary circumstances.

Note on Some Experiments With a New Form of Pressure Regulator.

William Kendrick Hatt.

General.—The writer here records some experiments which were made under his direction in the Engineering Laboratory of Purdue University on a new apparatus by Mr. Will Hull, of the class of 1901, who developed the details of the apparatus from the suggestion of Mr. J. T. Wilkin, engineer for the Connersville Blower Company, Connersville, Ind.

The apparatus (Fig. 1) consists essentially of an expanding nozzle and a flat circular disc, against which the jet from the nozzle is directed, the disc being enclosed in a suitable chamber. The action is similar to that of the well-known ball nozzle, and the disc replaces the ball. In case of the ball nozzle the back pressure forcing the ball against the jet is the pressure of the atmosphere. In the apparatus here described the disc is enclosed in a chamber, and the back pressure is the pressure of the water in the chamber. This pressure is greater than that in the rapidly moving sheet of water on the up-stream face of the disc, so that the disc moves toward the nozzle until equilibrium is established. The disc thus automatically throttles the up-stream.

When this apparatus is inserted in a pipe line the pressure on the down-stream face of the disc is preserved fairly constant (within the limits of the experiments and for certain range of pressure in case of the apparatus used), while the up-stream pressure varies within wide limits. The principle of the apparatus will have an application whenever it is desired to deliver water at a constant pressure to a machine from a source of supply subject to fluctuations of pressure. Whether a design of disc and nozzle could be reached which would regulate the pressure in case of air or steam is not determined.

The experiments were initiated with the desire to obtain information which would serve as a basis for proportioning this apparatus to serve various conditions of pressure and delivery. The experiments were interrupted before that point was reached. The results obtained and the example are generally interesting and it seems worth while to record them.

Mr. Hull used various combinations of disc and nozzle until he found the proper combination which would regulate the pressure used in case of the apparatus available.

SECTIONAL VIEW.

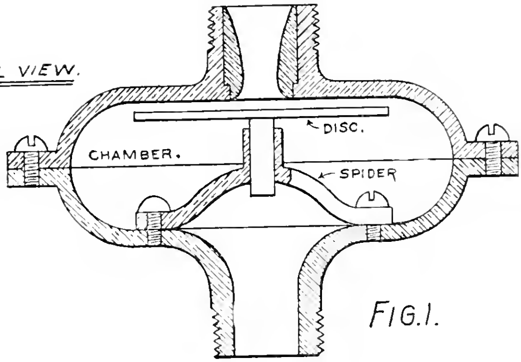
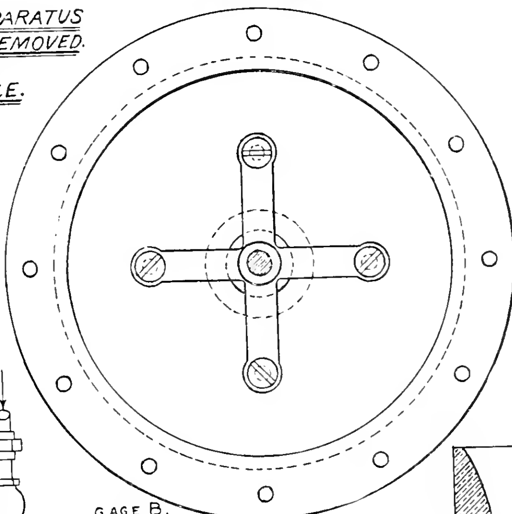


FIG. 1.

PLAN OF APPARATUS WITH TOP REMOVED.

2/3 FULL SIZE.

BRASS.



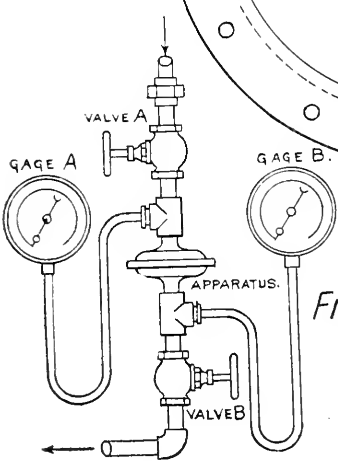


FIG 3

NOZZLE.

4/3 ACTUAL SIZE.

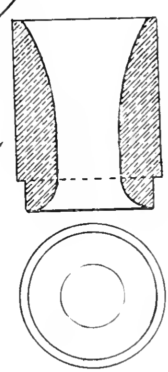
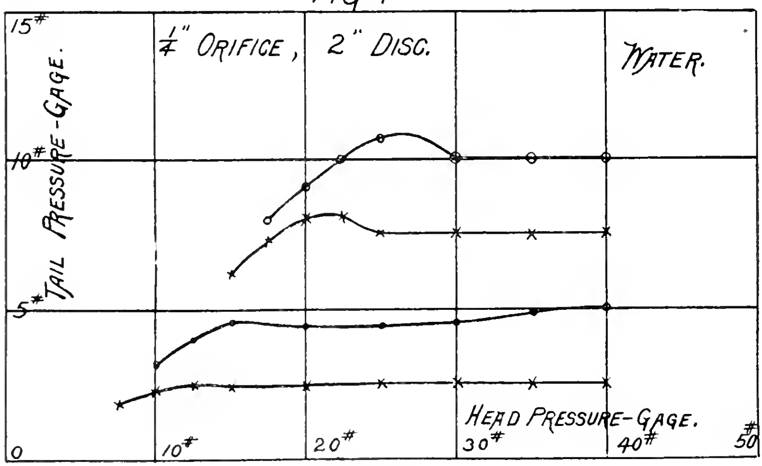


FIG 2

In brief, he found that a nozzle of form specified in Fig. 2 (called a ¼ inch nozzle), in combination with a 2 inch flat disc, would regulate the pressure in a 1½ inch pipe to the following extent:

The pressure on the down-stream section of the pipe was preserved constant at 2½ pounds by the action of the disc while the pressure of the up-stream section varied between 10 to 40 pounds per square inch by gauge (as shown on Fig. 4).

FIG 4



APPARATUS.

Fig. 1 shows the construction of the apparatus with nozzle, disc, chamber and spider for supporting the disc. The fitting of the apparatus for experimental work is shown in Fig. 3. The two gauges for measuring the pressures were placed as close as possible to the chamber containing the disc. The fittings were made with great care. The valves shown were for controlling the pressures used in experimentation.

METHOD OF EXPERIMENT.

The apparatus was attached to the standpipe of the hydraulic laboratory, the pressure in which was controlled by a steam pump. Starting with a given standpipe pressure, say 40 pounds, the water was allowed to flow through the apparatus, being throttled by the lower valve to indicate a down-stream pressure of, say 2½ pounds per square inch on the lower gauge. This down-stream pressure was allowed to remain fixed during the test, the lower valve not being disturbed. The up-stream pressure was varied by the use of the upper valve, throttling the up-stream section. In this way up-stream pressures of from 40 pounds per square inch down by 5 five pounds per square inch steps to the lower limit were effected. The apparatus discharged into a weighing tank and the discharge was weighed. The temperature of the water was taken every minute because this temperature varied greatly throughout the tests, due to the fact that the standpipe tank was connected to the condenser of a Corliss engine. (With respect to the effect of the temperature on the results, it may be said that when the temperature of the discharge rose above the 100° F., the tail pressure gauge showed a very unsteady pressure, the needle vibrating with a range of as much as one-half pound. The disc was no doubt at this time subject to vibrations, which, when the temperature of the water rose to 110° F., were of such frequency as to cause a musical note. Under the latter condition the needle was too sluggish to respond and remained at a fixed position. The movement is probably connected with alternate periods of vaporization and condensation of the water on the upper side of the disc.)

Results.—The following combinations of nozzle and disc were used: One-eighth-inch nozzle, 1-inch disc; 1/8-inch nozzle, 1½-inch disc; 1/8-inch nozzle, 2-inch disc; 3-16-inch nozzle, 1-inch disc; 3-16-inch nozzle, 1½-inch disc; 3-16-inch nozzle, 2-inch disc; ¼-inch nozzle, 1-inch disc; ¼-inch nozzle, 1½-inch disc; ¼-inch nozzle, 2-inch disc.

Of these, the ¼-inch nozzle gave successful results; the ¼-inch nozzle, with the 2-inch disc, gave the best results. These are shown in Fig. 4. In working the head pressure down toward the tail pressure the former would approach a critical point at which the difference of pressure became so slight that the regulating effect ceased and both head and tail gauges suddenly moved to the same reading. The disc at this period, no doubt, dropped away from the jet. That is a certain difference of pressures is needed to enable the apparatus to work. This difference of pressure became greater as the tail pressure was increased, as is shown in Fig. 4.

In experiments with the other orifices mentioned the lines shown in Fig. 4 became straight lines inclined to the horizontal. The hump in Fig. 4 was characterized by an unsteady head pressure.

One disc was bevelled so as to give a constant area of passageway to the expanding ring of water, that is, it was dished with the deepest part next to the nozzle. This disc preserved a constant difference of pressure between the head and tail pressures.

Some experiments were carried on with air as the fluid passing through the pipes. With the nozzle and discs used there appeared to be no governing effect, in case of these air pressures.

In general it may be said that the shape of the nozzle has most to do with the action observed. A number of nozzles of different form were used; those most nearly like that shown on Fig. 2 gave the best governing effect.

The size of the disc affects the results obtained with any given nozzle. Two-inch disc gave better results than 1-inch or the 1½-inch disc.

The action desired could be obtained with water at a temperature of 75° F. as well as at the higher temperatures.

A very pretty cylindrical sheet of water could be obtained by removing the lower part of the casing. The disc acted like the well-known ball-nozzle. Under these conditions, with a head pressure of 40 pounds and a nozzle velocity (as figured from the discharge) of 14.6 feet per second, it was found necessary to exert a force of 9 pounds to pull the disc from the jet.

WATER.

¼-Inch Orifice.				2-Inch Disc.			
Gage Pressure.		Discharge Per Min. Cubic Ft.	Temperature of Water.	Gage Pressure.		Discharge Per Min. Cubic Ft.	Temperature of Water.
Head.	Tail.			Head.	Tail.		
40 lbs.	2.5 lbs.	0.301	105 F.	40 lbs.	7.5 lbs.	0.334	88 F.
35 "	2.5 "	0.304	105 "	35 "	7.4 "	0.337	92 "
30 "	2.5 "	0.304	108 "	30 "	7.5 "	0.342	93 "
25 "	2.5 "	0.304	109 "	25 "	7.5 "	0.342	93 "
20 "	2.4 "	0.300	112 "	22.5 "	8.2 "	0.342	95 "
15 "	2.4 "	0.300	112 "	20 "	8.0 "	0.350	96 "
12.5 "	2.5 "	0.304	111 "	17.5 "	7.25 "	0.323	95 "
10 "	2.3 "	0.282	106 "	15 "	6.2 "	0.314	94 "
7.5 "	1.9 "	0.267	112 "				
40 lbs.	5 lbs.	0.330	95 F.	40 lbs.	10 lbs.	0.377	82 F.
35 "	4.8 "	0.322	100 "	35 "	10 "	0.385	81 "
30 "	4.5 "	0.315	99 "	30 "	10.2 "	0.388	80 "
25 "	4.4 "	0.306	97 "	25 "	10.7 "	0.388	78 "
20 "	4.4 "	0.306	100 "	22.5 "	10 "	0.385	78 "
17.5 "	4.5 "	0.315	105 "	20 "	9 "	0.361	78 "
15 "	4.5 "	0.315	104 "	17.5 "	8 "	0.336	78 "
12.5 "	4.0 "	0.302	105 "				
10 "	3.2 "	0.270	108 "				

On Changes in the Proportional Elastic Limit of Nickel Steel, With a Note on Calibration of Testing Machines.

W. Kendrick Hatt.*

The variability of the proportional elastic limit of metal due to overstrain and its subsequent recovery after a period of rest, or proper annealing, have been studied by investigators, among whom may be named Bauschinger, Professor Gray and Mr. Muir.

The writer records here the results of experiments on a special nickel steel rolled for the purpose by the Bethlehem Steel Company. The experiments had two ends in view:

1. To calibrate the testing machines of Purdue University, in comparison with the testing machines of the government testing laboratory of the Watertown Arsenal, and those of the University of Illinois.

2. To study the variability of the proportional elastic limit and yield point of this special nickel steel.

The proportional limit here mentioned is that limit beyond which stress ceases to be proportional to strain. The yield point spoken of below is that limit at which a sudden increase in the elongation occurs without an increase in stress.

CALIBRATION.

A testing machine of ordinary screw type consists of a screw press and a large platform scale. It is necessary, of course, to ascertain if the load on the scale beam correctly indicates the pressure on the platform. This is often accomplished by loading the platform with a dead load of pig iron. For light loads the purpose might be served by a calibrated spring. The use of nickel steel bars of high elastic strength furnishes us with a spring of high capacity, whose deformation may be accurately measured. Calibration by means of these bars may be readily effected and relative errors in the machines detected. The absolute error may be known by comparison with a machine that has been calibrated by the dead weight method. The bars can be preserved and used from time to time to detect changes in the machine due to wear of knife edges. This is

*The main observations on which this note is based were carried out under the author's supervision by Messrs. R. Hitt and J. H. Jascha, senior students in Purdue University, 1901.

a more accurate method than that often used, involving the breaking of a half dozen steel bars from one rod at different laboratories and comparing the average breaking load.

In the work of examining the accuracy of the Purdue University testing machines, three nickel steel bars were used; two with a length between shoulders of 12 inches, and one with a similar length of 30 inches. In the case of the latter bar, it was possible to attach two extensometers to the bar *in tandem*, and by exchanging the position of the extensometers to compare the latter. The modulus of elasticity was measured in case of each bar on the machines of the three laboratories using the extensometers possessed by the three laboratories. One of these extensometers was sent from one laboratory to the other. If the extensometers are alike in their graduation and the modulus of elasticity of the bars is found to be equal on the various machines, the latter may be judged to have no relative errors. The observations at the University of Illinois were taken under the direction of Professor A. N. Talbot.

Taking the average of three bars tested at the three laboratories it appears (Table I) that the value of Young's Modulus at the Purdue laboratory is (in 100,000 pounds per square inch units) 29.22; at Illinois laboratory, 29.33; at Watertown laboratory, 28.66. Between the Purdue laboratory and the Illinois laboratory there is thus a relative difference of only about $\frac{1}{3}$ of one per cent., an accuracy much in excess of that needed in any work for which these machines are used.

By interchanging the positions of two extensometers in case of the long bar, an opportunity existed of comparing the indications of two extensometers of different type the Riehle extensometer (a screw micrometer) and the Johnson extensometer (a roller type). In Table II it is seen that the two extensometers yield identical results.

It is thus assuring to know the reliability of the ordinary type of testing machine and extensometer. If the Watertown machine is correct, the other machines yield results about two per cent. high. The Watertown extensometer, however, was not compared with the other extensometers.

ELASTIC CHANGES.

After the work of calibrating apparatus was complete, two of the bars were used in the study of the variability of the proportional and yield limit.

The results are shown in Table III. These results show that the behavior of nickel steel under overstrain is like to that of ordinary steel, namely:

Overstrain destroys the P-limit, and elevates the Y-limit.

The P-limit may be restored by annealing for a few moments in a bath above 212° F. The P-limit may be also restored by a period of rest. By a process of overstrain and subsequent annealing, the P-limit may be elevated to nearly the ultimate strength.

The decrease of diameter was also measured. The ratio of side contraction to longitudinal extension was found to be nearly 1/4, which is the value of Poisson's ratio for this metal.

TABLE I.

Value of E. in 100,000 Units as Derived from Tests on Bars of Nickel Steel at Three Laboratories.

Bar.	Watertown.	Purdue.	Illinois.	Average.
1........................	28.71	29.29	29.40	29.23
2.....................	28.59	29.32	29.14	29.14
3......................	28 66	29.36	29.20	29.20
Average	28 66	29.22	29.33	

TABLE II.

Comparison of Extensometers

Extensometer.	Illinois, 200,000 Olsen.		Purdue, 300,000 Riehle.	
	Roller.	Screw—1.	Screw—2.	Roller.
Position—				
On top................	29.40	29.40	29.50	......
On bottom	29.00	29.00	......	29.10

TABLE III.

Showing Variability of P-Limit.

Bar No. 1.

Analysis	Carbon	0.27 %
	Manganese	0.58 %
	Silicon	0.214%
	Ph	0.024%
	Sulph	0.036%
	Copper	0.028%
	Nickel	4.552%

No. of Test.	Description of Test.	E. in Units of 100,000 lbs. to square inch.	P-Limit in Units of 1,000.	Y-Limit in Units of 1,000.	Maximum Stress.	Note Effect of Test.
1	Original	29.3	88.0	......	*96.0	Overstrain.
2	45 hours after	26.4	0.0	96.0	98.0	P-limit destroyed.
3	10 minutes after	24.8	0.0	94.0	*100.0	P-limit destroyed.
4	118 hours after and in 450 F. bath	29.0	100.0	116.0	116.0	P-limit restored by annealing.
5	22 hours after	28.2	112.0	117.0	117.0	Overstrain.
6	After in bath at 218 F.	29.2	109.0	112.0	114.0	Overstrain restored by annealing.
7	500 hours after	28.0	110.0	116.0	116.0	Overstrain restored by rest.
8	10 minutes after	26.0	110.0	116.0	116.0	Test to destruction 15% elongation, 42% contraction in 8".

Bar No. 2.

No. of Test.	Description of Test.	E. in Units of 100,000 lbs. to square inch.	P-Limit in Units of 1,000.	Y-Limit in Units of 1,000.	Maximum Stress.	Note Effect of Test.
1	Original	29.7	92.0	95.0	*100.0	Overstrain.
2	15 hours after	26.1	70.0	100.0	*117.0	Overstrain.
3	2 weeks after	24.8	0.0	100.0	109.0	P-limit destroyed.
4	10 minutes after	24.6	0.0	108.0	......	P-limit destroyed.
5	After in bath at 190 F.	25.3	0.0	112.0	115.0	P-limit not restored.

* Indicates that the test overstrained the metal.
E. taken between limits of stress of 25,000 to 85,000.

THE KIRKWOOD OBSERVATORY OF INDIANA UNIVERSITY.

JOHN A. MILLER.

At its November meeting of 1900 the Board of Trustees of Indiana University appropriated a sum of money for the purchase of a telescope and some accessories, and for the erection of an Observatory. The Observatory is built of Indiana limestone and was completed in January of 1901. It contains six rooms—a library and computing room; a lecture room, which may be darkened at any time, equipped with a Colt electric lantern, lantern slides and other illustrative apparatus, a convenient dark room; a transit room; the dome room and a room similar to it and immediately below it.

The skeleton of the dome, which is twenty-six feet in diameter, is of white pine and is built according to plans furnished by Messrs. Warner & Swasey, who also furnished the running mechanism. It is covered with tin. The performance of both dome and shutter is entirely satisfactory.

The design of the Board of Trustees, that the equipment is to be used in a large part for instruction and in part for purposes of research, determined largely the character of the instruments which we afterwards purchased. In the dome-room is mounted a twelve-inch refractor. The objective is by Brashear, and is of high optical excellence, giving star-images which are free from fringes or distortion and on a black field. The mounting is by Warner & Swasey. It is provided with coarse and fine circles in both declination and right ascension, the fine ones being provided with reading microscopes and electric illumination. A star dial-dial located on the north side of the pier and driven by the driving clock, from which the right ascensions can be read directly, is of almost indispensable convenience. The driving clock drives regularly and the entire mounting is of the highest mechanical excellence.

The telescope has as accessories a micrometer by Warner & Swasey, provided with electric illumination; a polarizing helioscope; a battery of positive and negative eyepieces by Brashear, and two positive eyepieces by Steinheil und Söhne of Munich. The transit room contains a small universal instrument by Bamberg, a chronograph by Fauth & Co., a Bond sidereal chronometer, and a sidereal clock. A Howard sidereal clock, with contact that breaks an electric current each second except the fifty-ninth, and the last ten seconds at the end of every five minutes, will be put in place in a few weeks. Mr. O. L. Petitidier, of Chicago, has kindly loaned the Observatory a parabolic mirror fifteen inches in diameter and with a focal length of 120 inches, which he constructed at his optical works. The mounting for this mirror has been designed by Mr. W. A. Cogshall and in large part constructed by him. The reflector will be in place by the first of March and will be used chiefly in photographing nebulæ.

These instruments, together with a portrait lens of five inches aperture and a Browning equatorial of four inches aperture, which for many years have been the property of the University, constitute a nucleus around which the University authorities hope to collect a more complete equipment.

The Observatory is located on the University campus, about 300 feet from the nearest building. With practically an unbroken horizon within 75 degrees of the zenith—as low as one can usually observe, and in most instances the view is entirely unobstructed.

We have found the seeing at the Observatory fair. On an average clear night a power of 300 can be used effectually; on about half the working nights we use a power of 480, while a night when a power of more than 600 can be used is comparatively rare.

The Observatory is essentially a Students' Observatory. Those who take courses in general astronomy are permitted to use the telescope a limited number of hours each week, and though this work is optional, few fail to avail themselves of an opportunity to use the telescope an hour. No accurate measurements or really scientific work is attempted by these students.

In addition to the work in spherical and practical astronomy and work carried on by the teaching force certain students are encouraged to undertake work in the nature of research. This generally consists of drawing planetary details or in making micrometical measures of double stars or of planetary disks. The observing lists are made out under the direction of the instructors and in general consist of stars that need measuring. We are engaged at present in measuring the double stars discovered in the process of making the catalogues of the Astronomische Gesellschaft. These as a rule are not difficult objects. Also search is being made for new pairs with a fair degree of success.

The Observatory bears the name of Dr. Daniel Kirkwood, the eminent astronomer, who, for nearly half a century, was a member of the faculty of Indiana University and who, by his manly qualities, won the lasting esteem of his students and his colleagues, and by his devotion to his science a lasting name among his contemporaries.

The Observatory was formally dedicated May 15, 1901. The dedicatory address was given by Astronomer W. J. Hussey, astronomer in the Lick Observatory. He spoke of "Astronomy and Modern Life." President Swain spoke of "Personal Recollections of Dr. Kirkwood."

Daylight Meteors.

John A. Miller.

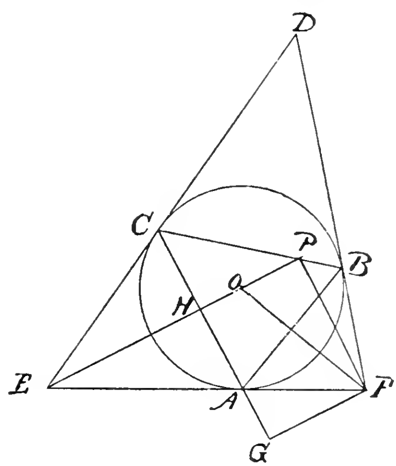
The Center of Population of the United States.

John A. Miller.

A Theorem in Geometry.

John C. Gregg.

DEF is the triangle formed by the tangents at the vertices of a triangle ABC inscribed in the circle O. Draw EOP meeting BC in P and join PF. Show that EPF is a right angle.



Demonstration.

Draw FG perpendicular to CA produced, and join OF. Denote the angles of ABC by A, B, C, and the sides by a, b, c. Then

$$FG = AF \sin B$$

$$= \frac{c}{2} \sec C \sin B$$

$$= \frac{b}{2} \sin C \sec C$$

$$= \frac{b}{2} \tan C$$

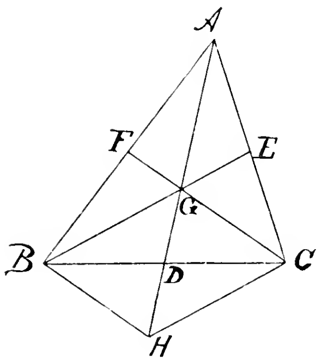
$= HP$, which is perpendicular to CG. Hence HPFG is a rectangle and EPF is a right angle.

A Simple Proof That the Medians of a Triangle Concur

John C. Gregg.

Theorem.—The three medians of a triangle are concurrent.

Demonstration.



Let AD and BE be two of the medians; they will meet in some point G. Join CG and extend it to meet AB in F. Extend AD to H, making DH = DG, and join HB and HC.

Since BC and GH bisect each other, BGCH is a parallelogram. In the triangle ACH, since GE is drawn through E, the middle point of AC and parallel to HC, G is the middle of AH. And in the triangle ABH, since G is the middle of AH and GF is parallel to BH, F is the middle of AB and CGF is the third median, and the theorem is established.

On the Density and Surface Tension of Liquid Air.

C. T. Knipp.

[Abstract. Published in the Physical Review, February, 1902.]

The variation of the density of liquid air with time was determined. The liquid was contained in a given Dewar bulb. The sinker method was used, and it was assumed that the coefficient of expansion holds at the temperature of liquid air. A curve was platted which indicates that .933 is the density of liquid air when first made.

In the determination of the surface tension two methods were employed—the capillary tube method and the maximum weight method. Owing to the distortion due to the bulb, also to the agitation of the liquid surface, the first was not considered reliable. The second method, however, worked very well. The variation of the surface tension with time of the liquid contained in the above bulb was determined. A curve was platted. From the curve the surface tension of liquid air when first made was found to be 9.4 dynes.

A Few Experiments with Liquid Air.

C. T. Knipp.

[Abstract.]

Three experiments were given, using the liquid as a refrigerant. (1) The resistance of manganin wire at the temperature of liquid air; (2) the absorption of heat by conduction into the liquid; (3) the action of a Cu-Fe thermostat when placed in the liquid.

(1) The temperature coefficient of manganin wire was found to agree fairly well with that found by Dewar. Cooling the wire to the temperature of liquid air caused it to undergo no permanent change.

(2) By connecting a block of copper through a copper rod to a bath of liquid air the temperature of the block of copper can be reduced to nearly that of the refrigerant. This principle enables any intermediate temperature to be maintained. By this method a connecting rod of copper about $\frac{1}{2}$ sq. cm. in area and 20 cm. long froze a cu. cm. of mercury placed in the block of copper in $6\frac{1}{4}$ minutes.

(3) A Cu-Fe. thermostat was found to be very sensitive, and it was also noticed that the same coefficients hold at the temperature of liquid air.

The Bitangential of the Quintic.

U. S. Hanna.

Note on an Attempted Angle Trisection.

R. J. Aley.

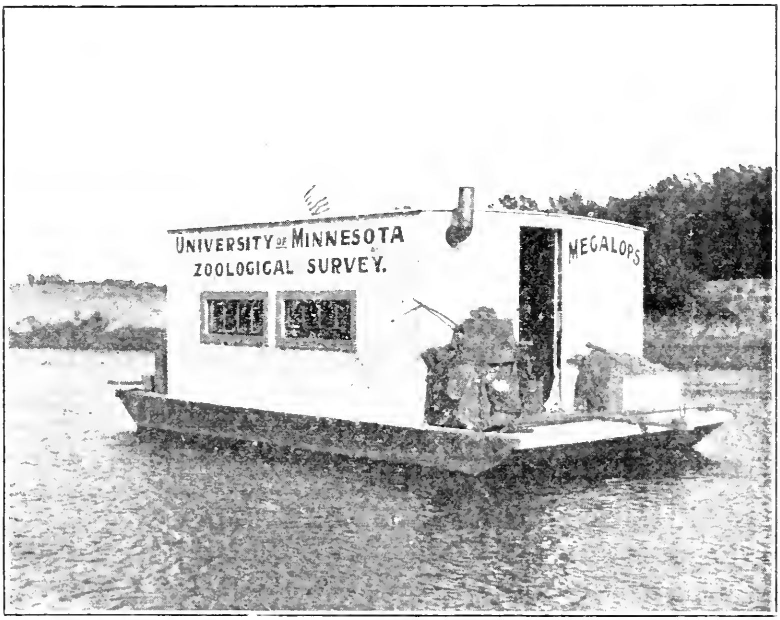
The Zoölogical Survey of Minnesota.

Ulysses O. Cox.

With the establishment of the Geological and Natural History Survey in Minnesota provision was thereby made for collecting and describing the various faunal forms of the State. For a number of years after the survey was established work was done only along geological lines. In 1886 there appeared a list of the Aphidæ of Minnesota, by Mr. O. W. Oestlund, and in the following year a synopsis of the same group by the same author. In 1890 there was published a report on the Mammals, by Professor C. L. Herrick. This report can not, however, be considered anything but preliminary, since it was written before any great amount of investigation had been done and it will, no doubt, be superseded later by an enlarged and up-to-date report. In 1892 there appeared a preliminary report on the Birds, by Dr. P. L. Hatch; in 1895, a report on the Copepoda, Cladocera and Ostracoda, by Prof. C. L. Herrick, which is probably final; and in 1897 a preliminary report on the Fishes, by the writer. The first three reports mentioned were issued under the direction of Prof. N. H. Winchell, State Geologist, but the others have been published under the direction of Prof. H. F. Nachtrieb, State Zoölogist, who for the past eleven years has had entire charge of the work of the survey. Every summer for ten years parties have been at work in the various portions of the State collecting material and data for the final reports. During the past three seasons the work has been especially active. In May, 1899, a house-boat, christened the Megalops, was built and launched at Mankato, on the Minnesota River, and very successfully floated to Red Wing, on the Mississippi, before the close of the season. A description of the Megalops and an account of the first season's trip appears in the Proceedings of the Indiana Academy of Science for 1899. In the summer of 1900, in early June, the Megalops was restocked and started from Red Wing on its second season's journey, down the Mississippi. Considerable time was spent on Lake Pepin, as the conditions and fauna there varied greatly from that of the Mississippi River proper. The territory along the Mississippi was quite carefully explored and material collected as far as Brownsville, Minn., which is within a few miles of the southern boundary of the State. Attention was given primarily to the fishes, but much other material was also collected, especially insects, batrachians and reptiles. Near the close of August the Megalops was again anchored for the winter, this time at Brownsville.

Early last spring Prof. Nachtrieb purchased for the survey a gasoline launch, and with it towed the Megalops back to the head of Lake Pepin, where it was beached and served as a station during the summer. This region is especially rich on account of the variety of conditions. On the one hand there is Lake Pepin, which is about two miles wide and nearly forty miles long. In many places it has fine sandy and gravelly shores and in others there are marshes. It is hemmed in by high bluffs, which are from two hundred to three hundred feet above the water level, but in places there are low points which extend out from the bluffs into the lake for one-fourth of a mile or more, and on these numerous fishermen are located. Seining, also other forms of netting, is allowed in the lake, so an abundance of material for study can readily be obtained. The water is usually clear and varies in depth from ten to thirty feet.

As is well known, Lake Pepin is simply a remnant of what was once the large glacial Mississippi River. At the lower end of the lake the Chippewa River empties from the Wisconsin side and carries with it a great



amount of sediment, chiefly sand. This deposit has filled up the bed of the original stream at that point, and consequently dammed it and produced a lake. At all other places along its course what was once the magnificent Mississippi, two to four miles in width, is now narrowed down to one, or at most two or three, small channels and a few bayous. At the upper end of the lake the delta is exceedingly well marked. There are three main channels of the river, several lakes and numerous bayous, some with water connection and others without, during the dry season.

There is water of various depths, marshes, clear pools and all the chief forms of aquatic vegetation that this region of Minnesota affords—in fact, all the conditions that could be desired for an inland laboratory. The region abounds in breeding places for fishes, batrachians and reptiles; many species of mollusks are found in the lake, and the lower forms of aquatic life are everywhere abundant.

Thus it would seem that an ideal spot had been found for a lake laboratory for the University of Minnesota, which it is hoped the authorities may see their way clear to establish there in the near future.

During the past summer Prof. Nachtrieb kept a small party at the head of Lake Pepin in the beached Megalops, with which he spent the greater portion of his own time. Large collections were made, among which were many insects, numerous fish stomachs and a quantity of histological material.

During the past summer Prof. Nachtrieb, with an assistant, spent a few weeks on the Lake of the Woods, studying the lake sturgeon, and the writer, with three assistants, put in the entire summer on Lake Vermilion, at Tower, Minn. Lake Vermilion is some forty miles long in one direction, much narrower in the other, but it is not one open body of water, but rather a number of small lakes connected by numerous channels. It is in the heart of what was once an evergreen forest region, and its shores, which are chiefly rocky, border on the granite on the one hand and the very early stratified forms on the other. The water is clear and pure except for the floating forms of aquatic life in midsummer, and it varies in depth from five to forty feet, with possibly a few small areas that are deeper.

We established our camp on Pine Island, about seven miles from Tower. There was no one living within six miles of the place and no facilities for camping except numerous beautiful locations among the pines and the outfit which we carried with us. We erected two tents and from the dilapidated roof of a former homesteader's cabin secured enough boards to make some tables. We also made an excavation in the bank, lined it with slabs split from cottonwood poles, roofed it over with boards and tar paper from the dilapidated cabin, and thus had a very efficient dark room, in which we successfully developed more than three hundred negatives. Our outfit, in addition to the culinary department, consisted of seines, gill-nets, other smaller nets, a canvas boat, microscopes, books, cameras, guns, preserving jars and fluids, and other minor articles. One member of the party, Mr. J. E. Guthrie, devoted nearly all his time to insects, of which he secured a large collection. Another member of the party gave special attention to leeches, and a third collected and studied the mammals. The writer devoted nearly all his time to a study of the fishes. Collections were made of the species found in the lake and the inflowing streams, and many of the species were dissected and photographed. Attention was also given to a study of the habits of these fishes. From the main camp expeditions were made to all parts of the lake.

We were on the lake about two months and a half, and found the camping method a very satisfactory and pleasant one. The limit of this paper will not permit me to state any of the results of our work, but they will appear later in the forthcoming reports of the survey, some of which are now under way.

Culture of Amoeba.

A. J. Bigney.

Several years ago I presented a paper before this Academy on a new method of obtaining amoeba. This method was as follows: Take some of the green scum from the surface of some ponds and place it aside for a few weeks, during which time great numbers of amoeba will have developed. This scum must be composed mostly of euglena in the resting stage. I have never known this method to fail.

During the past season I have had unusual success with this method of securing them. About the first of September I obtained some of these euglenae and placed them in a wide-mouthed two-ounce bottle and left them on my desk for about two months, at which time I needed them for class use. When I first took this material from the pond there were a few amoeba in the midst of the euglena. When I needed a supply I found them by the hundreds on almost every slide. Frequently there would be so many that they would literally fill the field of the microscope. They were large specimens. It was the largest supply that I have seen reported in this country. It may be that others have had equal success with some other method. We used them for some time and then nearly all the remaining ones went into the resting stage.

Protective Coloring in Terns.

A. J. Bigney.

Protective coloring in birds has been and still is a subject of great interest to the ornithologist. Since ecological factors are receiving so much attention now on the part of biologists, every item bearing upon variations due to environment is of interest, since it throws some light upon the question of evolution.

One of the most remarkable instances of protective coloring came under my observation during the past summer on the island of Penikese, made famous by Louis Agassiz's first marine laboratory. This island is occupied by only one family. Nothing is raised except a few garden plants and sheep. There are other inhabitants of the island, however, that are more important than sheep—at least to the biologist. These are the terns. Long before one reaches the island he can hear the shrill voices of myriads of these birds as they fly about the island almost constantly from daylight to dark. These terns are protected by law and hence have become very numerous. Almost countless thousands are to be found. The sounds of their shrill voices make a lasting impression upon a person. The island is entirely made up of glacial material, here and there covered with grass. The beaches around the entire island are quite wide and covered with granite pebbles of various colors, mostly of a white, gray or slate color, giving them a mottled appearance. The grass and the soil is very much the same in color. The dead grass furnishes a fine place for nesting and also for hiding-places for the young birds. In the breeding season the nests and young birds are so numerous that one has to pick his way carefully, lest he step on some of them. They are so nearly the color of the ground and grass that you can hardly see either bird or nest. If the parent bird is on the nest the deception is almost perfect.

The most deceptive coloring is in the young birds when they lie out on the pebbles to warm themselves in the sunlight. The imitation is so perfect that you have to look for some time before you can see the birds. The eggs are mottled in the same way as the sticks, grass and earth that compose the nests. The adult birds are not mottled as are the young birds or the eggs, thus showing that this is truly a protective coloring.

Experiments on Developing Eggs.

A. J. Bigney.

The greatest mysteries in the biological world are undoubtedly locked up in the egg. If we can understand the intricate changes that go on in a developing egg we have accomplished much. Considerable light has been thrown upon this subject during the past few years. Eminent biologists all over the world are spending their lives trying to solve the mysteries. Various experiments have been devised to try to throw light upon these early changes in the egg.

These experiments which I performed were under the direction of Dr. Lillie, of the Chicago University, at the Woods Holl Marine Laboratory.

Experiment 1.—The egg of a common sea minnow, the Fundulus, was used. When the egg was in the two-celled stage one of the blastomeres was punctured with a needle and pressed out of the vitelline membrane. The other blastomere went on developing. Its development, however, was slower. It went through all the regular changes and became an embryo. The only difference that could be discerned was in size. It was considerably smaller than the normal embryo. I succeeded in keeping it alive seven days. I have not studied the embryo any more to see whether there are internal changes that are different from the normal embryo. The significance of this ability of one blastomere to develop into a complete embryo is not fully understood. In this egg it seems to indicate that the developing power is equally distributed throughout the egg.

Experiment 2.—In this experiment the eggs of the sea-urchin Arbacia were used. The eggs just fertilized were placed under a long cover-glass with a thin piece of cover-glass under one end, thus giving a graded pressure upon them. In the segmentation of these eggs the first and second cleavage planes were natural, but the third was parallel to the first, the same as in the Fundulus. The blastoderm in the eight-celled and sixteen-celled stages were almost identical with corresponding stages of Fundulus. The eggs did not develop further than thirty-two cells where the pressure was greatest.

Experiment 3.—Arbacia eggs five minutes after fertilization were shaken violently for about a minute. The membranes surrounding the eggs were thereby broken; the eggs were then placed in artificial sea water in which there was no calcium. Eggs were thus treated at two-celled, four-celled and eight-celled, with the following results:

Those separated at the two-celled stage lived to form plutei.

Those separated at the four-celled stage formed regular blastulae in most cases.

Those separated at the eight-celled stage also formed regular blastulae.

Experiment 4.—This is an experiment in artificial parthenogenesis in arbacia. Plutei six days old were reared by Dr. H. J. Hunter, of Kansas University. He carried on the work longer and he has specially reported on this, hence only this reference.

These experiments are very interesting and may be of considerable importance when we learn how to perfectly interpret them.

The Eye of Palemonetes Antrorum.

Edwin Manson Neher.

Contributions from the Zoölogical Laboratory of the Indiana University, under the direction of C. H. Eigenmann. No. 47.

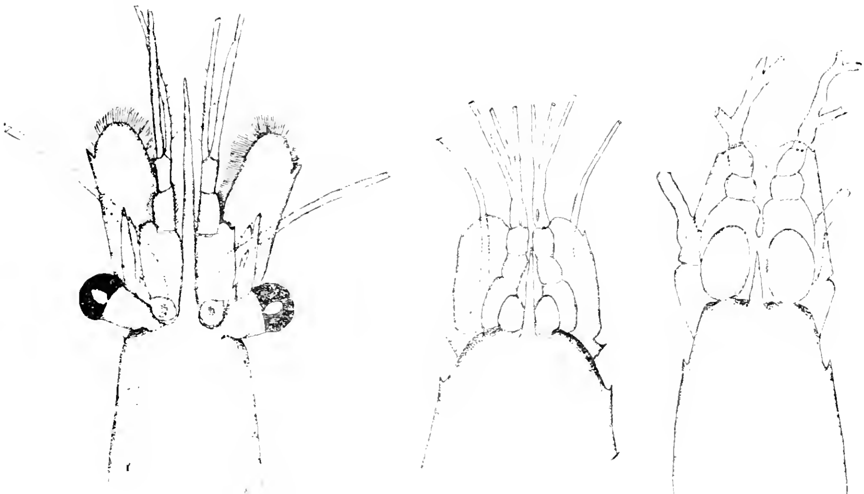
A blind shrimp, Palaemonetes antrorum, evidently occurs in abundance in the subterranean streams about San Marcos, Texas. It comes out of the artesian well of the United States Fish Commission at that place in large numbers. The well is about one hundred and ninety feet deep and has a yield of about one thousand gallons per minute.

A brief description of Palaemonetes was published by Benedict, 1896.

The material examined consists of young specimens, 5 to 5.5 mm. long from tip of rostrum to tip of telson and adult specimens measuring 15 mm. along the same line. Most of them were collected by Dr. C. H. Eigenmann at the San Marcos well in September, 1899. Others have since been sent by Mr. J. L. Leary, Superintendent of the United States Hatchery at that place.

The material at my disposal was preserved in 4 per cent. formalin. The anterior end of the cephalo thorax was dehydrated and imbedded in paraffin by the chloroform method. Sections were floated out on warm water and fixed to the slide with glycerin-albumen and stained with Mayer's haemalum, followed by eosine. Specimens of P. exilipes, which were used for comparison, were treated with Perenyi's fluid for forty-eight hours before imbedding and the sections were depigmented in 10 per cent. nitric acid for ten hours. The cuticle of the blind shrimp was found to section readily without softening in Perenyi's fluid.

According to Chilton, '94, the degeneration of the eyes of crustaceans may follow one of three lines. We may have—



1 2 3

4 5 6

1. Total atrophy of optic lobes and optic nerves, with or without the persistence in part of the pigment or retina and the crystalline lens.

2. Persistence of optic lobes and optic nerves, but total atrophy of the rods and cones, retina (pigment), and facets, or,

3. Total atrophy of the optic lobes, optic nerves, and all the optic elements.

The degeneration of the eye of the species under consideration has evidently followed the second of these lines. The optic stalk has suffered a foreshortening, and as a consequence the optic ganglia have become telescoped. The greatest reduction has taken place in the ecto-dermal portions of the eye, which are reduced to a group of cells not exceeding and probably fewer than 350. Inasmuch as a single normal ommatidium contains sixteen cells, the degree of degeneration reached is readily seen to be very great.

The extent of the modification of the eyes can perhaps be most readily described by a comparison of the eyes and optic stalk of this species with those of Palæmonetes exilipes, taken in the San Marcos River, but a short distance from the artesian well.

The eye and optic stalk of P. exilipes presents the general appearance of the crustacean eye. The stalk is a truncate cone (Fig. 1), attached by its smaller end. On the distal end is the large, dark, conspicuous, hemispherical eye. It is wider than the widest part of the stalk.

In P. antrorum the eye stalk is much smaller (Fig. 2), as may be seen from the following table:

	exilipes.	antrorum.
Length of specimen	17 mm.	15 mm.
Length of stalk to retina	787 μ	525 μ
Width of stalk at retina	700 μ	175 μ
Width of stalk at base	387 μ	387 μ
Width of retina	962.5 μ	0

Nothing appears to remain of the eyes except the short, colorless, delicate stalks. The stalks are conical, being attached by their larger end. The axis of the stalk is parallel with that of the body.

The distal end of the optic stalk of P. antrorum is covered with a single layer of indifferent hypoderm with nuclei 7.2 μ by 3.6 μ, except at a short distance from the distal end of the outer lower quarter of the stalk, where a group of slightly modified hypodermal cells, three deep, replace the single series of outer parts. The nuclei in this group of cells are rounded, measuring about 6 to 8 μ in diameter. This group of cells measures about 50 μ by 70 μ. There is no indication of an arrangement of these cells into anything resembling the arrangement of the cells in an ommatidium.

The following data gives the number of retinal cells found in each of a series of cross sections. Sections are $6\frac{2}{3}$ μ thick and counted from in front:

No. of Sections.	No. of Cells in Retina.
1 to 8	0
8	11
9	19
10	20
11	27
12	33
13	33
14	28
15	27
16	26
17	7
18	7
19	5
20	6
21	11
22	13
23	10
24	10
25	5
26	6
27	6
28	8
29	4
30	2
31	0
32	0
Total	327

In P. exilipes there is a space between the basement membrane of the hypoderm and the membrana propria of the optic ganglia, which is occupied by the fine fibers which connect the ommatidia and optic ganglia. In P. antrorum this space is filled with coagulated haemolymph (Fig. V). This haemolymph is in circular or angular blocks. These blocks begin about 40 μ from tip of eye and extend back through a space of about 60 or 70 μ to the cells of the optic ganglia. Small particles of coagulated haemolymph also extend down the outside of the eye for about half of its length.

Only a very few specimens of the young shrimp, P. antrorum, could be obtained. These were from 5 to 5.5 mm. long. The optic stalk and eye are much larger in proportion to the size of specimen (Fig. III) than in the adult antrorum, but they are actually not as large as in the adult. The internal structure showed no greater differentiation than in the eye of adult.

I am very grateful to G. H. Parker for assistance in the interpretation of the structure of this eye.

EXPLANATION OF FIGURES.

Figure 1. Dorsal view of the front end of P. exilipes.

Figure 2. Dorsal view of the front end of P. antrorum, showing the small eyes.

Figure 3. Dorsal view of the front end of a young P. antrorum about 5 mm. long.

Figure 4. Photograph of a cross section through the optic stalk of P. antrorum, showing the group of retinal hypodermal cells of the right eye.

Figure 5. Photograph of a longitudinal section through the optic stalk of P. antrorum, showing the group of retinal hypodermal cells.

Figure 6. Enlarged view (photograph) of group of retinal hypodermal cells shown in Fig. 5.

Figure 7. Photograph of another group of retinal hypodermal cells. Horizontal section.

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The History of the Eye of Amblyopsis.

C. H. Eigenmann.

[Abstract.]

A. Development.

The eye of Amblyopsis appears at the same stage of growth that it appears in fishes developing normal eyes.

The eye grows but little after its appearance.

All the developmental processes are retarded and some of them give out prematurely. The most important of the latter is the cell division and the accompanying growth that provides the material for the eye.

The lens appears at the normal time and in the normal way, but its cells never divide and never lose their embryonic character.

The lens is the first part of the eye to show degenerative steps and it disappears entirely before the fish has reached a length of 1 mm.

The optic nerve appears shortly before the fish reaches 5 mm. in length. It does not increase in size with the growth of the fish and possibly never develops normal nerve fibers.

The nerve does not increase in size with growth of the fish.

The optic nerve gradually loses its compact form, becomes flocculent, dwindles and can not be followed by the time the fish has reached 50 mm. in length. In the eye it retains its compact form for a much longer time, but disappears here also in old age.

The scleral cartilages appear when the fish is 10 mm. long; they grow very slowly—possibly till old age. They do not degenerate at the same rate as other parts of the eye if they degenerate at all.

B. HISTORY.

The history of the eye may be divided into four periods:

(a) The first period extends from the appearance of the eye till the embryo reaches 4.5 mm. in length. This period is characterized by a normal palingenic development except that cell division is retarded and there is very little growth.

(b) The second period extends from the first till the fish is 10 mm. long. It is characterized by the direct development of the eye from the normal embryonic stage reached in the first period to the highest stage reached by the Amblyopsis eye.

(c) The third period extends from the second period to the beginning of senescent degeneration, from a length of 10 mm. to about 80 or 100 mm. It is characterized by a number of changes, which, while not improving the eye as an organ of vision, are positive as contrasted with degenerative. There are also distinct degenerative processes taking place during this period.

(d) The fourth period begins with the beginning of senescent degeneration and ends with death. It is characterized by degenerative processes only, which tend to gradually disintegrate and eliminate the eye entirely.

C. SUMMARIAL TABLE OF THE ORIGIN, DEVELOPMENT AND DEGENERATION OF THE EYE AND ITS PARTS.

	Earliest Appearance or Differentiation.	End of Cell Division.	End of Morphogenesis.	End of Histogenesis.	Beginning of Degeneration.	Disappearance.
Eye	1.5 mm.	5-7 mm.	10 mm.	Before 25 mm.	25 mm.	Beyond 130 mm.
Choroid fissure	2.5 mm.	—	—	—	—	10-130 mm.
Pigmented layer	2 mm.	?	2.5 mm.	10 mm.	100 mm. or before.	Beyond 130 mm.
Cones	Rarely and then after 10.	—	?	?	?	?
Outer nuclear	4.4-5 mm.	5-7 mm.	—	10 mm.	Before 25 mm.	Beyond 130 mm.
Outer reticular	Never.	—	—	—	—	—
Horizontal cells	Never.	—	—	—	—	—
Inner nuclear	4.4-5 mm.	—	—	10 mm.	Before 25 mm.	130 mm. and beyond.
Ganglionic	4.4-5 mm.	—	—	10 mm.	Before 25 mm.	130 mm. and beyond.
Optic fiber layer or nerve	4.4-5 mm.	—	—	5 mm.	25 mm.	100 mm.
Scleral cartilages	9-10 mm.	?	?	75 mm.	—	—
Lens	2.5 mm.	5 mm.	5 mm.	—	3 mm.	6-10 mm.
Corneal epithelium	5 mm.	?	—	—	7 mm.	10 mm.

? I do not know.
— Does not take place.

D. CONCLUSIONS OF GENERAL BIOLOGICAL INTEREST.

Some late stages of development are omitted by the giving out of developmental processes. Some of the processes giving out are cell division, resulting in the minuteness of the eye and the histogenic changes which differentiate the cones and the outer reticular layer.

There being no causes operative or inhibitive either within the fish or in the environment that are not also operative or inhibitive in Chologaster agassizii, which lives in caves and develops well-formed eyes, it is evident that the causes controlling the development are hereditarily established in the egg by an accumulation of such degenerative changes as are still notable in the later history of the eye of the adult.

The foundations of the eye are normally laid, but the superstructure, instead of continuing the plan with additional material, completes it out of the material provided for the foundations. The development of the foundation of the eye is phylogenic, the stages beyond the foundations are direct.

E. TABLE OF MEASUREMENTS OF EYES OF EMBRYOS OF DIFFERENT SIZES.

Condition of Embryo Living or Direction of Sections.	Length of Embryos.	No. of Embryos Measur'd.	Longitudinal Diameter.	Vertical Diameter.	Axial Diameter of Eye from Cornea to Optic Nerve.
	1.6 mm	1	80 μ.	....	36 μ.
	1.76	....	100	....	48
	2	3	135	....	....
	2.5	2	190	....	100
	2.8	1	170	....	....
Alive	4	1	200	150	100
Alive	5	7	144	134	....
Sagittal	6	1	136	88	....
Cross.....................	6	1	....	70	100
Horizontal	6	1	136	....	80 and 108
Mounted entire...........	6.5–7	1	160	160	....
Cross.....................	5.5–7	3	....	126	99
Horizontal...............	6.5–7	3	152	....	115
Sagittal	9–9.5	1	108	....	88
Cross.....................	9–9.5	1	....	106	90
Horizontal...............	9–9.5	1	114	....	98
Sagittal	10	1	120	112	....
Cross.....................	10	2	....	108	109
Entire....................	10	1	135	130	....
Horizontal...............	25	1	120	....	128
Cross.....................	25	1	....	160	160
Horizontal...............	35	1	192	....	144

The Eye of Rhineura Floridana.

C. H. Eigenmann.

[Abstract.]

Rhineura floridana is a legless, burrowing, amphisbaenian lizard, found in Florida. My attention was called to it by Mr. W. S. Blatchley, and I secured specimens through dealers and through Dr. W. B. Fletcher, of Indianapolis, who kindly forwarded a number of living specimens to me.

A study of the eye of this lizard has led to the following conclusions:

1. The eye of Rhineura has reached its present stage as the result of a process of degeneration that probably began in the early miocene.

2. The dermis and epidermis pass over the eye without any modification. The conjunctival pocket has vanished.

3. Harder's gland is many times as large as the eye and pours its secretion into the tear duct and thus into the nasal cavity.

4. The eye muscles have disappeared.

5. A cornea is not differentiated.

6. The lens is absent in half the eyes examined and varies greatly in those in which it was found.

7. The vitreous body has practically disappeared.

8. The pigment epithelium is variously pigmented. It is of greater extent than is sufficient to cover the retina and has been variously invaginated or puckered over the proximal and posterior faces of the eye.

9. An uveal part of the iris is not found.

10. The eye of Rhineura does not represent a phylogenetically primitive stage; it is an end product of evolution as truly as the most highly developed eye.

11. The adult eye shows few indications that there has been a cessation of development at any definite ontogenic stage. It does not resemble as a whole any ontogenic stage.

12. An arrest in the ontogenic development has taken place in so far as the number of cell multiplications concerned in forming the anlage of the various parts of the eye have decreased in number, and in the lack of union of the lips of the choroid fissure.

13. It is possible that the absence of cones or rods is due to an arrest in the histogenesis of the retina, but since these structures are normally formed in the young of Typhlotriton and disappear with age, it is possible

that their absence in the adult eye of Rhineura is also due to ontogenic degeneration.

14. The irregularity in the structure and existence of the lens and the great reduction of the vitreous body offer evidence in favor of the idea of the ontogenically and phylogenically earlier disappearance of the ontogenically and phylogenically newer structures.

15. Horizontal nuclei found between the pigment epithelium and the outer limiting membrane are probably derived from the proximal layer of the optic cup.

16. The different layers of the retina have reached a degree of differentiation out of proportion to the great reduction of the dioptric apparatus and general structure of the eye.

Zoölogical Miscellany.

C. H. Eigenmann.

1. Portions of a mastodon were found on a sand-bar in the Ohio River, near Rockport, Ind. They have been presented to Indiana University by Karl Cramer.

2. The bones of Megalonyx jeffersoni, from the Owen collection, have been mounted in their relative positions and are now on exhibition in Owen Hall.

3. The Museum of the Indiana University finds itself in possession of a collection of birds, made by President Roosevelt at St. Regis Bay and at Oyster Bay, between 1872 and 1877. Most of the specimens bear the original labels written by Mr. Roosevelt, which are examples of explicitness and fulness in labeling. The earliest specimen was collected February 12, 1872, and bears the serial number 4 of his collection. Mr. Roosevelt published a small paper upon the birds of the Adirondacks and another on those of Long Island, based in part on these specimens. The trustees of the University have ordered a dust-proof case to be made, in which they are to be preserved for the future.

There are forty-six birds in all, forty-two species, fifteen less than the number sent here by the National Museum.

The labels read as follows:

Roosevelt Number.	*Name.*	*Date.*	*Habitat.*	*Reverse.*	*I. U. Number.*
4A.	Larus.	2-12-1872.	Peninzeah.		860
4A 37.	Mimus rufus ad. ♂.	9-10-1872.	Piermont, N. Y.		1061
2C 5.	Tinnunculus alaudarus ad. ♂.	2-24-1873.	Ramleh, Syria.		586
319.	Corvus americanus ♀.	7-10-1874.	Oyster Bay, L. I.	16.5 34.2 11.6 7.4 1.9 2.3 2.0 1.6. Iris, brown. Bill, black. Legs, black.	1045
354.	Ceryle alcyon ♀.	8-21-1874.	St. Regis L., N. Y.	13.6 22.3. Iris, brown. Bill, black. Legs, slate.	1038
490.	Plotis anhinga.	3-10-1875.	Gainesville, Fla.	27.0 39.0. Bill, yellow. Feet, black.	1047
525.	Pipilio erythropthalmus ♀.	6- 5-*1875*.	*Oyster Bay, L. I.*	7.4 10.5. Iris, red. Bill, brown. Legs, yellow.	1054
540.	Icterus spurius ♀.	6-23 -*1875*.	*Oyster Bay, L. I.*	6.5 9.8. Iris, brown. Bill, black and slate. Legs, slate.	1046
551.	Cyanospiza cyanea ♂.	7-17-*1875*.	*Oyster Bay, L. I.*	5.0 8.5. Iris, brown. Bill, black and white. Legs, brown.	1055

578.	Dendroica maculosa ♂.	8– 7–1875.	St. Regis L., N. Y.	4.5 7.8 Iris, brown. Bill, brown. Legs, brown.	1059
590.	Empidonax Trailli.	8–25–1875.	Oyster Bay, L. I.	5.0 8.0. Iris, brown. Bill, brown and yellow. Legs, brown.	1044
594.	Picus pubescens ♀.	8–28–1875.	Oyster Bay, L. I.	6.6 12.9. Iris, brown. Bill, slate. Legs, slate.	1042
599.	Icterus Baltimore.	9– 3–1875.	Oyster Bay, L. I.	7.2 12.2. Iris, brown. Bill, brown and whitish. Legs, slate.	1050
622.	Zonotrochia melodia ♀.	10–23–1875.	Oyster Bay, L. I.	6.3 7.8. Iris, brown. Bill, brown. Legs, ——. Cont. crop, seeds and insects.	1053
641.	Parus atricillus ♀.	3–24–1876.	Oyster Bay, L. I.	5.2 8.2. Iris, brown. Bill, black. Legs, slate. Cont. crop, insects.	1062

Roosevelt Number.	Name.	Date.	Habitat.	Reverse.	I. U. Number.
666.	Helminthophaga ruficapilla ♀.	5-20-1876.	Garrisons, N. Y.	4.6 7.9. Iris, brown. Bill, brown. Legs, brown.	....
669.	Dendroica Blackburniae ♂.	5-20-1876.	Garrisons, N. Y.	5.2 8.9. Iris, brown. Bill, brown. Legs, brown.	1060
704.	Tringoides macularius ♀.	7-25-1876.	Oyster Bay, L. I.	7.8 13.8. Iris, brown. Bill, brown and light. Legs, greenish.	1037
708.	Chaetura pelagica ♂.	7-26-1876.	Oyster Bay, L. I.	5.2 12.5. Iris, brown. Bill, brown. Legs, brown. Cont. crop, gnats and flies.	1041
712.	Empidonax acadicus ♂.	7-27-1876.	Oyster Bay, L. I.	6.0 9.8. Iris, brown. Bill, brown, lower mand. yellow. Legs, brown.	1043
741.	Dafila acuta ♂.	3- 5-1877.	New Jersey.	25.6 37.8. Iris, chestnut. Bill, brown. Legs, brown. Cont. crop, veg. substance, gravel.	776

757.	Turdus Pallasi ♀.	6-23-1877.	St. Regis L., N. Y.	7.0 11.2. Iris, brown. Bill, brown and yellow. Legs, yellowish. Cont. crop.	11
758.	Picus villosus ♀.	6-23-1877.	St. Regis L., N. Y.	9.0 15.0. Iris, brown. Bill, slate. Legs, slate.	1039
761.	Vireo solitarius ♂.	6-25-1877.	St. Regis L., N. Y.	5.4 9.3. Iris, brown. Bill, brown. Legs, slate. Cont. crop, small beetles.	1056
770.	Sphyrapicus varius ♂.	6-20-1877.	St. Regis L., N. Y.	8.4 15.2. Iris, brown. Bill, brown. Legs, slate.	1040
820.	Spizella pusilla.	4-17-1878.	Oyster Bay, L. I.	5.7 7.8. Iris, brown. Bill, pink. Legs, yellow-brown. Cont. crop, beetles, ants and gravel.	1052

The original labels of the following birds are not with the specimens:

I. U. Number.	*Name.*	*Date.*	*Habitat.*
702.	Vanellus cristatus ad. ♂.	2–10–1873.	Beni Hassan.
166.	Vireo noveboracensis ♀.	5–30–1874.	Oyster Bay, Long Island.
57.	Certhia familiaris rufa ♀.	12–30–1874.	Oyster Bay, Long Island.
118.	Dendrœca virens ♀.	5–11–1875.	Oyster Bay, Long Island.
709.	Calidris arenaria.	6–11–1875.	Oyster Bay, Long Island.
426.	Empidonax minimus ♂.	7–19–1875.	Oyster Bay, Long Island.
264.	Poœcetes gramineus ♂.	8– 2–1875.	St. Regis, New York.
187.	Tachycineta bicolor ♂.	9– 2–1875.	Oyster Bay, Long Island.
418.	Contopus virens.	6–27–1877.	St. Regis Lake, New York.
124.	Dendrœca discolor.	6–11–1878.	Oyster Bay, Long Island.
121.	Dendrœca pinus ♂.	6–12–1878.	Oyster Bay, Long Island.

The following are undated and arranged according to I. U. number:

I. U. Number.	*Name.*	*Habitat.*
243.	Spinis tristis ♂.	Oyster Bay, Long Island.
314.	Passerina cyanea ♀.	Oyster Bay, Long Island.
455.	Picus villosus ♂.	
792.	Fulix marila ad. ♂.	Northeastern United States.
1036.	Tringoides macularius ♂.	Oyster Bay, Long Island.
1048.	Aluco flammeus, ad.	
1049.	Icterus spurius, juv. ♂.	Oyster Bay, Long Island.
1051.	Aegiothus linaria.	
1057.	Helminthophaga pinus, ad. ♂.	Long Island.

Variation Notes.

C. H. Eigenmann and Clarence Kennedy.

The Spinning of the Egg-Sac in Lycosa.

W. J. Moenkhaus.

The habit of the female spinning a round, ball-like egg-sac and carrying this suspended from the spinners during the period of incubation, is, so far as I can determine, characteristic of the entire family of ground spiders, the *Lycosidae*, with the exception of the single genus *Dolomedes*. The process of the construction of the cocoon has been seldom observed, so far as I can determine from the literature. This is due to the difficulty attending such observation, since all of the species either tunnel more or less deeply into the ground or live in retreats under stones, boards, and the like. I had tried for a long time, without satisfactory results, to observe this until I finally hit upon a species *Lycosa sp.* that permitted me to make the observation very completely. The plan had been to place gravid females in glass jars half-filled with earth, and by moistening this next to the glass induce her to construct her burrow there and thus enable me to watch her actions through the glass. While I got several females thus to construct their burrows and spin their egg-sacs, I was not able to see sufficiently well through the glass, which always became pretty well besmeared with earth during the excavation. In the case under consideration, however, the whole process occurred above ground, so that I could see it step by step. This, briefly, ran as follows:

She first excavated a shallow hole in the middle of the jar about one-third greater in diameter than the length of her body. This she did with her mandibles and palpi, piling the excavated ground in a crescentic heap around one side of the hole. Then she spun a thin sheet over the hole, extending from the top of the crescentic heap to the opposite side, completely covering the hole. This sheet, thus, was not horizontal, but inclined, and in the instance observed about 25 degrees, the inclination, of course, being determined by the height of the crescentic embankment. Upon the center of this sheet a crescent-shaped pocket was constructed with the broad and open side directed toward the higher end of the incline. Into this the eggs were deposited immediately after its completion. The eggs filled the pocket heaped full. The exposed surface of the eggs was then closely spun over so that they were completely enclosed in a slightly compressed spherical cocoon, suspended in the center of the sheet. The edges of the sheet were then cut loose from the ground, carefully rolled up with the mandibles and palpi and tucked up against the cocoon, being spun fast as the work proceeded. This appeared as a rather prominent equatorial band around the cocoon at the line of attachment of the sheet. The whole cocoon was strengthened by further spinning, and, when finished, was fastened to the spinners and carried away. The whole was completed in a little more than one-half hour.

I have examined the cocoons of over fifty different species of *Lycosidae* and all show their equatorial band more or less prominently, so that it would seem that all the species adopt in general this same plan of constructing their egg-sac.

Experiments in the Hybridization of Fishes.

W. J. Moenkhaus.

[Abstract.]

During the past three years thirty-three different crosses were made among fishes. Most of these were between marine species; several were between fresh-water species, and three between marine and fresh-water species. In no combination was there a failure of impregnation. The per cent. of eggs impregnated was usually large—50 to 100 per cent.; in a few instances as low as 1 per cent. This per cent. bore no relation to the blood relationship of the species. In most of the cases there was either no polyspermy or the per cent. of polyspermy was small. In two crosses this was as great as 50 per cent. of the impregnated eggs. The degree of polyspermy bore no relation to the nearness of relationship.

In all cases of normal impregnation the earlier phases of development were passed through normally. All crosses except where *Batrachus tau* was used as the female, the development went beyond the segmentation stages, the embryonic shield being apparently perfectly formed. Many crosses went beyond this to the closure of the blastopore, but in these cases the embryo was varyingly shorter than the normals. Seven crosses developed into healthy fry. Some of these, however, showed abnormalities, usually in the caudal peduncle and the anal fin. These latter crosses were either between species of the same genus or nearly related genera.

An Aberrant Etheostoma.

W. J. Moenkhaus.

While seining in Tippecanoe Lake during the summer of 1896, there was taken among a great many Etheostoma caprodes a single very aberrant specimen of darter. I have been unable to identify it with any described species. Its close affinity to Etheostoma caprodes and to Etheostoma aspro at once strikes one, and a closer study shows it to be in many respects intermediate between these two species.

The specimen is rather large, although not too large for an Etheostoma aspro, measuring 78 mm. in length. The form of the head and body is very much like Etheostoma aspro. The snout is evidently longer and the interorbital space broader. The cheeks, opercle and nape are scaled. The color pattern, on the whole, also resembles more closely that of Etheostoma aspro. The barred character of Etheostoma caprodes in the upper half plainly shows itself. Along the side is a series of nine large dark blotches, more or less confluent with intermediate smaller ones. The dorsal, pectoral and caudal fins are barred. The ventral and anal fins, plain.

In the table are given measurements and counts of the aberrant specimen and the two most nearly related species:

	Etheostoma caprodes.	Etheostoma sp.?	Etheostoma aspro.
Dorsal fins..............	XIV-16 (average)....	XVI-14..............	XIII-13
Anal fin	II-11 (average)	II-11	II-9
Lateral line	88 (average)..........	80.....................	69
Head in body	4.27	4.21..................	4.00

Three possibilities present themselves: (1) The specimen may be merely an unusually aberrant form of Etheostoma caprodes or of Etheostoma aspro; (2) it may be a new species; (3) it may be a hybrid.

In regard to the first, it may be said that, considering all the characters, it is scarcely within the range of normal local variability of either species. If we consider the spines and rays, the scales and the proportions as set forth in the above table, it would seem easiest to consider it a variation of Etheostoma caprodes. In the form of the body and the coloration it could more easily fall within the range of variation of Etheostoma aspro. Indeed, this affinity is so strong that if it is merely a variation it can only have come from Etheostoma aspro.

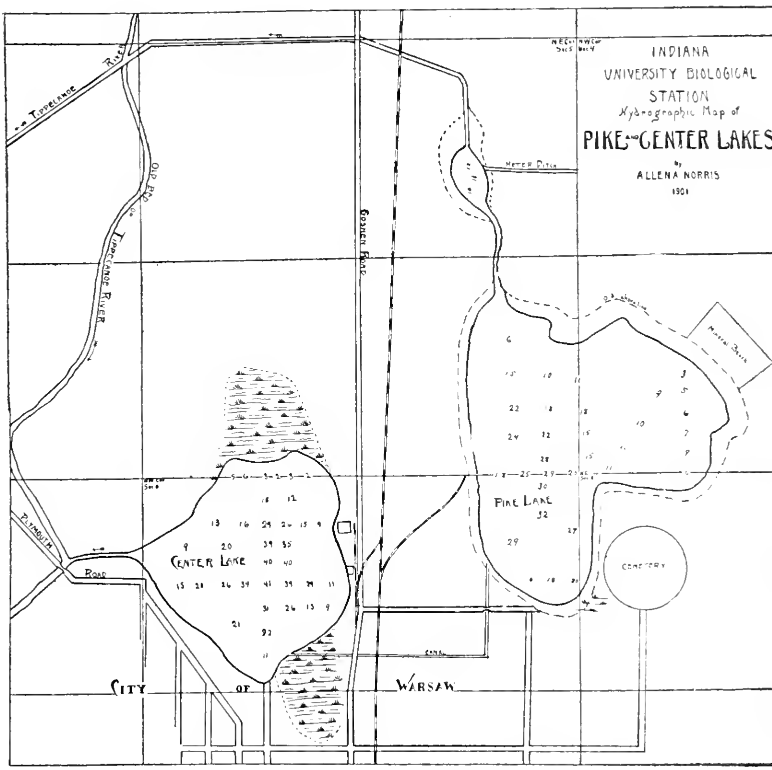
Both in coloration and in structural characters it can readily be distinguished from either of the two most closely related species, so that it would be easy enough to characterize it as a new species. The reasons against this are the usual ones, namely, that we have only a single specimen and that if it represented a species that is even only poorly established more specimens should have been obtained in the enormous amount of seining that was done during the same, previous and subsequent summers.

It is entirely possible that we have here a hybrid. There are characters that show a strong affinity for each of the supposed parent species, as well as characters (scales) that are intermediate. Both parent species occur in the lake, Etheostoma caprodes abundantly, Etheostoma aspro sparingly. The most serious objections against considering this a hybrid is the large number of dorsal spines—sixteen—in the dorsal, larger than in either parent species. About 2 per cent., however, of Etheostoma caprodes have sixteen spines in this lake and an occasional specimen is found with seventeen. It should be stated in this connection that I have experimentally obtained healthy fry between *Etheostoma coeruleum* and *Etheostoma nigrum*, two species much more distinct than the assumed parent species. There seems, therefore, to be considerable evidence in favor of the assumption that this is a hybrid.

REPORTS FROM THE BIOLOGICAL STATION.

I. MAPS OF WINONA, PIKE AND CENTER LAKES.*

ALLEN A. NORRIS.



* Contributions from the Zoölogical Laboratory of the Indiana University, under the direction of C. H. Eigenmann, No. 48.

II. FAUNA AND FLORA OF WINONA LAKE, PARTS A, B, C, D.*

A. A List of the Mollusca of Eagle, Center and Pike Lakes, Kosciusko County, Indiana.

A. A. Norris.

The mollusks mentioned below were collected during the summer of 1901. In the preparation of the list I have been under obligations to Dr. Call, of the Children's Museum, Brooklyn, and to Chas. T. Simpson, of the Smithsonian Institution, each of whom examined and named a part of the collection.

UNIVALVES.

1. *Selenites concava* Say. Common on the marsh shores of Pike Lake.
2. *Mesodon multilineatus* Say. Abundant.
3. *Mesodon mitchellianus* Lea. Common.
4. *Limnophysa caperata* Say. Common.
5. *Limnophysa humilis* Say.
6. *Physa gyrina* Say. Common.
7. *Helisoma campanulata* Say. Abundant.
8. *Helisoma trivolvis* Say. Abundant.
9. *Helisoma bicarinata* Say. Common.
10. *Gyraulus parvus* Say. Common.
11. *Amnicola limosa* Say. Common.
12. *Amnicola parata* Say. Common.
13. *Valvata tricarinata* Say. Common
14. *Campeloma subsolidum* Anthony. Found in outlet of Eagle Lake.
15. *Campeloma rufum* Haldeman. Abundant in the outlet of Eagle Lake.
16. *Pleurocera subulare* Lea. Very abundant in Pike Lake and Eagle Lake.
17. *Pleurocera elevatum* Say. Outlet of Pike Lake.
18. *Sphaerium transversum* Say. Frequent in the outlet of Eagle Lake.

BIVALVES.

19. *Unio undulatus* Barnes. Abundant in the outlet of Pike Lake, rare in the other outlets, not found in the lakes.
20. *Unio gibbosus* Barnes. Three specimens were taken in the outlet of Eagle Lake.

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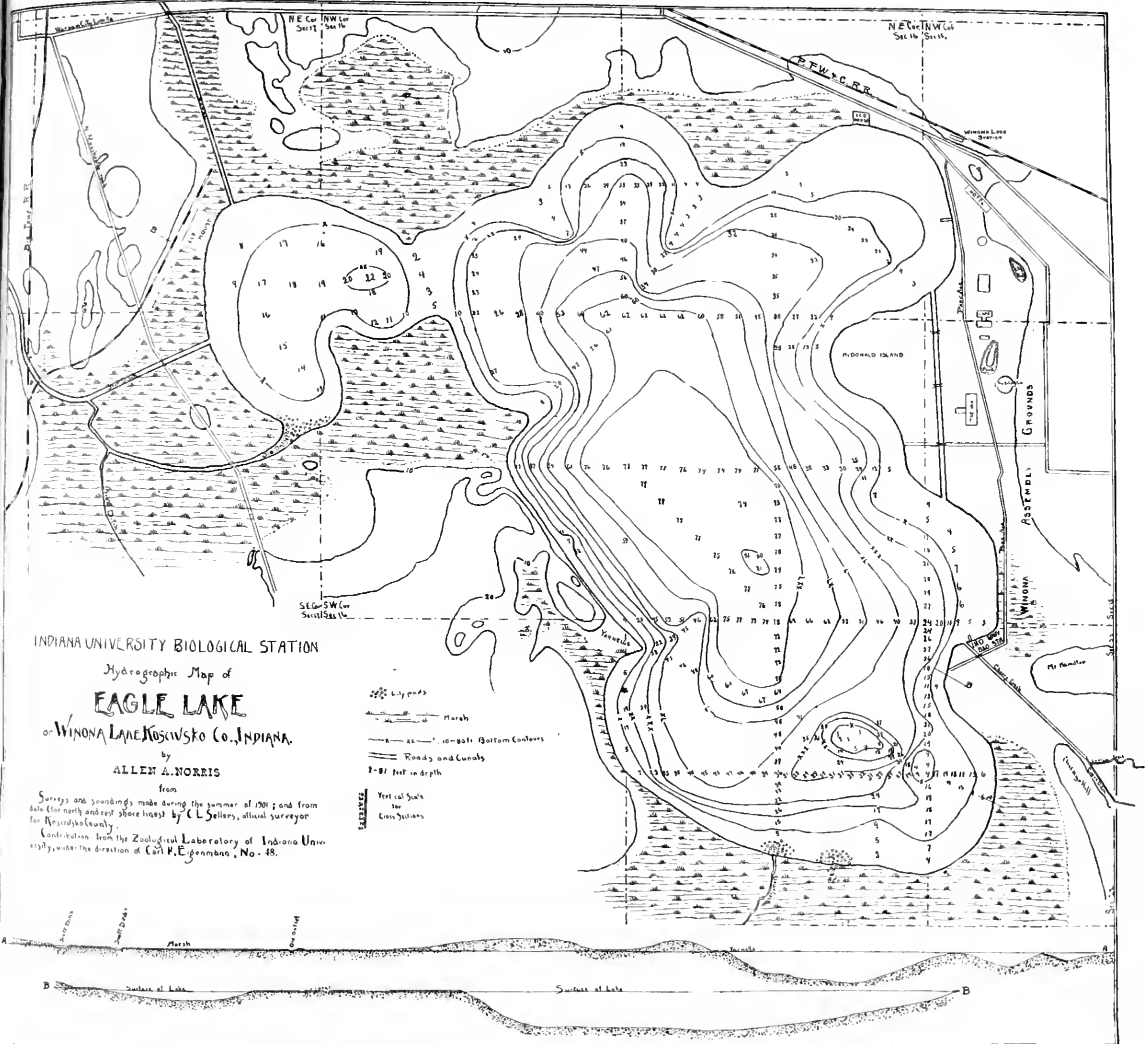
* Contributions from the Zoölogical Laboratory of the Indiana University, under the direction of C. H. Eigenmann, No. 49.



INDIANA UNIVERSITY BIOLOGICAL STATION
Hydrographic Map of
EAGLE LAKE
or WINONA LAKE KOSCIUSKO Co., INDIANA.
by
ALLEN A. NORRIS
from
Surveys and soundings made during the summer of 1901; and from data (for north and east shore lines) by C L Sellers, official surveyor for Kosciusko County.
Contribution from the Zoological Laboratory of Indiana University, under the direction of Carl H. Eigenmann, No. 48.
Lily pads
Marsh
10-80 ft Bottom Contours
Roads and Canals
2-81 feet in depth
Vertical Scale for Cross Sections
P. F. W. & C. R.R.
Winona Lake Station
McDONALD ISLAND
WINONA ASSEMBLY GROUNDS
Yarnells
Mt Hamilton
Surface of Lake
Marsh

direction of C. H. Eigenmann, No. 43.

21. *Unio iris* Lea. Frequent.
22. *Unio subrostratus* Say. Abundant.
23. *Unio fabalis* Lea. Eagle Lake and Pike Lake.
24. *Unio cylindricus* Say. A single specimen was taken in the outlet of Eagle Lake.
25. *Unio luteolus* Lamarck. Abundant.
26. *Unio ventricosus* Barnes. A single specimen (dead) was found in the outlet of Pike Lake.
27. *Unio rubiginosus* Lea. Common in Eagle Lake and in the outlet of Eagle Lake. None taken from other waters.
28. *Unio clavus* Lamarck. Rare in outlet of Eagle Lake.
29. *Unio glans* Lea. Common.
30. *Margaritana rugosa* Barnes. Outlet of Eagle Lake.
31. *Anodonta edentula* Say. Six.
32. *Anodonta grandis* Say. Common in Eagle and Pike Lakes.
33. *Anodonta footiana* Lea. Abundant in Pike Lake, rare in Center Lake, not found in the streams.
34. *Anodonta ferrusaciana* Lea. Abundant in Pike Lake.

B. Additions to the Indiana List of Dragonflies, with a Few Notes.—No. II.*

E. B. Williamson.

ADDITIONS.

1. *Enallagma aspersum* Hagen. A single female was taken June 27, 1901, in the woods on Chapman Hill, near Winona Lake. The female of this species of *Enallagma* is so distinctively colored that I do not hesitate to record the species for the State on such scanty material. I think this species will be found to be extremely local in di-tribution

2. *Dromogomphus spoliatus* Hagen. Old canal feeder along the St. Joseph River, and St. Joseph River, Robison Park, Ft. Wayne, July 19 and August 11, 1901. Abundant; both sexes taken; several exuviae gathered from piles at boat landings in Robison Park; observed feeding on adult imagoes of the following insects: *Pieris rapae*, white cabbage butterfly, and the two dragonflies, *Hetaerina americana* and *Argia putrida*. An active, inquisitive species, relentless in love

* No. I was published in last year's proceedings (1900), pp. 173-178.

and war, more wary than *D. spinosus*, and most numerous about the water from 9 a. m. to 4 p. m., where they are conspicuous by reason of the yellow or reddish-yellow seventh to ninth abdominal segments.

3. *Gomphus villosipes* Selys. Tippecanoe River, near Warsaw, June 23, 1901, 3 males. Holliday and Williamson.

4. *Gomphus dilatatus* Rambur. Tippecanoe River, near Warsaw, June 23, 1901, 5 males, 1 female. Williamson and Holliday. This species was found only near the P., Ft. W. & C. R. R. bridge over Tippecanoe River, and only on this one date. The bridge was being repaired, and the dragonflies were taken resting on some of the timbers, usually near the water, which flowed swiftly here. Possibly half the number seen were captured. They did not patrol the river, apparently, and, when frightened, they usually left the river, disappearing over the fields on either side.

5. *Gomphus spiniceps* Walsh. Old canal feeder along the St. Joseph River, near Ft. Wayne, July 19, 1901, one teneral female taken, another teneral seen, and two exuviae found in grass clumps two or three feet from the water.

6. *Sympetrum corruptum* Hagen. Near Winona Lake, August 10, 1901, 1 male. Miss N. O. Harrah.

Ninety-seven species of dragonflies are now recorded for Indiana. If *semiaquea* (or the form usually known by this name) and *assimilatum* should be regarded as distinct from *Tetragoneuria cynosura* and *Sympetrum rubicundulum* respectively, then the Indiana list numbers 99 species.

NOTES AND CORRECTIONS.

1. *Argia translata* Hagen. Pl. I, Fig. 1. Ab., male 30, female 28; h. w., male 22, female 23. A dark colored species; post-ocular spots small, not connected; thorax nearly to first lateral suture black, narrow antehumeral and post-humeral pale stripes, the latter only above; these stripes wider and the post-humeral longer in the female; sides of thorax pale, second lateral suture with a black stripe. Abdomen black; pale, narrow, interrupted basal rings on 3–7; male with a blue basal spot on 8 and 9, spot apically three-pointed, one point on either side (half the length of the segment on 8, nearly the entire length on 9), and the middle one on the dorsum; female with a pale lateral stripe the length of the abdomen, interrupted at bases and apices of segments, and placed lower on 6 and 7. The distribution of this species, as now known, is such as to make its discovery in Indiana possible.

2. *Nehalennia irene* Hagen. Winona Lake, June 22, 1901; Wooden Lake, July 4, 1901. Clarence Kennedy.

3. In plate I are figured the male abdominal appendages, lateral and dorsal views, of four species of *Enallagmas*. Two of these, *calverti* and *aspersum*, have been taken in the State, and the occurrence here of *cyathigerum* and *doubledayi* is probable. The species here designated as *cyathigerum* is the same as *annexum*. I believe that *annexum* (North American) and *cyathigerum* (European) are identical. *Hageni* and *cyathigerum* are very closely related—much more closely than *calverti* and *cyathigerum*. *Doubledayi* finds its closest allies in *carunculatum* and *civile*

4. In the report of the State Geologist for 1897, p. 404, I have recorded *Enallagma laterale* Morse for Shriner Lake. This is a mistake in determination; the single male is *carunculatum*.

5. The seasonal range of *Enallagma traviatum* is possibly not so short. I have records of it at Winona Lake from June 24 to July 13, 1901. It is much less conspicuous than any other *Enallagma* with which I am acquainted.

6. On and about July 6, 1901, Mr. Kennedy and myself noticed on several occasions the increased activity of *Enallagma pollutum* and *signatum* as twilight came on. In the spatter-dock beds, where, during the mid-day hours only an occasional wandering male would be seen, just before sundown many pairs clung to the broad leaves or flitted in couple far out over the lake.

7. On August 25, 1901, at Cedar Lake, Whitley County, Mr. Kennedy and myself took, in two or three hours' time, 65 specimens of *Ischnura kellicotti* about water-lily beds at the southwestern end of the lake.

8. The distribution of *Herpetogomphus designatus* as now known is such that this species may be looked for in southwestern Indiana. In the key to genera, *Dragonflies of Indiana*, it will run out to *Ophiogomphus*. Professor Needham has pointed out that the two genera, *Ophiogomphus* and *Herpetogomphus*, may be distinguished by the form of the post anal cells. This character is indicated in figs. 2 and 3, pl. I. In the case of *Ophiogomphus* the two branches of the anal vein form a distinct loop. *Ophiogomphus rupinsulensis* was taken, June 23 and 30, 1901, along the Tippecanoe River, near Warsaw.

9. *Dromogomphus spinosus* has been observed during 1901, as follows: Tippecanoe River, June 23 and 30; Chapman Lake, June 30; and Ft. Wayne, along the old canal feeder, July 18. During July the species was taken several times at Winona Lake.

10. *Lanthus albistylus* Selys has been taken in Maine, Pennsylvania and Tennessee; and its occurrence in Indiana is very probable. In the *Dragonflies of Indiana* this species will run out to the genus *Gomphus*. *Lanthus* and *Gomphus* may be separated by the form of the post-anal cells (see figs. 4, 5, 6 and 7, pl. I). In *Lanthus* the portion of the second branch of the anal vein bounding the

first anal cell on its outer side (M) is longer than that portion of the anal vein bounding the outer side of the same cell (S). In *Gomphus* M is always shorter than S, unless a vein between post-anal cells meets S, as in fig. 4. The *Gomphi* occurring in Indiana can be readily separated into three groups on characters of the post-anal cells.

I. Second branch of anal vein not angled where the first cross vein between post-anal cells meets it (at point T); normally two post-anal cells in the first series (fig. 4). (North American and European.)

II. Second branch of anal vein angled at point T; normally one post-anal cell in first series, two in second (fig. 5). (North American.)

III. Second branch of anal vein angled at point T; normally one post-anal cell in first two series, followed by two (fig. 6). (North American.)

Lanthus is similar to this Group III of the genus *Gomphus*. It may be separated by the character indicated above.

The species of *Gomphi* known to occur or possibly occurring in Indiana may be arranged in these three groups, as follows:

I. brevis.	II. (?) pallidus.	III. externus.
viridifrons.	villosipes.	fraternus.
quadricolor.	(?) cornutus.	crassus.
exilis		ventricosus.
sordidus.		vastus.
spicatus.		dilatatus.
graslinellus.		amnicola.
furcifer.		plagiatus.
(?) pallidus.		notatus.
		spiniceps.

Prof. Hine and Mr. Tough have studied *G. cornutus* and *G. pallidus* for me. From their sketches I believe both species will come in Group II, but the material is so scanty I can not be sure of this.

11. *Gomphus viridifrons* Hine. Pl. I, figs. 16 and 17. Described in the *Ohio Naturalist*, Vol. I, No. 4, p. 60, Feb., 1901. The color description is quoted below.

"Length of the abdomen, about 33 mm.; hind wing about 27 mm.; black, face and occiput green; prothorax with anterior margin and three spots, green or yellow; thorax green with spaces at base of wings, lateral suture and six bands before, black; the two middle bands are abbreviated anteriorly and separated by the mid-dorsal carina, which is very feebly green. Abdomen black, a dorsal band and sides of first two or three segments yellowish; a yellow spot at base of each of segments, four to seven; and sides of 8 and 9, usually yellowish. * * * This is *Gomphus sp.* Williamson, Dragonflies of Indiana, p. 294." This species is most closely related to *abbreviatus*, which species, however, is not known west of the mountains. From *brevis*, another close relative, which has been taken in western Pennsylvania, it may be separated at sight by the green face, the face in *brevis* being sharply marked with black.

12. *Gomphus descriptus* Banks should be dropped from the Indiana hypothetical list. It was recorded from Illinois on an erroneous determination. The species has not been recorded west of the mountains.

13. Mr. Tough, in a recent letter kindly calls my attention to an error in the description of *Gomphus dilatatus*, p. 286, *Dragonflies of Indiana*. Second line from bottom, for *apical* read *basal*. Mr. Tough reports taking two males of this species in Illinois, and one of these has a small but distinct yellow basal spot on the eighth abdominal segment. The few specimens I have seen of *dilatatus* have had eight immaculate above.

14. *Gomphus segregans* Needham is a synonym of *Gomphus spiniceps* Walsh.

15 On June 17, 1901, at a ripple near the Clover Leaf railroad bridge over the Wabash River at Bluffton, I took *Gomphus fraternus*, *G. crassus*, and *Progomphus obscurus*. *P. obscurus* was the most abundant and *G. crassus* the rarest. The next day at the same ripple, at the same time of day, under conditions which to me seemed the same as the day before, I took *G. graslinellus*, *G. crassus* and *P. obscurus*. But *G. fraternus* was not seen, and *G. graslinellus*, not seen on the 17th, was the commonest species of the three on the 18th. Specimens of the four species were all bright and clean, not at all worn. The why, whence and whither of imago *Gomphi* is a puzzle. On both these dates in the crowded willow herbs at the ripple *Argia putrida*, *apicalis*, *tibialis*, *sedula* and *violacea*—the five *Argias* known for the State—were pairing.

16. During the season of 1901 *Progomphus obscurus* was observed at Bluffton, June 17 and 18; Tippecanoe River, near Warsaw, June 23 and 30; Chapman Lake, June 30, where half a dozen exuviae were gathered on the sand beaches near the water's edge; old canal feeder and St. Joseph River near Ft. Wayne, July 19.

17. An exuvia of *Hagenius brevistylus* was collected from a pile in Tippecanoe River, June 23, 1901. On June 30 Mr. Kennedy took an imago along the river, and on the same date several were seen in a second growth brush lot, flying leisurely about—if no insect collector was in striking distance—and frequently alighting on twigs, stumps or an old rail fence.

18 During the summer of 1901 *Boyeria vinosa* was not rare in the low woods about the Biological Station at Winona Lake. Students collected a large number of nymphs of all sizes at Turkey Lake, July 19, 1901.

19. A single exuvia of *Basiaeschna janata* was found along the Tippecanoe River near Warsaw, June 23, 1901, identified by Professor Needham.

20. On August 24 and 25, 1901, Mr. Kennedy and myself collected several males of *Aeschna clepsydra* at Shriner Lake, Whitley County. This makes the Shriner-Round Lake list number 47 species. As observed on these two days, *clepsydra*, as his brighter color pattern would indicate, is a more dashing fellow than his common congener *constricta*.

21. *Macromia illinoiensis* Walsh. Wabash River, Bluffton, June 20, 1901; Tippecanoe River, near Warsaw, June 23, 1901; old canal feeder and St. Joseph River, near Ft. Wayne, July 19 and August 11, 1901. *Macromia taeniolata* Rambur. Old canal feeder and St. Joseph River, near Ft. Wayne, July 19 and August 11, 1901; associated with *illinoiensis*, *taeniolata* being the most numerous. This large dragonfly, floating idly or cutting through the air without apparent effort, always flashing the sunlight like darts from glimmering wings and metallic body, can not fail to draw the interest and admiration of any idle observer who may wander along its haunts. Its alertness usually brings dismay to the collector who has waited patiently in waist-deep mud and water for its coming, and whose deep and fervent reproaches follow the beautiful form as it sails away, first tree-top high, then skimming the water with its strong front wings, in pure derision of the impotent wretch who plotted so clumsily against its life.

22. During the whole of July, 1901, and possibly later, *Epicordulia princeps* was on the wing along the reed-grown shores of Winona Lake. This species spends more hours per day on the wing than any other species in Indiana. In the gray twilight, before sunrise, while the black bass were noisily gathering their breakfasts in the shallow water, as we sat in the boat casting to right and left with an indigestible, hook-enshrouded minnow, *princeps*, misty and indistinct, floated by. After sunset, when we went to the shore with the shotgun to snapshot at bats, there he was again, out over the water, hurrying along in the gathering dusk as though his day were not yet completed.

23. On September 3, 1901, at an old gravel pit near Bluffton, I observed *Sympetrum vicinum* ovipositing. The male held the female by the head as they hovered a minute in front of a curtain of algae, formed by a mass of the plant clinging to the edge of an old plank as the water had become lower in the pit. This curtain was about nine inches high, the lower edge of it trailing in the water. The dragonflies moved swiftly forward and the abdomen of the female

was tapped quickly against the curtain. At once they moved backward and downward, and the female struck the water with her abdomen. Then they rose again, hovered a moment a few inches in front of the curtain, and repeated the performance. After some time they separated and alighted among some cat-tails growing near. Oviposition was not interrupted by copulation. Part of this curtain of algae was collected. Portions of it were literally piled up with the dragonflies' eggs. Doubtless some of the eggs were washed from the abdomen into the water, but the majority were placed on the algae. Eggs had been placed at the top of the curtain, but this had become thoroughly dry. Females, which I saw ovipositing were placing the eggs two or three inches above the water where the curtain was very damp. The hatching of the egg, and possibly the first moult of the nymph, takes place on this curtain.

24. Though the subject of Odonate copulation has been considered by many authors with "presque toujours une description detailée et souvent poetique," I have been unable to find any statement concerning the filling of the seminal vesicle of the male dragonfly, other than that this takes place before copulation. In the case of *Calopteryx*, *Argia* and *Enallagma*, where I have been able to make positive observations, the male fills the seminal vesicle at once after he has captured the female. It seems probable that during the wild flight of mating *Aeschnas* and some of the gomphines (I have noticed especially *Dromogomphus spoliatus*) the seminal vesicle is being filled, and, this accomplished, the pair come to rest in tree-top, on the ground, or where not, and copulation takes place. The Anisoptera, which I have observed, do not copulate while flying, if they are undisturbed.

EXPLANATION OF PLATE.

1. *Argia translata* Hagen. Ohio Pyle, Pa., September 8, 1901, J. L. Graf. Lateral view of ♂ abdominal appendages.
2. *Herpetogomphus designatus* Hagen. Portion of right wing; *t*, triangle; *i*, internal triangle; *a*, anal vein (or postcosta); b, first branch of anal vein; c, second branch of anal vein; p, post-anal cells (middle post costal space).
3. *Ophiogomphus rupinsulensis* Walsh. Portion of right wing. Lettering same as for fig. 2.
4. *Gomphus spicatus* Hagen. Portion of right wing. Lettering same as for fig. 2.
5. *Gomphus villosipes* Selys. Portion of right wing. Lettering same as for fig. 2.
6. *Gomphus scudderi* Selys. Portion of right wing. Lettering same as for fig. 2.
7. *Lanthus albistylus* Selys. Portion of right wing. Lettering same as for fig. 2.

8 and 9. *Enallagma doubledayi* Selys. Provincetown, Mass., August 4, 1899, J. E. Benedict. Lateral and dorsal views of ♂ abdominal appendages.

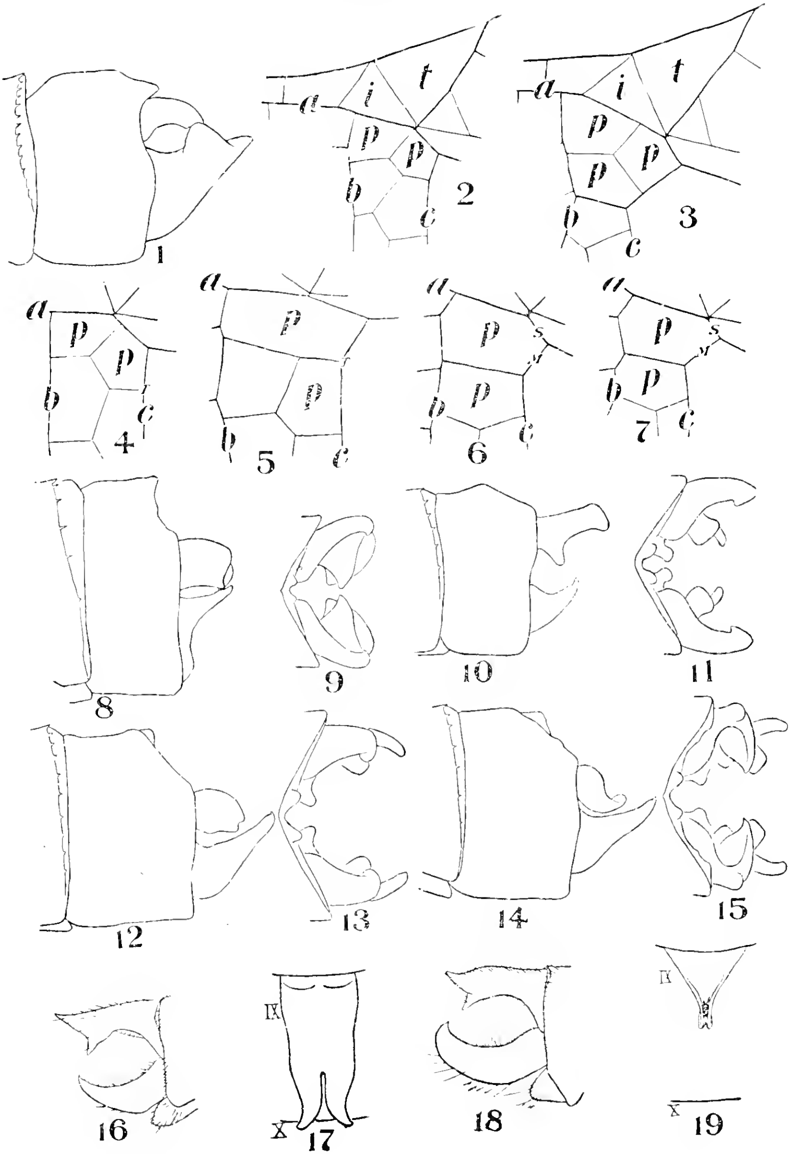
10 and 11. *Enallagma aspersum* Hagen. Conneaut Lake, Pa., August 18, 1899, D. A. Atkinson. Lateral and dorsal views of ♂ abdominal appendages.

12 and 13. *Enallagma calverti* Morse Sheep Creek, Wyoming, August 6, 1899, E. B. Williamson. Lateral and dorsal views of ♂ abdominal appendages.

14 and 15. *Enallagma cyathigerum* Charpentier. Sheep Creek, Wyoming, August 6, 1899, E. B. Williamson. Lateral and dorsal views of ♂ abdominal appendages.

16. *Gomphus viridifrons* Hine. Ohio Pyle, Pa., June 25, 1900, E. B. Williamson. Lateral view of ♂ abdominal appendages.
17. *Gomphus viridifrons* Hine. Ohio Pyle, Pa., June, 1900, E. B. Williamson. Vulvar lamina.
18. *Gomphus brevis* Selys. Ohio Pyle, Pa., June 24, 1900, E. B. Williamson. Lateral view of ♂ abdominal appendages.
19. *Gomphus brevis* Selys. Ohio Pyle, Pa., June 28, 1900, E. B. Williamson. Vulvar lamina.

PLATE I.



C. Flora of Eagle Lake and Vicinity.

H Walton Clark.

The work embodied in the following report was accomplished by the writer, assisted by Mr. Charles M. Ek, during the summers of 1899 and 1900, under the auspices of the Indiana University Biological Station. The purpose of the work is to present a study of Eagle Lake as a unit of environment as regards plant life, and the special line of investigation was that of the various plant aggregates of the lake, including their relations to each other and to that body of water. Many thanks are due to Dr. C. H. Eigenmann, Director of the Station, and to Dr. Mottier, Head of Department of Botany of the the Station, for assistance in suggesting and mapping out lines of work.

As regards the plan of the work, it will be helpful to the reader to bear in mind that the survey of the area studied was made in a series of concentric rings, beginning at the northeast corner of the region described, that is, at the laboratories, and starting southward. All descriptions have this beginning and sequence, and the sides of the lake are described in the following order: (1) east side, (2) south side, (3) west side, (4) north side.

Eagle Lake is one of the many small lakes of northern Indiana which occupy depressions in the surface of the glacial drift. It is somewhat irregular in outline, and consists of a large main body, a somewhat narrow neck or channel, and a large bay at the west end. According to Mr. Large, who made a survey of the lake several years ago (Proceedings Ind. Acad. Sci., 1896), the area of the lake is about 0.897 square mile.

Before entering into a detailed description of the lake and its flora, however, it may be well to consider briefly the surrounding country. This description of the region surrounding the lake is not intended to be exhaustive; it is simply presented as a sort of frame for the picture of the lake itself. The whole region from the lake shore to and including characteristic portions of the high ground beyond the limits of the lake plain, moreover, not only represents a sort of unit area in itself, but at the same time includes an interesting variety of conditions and furnishes interesting bits of well marked biological areas that are to be found on a large scale elsewhere, but which here in their limited size offer very favorable opportunities for study.

Eagle Lake and its plain are nearly surrounded by a rather abrupt terrace of yellow sand, which rises at varying distances from the lake shore and beyond which extends the undulating upland, forming the characteristic topography of the region in general. In only three rather narrow points does the terrace approach very near to the water's edge. These places are (1) along the northern part of the lake, near the northern end of the Assembly grounds, (2) at the place known locally as Yarnelle's landing, or Yarnelle's point, and (3) near the outlet. At all other places it recedes from the lake, leaving a large, level, lake plain. The rampart of hills, or terrace, is cut through in three places: (1) Cherry Creek valley, (2) the valley of Clear Creek, and (3) at the outlet. In the direction of Warsaw there is a long stretch of low ground, the exact natural limits of which it is impossible to define on account of many artificial changes, but which contains Market-street pond, an interesting body of water, and extends farther on toward the lakes on the other side of Warsaw, such as Pike Lake, Center Lake and others.

Along the southeast and south shore is a high, narrow ice ridge between the lake and the lake plain. The ice ridge is present elsewhere also, but is nowhere else so plainly marked. Fig. 1 shows a bit of old tolerably well marked ice ridge in this region.

In the discussion the regions about and including the lake will be noted in the following order: (1) The terrace and upland, along with the gullies through them. (2) The lowland between the terrace and the lake, consisting of lake plain and lowland forest. (3) The lake shore and belt of shore plants. (4) The ponds and bayous belonging to the lake plain. (5) The belt of marsh plants (plants with emersed leaves), and of short-stemmed aquatics. (6) The belt of long-stemmed aquatics. In the general discussion, simply typical species will be mentioned. The lake plants proper will be discussed more thoroughly later.

The terrace is composed of a yellow sand with an admixture of some clay. The slope from the lake plain is occasionally gradual; always, however, there is finally a rather steep and bluffy ascent. At Yarnelle's point there is no gradual slope at all, but the bank rises sheer from the water's edge.

THE UPLAND.—In the state of nature the upland is covered with a forest of such trees as the various oaks and hickories, some walnuts, a few tulip trees, wild cherry, ash and elm. In some cases there is no undergrowth of shrubs, and very little grass or herbs, as the forest floor is covered with a thick carpet of dried leaves. At other places, especially near the sides of gullies, there is an undergrowth of such shrubs as prickly

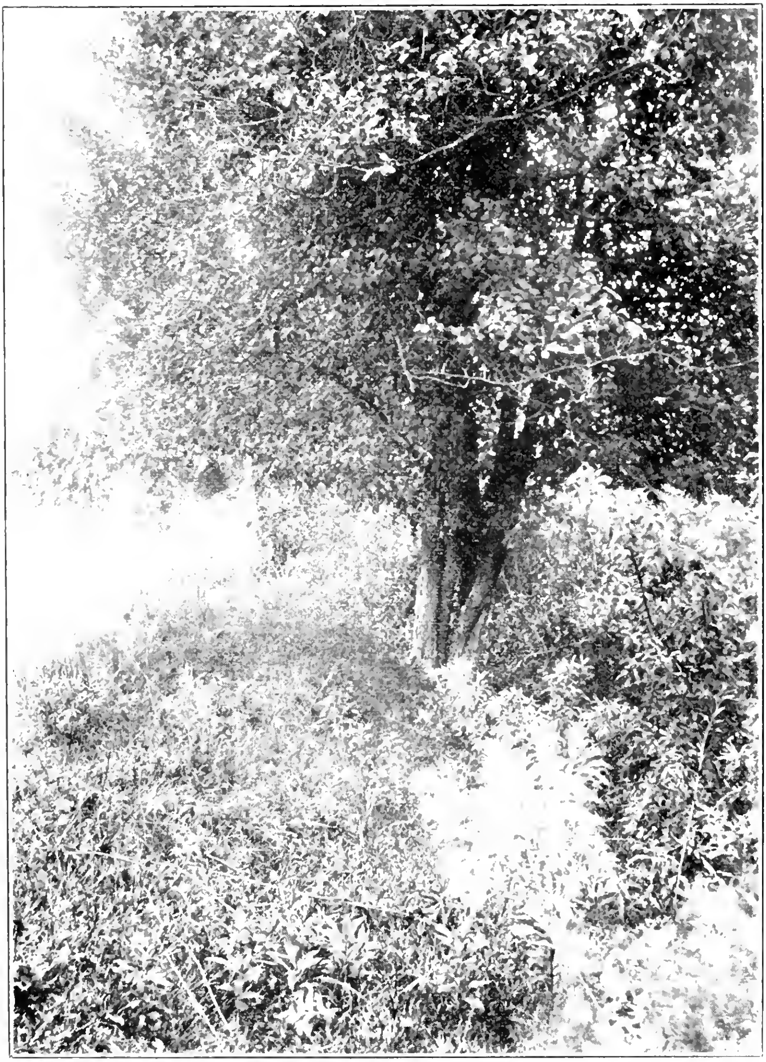


Fig. 1.

ash, raspberry and blackberry, some hoptree (*Ptelea*) and witch hazel, while the forest floor is covered with a carpet of common bladder fern, *Cystopteris fragilis*, some maiden-hair fern (not very common), Indian turnips, wood rush, various galiums, pinks, may-apples, hawkweeds, wood sunflowers, tick trefoils, and so on. *Anychia* is abundant in some places. In other places are a few scattered patches of *Sabbatia angularis*, frostweed, pinweed and *Hepatica hepatica*, the round-lobed liver leaf. This is the predominant species of the genus here; in fact, the only species the writer has seen at all, while in other parts of the State, except in Marshall County, the only species the writer has seen was *H. acuta*. In a hasty trip to Chapman's Lake, not far from Eagle Lake, plenty of *Hepatica acuta* was seen and no *H. hepatica*. (At Chapman's Lake, too, *Impatatiens pallida* was the only species seen. At Eagle Lake I have seen only *I. fulva*.)

Syndesmon thalictroides, which is usually regarded an early spring bloomer, flowers occasionally in late summer in various forests near the lake. During the summer of 1899 a specimen was found in the woods south of Cherry Creek, about one-half mile from the lake, in flower in August. In 1900 a plant was found in full bloom June 29, over near the Pennsylvania railroad, and another on July 30, up Clear Creek ravine.

Toward the foot of some of the hills, and in rather open spaces, is found an abundance of such plants as the black huckleberry (*Gaylussacia resinosa*), mullein foxglove, downy false foxglove, wild flax, frostweed, and in some places *Frasera*. Here, too, is an abundance of dense tufts of various mosses, while a small cup lichen, *Cladonia*, covers the earth with a continuous gray mantle. Toward the outer edge of the forest and at the foot of the hills is a sparse growth of wild oat grass and *Fimbristylis*.

The heavy forest southeast of the lake contains about the same species of trees as those mentioned above as characteristic of the hill forest. Here is a large number of introduced plants, as motherwort, burdock, and sweet briar rose. The forest near Yarnelle's point contains a basin where pin oak is almost the only species, while in the forest near the outlet there is coral root in considerable abundance. There is an abundance of fungi in all the forests, of Myxomycetes, Boleti and various Agarics.

In certain places the forests have been removed from the hills, where it has been left to grow up again without apparently having ever been cultivated much; we have a growth peculiar to such places everywhere. In one such region sassafras, not frequently to be met with in the native forest, has taken the place and grows so thickly as to shade out all undergrowth except a few spindly, discouraged-looking plants of red sorrel, *Rumex acetosella*. The lower leaves of this copse of sassafras took on beautiful autumnal coloration quite early in 1900. It was quite noticeable toward the end of July. Other parts of this once cleared place are covered with a thick sod of Kentucky blue grass.

There is also in the region just described (east of the lake) a sparse growth of scrubby oaks with clumps of raspberry and blackberry and wild grapes here and there.

The Russian mulberry has established itself here and forms an abundant sprinkling through the copse. The trees have in all probability sprung from seed scattered by birds. A peculiarity of this place is the tendency of plants of one species to form continuous patches to the exclusion of almost everything else. The sassafras has been cited as an example of this. One finds here and there a large bright green spot where dewberry vines have crowded out everything else. In other spots large patches of common five-finger (*Potentilla canadense*), in others *Steironema ciliatum*, and in others of prostrate tick trefoil cover the ground exclusively.

Where the ground has been wholly cleared, and cultivated, and then abandoned, we have, besides the ever present ragweed and *Chenopodium*, such rosette plants as mullein, pasture thistle, and canada thistle. Pepper grass is abundant, shepherd's purse scarce. There is also an abundance of such mat plants as purslane, carpetweed, and spreading spurges. Species of *Eragrostis* spread out in the form of mats. Crabgrass is abundant, and where the ground is cultivated, one of the most persistent and annoying weeds. *Euphorbia corrolata* is particularly abundant and conspicuous.

The gullies and immediately adjacent forests have a flora of their own somewhat different from the rest. The gully of Cherry Creek is a broad, level, swampy tract of country, covered with willows, sedges, skunk cabbages and various other marsh plants. It has a mucky soil, and resembles an extension of the lake plain.

Along the sides of this gully is considerable underbrush in the forest. There are plenty of such small trees as juneberry, flowering dogwood, ironwood, water-beech and haws, and such shrubs as hop-trees (*Ptelea*), witch hazel, bladdernut, and so on. Far up the gully is a specimen of the laurel-leaved oak, *Quercus imbricaria*, and one of alternate-leaved dogwood, neither of which are particularly common in the region. At the foot of the hills are a few ferns, lady-fern, maiden-hair and brittle bladder fern (*C. fragilis*). In general, however, the delicate wood ferns are not abundant in this region. *Mitella diphylla* fringes the slope of the hills here and there. Both in this gully and at places in the lake plain, as the southern end of the Assembly grounds, are soggy hills covered with a growth of sedges, shrubby five-finger, grass of parnassus, and so on. Numerous springs issue from these hills. In the bottom of the gully, and near the creek itself, is an abundance of swampy ground, with *Sagittarias* and other marsh plants. Here is an abundance of the liverwort, *Conocephalus*.

One dry hillside along this gully is completely covered with hounds-tongue. The hillsides from which springs issue bear in places large patches of horse-mint (*Monarda fistulosa*) and are made purple in August by masses of iron-weed in bloom.

The upper part of the gully of Clear Creek is different both in appearance and flora from that of Cherry Creek. Here the creek cuts its way through hills of sand and gravel. The bottom of the tolerably wide gully is mostly sandy soil, and the creek bottom is solid and often contains sand-bars and gravel-banks. The different slopes have a somewhat different flora. There are a few large basswood trees, and some beech and a few box-elder on the east side. On the slope on this side are found rock cress, *Blephilia*, nettles, beech-drops, and so on. On the west side of the gully were found spice bushes, *Celastrus scandens*, or climbing bitter-sweet, hedge hyssop, tall scouring rushes, blood-root, celandine poppies, remains of trillium, wood anemones, dutchman's breeches, and the like.

The sides of the outlet, where there is a broad marshy region without any pronounced gully, showed no plants different from those common to the region, except there was an especial abundance of the reindeer lichen, *Cladonia rangiferina*. There is here a broad, densely overgrown, swampy tract, full of willows.

At different places between the sand hills and the lake are the *low ground forests*, the bottoms of which seem to be slightly higher than the surface of the lake plain itself. One of these forests is to be found in the vicinity of the laboratories and another down along Clear Creek. This forest differs considerably from the high-ground forest in both soil and vegetation. The soil is a rich, black, sandy loam. The trees are burr oak, ash, aspen, willow, elm, plum, and so on. At the junction between the low-ground and high-ground forests we have at one place, near Chicago

Hill, a clump of red-bud trees. At another, on the border line between the upland and lowland forest, the ground is thickly covered with ground ivy, *Nepeta gleichoma*.

Here in the low-ground forest we have, especially in the first forest mentioned (that near the laboratories), a dense undergrowth of hazel-nut, prickly ash, hop tree and many other shrubs, so that the wood was somewhat difficult to pass through. The forest floor is also thickly covered with a quite dense growth of vines and tall weeds of numerous species, among which may be mentioned virgin's bower (*Clematis virginiana*), grape, hop, spotted touch-me-not, false nettle, American bell flower, great blue lobelia and cardinal flower, rice cut-grass, and many other such plants.

The low-ground forest in the vicinity of the laboratories was much modified during the summer of 1900, as a good deal of the underbrush was removed. In all cases it goes entirely down to the fringe of willows which grows at the edge of the lake.

The second low-ground forest, at the southern or west of southern side of the lake, not far from the region of Clear Creek mouth, consists of nearly the same sort of trees as the other, but the ground is rather more marshy, black and level, and the vegetation of the forest floor is of a somewhat different sort. There are more soft maples and large willows here, and lizard's tail is a characteristic plant. A small part of the shore is sandy here, and there is, between the lake shore and the low ground, back from the lake, a high, narrow ice ridge, four or five feet wide and breast high, and quite steep on each side. There are tolerable good ice ridges in other places, as south of Chicago Hill pier a little way, shown in Figure 2 (Fig. 2 shows lake plain on the left with willows on the ice ridge on the right), and over by Yarnelle's point, but these are not nearly so well marked.

The greater part of the country between the lake and the hills is a flat, level, meadow-like tract, forming the *Lake plain*. The soil of this plain is generally of a black or brown muck, with plenty of marl in places. Ditches dug through it reveal an abundance of gasteropod shells, many of them yet entire but very fragile, and many of them broken. These attest the former existence of the lake over the lake plain.

Traditions of old settlers refer to a time when the lake shore came up, in places at least, to the foot of the hills. One such tradition refers to the lake reaching the base of the hill known as Hamilton Mound, and the date assigned is about 1836. It is not reported whether this was simply the result of a temporary flood or a constant condition. The area of the surface is subject to quite marked variation at present, possibly more so than before the removal of much of the surrounding forest. The Government Survey shore line of 1834 lies at places considerably outside present maps of the lake. Mr. Large expresses his opinion that it perhaps marked the limit of the swampy ground.

In appearance and vegetation the various parts of the lake plain differ considerably from each other. In some places the soil is a reddish or brownish muck, in other places it is a blackish soil. In some parts it is a

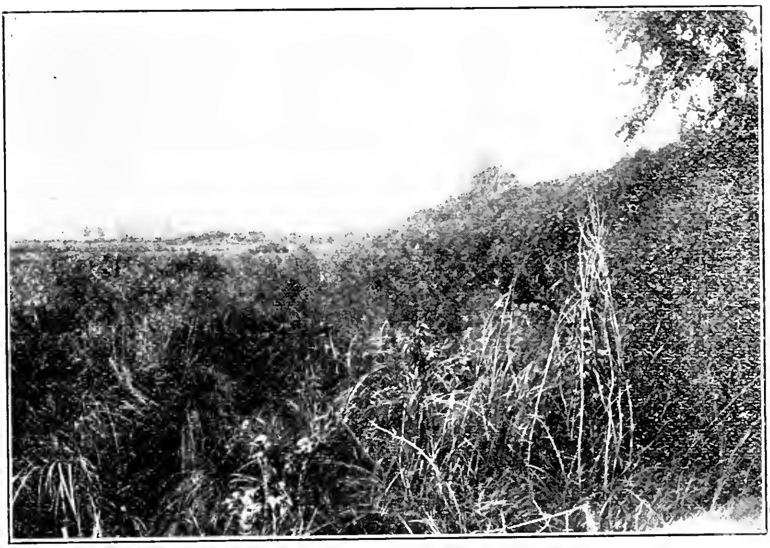


Fig. 2.

sedgy, ferny meadow, in others it is covered with a dense growth of bushes, as clumps of willow, *Cephalanthus* and *Cornus*. There seem to be indications, however, that it was once nearly alike in vegetation, and that the sedgy, ferny meadow has been cleared off by artificial means. One indication of this is that we have wholly different regions on different sides of fences, one side of the fence being bushy, and the other covered with sedges, grasses and ferns only. In one place where there was such a level meadow, a few dead willow sprouts were noticed. Examination revealed that they were charred about the roots and had probably been killed by fire, which had passed through and left the ground rough and tussocky. Between this meadow just described and the lake, near the lake shore, were plenty of low bushes, which had probably been saved by the proximity of the lake and possible resulting saturation of the ground, or more probably by the amount of sand in the low ice ridge upon which they grew. A few characteristic portions of the lake plain will be described in order:

(1) At the Assembly grounds, where the lake plain was once quite broad, it has been modified by filling in, and by the construction of base ball grounds and race track. This portion is now a level field overgrown with grass.

(2) The portion of the lake plain bordering on the southern end of the Assembly grounds was once brushy like the portion next to be described now is, but the brush has been cleared off. At present it is a level tract, covered thickly with sedges and ferns. Toward midsummer it is made purple in patches by the blossoms of loosestrife, *Lythrum alatum*. Later in the year there is a zone of blue about the height of one's head from the many blossoms of tall blue vervain, while later still the ground is yellow in places with blossoms of the cone-flower or black-eyed susan, which grows in great abundance here, and blossoms quite late in the season.

Farther on down, near the Biological Station, the lake plain is more in its natural condition. Here, at the foot of the hills, is a belt of sensitive fern extending for a good way along the edge of the plain. The whole plain is pretty densely covered with low clumps of *Cornus*, willows, Carolina rose, and button-bush. An examination of this region shows three distinct formations of vegetation. Upon a casual glance one sees very little but bushes. A close examination, lower down toward the ground, will show a thickish growth of tall sedges and a few coarse grasses, while an examination still nearer the surface of the ground will reveal a growth of slender prairie fern. These formations are shown to particularly good advantage where artificial agencies have been at work. Where the bushes only are removed, one sees for the most part simply a level stretch of tall, narrow-leaved sedge, with a few stalks of tall grass here and there. Where the grass has been mown one sees an unbroken patch of fern.

In the vicinity of the laboratories a low-ground forest, already described, comes down entirely to the water's edge. South of this is another stretch of lake plain. This plain is mostly devoid of bushes, except a narrow fringe along on the low ice ridge. It is covered with sedges, tall grasses and an under-formation of marsh fern. The distribution of plants in this region is somewhat patchy in places. There are several areas covered with the royal fern, *Osmunda regalis*, at the outer edge, near the hills. This fern grows so thickly here that at certain times the ripened sporangia give the whole landscape a brownish cast. Toward the lake is a pond of considerable size fringed with cat-tails and a whitish sedge, along with *Eleocharis* and *Sagittaria*. Near the lake shore, as has been said, is a fringe of willows. In this portion of the plain, during the month of August, the wand-like stems of blazing star, *Lacinaria spicata*, with long spikes of violet purple flowers, rise here and there and give a peculiar effect.

The portion of the lake plain south of the lake is continuous with that just mentioned and extends to Clear Creek. Along its outer margins it is much like the portion just described—a sedgy, flat stretch of country. To this during the late summer an abundance of swamp milk-weed and joe pye weed tint the whole landscape a light purple. Near the lake is a large pond or marsh where grows in one place great patches of *Sagittaria*. Here are the most extensive patches of bulrush, cat-tail, *Sparganium* and *Calamus* in the vicinity. Beside growing by themselves in places, these plants also grow together in other spots, forming a mixed flora. The soil is more than saturated with water, and is very miry. There are not many willows here, but just a little distance west, near Clear Creek, the large marsh extends back a long distance, and consists of an almost impenetrable willow thicket. Back of this willow thicket is a low-ground forest, already mentioned. At the extreme west end of this marsh it becomes more open and prairie-like, and has the appearance of having been burned over. Among the tall sedges of this place is an abundance of such plants as prairie fern, prairie dock and a tick trefoil (*Meiboma canadense*), very showy when in bloom. Some of the ground is mossy. One large tamarack with several smaller ones, probably its seedlings, are growing here isolated from others of the kind. The ground is not like that generally found in tamarack swamps.

At the termination of this marsh, a hill, part of it under cultivation and part of it upland forest, comes down near to the lake. From this place the hill and high-ground forest extend along the lake shore to some distance beyond Yarnelle's point, and for a space the lake plain and low ground wholly disappear.

Beyond Yarnelle's landing, and near the neck of the lake, the lake plain begins again and broadens considerably. Part of the plain has been cleared and pastured and mown so that little is left but the sedges. Part of it is covered densely with willows. It is not different in appearance from other portions of the lake plain, and is different in vegetation only in that in the wet portion adjacent to the lake two *Utricularias* are found among the sedges, one, *U. vulgaris* sparsely, and probably left by the lake as it retreated after a flood, and the other, *U. intermedia*, forming a dense and continuous mat over the ground. Here, too, is a large cat-tail and bur-reed marsh, and the bottom of the ground among these plants is thickly covered with moss, a long, bright green species. Wild senna is abundant in this place. The open plain continues until near the outlet, where it has never been cleared, and consists of a dense willow thicket. The plain on the western side of the lake is cleared, and at one place extends through a narrow neck between the hills for a considerable distance from the lake.

The lake plain along the northern shore is so much like that of the other part that no detailed description need be given, except to say that that portion along the neck of the lake, that is, the western end, is still a willow thicket, while the remainder is cleared. In the direction of Warsaw, along the middle part of the north shore of the lake, the hills make a large loop, so that the lake plain spreads out into a large round bay, with a narrow neck or channel. Here is one large and many small tamarack trees and many alders. The ground, however, is tolerably dry and there is no marsh in this region. One bunch of *Sphagnum* was found growing high and dry at the foot of the hills in the sandy ground, forming a tussock around the base of a tree. The plain narrows as one goes eastward until the hills nearly reach the lake near the railroad station at Winona.

From Eagle Lake, toward Warsaw, extends an interesting stretch of level ground. The surface is higher than that of the plain, but it is swampy and mucky. Part of this was once an old tamarack marsh; and, although no tamarack trees remain, it still abounds in *Sphagnum*, choke berries, chain fern, hispid dewberries and huckleberries. It has probably once been the home of many of those interesting plants generally found in tamarack marshes—pitcher plants, orchids of various species, cranberries, and perhaps droseras.

At this place the railroad intersecting the region brings in its interesting accompaniment of introduced plants. Among these are *Lupinus perennis*, squirrel-tail grass, *Salsola kali*, and so on.

Along the lake shore there is in many places a narrow fringe of willows and dogwoods. These probably once formed a continuous stretch, but have been removed by artificial means. Just edging the lake, too, was found, during the summer of 1899, an abundance of creeping *Selaginella*, but it was not nearly so abundant in 1900.

PONDS.—Just as the lake occupies a large hollow in the surface of the drift, so are lesser hollows in the surface of the lake plain, and in the region surrounding the lake, occupied by *ponds*. In some of the shallower ponds, and those remote from the lake, the supply of water is temporary and they are dry basins during the drier parts of the year. The ponds are exceedingly varied in appearance and flora, and are interesting objects to study. They are really lakes in miniature, and may represent future stages of the lake itself. Lack of space, however, will prevent the discussion of this interesting feature of the region, except to say that their quiet waters contain in abundance many interesting aquatic forms which are not to be found in the lake, or which occur there only in limited quantity. Among these plants are the various duckweeds, *Lemna minor*, *L. trisulca*, *Spirodella polyrhiza*, *Wolffia columbiana* and *W. braziliensis*, which are to be found in the ponds and lagoons on the eastern side of the lake. Other ponds contain an abundance of liverwort, two species, *Ricciocarpus natans* and *Riccia fluitans*, being abundantly represented. Some of the ponds containing foul water have *Utricularia vulgaris* in abundance. Here the bladders are black and full of dark, solid dirt, and the plants blossom profusely. This plant is found only scantily in the lake itself, and in this situation the bladders are empty and more or less transparent. The whole plant is bright green and I have not seen it in blossom at all. One of the ponds (Market street) contained *Brasenia* in abundance, and it blossoms profusely. A small patch was found in the southwestern part of Eagle Lake, but I have never seen it in bloom there. One of the ponds east of the lake contained large balls of nostoc in great abundance.

THE LAKE PROPER.—Preparatory to the task of mapping the various plant aggregates of the lake, it was found necessary to measure along the shore line, and so become acquainted with the relative distance of various objects. This work was done quite carefully and lengthy notes taken concerning the nature of the shore. Stations were established and full descriptions written of neighboring objects, so as to make their recognition possible. This was the most laborious and tedious part of the work, and not particularly fruitful of direct results, for of the great mass of notes taken the greater number would be tedious and uninstructive to the reader. The value of this work was evident, however, during every succeeding stage of the work; for during all the subsequent observations of the lake, every detail of the shore was familiar as nothing else could have made it, and objects could be oriented at a glance from any position in the lake.

Of the many things that might be said in detail concerning the physiography of the lake only a few of the most important and striking, as character of soil along shore, etc., can be noted.

SOIL OF SHORE.—Various parts of the shore, as along the Assembly grounds, at the Biological Station, and south of Chicago Hill pier, are sandy beach. This sand is not like that of the sand hills; it is a solid, whitish sand, with small banks or streaks of quite reddish sand here and there. Other parts of the shore are of a tough, blackish or brownish muck; the greater portion of the shore is of this nature. The shore about Yarnelle's point is rather coarse gravel.

Some parts of the shore are suffering wave erosion. Particular examples of this are the region just south of the mouth of Cherry Creek, and again at the cape just beyond the neck of the lake, and on the southern side. At these places the lake has encroached a good deal on the land in spite of the protection afforded by the roots of bushes, etc. Trees and bushes are undermined and fall over, and there are stumps in the lake bottom for some way out. At other places, as at the south end of the lake and along parts of the north end, the treeless, mucky shore is being worn away. Here the waves act as a "horizontal saw" (to use Le Conte's illustration), leaving a solid, mucky platform in the bottom and a steep, almost vertical step off at the water's edge from the level plain to the bottom. The waves often cut between tussocks of grass and leave minute fiords. At other places the sod or turf is undermined, and moves up and down with the waves. The muck is in places very tough and resisting. Large chunks of the fibrous soil are torn loose from the shore or bottom and rolled by the waves into a peculiar rounded form, much like a rounded rock in shape, and yet not torn apart. The work of erosion along these mucky stretches of shore is hastened and assisted very materially by holes, presumably water-dog burrows, which honeycomb the soil and render it susceptible of being broken up into pieces.

Elsewhere, especially between the patches of *Scirpus lacustris* to be described later, sedimentation is going on quite rapidly, and banks of soft.

black mud are in the progress of formation. The waves throw up the mud in the form of loops and bands, and so form small irregularities in the coast line. An examination of the mud thrown up or built up in these situations shows it to be composed of small pieces of *Scirpus* in various stages of decay. Thus the *Scirpus* furnishes a large amount of material for the building up of new shores. Besides the comminuted and decayed *Scirpus* there are occasional banks of broken *Scirpus* stems, not yet decayed nor much broken up, piled like windrows up beyond the summer water line. These banks are probably piled up during the high water of spring or shoved up by the ice. Upon the soft, black mud banks mentioned above, there springs a dense growth of annual weeds which forms the advance guard of land vegetation in these regions.

It may be that the lake plain has for its foundation decayed *Scirpus* stems, to which is added turf from the sedges that today so thickly clothe its surface.

As has been said, long stretches of shore are made up of a firm, whitish sand. Such stretches are to be found along the Assembly grounds, north of Chicago Hill pier, and in the vicinity of the mouth of Clear Creek. This sand is often found floating in films on the surface of the water near shore. At the mouths of the creeks, banks or deltas of white sand are built up and these project above the surface of the water when the lake is low, and form islands. At other places it can not be said definitely that either erosion or sedimentation is taking place. Gently lapping waves will pile up a narrow ridge of sand just at the edge of the water, but high, strong waves will wash them down again. During active wave motion the advance of the waves will move particles of sand shoreward, while the back flow will move them back about the same distance.

Frequently on the sandy banks, perhaps everywhere in such places where not interfered with, the three-cornered rush *Scirpus americanus*, grows out and forms the advance guard of vegetation.

THE FLORA OF THE LAKE SHORE is not essentially different in species from that of the shallow ponds adjacent to the lake, especially the large pond on the southern shore. The only difference is that the plants in that pond (bulrush, cat-tail, spatterdock, pickerel-weed and arrowhead) form large patches, as they have here a broad region of shallow water and congenial soil. Along the lake shore the plants, all except the bulrush, form comparatively narrow belts. Most of the bulrushes (*Scirpus lacustris*) in the ponds outside of the lake are light in color and soft in texture (there are only a few found of the dark green firm form), while the reverse is true of the bulrushes in the lake.

THE FLORA OF THE LAKE PROPER now comes up for consideration. In the beginning it may be well to state that many of the plants growing in the neighborhood of the shore exhibit decided variations in general appearance. They have two extreme forms, one found growing in shallow water and the other in deep water. Among such plants may be mentioned the following:

(1) *Scirpus lacustris* (light green, apparently glaucescent — easily crushed—form already noted) grows in rich muck in shallow water. This appears to continue in blossom longer than the other, and but one patch is found in the lake proper, though it is abundant in the ponds. The dark-green, firm form, growing in the marl and in deeper water, generally has the umbel more contracted. At a few places these forms seem to intergrade, although there is no gradual shading-off at the place in the lake where they grow side by side.

(2) *Nymphaea advena*, or spatterdock, exhibits a variation in habit really very slight but quite conspicuous, and readily noticed by the most superficial observer. In rich soil and shallow water it is stout and erect, the large petioles holding the leaves high out of the water. In deep water all, or nearly all, the leaves float, and the petioles are lax.

(3) White water lily—the same general change, only more marked. The shallow water form has stout petioles, holding the leaves far above the surface of the water and at an angle, and the leaves show a radical ribbing or faint fluting, not coincident with the veins, but in direction like that of a palm-leaf fan—deep water form, with slender, weak, often coiled petioles and leaves floating on the surface of the water. On sandy bottom the plant is much smaller in leaf and flower, giving the form (Var. *minor* Simms).

(4) Water plantain, leaves exceedingly variable in shape, those under water resembling eelgrass; those floating are much like leaves of some of the *Potamogetons*, while the aerial leaves resemble the ordinary plantain.

The following brief synopsis will suffice to give a general idea of the centripetal sequence of the various plants of the lake. (1) On shore, out of water: *Scirpus americanus*, *Sagittarias*, *Eleocharis acicularis* and cattails. Here, too, may be reckoned *Polygonum amphibium*, with its roots on shore and its prostrate stem floating. It strikingly resembles a *Potamogeton*. (2) On shore and extending away into the water; *Scirpus* *lacustris, Potamogeton fluitans, Nymphaea advena.* (3) Confined to shallow water: *Pontederia cordata, Naias flexilis, Nitella* (a small moniliform species), *Eleocharis interstincta, Eleocharis palustris, E. mutata, Cladium mariscoides, Vallisneria spiralis* and *Potamogeton natans.* (4) Deep-water plants: *Ceratophyllum, Myriophyllum, Potamogeton lucens, P. amplifolins* and *P. pectinatus.* Beyond this last group belongs mostly the floating confervoid algae of the lake.

A consideration of the habits of the plants just mentioned will show at once how their forms correspond to their position. Each group mentioned have certain common characteristics, and may be placed in the same ecological group. (1) The shore plants already mentioned generally have stiff, stout petioles and stiff, generally rather thick, leaves. (In the *Scirpi* and *Eleochari* the culms function as leaves.) They all have large air tubes leading to the roots. This applies to all the lake-dwelling species.

Growing near the shore in places are the aquatics with short stems and the plant wholly submersed. *Naias* is a good type. They form a band in the center of a group which forms a wider belt, the emersed leaved lake plants.

These *lake plants with emersed leaves* extend from the shore out to where the water is about 6½ feet deep. Among these are reckoned the *Scirpi* and *Eleochari* (with the explanation above). These plants form the broadest belt in the lake, and one reason for the breadth of their distribution is to be found in the variability of the species which compose it, as has been dwelt upon somewhat fully above. This belt may, on this account, be divided into two strips; one including the shallow water forms and the other the deep water forms. *Castalia* and *Nymphaea*, which belong here, grow out to a depth of about five feet eight inches. *Scirpus lacustris* grows out farther, that is, to a depth of 6½ feet, and it here projects up out of the water about 5 feet, making the total length of some of the longest culms 11½ feet. Where Scirpus grows out into deep water it seems to exhaust itself in the effort to reach light and air, and so they are generally few-fruited or wholly sterile, with deadish brown tips. They progress out into the lake by means of rhizomes, and at the outer edges of the belt one can frequently note their arrangement in straight lines, corresponding to the position of the root stock.

The Aquatics with Submersed Leaves.—It is difficult to fix the exact limits of these plants with certainty, especially so that they could be represented on a map, for they do not form visible patches at the surface. It is convenient, as said above, to divide them into two groups—the short-stemmed aquatics—for length of stem seems to be the chief factor in determining the habitat. It should be borne in mind, however, that the long-stemmed are quite variable in length, depending on depth in which they grow. In general the influences which determine the habitat of wholly submersed aquatics, aside from the kind of soil at the bottom, is the amount of light (and probably dissolved gases) available. The amount of light and dissolved gases is determined by the nearness to the surface. The former is also determined by the clearness of the water; and in case the clearness of the water is disturbed by organisms characterized by holophytic nutrition, the amount of gaseous plant food, as well as the light, would be decreased with the increase of amount of suspended organic material. This feature of the case will be touched upon later.

The short-stemmed aquatics (*Naias*, *Chara* and the like) grow only in shallow water. They were found out to a depth of six feet of water, rarely more.

Among the *long stemmed aquatics* Potamogeton *lucens* is generally found in isolated patches, while *Myriophyllum*, *Ceratophyllum*, and *Potamogeton pectinatus* grew together, making long belts. These form the extreme central belt of (phanerogamic) lake plants. They are to be found from 100 or 150 to 600 feet from shore, according to depth of water. By means of dredging it was ascertained that these plants rarely or never grow out much deeper than can be seen from a boat with favorable light. Twelve feet was the greatest depth at which any were found. As they grew to be about six feet long, the distance from their tops to the surface of the lake varies from about six feet, at the deepest, to nothing at the shallowest places where they grew. During the latter part of August, 1899, when the lake surface was quite low, due to a protracted drouth, some of the plants of *Myriophyllum* projected up to the surface and the tops floated, but they did not seem to be thriving well.

Toward the south-central part of the lake is a large bar, and its position is marked on the water surface by the presence of Potamogetons and other deep-water plants.

It is seen, therefore, that the greater part of the lake bottom is devoid of coarse vegetation, the plants making only a rather narrow belt around near the shore. The plants seem limited, moreover, to depths much shallower than might be expected. Records of these species growing to considerably greater depths are common. This limit in depth may perhaps be partly explained by the large amount of diffused matter to be found in Eagle Lake. This material is so abundant that it gives the lake water a decided amber color, and the rays of the sun penetrating into the water make streaks much like those formed by sunlight entering into a very dusty room, or dusty atmosphere, as in the phenomenon commonly spoken of as the "sun drawing water." It is very certain that this material cuts off a great deal of light, and perhaps absorbs considerable of plant food. At any rate, there seems to be an interference of some sort between the larger plants and the plankton—a fact generally observed. (See a reference to this relation, part 5, page 257, of Science, Vol. XI, No. 268.)

THE LAKE ALGAE.—No particular attention was paid to the Algae except where they formed conspicuous masses. Most of the work in this group was left to the investigators in plankton. *Oedogonium*, *Cladophera* and *Spirogyra* could be found almost any time in the ditches and along the edges of the lake.

Throughout both summers of the work, 1899 and 1900, *Mougeotia* was very abundant in the lake, especially in the head bay. Much of it formed immense cloudy patches among the water weeds, and much of it was in the shape of large, floating, yellowish green patches. There was a good deal of *Rivularia* in the lake. All I saw here was attached. It grew in a semi-globular form, fastened to water weeds and rushes. Upon rich, muddy bottom, where there is an abundance of dead bits of Scirpus, there is a good deal of *Chaetophora*, which assumes the form of a narrow, elongated, dichotomously branching thallus, which resembles some of the narrow *Riccias* in outward aspect. The water is full of fine granular masses of *Clathrocystis*, and short, stout, rigid filaments of *Oscillaria*, which resemble hair clippings. *Hydrodictyon* is very peculiar in its occurrence in the lake. It suddenly appears in great masses at the mouth of Cherry Creek, and then, after remaining a few days, it is washed in great masses upon the shore and suddenly disappears, generally after reproduction, so that after the large plants have disappeared the water is full of very tiny ones. The date of appearance of this plant in 1900 was July 13. By July 27 all the older *Hydrodictyon* had disappeared as a mass and the water was full of young plants.

Many large *Nostoc*-like jelly masses of an unicellular alga, probably *Aphanotheca*, were found along the northern shore of the West bay. Among other algae noted in considerable masses was *Microthamnion*. There was also a few plants of a small momiliform species of *Nitella* found in the south part of the lake, quite near shore, in 1899. None was seen in 1900.

The water is quite full of minute algae, which is generally kept well mixed up with the water by the constant churning of the waves. In quiet places, however, as near the shore in sheltered places, or among the rushes, these algae, mainly *Clathrocystes*, form a surface scum. On one day during the latter part of the summer of 1899, when the lake was tolerably low, and after a very calm night, these algae formed an unbroken film or scum over the surface of the lake, except where broken up by the jumping of fishes, etc. The track of the boat and every oar-stroke could be noted across the lake as far as could be seen clearly at all, and, as said above, every place where a fish had splashed up was left as a break on the surface. Some phenomenon similar to this is briefly noted in an article by C. D. Marsh, and various names given for it, as "breaking of the meres," or "working of the lakes." (See Science, Vol. XI, No. 268, first column, page 379.)

DETAILS OF DISTRIBUTION.—In the preceding discussion the only determining condition of plant distribution taken into consideration was the amount of water present in the soil or about the plant; and the various plant groups have been spoken of as if they occurred in regular concentric belts or circles.

The amount of water has indeed been the most conspicuous influence, and the most easily measured, here as everywhere, and it has been this fact that has determined the conception of the ecological groups, xerophytes, mesophytes, and hydrophytes. It is needless to say, however, that there are multitudes of other influences, such as soil, temperature, and many obscure and perhaps undiscovered influences which operate to make the distribution of the various species tolerably irregular.

Some of the most noteworthy irregularities will now be discussed more in detail. Only lake plants will be noted.

SCIRPUS AMERICANUS (three-cornered bulrush) is found in scattered patches at almost any bit of sandy shore. Along the east and south shores it grows rather thinly and covers only small areas. Its general absence or scarcity along the eastern side of the lake is due in some cases (as in front of the Assembly grounds) to artificial removal. Beginning at the southeastern bend of the lake, however, it extends in large and frequent patches almost to the bend which forms the neck of the lake. At places where it is thickest, as at the gravelly shore at Yarnelle's landing, it is the predominant form, here growing very dense and close. There are also dense strips of considerable length on the shore along the northern end of the lake. Its distribution seems to be determined by the presence of solid sand-beds or bars where it delights to grow. It generally grows wholly on shore or in only quite shallow water, and does not seem to like the beating of waves so well as does *S. lacustris.* Fig. 3 shows a characteristic set of relations (south of Chicago Hill pier). Willows on ice ridge at the left. *Scirpus americanus* on sandy bank, *S. lacustris* in water with stems on shore. A patch of *Pontederia cordata* in water in foreground.

Fig. 3.

PONTEDERIA CORDATA occurs in small or isolated patches all around the lake, but by far the largest and most continuous stretch is at the south end, not a great way from the mouth of Clear Creek. This plant is generally associated with *Nymphaea advena* and is closely similar to it in structure and habit. It generally forms a belt between the main mass of *Nymphaea* and the shore. The *Pontederia* farthest from shore grows in among the *Nymphaea* nearest the water's edge. *Sagittaria*, in so far as it grows along the shore, occupies nearly the same position, except that it grows at the water's edge. *Pontederia* and *Nymphaea* grow in considerable abundance in the pond south of the lake, and *Sagittaria* has its best development here, forming an immense patch intermixed with other plants. Among other plants which frequently come down to the water's edge, but which are most abundant on the lake plain or in its ponds, are cat-tails, Calamus, and some *Phragmites*.

The chief representatives of the short-stemmed aquatics are *Naias flexilis* and *Chara*. *Naias* grows in scanty patches nearly everywhere in the shallow water near the shore. There are occasionally very dense patches. Such were found in 1900, midway between the Biological Station and Willow point, near the mouth of Clear Creek, and out in front of the laboratories. There was also considerable on the west side of the lake near the shore.

CHARA begins at the southwest corner of the lake and covers a considerable area there. Then it stops until near the neck of the channel which lies between the lake and West Bay. It covers nearly all the bottom of this channel, and extends in a good way, about 300 or 400 feet nearly all around the bay, except for a distance along the western side, where it is mucky. Another patch of Chara occurs, mixed in with Naias, in front of the Assembly grounds. The specimens of Chara found in this latter place were much larger and longer than those found elsewhere, and were fuller of fruit.

SCIRPUS LACUSTRIS is the most abundant and conspicuous of the lake plants. One belt begins about 200 feet north of Chicago Hill pier. From this place it extends, with the exception of a few very narrow interruptions, almost to Yarnelle's point, where it thins out and wholly disappears for a little way, its place being occupied, as before noted, by *S. americanus*. Not far north of the landing, however, it begins again and extends up to the channel, and runs far out into a sharp cape at this point. There is another small patch in the middle of the channel, which is cut in two by the steamboat track. This plant fringes the outlet bay quite thickly, and then occurs again at the mouth of the canal which leads from the lake to Warsaw. Another strip begins at the channel and extends up to the red ice-house. There is a broad region bare of any *Scirpus* all along the Assembly grounds; its absence here is in all probability due to artificial removal, for the conditions of growth are in every way favorable. The last patch begins along Willow Cape and extends far out into the lake, and grows along the shore until a little north of the laboratories. This leaves a large gap until nearly to Chicago Hill pier. This plant seems to delight in a soft, marly soil, and does best in rather shallow water. Its absence at Yarnelle's landing may probably be accounted for by the sudden slope at that shore and by the gravelly beach. Whenever long bars run out into the lake, *S. lacustris* marks the place by projecting out into long capes. Fig. 4 represents a characteristic patch of *S. lacustris* (south of Chicago Hill pier), along with other relations. On the left, shore with willows, and mud bar with *Scirpus stems*. Between the shore and Scirpus are patches of *Pontederia cordata*.

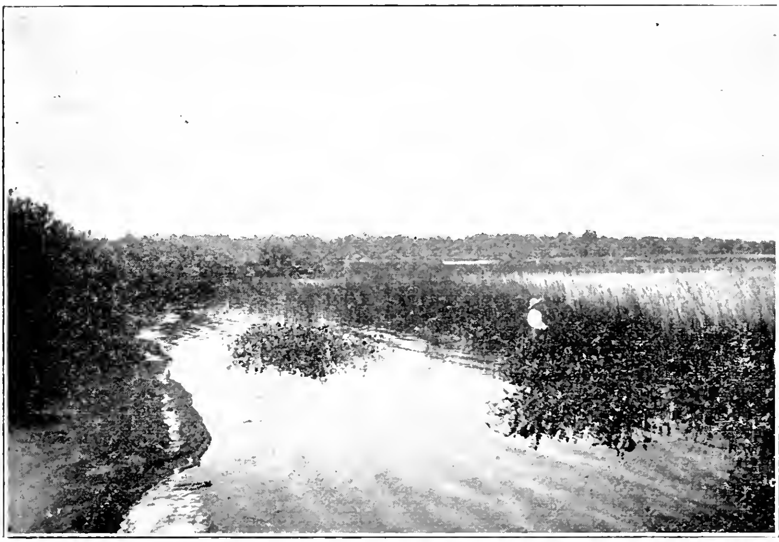


Fig. 4.

Potamogeton pectinatus forms a wide belt extending from rather shallow water (four feet) to seven or eight feet. It occurs in scattered patches all round the lake. *P. amplifolius* grows in somewhat deeper water than the preceding. It forms several large patches, one in front of the laboratories and one near the mouth of Clear Creek. Other smaller patches are distributed quite generally. *Myriophyllum* and *Ceratophyllum* generally grow in the same depth of water and often form mixed patches. The latter is found almost all round the lake in considerable quantities. These two plants form their thickest patches in the mud near the outlet.

Potamogeton lucens, though abundant, is rather scattered. *P. zosteraefolius* and *Heteranthera dubia* grow intermixed in about five feet of water, and resemble each other somewhat, except *Heteranthera* has a round stem. Bits of *Heteranthera*, broken off by the waves and washed ashore, take root and grow and blossom, forming mats of short, bright green plants with yellow blossoms.

The spatterdock (*Nymphaea*) and water lily (*Castalia*) are to a cons'derable extent found growing together. *Nymphaea* forms a tolerable large patch in the pond in southern lake plain. It is not found in the lake along any part of the northwestern shore at all. It covers a very large area at the southern end of the lake near the mouth of Clear Creek (see Fig. 5), and runs its greatest distance out from shore on a bar formed at the

Fig 5.

mouth of the creek. It begins again at the extreme end of the West Bay, near the outlet, and forms a broad marginal belt around this part of the shore. There is a third patch at the mouth of the steamboat canal. It extends for some distance beyond the canal mouth to the north side. Nymphaea seems to prefer a muddy bottom. It seems to be fond of a gentle current, and extends from the lake for some distance up Clear Creek, and down the outlet. Its greatest development in the southern part of the lake is due to the protection it has there from lashing winds, as this is the sheltered side of the lake. Fig. 6 shows a patch of spatterdock, with intermixed bulrushes, near the outlet.

Castalia odorata, or white water lily, has a somewhat more general distribution, as scattered plants occur nearly all round the shore. There is a number of stout plants growing in the bayou in front of the laboratories, then there is none whatever until about 700 feet south of Chicago Hill pier. From this place occurs occasional patches of the small form until the large stretch of *Nymphaea* at the mouth of Clear Creek, is reached. Here there is a wide, dense growth of the ordinary floating-leaved form. There is a second large patch, similar to this one, in the bend at the south-

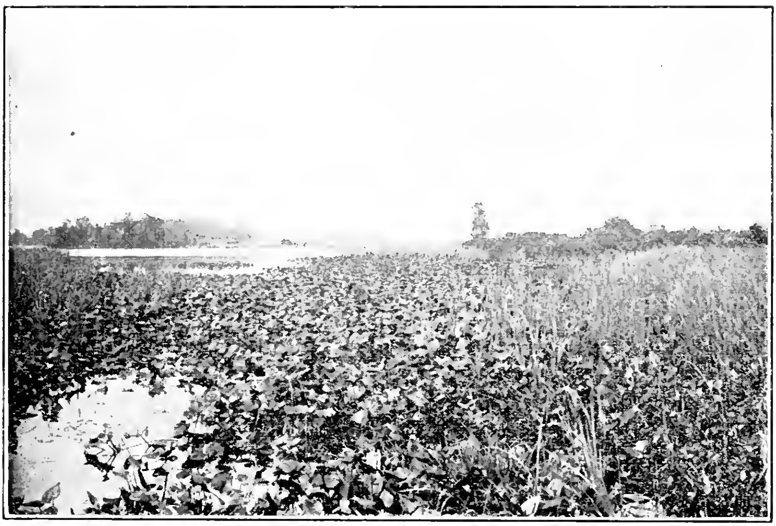


Fig. 6.

west corner of the lake. It is here nearly free from spatterdock. The broad bay leading to the outlet has two belts, the outer belt of the stout form growing almost out of the water in the rich muck at the edge of the shore, and the ordinary form out in the water. (These are shown in Fig. 7.) There are scattered small patches all along the west coast of the West Bay. In 1899 a good-sized patch grew about the region of the mouth of the steamer canal. It was not noted in 1900. Here the species ends except for occasional plants.

Many other plants are found in the lake, but not in quantities sufficient to call for more than passing notice. Only a few plants of *Philotria* were seen here, although it grows abundantly in bayous. *Vallisneria* grows most plentifully just south of the mouth of Cherry Creek, about Chicago Hill pier, about 700 feet south of this, near Clear Creek mouth, at the western end of West Bay, near the pier by the ice-houses, and off the Assembly grounds. Bladderwort, *Utricularia vulgaris*, fringes the edges of the channel, but it is not particularly abundant here. It was really found in much greater quantities in the lake plain just beside the channel. The

Fig. 7.

plants in the lake are bright green, with empty bladders and no blossoms, while those in the foul water of Willow Point bayou and elsewhere were very different in appearance, the bladders black with contents, and the stems bearing abundant flowers.

Water-shield (*Brasenia purpurea*) covers rather thinly only one small area at the south side of the lake. The plants are small and unthrifty, and I have never seen them in blossom at this place. In a pond not far away (Market-street pond) they blossomed abundantly during the summer of 1899.

Cladium mariscoides grows in several small patches at the edge of the lake, mixed in with the *Scirpus*. *Eleocharis palustris* grows in the lake rather scantily in two places, one just a little north of Chicago Hill pier, at the beginning of the *Scirpus* patch, and the other a little south of Yarnelle's landing. *Eleocharis interstincta* and E. *mutata* form each two small patches along the southwestern shore of the lake and at Yarnelle's landing. There were only a few duckweeds (*Spirodela*) found in the lake proper. This was along the southern edge, where it was shady and calm.

GENERAL RELATIONS.—The plants on the shore, especially those which grow out upon newly-made soil, probably have a good deal of influence in binding the shore together, and assist in the encroachments of the land upon the lake. This influence, however, is difficult to measure or express in definite terms, for it seems irregular and uncertain, as erosion goes on quite rapidly even where there are forests on shore, wherever the wind has full sweep. Small trees are uprooted and fall, and in some places stumps are found in the bottom of the lake near shore.

THE PLANTS IN THE WATER, especially the *Scirpus*, form a large amount of material for the building up of new shore. They also break the influence of the waves against the shore. At times, when the surface of the lake was quite rough, the water above a large patch of water weeds, particularly *Potamogeton amplifolius*, was often noted to be perfectly calm. The large submersed leaves of the latter plant are very effective in catching the moving molecules of water, retarding their motion, and so preventing waves.

The larger plants in the lake bear certain relations to the plankton. Among the *Scirpi*, the *Clathrocystis* scum is abundant almost any time during the latter part of the summer. Here we have a marked influence on the vertical distribution of the plankton. On the afternoon of August 21, 1900, a thickish coating of clathrocystis was noted among the bulrushes near the shore, and during the night the lapping waves piled it up in a narrow streak along the water line.

The stems of the water plants furnish lodgment for many aquatic plants and animals. Fresh water sponges grow abundantly upon the *Scirpus* stems.

A peculiarity of a species of *Rivularia* may be noted in this connection. It frequently grows quite abundantly attached in small hemispheric masses to stems and leaves of water plants. I have never seen it floating in Eagle Lake at all, and Dr. Howe, who has worked particularly with the plankton, has found it floating but once. At Turkey Lake it is said to float in great quantities, the whole lake appearing crowded full of dark green spheres the size of a large pinhead, and on a short visit to Tippecanoe Lake I noticed the same phenomenon. I have not had opportunity to compare the richness of vegetation of Turkey and Tippecanoe Lakes with that of Eagle Lake. It is possible that the condition *Rivularia* assumes depends upon the abundance or scarcity of plants which will serve as places of attachment. In assuming this attached position it escapes the plankton nets, and so its abundance is liable to be underestimated; for as there is difficulty in manipulating the net among the water weeds, direct comparison of its abundance would be impossible to obtain.

As an agent in the dissemination of seeds the lake acts only to a limited extent, as a floating seed would need sufficient surface projecting above the water in order to be wafted far. Many such seeds as acorns, hazel nuts and butternuts were floating in the water, but all of them were decayed. In the case of winged seeds, however, it was different. A number of small seedlings of the soft maple were found growing along the shore about high-water line, and the seeds had evidently been deposited there by the waves. The year of 1899 was somewhat noteworthy for the very heavy crop of elm seed, especially white elm. In the early summer of that year, in the vicinity of Fort Wayne, the writer noted woodland ponds, the surfaces of which were entirely covered with the seeds of this species. In the same summer, but later, there was found at the high-water line of the lake just north of the laboratories a row of small seedling elms growing as thickly as they could stand. There was another long, thick row in a corresponding position along the southeast shore of the lake. In the summer of 1900 quite a number of the elms were found. They had increased well in size and looked quite thrifty. If undisturbed they may form the beginning of a forest, much like the present low-ground forest along the lake shore. There was no elm seedlings of 1900 noted; the crop of seed in the forests was not by any means so large during that summer.

Below is appended a list of plants noted in the vicinity of Eagle Lake. The list of plants occurring in the neighboring forests, or at any distance from the lake, is not intended to be complete, as observations were made here only incidentally as time could be taken from the lake work. It is believed that all the phanerogams of the lake have been noted. The order and synonymy is that of Britton and Brown's Illustrated Flora. Wherever these names differ from those of the sixth edition of Gray's Manual the latter are given also. In arranging this list I have availed myself of the labors of Dr. Stanley Coulter in his list of the flowering plants and ferns of Indiana in the State Geological Report of 1899. Much botanical survey work has been done in the county (Kosciusko) in which Eagle Lake is situated by various botanists, among them chiefly Dr. Stanley Coulter and Mr. W. W. Chipman.

LIST OF PLANTS NOTED AT EAGLE LAKE AND VICINITY.

1. Botrychium virginianum (L.) S. W. Virginia Grape Fern.
   In upland forests; not common.
2. Osmunda regalis L. Royal Fern.
   Very common in the southeastern portion of the lake plain, near Chicago Hill. Frequent in tamarack swamps.
3. O. cinnamonea L. Cinnamon Fern.
   Not rare in swamps. Quite abundant in a tamarack swamp a few miles southeast of Warsaw.
4. O. claytonia. Clayton's Fern.
   Not rare along Clear Creek mouth.
5. Onoclea sensibilis L. Sensitive Fern.
   Very common at edges of lake plain in places, especially on the eastern side. Common in low, flat swales.
6. Cystopteris fragilis (L.) Bernh. Brittle Fern.
   Not common. Found in moist, but not wet woods.
7. Dryopteris acrostichoides (Michx.) Kuntze. Christmas Fern. (*Aspidium achrosticoides* S. W.)
   Not abundant; found on a bank along Clear Creek.
8. D. thelypteris (L.) Gray. Marsh shield Fern. (*Aspidium thelypteris* S. W.)
   The most common fern, growing in the flat plains in great abundance, making a distinct strata in places.
9. D. cristata (L.) A. Gray. Crested Shield Fern. (*Aspidium cristatum* S. W.)
   Not very common; found scattered in low, flat woods.
10. Phegopteris hexagonoptera (Michx.). Fee. Broad Beech Fern.
   Not very common; found in dry woods.

11. Woodwardia virginica (L.) J. E. Smith. Virginia Chain Fern.
Abundant in old tamarack swamps, especially along the steamboat canal to near Warsaw, and a tamarack about one mile east of the lake.

12. Asplenium angustifolium Michx. Narrow-leaved Spleenwort.
Some found in the county, but not very near Eagle Lake.

13. A. filix foemina (L.) Bernh. Lady Fern.
Scattered in low, moist woods.

14. Adiantum pedatum L. Maiden-hair Fern.
Not common near the lake; a few plants found at the foot of a hill about a quarter of a mile east of the lake.

15. Pteris aquilina L. Brake.
Found pretty abundantly on sandy hills, especially along the railroad.

16. Equisetum arvense L. Field Horse-tail.
Common along the railroad and on side base of a hill about one-quarter mile east of the lake.

17. E. fluviatile L. Swamp Horse-tail.
In the margins of the ponds adjacent to the lake, in shallow water.

18. E. hyemale L. Common Scouring Rush.
Abundant on hillsides and along the railroad; a good deal of variation in size and general appearance.

19. Lycopodium lucidulum Michx. Shining Club Moss.
In a tamarack east of Eagle Lake.

20. Selaginella apus. (L.) Spring Creeping Selagenella.
In flat, moist plains, among the grass. Abundant in various portions of the lake plain.

21. Larix laricina (Du Roi) Koch. Tamarack. (L. Americana Michx.).
There are several tamarack swamps in the vicinity of Eagle Lake. Most of them are dying.

22. Juniperus virginana L. Red Cedar.
Plants found in the county, but not very near the lake.

23. Typha latifolia L. Broad-leaved Cat-tail.
Abundant in marshes and occasionally at the lake shore. Great patches on the southern lake plain.

24. Sparganium eurycarpum Engelm.
Common in swamps.

25. S. simplex Huds.
Not rare in a few swamps, quite local, however.
26. Potamogeton natans L. Common Floating Pondweed.
Abundant in shallow water, Eagle Lake.
27. P. amplifolius Tuckerm. Long-leaved Pondweed.
In patches, common. Eagle Lake.
28. P. lonchites. (P. fluitans Roth.)
Common in the lake, especially near outlets and inlets.
29. P. lucens L. Shining Pondweed.
Abundant in the lake.
30. P. pērfoliatus.
Quite plentiful in Eagle Lake.
31. P. zosteraefolius Schum. Eel Grass Pondweed.
Abundant.
32. P. pusillus L. Small Pondweed.
Only a few specimens seen.
33. P. pectinatus L. Fennel-leaved Pondweed.
One of the most common and widely distributed.
34. Naias flexilis (Willd.) Rost and Schmidt.
Quite abundant in shallow water, sometimes forming extensive carpets.
35. Triglochin palustris L. Marsh Arrow Grass.
In a swamp south of the lake about a half mile.
36. Alisma plantago aquatica L. Water Plantain.
Abundant in moist places.
37. Sagittaria engelmanniana J. G. Smith. (S. variabilis gracilis Engelm.)
A few plants along the shore of Eagle Lake in lagoons.
38. S. latifolia Willd. Broad-leaved Arrowhead. (S. variabilis Engelm.)
Quite abundant, especially on the southern lake plain.
39. S. rigida Pursh. (S. heterophylla pursh.)
A few plants noted in shallow water.
40. S. graminea Michx. Grass-leaved Arrowhead.
At the Laboratory bayou.
41. Philotria canadensis (Michx.) Britton. Ditch Moss. (Elodea canadensis Michx.)
In bayous and cut-offs; very little found in the lake itself.
42. Vallisneria spiralis L. Tape-grass. Eelgrass.
In patches, scattered, not abundant in Eagle Lake.

43. Andropogon scoparius Michx. Brown Beard Grass.
Some along the railroad.

44. A. furcatus. Forked Beard Grass.
Some in the southeast lake plain, and occasional elsewhere.

45. Chrysopogon avenaceus (Michx.) Benth. Indian Grass. (C. Nutans Benth.)
Common, especially along the Pennsylvania Railroad.

46. Syntherisma sanguinalis (L.) Nash. Crab Grass. (Panicum sanguinale L.)
Abundant in cultivated places and a troublesome weed.

47. Panicum crus-galli L. Barnyard Grass.
Abundant in moist places.

48. P. walteri. Salt Marsh Cockspur Grass.
Some along the southeast shore of the lake.

49. P. porterianum Nash. (*P. latifolium* Walt.)
In dry woodlands.

50. P. pubescens Lam. Hairy Panicum.
Common in open woodlands.

51. P. capillare L. Old Witch Grass.
Found abundant in Winona Park.

52. Ixophorus glaucus (L.) Nash. Yellow Fox-tail. (*Setaria glauca* Beauv.)
Abundant in waste places.

53. I. viridis (L.) Nash. Green Fox-tail Grass. (*Setaria viridis* Beauv.)
Quite common.

54. I. italicus (L.) Nash. Hungarian Grass. (*Setaria italica* Kunth.)
Escaped cultivation in various places.

55. Cenchrus tribuloides L. Burr Grass. Sandbur.
Found in dry sandy soil.

56. Zizania aquatica L. Wild Rice.
Some found in a tamarack not far from the lake.

57. Homalocenchrus virginicus (Willd.) Britton. White Grass. (*Leersia virginica* Willd.)
Grows sparsely in damp woods near the lake.

58. H. oryzoides (L.) Poll. Rice and Cut-grass. (*Leersia oryzoids* Swartz.)
Forming tangled, scratchy masses in places along the lake shore.

59. Phalaris arundinacea L. Reed Canary Grass.
Some found on the lake plain.

60. Muhlenbergia diffusa.
Some growing in dry, sparsely wooded places.

61. Phleum pratense L. Timothy.
Abundant.

62. Cinna arundinacea L. Wood Reed Grass.
Found in moist places, especially where shaded.

63. Agrostis alba L. Red Top.
Found along Cherry Creek.

64. Agrostis perennans (Walt.) Tuckerm. Thin Grass.
Some found along Cherry Creek.

65. Calamagrostis canadensis (Michx.) Beauv. Blue-joint Grass.
Scattered among other grasses on the lake plain.

66. Danthonia spicata (L.) Beauv. Wild Oat Grass.
Grows thinly at edges of dry hills.

67. Spartina cynosuroides (L.) Willd. Fresh-water Cord Grass.
Tolerably common in swamps and along the railroad.

68. Bouteloua curtipendula (Michx.) Torr. (*B. racemosa* Lag.)
One patch on a hill toward the southern end of the Assembly grounds.

69. Eleusine indica (L.) Gaertn. Yard Grass.
Found along streets at Warsaw.

70. Phragmites phragmites (L.) Karst. Reed. (*P. communis* Trin.)
Some grows along the lake shore. Abundant in a tamarack swamp northeast of Eagle Lake.

71. Eragrostis purshii Schrad.
Not rare, along roadsides and old fields.

72. E. major Host.
Abundant in old fields and along roadsides.

73. Dactylis glomerata L. Orchard Grass.
A little found growing along roadsides.

74. Poa annua L. Low Spear Grass.
Found in a dooryard east of Eagle Lake.

75. Poa compressa L. Wire Grass.
Not rare in old fields.

76. Poa pratensis L. June Grass. Kentucky Blue Grass.
Scattered everywhere.

77. Panicularia nervata (Willd.) Kuntze. (*Glyceria nervata* Trin.)
Common at the edges of various ponds.

78. Panicularia fluitans (L.) Kuntze. Floating Manna Grass.
Not uncommon in ponds.

79. Festuca eliator L. Fall Fescue Grass.
Scattered, principally along the railroad.

80. Bromus ciliatus L. Wood Chess.
Tolerably common, scattered in thin forests.

81. B. secalinus L. Cheat. Chess.
In old wheat fields.

82. Agropyron violaceum (Hornem) Vasey. Purplish Wheat Grass.
Along the Pennsylvania Railroad, near Warsaw.

83. Hordeum jubatum L. Wild Barley. Squirrel-tail Grass.
Found in scant tufts along the Pennsylvania Railroad

84. Elymus virginicus L. Wild Rye.
Scattered.

85. Hystrix hystrix (L.) Millsp. Hedge-hog Grass.
Some found at the edges of a field east of Eagle Lake.

86. Cyperus diandrus Torr. Low Cyperus.
In the lake plain, especially along the south part of Chicago Hill.

87. C. strigosus L. Straw-colored Cyperus.
Common in moist places.

88. C. filiculmis Vahl. Slender Cyperus.
Abundant on open sandy hillsides.

89. Dulichium arundinaceum (L.) Britton. (*D. spathaceum* Pers.)
Common in marshy places. Most abundant in Market-street pond.

90. Eleocharis interstincta (Vahl.) R. and S.
A few patches in the lake. One in the south end, the others near Yarnelle's landing.

91. E. mutata (L.) R. and S. Quadrangular Spike Rush. (*E. quadrangulata* R. Br.)
A few small patches in nearly the same regions as the above.

92. E. ovata (Roth.) R. and S.
The most abundant species of the genus. Found everywhere in moist places.

93. E. palustris (L.) R. and S. Creeping Spike Rush.
Scattered along the edge of the lake, among the *scirpi.* A good patch just a little way north of Chicago Hill pier.

94. E. acicularis (L.) R. and S. Needle-spike Rush.
Tolerably abundant, often found in flower but rarely in fruit, at the edge of the lake and in marshes.

95. E. tenuis (Willd.) Schultes. Slender Spike-rush.
Some found in the lake plain.

96. Stenophyllus capillaris (L.) Britton. (*Fimbristylis capillaris* Gray.)
Found in sandy soil. Some in a field, some at the edge of the lake plain, on the bank at Chicago Hill.

97. Scirpus smithii Gray.
Some found in the county, but not near Eagle Lake.

98. S. americanus Pers. Chair-maker's Rush. (*S. pungens* Vahl.)
Quite abundant along the edges of the lake.

99. S. lacustris L. Great Bulrush.
The most abundant of the species, forming a broad belt around the margin of the greater part of the lake.

100. S. atrovirens Muhl. Dark-green Bulrush.
Common in swamps.

101. S. lineatus Michx. Reddish Bulrush.
Common in wet grounds.

102. S. cyperinus (L.) Kunth. Wool Grass.
Grows in clumps, in ponds.

103. Eriophorum virginicum.
Scattered in marshes—generally old tamaracks.

104. Rynchospora alba (L.) Vahl. White-beaked Rush.
In a marsh south of the lake, also in the tamarack northeast of Eagle Lake.

105. R. Capillacea laeviseta E. J. Hill.
In a marsh south of the lake.

106. Cladium mariscoides (Muhl.) Torr. Twig Rush.
In the lake plain and along the edge of the lake on the west side of the lake.

107. Scleria verticillata Muhl. Low Nut Grass.
Found in a tamarack, and in a flat pasture south of Eagle Lake.

108. Carex lupulina Muhl. Hop Sedge.

Found in swampy places, abundant.

109. C. pseudo-cyperus L.

Found occasionally in swamps.

110. Carex comosa Boot. Bristly Sedge.

Along the edges of the lake, near the outlet, and in ponds.

111. C. lanuginosa Michx. Woolly Sedge.

Some growing in the vicinity of the laboratories.

112. C. filiformis L. Slender Sedge.

A small patch near a pond on the southeast part of the lake plain.

113. C. granulatus Muhl. Meadow Sedge.

Scattered, moist places.

114. C. albursina Sheldon. White Bear Sedge.

Found occasionally in damp woods.

115. C. pennsylvanica Lam.

Found on dry hills, scattered.

116. C. pubescens Muhl. Pubescent Sedge.

A few plants found in dry ground at the southwest side of the lake.

117. C. leptalea Wahl. (*C. polytrichoides* Willd.)

Found in a tamarack northeast of the lake, and in a marsh southeast.

118. C. vulpinoidea Michx.

Common, scattered.

119. C. rosea Schk. Stellate Sedge.

Found sparingly in shaded places.

120. C. cephalophora Muhl.

Found scattered in dry soil, back from the lake.

121. C. tribuloides Wahl.

Growing in clumps, among various grasses in parts of the lake plain.

122. Arisaema triphyllum (L.) Torr. Jack-in-the-Pulpit. Indian Turnip.

Found in forests.

123. A. dracontium (L.) Schott. Green Dragon.

Found in quite moist woods.

124. Peltandra virginica (L.) Kunth. Green Arrow Arum.

Found in a tamarack northeast of the lake.

125. Spathyema foetida (L.) Raf. Skunk Cabbage. (*Symplocarpus foetidus* Nutt.)

Common in moist places, especially up along Cherry Creek.

126. Aeorus calamus (L). Sweet Flag. Calamus.

Found in low ground along the lake and various other moist places.

127. Spirodela polyrhiza (L.) Schleid. Greater Duckweed.

Very common in lagoons, some in sheltered parts of the lake, near shore.

128. Lemna trisulca L. Ivy-leaved Duckweed.

In lagoons and ditches; common.

129. Lemna minor L. Lesser Duckweed.

In lagoons, and in ponds near the lake.

130. Wolffia columbiana Karst.

Very abundant in lagoons.

131. W. braziliensis Wedd.

In lagoons, but not very common.

132. Tradescantia virginiana L. Spiderwort.

Grows everywhere in dry ground; not much seen in moist ground here.

133. Pontederia cordata L. Pickerel Weed.

Common about the edges of the lake.

134. Heteranthera dubia (Jacq.) MacM. Water Star-grass. (H. graminea Vahl.)

Both forms found, the larger in the water and the short on muddy banks.

135. Juncus effusus L. Soft Rush.

Grows along the steamboat canal leading to Warsaw.

136. J. tenuis Willd. Yard Rush.

Abundant.

137. J. canadensis J. Gray.

Found in low ground along the railroads northeast of the lake.

138. Juncoides campestre (L.) Kuntze. Common Wood Rush. (*Luzula campestris* D. C.)

Found scattered in woodlands.

139. Tofieldia glutinosa (Michx.) Pers.

Found in a tamarack northeast of the lake.

140. Allium canadense L. Meadow Garlic.

Found in moist woods.

141. Lilium umbellatum Pursh. Western Red Lily.

Found on sand hills northeast of the lake.

142. L. canadense L. Yellow Lily.

Found growing in moist places.

143. L. superbum L. Turk's Cap Lily.

Grows in the southwestern part of the lake plain.

144. Asparagus officinalis L. Asparagus.

Scattered, quite frequent.

145. Vagnera racemosa (L.) Morong. Wild Spikenard. (*Smilacina racemosa* Desf.)

Found growing in forests.

146. V. stellata (L.) Morong. Star-flowered Solomon's Seal. (*Smilacina stellata* Desf.)

One patch across Cherry Creek from the laboratory.

147. Unifolium canadense (Desf.) Greene. False Lily of the Valley.

In dried tamarack swamps.

148. Polygonatum commutatum (R. and S.) Dietr. Smooth Solomon's Seal. (P. giganteum Dietr.)

Common, especially along the railroad.

149. Trillium recurvatum Beck. Prairie Wake Robin.

Found abundantly in damp woods.

150. Smilax herbacea L. Carrion Flower.

Found in considerable abundance.

151. S. hispida Muhl. Hispid Green Briar.

Found in dry places.

152. Dioscorea villosa L. Wild Yam.

Found in moist, rich woods.

153. Iris versicolor L. Larger Blue Flag.

Abundant in various places along the shore of the lake.

154. Sisyrinchium angustifolium Mill. Blue-eyed Grass.

Abundant in open places, especially along the railroad.

155. Cypripedium acaule Rit. Moccasin Flower.

Found abundantly in a tamarack south of the lake.

156. C. reginae Walt. Showy Lady's Slipper. (*C. spectabile Salisb.*)

Found in a marsh west of the lake.

157. C. hirsutum Mill. Large Yellow Lady's Slipper. (*C. pubescens* Willd.)
Found in dry soil by Yarnelle's landing.

158. Habenaria lacera (Michx) R. Br. Ragged Orchis.
Found in the southwestern portion of the lake plain.

159. H. leucopaea (Nutt) Gray. White-fringed Prairie Orchis.
In the tamarack marsh northeast of the lake.

160. H. psycodes (L.) Gray. Purple-fringed Orchis.
Southeast edge of lake plain.

161. Pogonia ophioglossoides (L.) Ker. Rose Pogonia.
In the tamarack northeast of the lake.

162. Gyrostachys gracilis (Bigel) Kuntze. Slender Ladies' Tresses.
Found in a dry wood east of the lake.

163. Corallorhiza odontorhiza (Willd.) Nutt. Small-flowered Coral Root.
Not rare in a wood south of the outlet.

164. Limodorum tuberosium L. Grass Pink. (*Calopogon pulchellus* R. Br.)
Abundant in tamarack northeast of the lake.

165. Saururus cernuus L. Lizard's Tail.
In wet grounds along Cherry Creek and Clear Creek.

166. Juglans nigra L. Black Walnut.
Scattered in rich woodlands.

167. J. cinera L. Butternut.
Occasional, in woodlands.

168. Hicoria ovata (Mill) Britton. Shagbark Hickory. (*Carya alba* Nutt.)
In woodlands.

169. H. laciniosa (Michx. f.) Sarg. Big Shellbark. (*Carya sulcata* Nutt.)
In woods near Cherry Creek.

170. H. alba (L.) Britton. Mocker Nut. White-heart Hickory. (*Carya tomentosa* Nutt.)
A few trees noted.

171. Populus alba L. White Poplar.
A few trees have escaped cultivation near Warsaw.

172. P. grandidentata L. Great-toothed Aspen.
Occasional.

173. P. tremuloides Michx. American Aspen.
Grows along the lake shore near Chicago Pier.

174. P. deltoides Marsh. Cottonwood. (P. *monilifera* Ait.)
Not rare in low grounds.

175. Salix nigra.

Common along the shores of the lake.

176. Salix discolor.

Forming clumps in low flat grounds. The willows were neither in flower nor fruit during the period of investigation, and were consequently indeterminate; there are doubtless more present than mentioned.

177. Carpinus caroliniana Walt. Water Beech.

In woodlands along the sides of gullies.

178. Ostrya virginiana (Mill) Willd. Ironwood.

In locations similar to the preceding.

179. Corylus americana Walt. Hazelnut.

Abundant in dry ground.

180. Betula pumila L. Low Birch.

Abundant in tamarack marshes.

181. Fagus americana. Sweet Beech. (*F. ferruginea* Ait.)

Not very abundant, only a few trees seen.

182. Castanea dentata (Marsh) Borkh. Chestnut. (*C. sativa americana Wats. and Coult.*)

A quite large tree in the park, evidently pretty old, but probably not native.

183. Quercus rubra L. Red Oak.

In woodlands.

184. Q. palustris Du Roi. Pin Oak.

Found pretty abundantly at the edges of some low slopes.

185. Q. coccinea Wang. Scarlet Oak.

Quite common.

186. Q. imbricaria Michx. Laurel Oak.

Only one tree seen, far up Cherry Creek gully.

187. Q. alba L. White Oak.

Abundant in woodlands.

188. Q. macrocarpa Michx. Bur Oak.

Not particularly abundant; only a few trees noted.

189. Q. platanoides (Lam.) Sudw. Swamp White Oak. (*Q. bicolor* Willd.)

Pretty common in moist places.

190. Q. acuminata (Michx.) Sarg. Yellow Oak. (*Q. muhlenbergii* Engelm.)

A few trees noted; none very near the lake.

191. Ulmus americana L. American or White Elm.
Abundant.

192. U. fulva Michx. Slippery Elm. Red Elm.
Not many trees seen.

193. Celtis occidentalis L. Hackberry. Sugar Berry.
A few trees noted.

194. Morus rubra L. Red Mulberry.
Found in woods; not rare.

195. M. alba tartarica. Russian Mulberry.
An abundant escape in waste land east of the lake.

196. Toxylon pomiferum Raf. Osage Orange. (*Maclura aurantiaca* Nutt.)
Used abundantly for hedges.

197. Humulus lupulus L. Hop.
Found growing in low rich grounds.

198. Cannabis sativa L. Hemp.
A common escape on commons near Warsaw.

199. Urtica gracilis Ait. Slender Nettle.
In clumps in waste places.

200. Urticastrum divaricatum (L.) Kuntze. Wood Nettle. *Laportea canadensis* Gaud.
Abundant in low woods.

201. Adicea pumila (L.) Raf. Clear Weed. Rich Weed. (*Pilea pumila* Gray.)
Abundant in moist places.

202. Boehmeria cylindrica (L.) Willd. False Nettle.
Abundant in moist woods.

203. Parietaria pennsylvanica Muhl.
Not particularly abundant.

204. Commandra umbellata (L.) Nutt. Bastard Toad Flax.
Found growing abundantly in dry places, along the road east of the lake.

205. Asarum canadense L. Wild Ginger.
Rather common in shady woods.

206. Aristolochia serpentaria L. Virginia Snake Root.
Scattered in loose soil of forests.

207. Rumex acetosella L. Field Sorrel. Red Sorrel.
A common nuisance in sandy fields.

208. R. verticillatus L. Swamp Dock.

Found at the edge of bayous and in shallow water.

209. R. brittanica L. Great Water Dock.

Not rare in the lake plain and in low, flat places.

210. R. crispus L. Curled Dock.

Common in waste places.

211. R. obtusifolius L. Bitter Dock.

In situations similar to the preceding.

212. Fagopyrum fagopyrum (L.) Karst. Buckwheat. (F. *asculentum* Moench.)

Along roadsides where it has escaped.

213. Polygonum amphibium L. Water Smartweed.

Common at the edges of the lake.

214. P. emersum (Michx.) Britton. Swamp Smartweed. (P. *muhlenbergii* Watson.)

Abundant in bayous and low places about the lake.

215. P. incarnatum Ell. Slender Pink Smartweed.

Common in wet soil.

216. P. pennsylvanicum L.

Abundant.

217. P. hydropiperoides.

Common, especially in a shallow pond in the southeastern portion of the lake plain.

218. P. orientale L. Prince's Feather.

Escaped cultivation in a field east of the lake.

219. P. virginianum L. Virginia Knotweed.

Rather sparingly found at the edges of low woods.

220. P. aviculare L. Doorweed.

Common in yards.

221. P. erectum L. Erect Knot Grass.

Not so abundant as the preceding, and in moister places.

222. P. convolvulus L. Black Bindweed.

In dry cultivated fields.

223. P. scandens L. Climbing False Buckwheat. (*P. dumetorum scandens* Gray.)

Some in moist ground along Cherry Creek.

224. P. saggitatum L. Arrow-leaved Tear Thumb.

In moist soils about the lake. Very abundant.

225. P. arifolium L. Halberd-leaved Tear Thumb.
Some found along Clear Creek, south of the lake.

226. Chenopodium album L. Lamb's Quarters.
Common in waste grounds.

227. C. boscianum Moq.
Only a few plants seen, over near Warsaw.

228. C. urbicum L. Common or City Goosefoot.
Common in waste places.

229. C. hybridum L. Maple-leaved Goosefoot.
Common; somewhat scattered in waste places.

230. C. botrys L. Feather Geranium. Jerusalem Oak.
Not rare along the railroad.

231. Salsola kali L. Common Saltwort.
Found quite abundantly along the railroad.

232. Amaranthus retroflexus L. Rough Pigweed.
Abundant in waste places.

233. A. blitoides S. Wats. Prostrate Amaranth.
Found along the Pennsylvania railroad.

234. A. graecizans L. Tumbleweed. (*A. album* L.)
Found in waste places and along the railroad.

235. Phytolacca decandra L. Pokeberry.
In moist, rich grounds.

236. Mollugo verticillata L. Carpetweed.
Abundant in sandy fields.

237. Portulaca oleracea. Purslane.
Plentiful in fields and gardens.

238. Agrostemma githago L. Cockle. (*Lychnis githago* Scop.)
Abundant in grain fields.

239. Silene stellata (L.) Ait. Starry Campion.
In woods and corners of fields.

240. S. virginica L. Fire Pink.
Found in woods.

241. S. antirrhina L. Sleepy Catchfly.
Common in sandy, open places.

242. Saponaria officinalis L. Bouncing Bet.
Abundant, especially along the embankment of the Pennsylvania railway.

243. Alsine media L. Common Chickweed (*Stellaria media* Cyr.)
Abundant, especially in the park.

244. A. longifolia (Muhl.) Britton. Long-leaved Chickweed. (*Stellaria longifolia* Muhl.)
Found in moist ground.

245. Cerastium longipedunculatum Muhl. Nodding Chickweed. (*C. nutans* Raf.)
Found near Cherry Creek.

246. Anychia canadensis (L.) B. S. P. Slender-forked Chickweed. (A. *capillacea* D. C.)
Scattered in open, sandy woods.

247. Brasenia purpurea (Michx.) Casp. Water Shield. (B. *Peltata* Pursh.)
A little in Eagle Lake; much, and profusely flowering, in Market-street pond.

248. Nymphaea advena Soland. Spatterdock. (*Nuphar advena* R. Br.)
Quite plentiful in Eagle Lake.

249. Castalia odorata (Dryand) Woodv. and Wood. White Water Lily. (*Nymphaea odorata* Ait.)
Abundant in Eagle Lake.

250. Ceratophyllum demersum L. Hornwort.
Abundant in Eagle Lake.

251. Liriodendron tulipfera L. Yellow poplar. Tulip tree.
In woods, no longer particularly abundant.

252. Asimina triloba (L.) Dunal. Pawpaw.
Not many trees seen.

253. Caltha palustris L. Cowsnip.
Common in marshy places.

254. Coptis trifolia (L.) Salisb. Gold-thread.
In a tamarack swamp southeast of the lake.

255. Actaea alba (L.) Mill. White Baneberry.
Common in woods.

256. Anemone cylindrica A. Gray. Long-fruited Anemone.
Found abundantly, principally along the Pennsylvania railway.

257. A. virginiana L. Tall anemones.
Plentiful in open places.

258. A. canadensis L. Canada Anemone. (*A. pennsylvanica* L.)
Found in moist ground along the Pennsylvania railroad.

259. A. quinquefolia L. Wind Flower. (A. *nemorosa Michx.*)
Plants found, out of flower, along Clear Creek.

260. Hepatica hepatica (L.) Karst. Round-leaved Liverwort. (*H. triloba* Chaix.)
Scattered in woodlands about the lake.

261. H. acuta (Pursh.) Britton. Liverwort. (*H. acutiloba* D. C.)
Found at some distance from the lake; none seen near.

262. Syndesmon thalectroides (L.) Hoffmng. Rue Anemone.
Found in woods; abundant.

263. Clematis virginiana L. Virgin's Bower.
Abundant in places, generally in rich, damp places.

264. Ranunculus abortivus L. Kidney-leaved Crowfoot.
Abundant in shaded places.

265. R. recurvatus Poir. Hooked Crowfoot.
Common in the regions at some distance from the lake.

266. R. pennsylvanicus L. Bristly Buttercup.
Some found north of the lake, near Clear Creek.

267. Caulophyllum thalictroides L. Blue Cohosh.
Found in the Clear Creek region.

268. Podophyllum peltatum L. Mayapple.
Scattered in woods.

269. Menespermum canadense L. Moonseed.
Not very abundant in the region of the lake.

270. Sassafras sassafras (L.) Karst. Sassafras. (*S. officinale* Nees.)
Abundant in open places.

271. Benzoin benzoin (L.) Coulter. Spice Bush. (*Lindera benzoin* Blume.)
Not rare in moist, rich woods.

272. Papaver somniferum L. Garden Poppy.
A few were found growing in the railroad gravel pit northeast of the lake.

273. Sanguinaria canadensis L. Blood Root.
Common in open woods, by bluffs and Clear Creek.

274. Stylophorum diphyllum (Michx.) Nutt. Celandine Poppy.
One seen, out of flower, up Clear Creek gully.

275. Bicuculla cucullaria (L.) Millsp. Dutchman's Breeches. (*Dicentra cucularia* Torr.)
Old plants and roots found, Clear Creek gully.

276. Lepidum virginicum L. Pepper Grass.
Common in dry ground.

277. Sisymbrium officinale (L.) Scop. Hedge Mustard.
Common in dry ground in waste places.

278. Brassica juncea (L.) Cooson. Indian Mustard.
A plant found along the Pennsylvania railroad.

279. Roripa palustris (L.) Bess. Marsh Cress. (*Nasturtium palustre* D. C.)
Common in flat, marshy ground.

280. R. nasturtium (L.) Rusby. Water Cress. (*Nasturtium officinale* R. Br.)
Common, especially near springs.

281. Bursa bursa-pastoris (L.) Britton. Shepherd's Purse. (*Capsella bursa-pastoris* Moench.)
Some plants seen; dry ground.

282. Arabis laevigati (Muhl.) Poir. Smooth Rock Cress.
On bluffs along Clear Creek.

283. Polanisia graveolens Raf. Clammy Weed.
Abundant in the railroad gravel pit.

284. Sarracenia purpurea L. Pitcher Plant.
In tamarack bogs.

285. Saxifraga pennsylvanica L. Swamp Saxifrage.
Occasional in wet places.

286. Heuchera hispida Pursh. Rough Heuchera.
Some plants found, Chapman's Hill.

287. Mitella diphylla L. Bishop's Cap.
On a bank along Cherry Creek.

288. Parnassia caroliniana Michx. Grass of Parnassus.
Tolerably plentiful in low, wet grounds.

289. Ribes cynosbatti L. Wild Gooseberry.
Common in woods.

290. R. oxyacanthoides L. Northern Gooseberry.
Found especially in tamaracks.

291. R. floridum L. Her. Wild Black Currant.
Occasional in moist, flat woods north of Eagle Lake.

292. Hamamelis virginiana L. Witch Hazel.
On dry hills southeast of the lake.

293. Platanus occidentalis L. Sycamore.
On low ground common; a few on high ground.

294. Spiraea salicifolia L. Meadow Sweet.
Common in low, flat ground, as the lake plain.

295. S. tomentosa L. Hardhack.
Sparingly found in moist grounds.

296. Rubus strigosus Michx. Wild Red Raspberry.
None near the lake; some found in a tamarack swamp some distance away.

297. R. occidentalis L. Black Raspberry.
Very common in neglected fields and open woods near the lake.

298. R. americanus (Pers.) Britton. Dwarf Raspberry.
Quite abundant in a tamarack northeast of the lake.

299. R. villosus Ait. High Bush Blackberry.
Abundant near the lake.

300. R. hispidus L. Running Swamp Blackberry.
Common in the marsh along the steamer canal, near Warsaw.

301. R. canadensis L. Dewberry. Low Blackberry.
Common on sandy banks and in sandy fields.

302. Fragaria virginiana Duchesne. Wild Strawberry.
Common in dry ground.

303. Potentilla argentea L. Hoary Cinquefoil.
In a field east of Eagle Lake.

304. P. monspeliensis L. Rough Cinquefoil. (*P. norvegica* L.)
Common in low grounds.

305. P. fruiticosa L. Shrubby Cinquefoil.
Common in wet grounds.

306. P. canadensis L. Five-finger.
Common everywhere in open places.

307. Comarum palustre L. Marsh Five-finger. (*Potentilla palustris* Scop.)
Common in tamarack bogs.

308. Geum canadense Jacq. White Avens. (*G. album* Gmelin.)
At edges of woods and shady places.

309. G. strictum Ait. Yellow Avens.
At the southeast edge of the lake plain.

310. Agrimonia mollis (T. and G.) Britton. Soft Agrimony. (*A. eupatoria mollis* T. and G.)
Common in light woods.

311. A. parviflora Soland. Small-flowered Agrimony.
Abundant in low, flat ground.

312. Rosa setigera Michx. Climbing Rose. Prairie Rose.
Not very common. I have seen only one plant in the region.

313. Rosa carolina L. Swamp Rose.
Very abundant in low places.

314. R. humilis lucida (Ehrh.) Best. (*R. lucida* Ehrh.)
Abundant in dry ground.

315. R. rubignosa L. Sweet Briar.
A few scattered plants were noted.

316. Malus coronaria (L.) Mill. Crab Apple. (*Pyrus coronaria* L.)
A few scattered trees.

317. Aronia nigra (Willd.) Britton. Black Choke Berry. (*Pyrus arbutifolia melanocarpa* Hook.)
Not rare in tamarack swamps.

318. Amelanchier canadensis (L.) Medic. June Berry.
Found on the brows of hills and bluffs.

319. A. botryapium (L. F.) D. C. Shad Bush.
A small bush found in the tamarack swamp northeast of the lake.

320. Crataegus coccinea L. Red Haw.
Scattered; generally found along in open woods and fence rows.

321. Prunus americana Marsh. Red Plum.
Scattered.

322. P. serotina Ehrh. Wild Cherry.
Some trees noted, scattered about in forests.

323. Cercis canadensis L. Red Bud. Judas Tree.
Some trees near the lake up Cherry Creek a little way from the lake.

324. Cassia marylandica L. Wild Senna.
Common in wet places.

325. Gymnocladus dioica (L.) Koch. Coffeenut. (*G. canadensis* Lam.)
Common up Cherry Creek gully.

326. Baptisia tinctoria (L.) R. Br. Wild Indigo.
One plant seen along the railroad, 1899.

327. Lupinus perennis L. Wild Lupine.
Common along the railroad.

328. Medicago sativa L. Alfalfa.
Along the road near the Assembly grounds; probably an escape.

329. Melilotus alba Desv. White Sweet Clover.
Abundant about the park entrance.

330. Trifolium procumbeus L. Low Hop Clover.
Found along streets in Warsaw.

331. T. arvense L. Rabbit's Foot Clover.
Scattered. in sterile soil.

332. T. pratense L. Red Clover.
Abundant in open places.

333. T. hybridum L. Alsike.
Scattered at edge of roadsides.

334. T. repens L. White Clover.
Abundant in open places.

335. Amorpha canescens Pursh. Lead plant.
A few plants growing in the park.

336. Robinia pseudacacia L. Black Locust.
Planted in various places.

337. Meibomia nudiflora (L.) Kuntze. Naked Flowered Tick Trefoil. (*Desmodium nudiflorum* D. C.)
In open woods.

338. M. michauxii Vail. Prostrate Tick Trefoil. (*Desmodium rotundifolium* D. C.)
In an open, dry thicket.

339. M. canadensis (L.) Kuntze. Showy Tick Trefoil. (*Desmodium canadense* D. C.)
Common in damp situations.

340. Lespedza violacea (L.) Pers. Bush Clover.
Abundant in open, dry places.

341. L. capitatata Michx. Round-headed Bush Clover.
Common in dry soil.

342. Vicia americana Muhl. Pea-vine.
In damp places near the lake.

343. Falcata comosa (L.) Kuntze. Hog Peanut. (*Amphicarpaea monoica* Ell.)
Common in rich woods.

344. Apios apios (L.) MacM. Groundnut. (*A. tuberosa* Moench.)
Common in various parts of the lake plain.

345. Geranium maculatum L. Wild Geranium.
Common in open woods.

346. G. carolinianum L. Carolina Crane's Bill.
Along the tracks in the railroad gravel pit.

347. Oxalis stricta L. Sheep Sorrel. (*O. corniculata stricta* Sav.)
Abundant.

348. Linum virginianum L. Wild Yellow Flax.
In dry ground, on hillsides, in open woods.

349. Xanthoxylum americanum Mill. Prickly Ash.
In woods; not abundant.

350. Ptelea trifoliata L. Hop Tree.
A few plants noticed in open woods.

351. Polygala verticillate L. Whorled Milkwort.
On hillsides.

352. Polygala viridescens L. (*P. sanguinea* L.)
Found on open hillside, east of the lake.

353. Acalypha virginica L. Three-seeded Mercury.
Found growing in the park.

354. Euphorbia humistrata Engelm. Hairy Spreading Spurge.
Common in dry, open, sandy places.

355. E. nutans Lag. Large or Upright Spotted Spurge. (*E. preslii* Guss.)
Common on dry banks and embankments.

356. E. corollata L. Flowering Spurge.
Very common in dry, open places and old fields.

357. E. cyparissias L. Cypress Spurge.
Escaped from an old cemetery near Warsaw.

358. Rhus copallina L. Dwarf or Black Sumac.
In scattered clumps, various places in dry soil.

359. R. hirta (L.) Sudw. Staghorn Sumac. (*R. typhina* L.)
Occasional in clumps in open places.

360. R. glabra L. Scarlet Sumac.
Grows in clumps, frequently on dry hill sides at the edges of fields.

361. R. vernix L. Poison Sumac. (*R. venenata* D. C.)
Common in tamarack swamps.

362. R. radicans L. Poison Ivy. (*R. toxicodendron* L.)
Common.

363. Ilex verticillata (L.) A. Gray. Winterberry.
Not rare in low marshes, as tamarack swamps.

364. Ilicioides mucronata (L.) Britton. (*Nemopanthes fascicularis* Raf.)
Not rare in tamarack marshes.

365. Euonymus obovatus Nutt. Running Strawberry Bush. (*E. americanus obovatus* T. and G.)
In moist woods, near hillsides or slopes.

366. E. atropurpureus Jacq. Burning Bush.
Common up Cherry Creek gully on flat, rich ground.

367. Celastrus scandens L. Bittersweet.
In woodlands, especially near the edges.

368. Staphylea trifolia L. Bladdernut.
Found growing in moist, shady woods.

369. Acer saccharinum. Silver Maple. (*A. dasycarpum* Ehrh.)
In moist situations.

370. A. saccharum Marsh. Sugar Tree. (*A. saccharinum* Wang.)
In dry ground, in woodlands.

371. A. negundo L. Box Elder. (*Negundo aceroides* Moench.)
Up Clear Creek valley.

372. Aesculus glabra Willd. Ohio Buckeye.
A few trees noted, not very near the lake.

373. Impatiens aurea Muhl. Pale Touch-Me-Not.
Some plants noted some distance from the lake.

374. I. biflora Walt. Spotted Touch-Me-Not. (*I. fulva* Nutt.)
Common about the lake.

375. Ceanothus americanus L. New Jersey Tea.
Abundant in dry sand.

376. Vitis aestivalis Michx. Summer Grape. Small Grape.
Common.

377. Vitis bicolor LeConte. Blue or Winter Grape. (*Vitus aestivatis var bicolor* LeConte.)
Common, but I have seen very little in fruit.

378. Parthenocissus quinquefolia (L.) Virginia Creeper. Wild Ivy. (*Ampelopsis quinquefolia* Michx.)
In woodlands and on fences.

379. Tilia americana L. Basswood. Lin.
Not very common; a few trees seen.

380. Malva rotundifolia L. Common Mallow Cheeses.
Common in waste places, about houses, etc.

381. Abutilon abutilon (L.) Rusby. Velvet Leaf. (*A. avicennae* Gaertn.)
Common in rich grounds.

382. Hypericum prolificum L. Shrubby St. John's Wort.
Abundant in moist places.

383. H. mutilum L. Dwarf St. John's Wort.
Common near the lake.

384. Triadenum virginicum L. Marsh St. John's Wort. (*Elodes campanulata* Pursh.)
Abundant in marshes.

385. Helianthemum canadense (L.) Michx. Frost Weed.
Abundant on dry hills.

386. Lechea villosa Ell. (*L. major* Michx.)
Not rare on dry hills.

387. Viola obliqua Hill. Common Blue Violet. (V. palmata cucullata.)
Common.

388. V. pedata L. Bird's-foot Violet.
On dry hills.

389. V. blanda Willd. Sweet White Violet.
Common in tamarack bogs.

390. Decodon verticillatus (L.) Ell. Swamp Loosestrife.
Common in wet places, especially in a tamarack southeast of the lake.

391. Lythrum alatum Pursh. Loosestrife.
Common in the lake plain.

392. Isnardia palustris L. Water Purslane. (*Ludwigia palustris* Ell.)
In ditches and pools. In Cherry Creek.

393. L. alternifolia L.
Not rare about a pond near the lake plain and northeast of the lake.

394. Chamaenrion angustifolium (L.) Scop. Great Willow Herb. (*Epilobium angustifolium* L.)
Low grounds near Warsaw.

395. Epilobium coloratum Muhl.
Common in low flat grounds.

396. E. adenocaulon Haussk.

A specimen collected by a student and examined in the laboratory was of this species.

397. Onagra biennis (L.) Scop. Common Evening Primrose.

Abundant. A patch, probably of recent introduction, of var grandiflora was found in moist ground near Warsaw.

398. Kneiffia pumila (L.) Spach. (Œnothera pumila L.)

A few plants found along the Pennsylvania Railroad.

399. Circaea lutetiana L. Enchanter's Nightshade.

In shady woods.

400. C. alpina L. Smaller Enchanter's Nightshade.

In moist woods.

401. Proserpinaca palustris L. Mermaid Weed.

Common in swamps near the lake.

402. Myriophyllum verticillatum L. Whorled Water Millfoil.

Common.

403. Aralia nudicaulis L. Wild Sarsaparilla.

Found in damp woods.

404. Heracleum lanatum Michx. Cow Parsnip.

Common in wet grounds.

405. Eryngium aquaticum L. Button Snakeroot. (*E. yuccaefolium* Michx.)

In wet soil along the railroad.

406. Sanicula marylandica L. Black Snakeroot.

In damp woods.

407. Pimpinella integerrima (L.) Gray. Yellow Pimpernel.

In sandy places.

408. Washingtonia claytoni (Michx.) Britton. Woolly Sweet Cicely. (*Osmorrhiza brevistylis* D. C.)

In damp woods.

409. Sium cicutaefolium Gmel. Hemlock Water Parsnip.

Abundant south of the lake.

410. Cicuta maculata L. Water Hemlock.

Common in low grounds about the lake.

411. Deringa canadensis (L.) Kuntze. Honewort. (*Crypotaenia canadensis* D. C.)

Common in rich woods.

412. Hydrocotyle umbellata L. Marsh Pennywort.

Found within the county, but not near Eagle Lake.

413. Cornus florida L. Flowering Dogwood.
In woods, frequent.

414. C. amomum. Mill. Silky Cornel. (*C. sericea* L.)
A species, thought to be this, common at the edge of the lake.

415. C. stolonifera Michx. Red Osier Dogwood.
Very common at the edge of the lake.

416. C. candidissima Marsh. Panicled Cornel. (*C. paniculata* L'Her.)
Some bushes seen near a marsh east of the lake.

417. C. alternifolia L. f.
A few trees seen far up Cherry Creek gully.

418. Nyssa sylvatica Marsh. Sour Gum.
A few scattered trees seen.

419. Pyrola elliptica Nutt. Shin Leaf.
Seen in woods, on hillsides.

420. Monotropa uniflora. Indian Pipe.
Serace, in woodlands.

421. Andromeda polifolia L. Wild Rosemary.
Found in a tamarack swamp southeast of the lake.

422. Gaylussacia resinosa Lam. Black Huckleberry.
At the edges of woods in sandy soils.

423. V. pallidum Ait. Mountain Blueberry. V. corymbosum pallidum Gray.
In sandy soils in woods.

424. Oxycoccus macrocarpus (Ait.) Pers. Large Cranberry.
Found in tamarack swamps; not common.

425. Samolus floribundus H. B. K. Water Pimpernel.
Occasional in moist places.

426. Lysimachia terrestris (L.) B. S. P. Bulb-bearing Loosestrife.
At the edge of the lake in various places.

427. Steironema ciliatum (L.) Raf. Fringed Loosestrife.
Common in damp situations.

428. S. lanceolatum (Walt.) Gray. Lance-leaved Loosestrife.
Common in wet places.

429. Trientalis americana Pursh. Chickweed. Wintergreen.
Found in a tamarack east of the lake.

430. Dodecatheon meadia L. Shooting Star.
Found east along the Pennsylvania Railroad.

431. Fraxinus americana L. White Ash.
Common in woods.

432. Sabbatia angularis (L.) Pursh. Rose-Pink.
Occasional, open woods.

433. Gentiana andrewsii Griseb. Closed Gentain.
A few plants found north of the lake.

434. Frasera carolinensis Walt. American Columbo.
Occasional in open woods.

435. Bartonia virginica (L.) B. S. P. Yellow Bartonia. (*B. tenella* Muhl.)
Found in the county, but not near Eagle Lake.

436. Menyanthes trifoliata L. Marsh Bean.
In a tamarack northeast of the lake.

437. Apocynum androsaemifolium L. Spreading Dogbane.
Common at the edges of fields.

438. A. canabinum L. Indian Hemp.
In similar situations to the preceding.

439. Asclepias tuberosa L. Butterfly Weed.
Common in dry sandy places.

440. A. incarnata L. Swamp Milkweed.
So abundant its blossoms give their color, when in bloom, to the southern part of the lake plain, in places.

441. A. syriaca L. Common Milkweed. (*A. cornuti Decaisne.*)
Abundant in dry soils.

442. Ipomoeca pandurata (L.) Meyer. Man-of-the-Earth.
Found west of the lake.

443. Convolvulus sepium L. Hedge Bindweed. (*C. sepium americanus* Sims.)
Common in parts of the lake plain.

444. C. spithaemus L. Upright Bindweed.
Common on the Pennsylvania Railroad embankment. Not seen in flower.

445. Cuscuta polygonorum Engelm. Smartweed Dodder. (*C. chlorocerpa* Engelm.)
In moist grounds near the lake on various plants.

446. C. gronovii Willd. Common Dodder.
Common on various plants in low places.

447. Phlox pilosa L. Downy Phlox.
Not rare; found along the Pennsylvania Railroad.

448. Polemonium reptans. L. Jacob's Ladder. Blue Bells.
In moist, shady places.

449. Hydrophyllum appendiculatum Michx.
In various places in damp woods.

450. Cynoglossum officinale L. Hound's Tongue.
Common on dry, open hills.

451. Lappula lappula (L.) Karst. Stickseed. (*Echinospernum lappula* Lehm.)
Common in open places.

452. L. virginiana (L.) Greene.
Common in dry places.

453. Lithospermum arvense L. Corn Gromwell.
Not rare in Winona Park in places.

454. Verbena urticifolia L. White Vervain.
Quite common.

455. V. hastata L. Blue Vervain.
Very abundant in low, flat places, at various parts of the lake plain. In places, its blossoms lend great blue unbroken stretches to the landscape.

456. V. stricta.
Common along the railroad.

457. V. bracteosa.
Some found along the railroad.

458. Teucrium canadense L. Wood Sage.
Quite common in low grounds.

459. Scutellaria lateriflora L. Mad-dog Skullcap.
Common in wet places in the lake plain.

460. S. galericulata L. Marsh Skullcap.
Quite common in parts of the lake plain.

461. Marrubium vulgare L. White Horehound.
Common on a bank about a mile up Cherry Creek.

462. Agastache nepetoides (L.) Kuntze. Giant Hyssop. (*Lophanthus nepetoides* Benth.)
Some plants found in the county (up by Chapman's Lake).

463. A. scrophulariaefolia (Willd.) Kuntze. Figwort. Giant Hyssop. (*Lophanthes scrophulariaefolius* Benth.)
In dry soils near Eagle Lake.

464. Nepeta cataria L. Catnip.

Common in dry soil.

465. Stachys palustris L. Common Hedge Nettle.

Common in damp soil.

466. Monarda fistulosa L. Horsemint. Wild Bergamot.

Common on dry hills.

467. M. punctata L. Spotted Horsemint.

A few patches along the Pennsylvania Railroad.

468. Blephilia hirsuta (Pursh.) Torr.

Abundant in woods near Clear Lake gully.

469. Koellia virginiana (L.) MacM. Mountain Mint. (*Pycnanthemum lanceolatum* pursh.)

Abundant, especially in low, flat places, and parts of the lake plain.

470. Lycopus americanus Muhl. Cut-leaved Water Horehound. (*L. sinuatus* Ell.)

In various places along the shore of the lake.

471. Mentha spicata L. Spearmint.

A large patch noted in a low place along the Pierceton Road.

472. M. piperita L. Peppermint.

Rather common in moist places.

473. M. canadensis L. Wild Mint.

Quite common in moist places.

474. M. rotundifolia.

A patch of this near the station at Winona Lake

475. Collinsonia canadensis. Horsebalm.

In moist soil near Chapman's Lake.

476. Physalis pubescens L. Low Hairy Ground Cherry.

Abundant in dry soils.

477. P. lanceolate Michx. Prairie Ground Cherry.

Rather common in dry soils.

478. Solanum nigrum. Black Nightshade.

Scattered in dry soils.

479. S. carolinense L. Horse Nettle.

Found along the railroad.

480. S. dulcamara L. Bittersweet. Nightshade.

A few plants found along the south shore of the lake.

481. Datura tatula L. Purple-stemmed Jimson.
Common in waste places, about barnyards.

482. Verbascum thapsus L. Common Mullein.
Common in dry places.

483. V. blattaria L. Moth Mullein.
In dry places; not so common as the preceding.

484. Scrophularia marylandica L. Pilewort. (*S. nodosa marylandica* Gray.)
Common in dry places.

485. Chelone glabra L. Snake-head. Turtle-head.
Common in moist or wet places.

486. Mimulus ringens L. Monkey Flower.
Common in low places, especially abundant about the Market-street pond.

487. Ilysanthes gratioloides (L.) Benth. False Pimpernel. (*I. riparia* Raf.)
Common in wet places.

488. Veronica anagallis aquatica L. Water Speedwell.
Scattered, in wet places.

489. V. officinalis L. Common Speedwell.
In various places in the Assembly grounds.

490. V. serpyllifolia L. Thyme-leaved Speedwell.
In open places, in dry soil, common.

491. V. peregrina L. Purslane Speedwell.
Common in cultivated places.

492. Leptandra virginica (L.) Nutt. Culvers Root. (*Veronica virginica* Nutt.)
Growing in clumps, in moist soils.

493. Afzelia macrophylla (Nutt.) Kuntze. Mullein Foxglove. (*Seymeria macrophylla* Nutt.)
In woods, near Hamilton Mound.

494. Dasystoma flava (L.) Wood. Downy False Foxglove. (*Gerardia flava* L.)
Not rare in dry woods.

495. D. virginica (L.) Britton. Oak-leaved False Foxglove. (*Gerardia quercifolia* Pursh.)
Common in dry woods.

496. Gerardia purpurea L. Large Purple Gerardia.
Common in low places and in parts of the lake plain.

497. Utricularia vulgaris L. Greater Bladderwort.

Abundant in ditches along the railroad and in Market-street pond; some, but not very abundant, in the neck of Eagle Lake.

498. U. intermedia Hayne. Flat-leaved Bladderwort.

Common in the lake plain south of the neck of the lake, and in a flat about one-half mile southeast of the lake.

499. Leptamnium virginianum (L.) Raf. Beech-drops. (*Epiphegus virginiana* L.)

Some found in dry woods south of Eagle Lake, near Clear Creek.

500. Phryma leptostachya L. Lopseed.

Common in moist woodlands.

501. Plantago rugelli Decaisne. Rugel's Plantain.

In cultivated grounds, common.

502. P. lanceolata L. English Plantain.

Not very common; found in cultivated fields.

503. Cephalanthus occidentalis L. Button Bush.

Common near the lake on the lake plain at various places, and at the edge of woodland ponds.

504. Galium aparine L. Cleavers.

Found in damp places up Cherry Creek valley.

505. G. circaezans Michx. Wild Liquorice.

Common in dry woods.

506. G. trifidum L. Small Bedstraw.

Found in flat, damp places; some at the outer edge of the lake plain.

507. G. asperellum Michx.

Some found east of Eagle Lake.

508. Sambucus canadensis L. Elder.

Rather common in clumps in open places, or more scattered in low, damp woods.

509. Viburnum acerfolium L. Maple-leaved Viburm.

Found growing in forests, rather common.

510. V. lentago. Sheepberry.

Grows along the south side of the lake.

511. Triosteum perfoliatum L. Horse Gentian.

Some found in open places.

512. Lonicera hirsuta Eaton. Hairy Honeysuckle.
Found, but not in flower, in the tamarack northeast of the lake.

513. Micrampelis lobata (Michx.) Greene. Wild Cucumber. (*Echinocystis lobata*, Torr. and Gray.)
Common in damp places and parts of the lake plain.

514. Companula aparinoides Pursh. Marsh Bell-flower.
Common in parts of the lake plain.

515. C. americana L. Tall Bellflower.
Common in woods.

516. Legouzia perfoliata (L.) Britton. Venus's Looking-glass.
In open sandy soil.

517. Lobelia cardinalis L. Cardinal Flower.
Common in damp situations.

518. L. syphilitica L. Great Lobelia.
Very common in the lake plain and damp grounds elsewhere.

519. L. leptostachys A. D. C.
In dry sandy soils, in open places.

520. L. kalmii L.
Common in the lake plain.

521. Cichorium intybus L. Chicory.
Escaped cultivation in various places.

522. Adopogon virginicum (L.) Kuntze. Virginia Goatsbeard. (*Krigia amplexicaulmis* Nutt.)
Not rare in open woods.

523. Taraxacum taraxacum (L.) Karst. Dandelion. (T. officinale Weber.)
Common everywhere.

524. Lactuca scariola L. Prickly Lettuce.
Common in waste places.

525. L. canadensis L. Wild Lettuce.
Common.

526. L. spicata (Lam.) Hitchk. Fall Blue Lettuce.
Not common, found in moist rich soil.

527. Hieracium scabrum Michx. Rough Hawkweed.
Scattered in dry woodlands.

528. H. gronovii L. Hairy Hawkweed.
In dry open woodlands.

529. Ambrosia trifida L. Great Ragweed. Horseweed.
Found in moist rich soil.

530. A. artemisiaefolia L. Ragweed.
Common, especially along roadsides.

531. Xanthium strumarium L. Cocklebur.
Common in rich moist places.

532. Vernonia gigantea (Walt.) Britton. Tall Ironweed. (*V. altissima* Nutt.)
Common in moist rich soils.

533. V. fasciculata Michx. Western Ironweed.
Common in open places.

534. Eupatorium purpureum L. Joe-Pye-Weed.
Very common in moist places, especially on the southern lake plain.

535. E. perfoliatum L. Boneset.
Common in moist ground.

536. Lacinaria scariosa (L.) Hill. Large Blazing Star. (*Liatris scariosa* Willd.)
Not common. Found along the railroad.

537. L. spicata (L.) Kuntze. *Liatris spicata* Willd.)
Quite common in parts of the lake plain, especially the south-eastern part.

538. Solidago caesia L. Blue-stemmed Golden Rod.
In moist woodlands.

539. S. ulmifolia Muhl. Elm-leaved Golden Rod.
Common in open places.

540. S. canadensis L. Canada Golden Rod.
Common in dry soils.

541. S. nemoralis Ait. Field Golden Rod.
Quite abundant in open places.

542. S. riddelli Frank.
Not rare in portions of the lake plain.

543. Euthamia graminifolia (L.) Nutt. Fragrant Golden Rod. (*Solidago lanceolata* L.)
Common in low grounds.

544. Aster macrophyllus L. Large-leaved Aster.
A few plants found along the bluff, north of Cherry Creek.

545. A. shortii Hook.

Common in dry, open places.

546. A. nova-angliae L.

Common along the railroad.

547. A. ericoides L. White Heath Aster.

Common along the railroad.

548. Erigeron annuus (L.) Pers. Daisy Fleabone.

An abundant weed in fields.

549. Leptilon canadense (L.) Britton. Horseweed. (*Erigeron canadensis* L.)

Common in open places.

550. Antennaria plantiginifolia (L.) Richards. Plantain-leaved Everlasting.

Quite common in dry places and open woods.

551. Gnaphalium oblusifolium L. Common Everlasting. (*G. polycephalum* Michx.)

Common in dry places.

552. Silphium perfoliatum L. Cup Plant.

Some found in low, rich ground up Cherry Creek.

553. S. integrifolium Michx. Entire-leafed Rosinweed.

Rather common in low places along the railroad.

554. S. terebinthinaceum Jacq. Prairie-dock.

Not rare in damp places.

555. Heliopsis scabra Dunal. Rough Ox-eye.

A few scattered patches noted in dry places.

556. Rudbeckia hirta L. Black-eyed Susan.

Common in both dry and moist soil.

557. R. laciniata L. Tall Cone Flower.

A few plants noted; grows in moist ground.

558. Ratibida pinnata (Vent.) Barnhart. Gray-headed Cone Flower. (*Lepachys pinnata* T. and G.)

Rather common along roadsides.

559. Helianthus giganteus L. Giant Sunflower.

Common and widely scattered in moist rich soil.

560. H. divaricatus L. Rough Sunflower.

Common in dry woods.

561. Verbesina alternifolia (L.) Britton. (*Actinomeris squarrosa* Nutt.)

Not rare in low woods.

562. Coreopsis tripteris L. Tall Tickseed.
Some noted in open waste places.

563. Bidens connata Muhl. Swamp Beggar Ticks.
Common in wet places.

564. B. frondosa L. Common Beggar Ticks.
Common, especially in moist soil.

565. B. trichosperma (Michx.) Britton. Tall Tickseed Sunflower. (*Coreopsis trichosperma* Michx.)
Very common in some swamps; sometimes the flowers make the whole landscape yellow.

566. Helenium autumnale L. Sneezeweed.
Common along the lake shore.

567. Achillea millefolium L. Yarrow.
Common in old orchards.

568. Anthemis cotula L. Dog-fennel.
In dry soils in waste places.

569. Chrysanthemum leucanthemum L. Ox-eye Daisy.
Some plants found in dry soil.

570. Erechtites hieracifolia (L.) Raf. Fire Weed.
Not rare in open woods.

571. Mesadenia atriplicifolia (L.) Raf. Pale Indian Plantain. (*Cacalia atriplicipolia* L.)
Some plants noted up Cherry Creek in dry soil.

572. M. tuberosa Nutt.
A few plants noted in boggy ground southeast of Eagle Lake.

573. Arctium lappa L. Burdock.
Common in waste places and about dwellings.

574. Carduus lanceolatus L. Common Thistle. (*Cnicus lanceolatus* Willd.)
Common everywhere in open and waste places.

575. C. altissimus L. Tall or Roadside Thistle. (*Cnicus altissimus* Willd.)
Rather common in open and waste places.

576. C. muticus (Michx.) Pers. Swamp Thistle. (*Cnicus muticus* Pursh.)
Common in swampy ground.

577. C. arvensis (L.) Robs. Canada Thistle. (*Cnicus arvensis* Hoff.)
A large patch in a pasture one-fourth mile east of the lake. Plants scattered at various places about the region of the lake.

ADDITIONS AND CORRECTIONS.

578. Anaphalis margaritacea (L.) Benth. and Hook. Pearly Everlasting. (*Antennaria margaritacea* Hook.)

Scattered, in dry places. Out of flower during the season at Eagle Lake, but noted, and found and determined in subsequent work. The patch of *Mentha rotundifolia* was noted too late to press, so the identification is doubtful.

SUMMARY.

The area included within a line along the crest of the hills surrounding Eagle Lake presents for study a remarkable variety of conditions and ecological regions, as (1) upland forest, with native trees and shrubs; (2) cleared and abandoned upland with the flora that has subsequently taken possession; (3) creek, valleys and gullies, with their peculiar soil and flora; (4) railroad and introduced flora; (5) lowland forest; (6) lake plain; (7) tamarack swamp; (8) ponds, temporary and permanent, and quaking bogs and bayous; (9) ice ridge; (10) beach; (11) the lake, with several zones of plants.

The upland forest is much like forests in general throughout Northern Indiana. In some places there is underbrush and herbs, in others a thick carpet of dried leaves. The soil is sandy, and many of the herbs of xerophytic habit. Fungi are abundant.

The cleared land is covered with sassafras, sumac, scrub oaks, Russian mulberry and so on. Many mat plants are present, and there is a tendency of various species of herbs to occupy exclusively the ground they grow on. Among these plants are five-finger and dewberry. Just at the base of the slopes *Fimbristylis* is abundant.

Creek valleys and gullies have a peculiar flora on their slopes, and also in the rich alluvial soil of their bottoms. In many cases they resemble extensions of the lake plain. Among many characteristic plants are skunk cabbage, *Conocephalus*, *Blephilia*, and so on.

The railroad has an interesting introduced flora of wild lupine, *Salsola kali*, squirrel-tail grass, white amaranth, and many other species.

The Lowland Forest, a dense, tangly jungle with a rich sandy loam soil, contains numerous and interesting species. Quaking asp, elm and sycamore are representative trees. The herbs are various, rank, shade and moisture loving species.

The lake plain is a perfectly flat area composed of muck and marl. In many places it is covered with copses of low willows, *Cornus*, *Cephalanthus Spirea* and carolina rose, and this is perhaps its original form. In other places it is a sedgy meadow. Peculiarities are (1) the distribution of plant species in horizontal strata, as, bushes above, then sedges, then ferns, and lower, mosses and *Selaginella*. (2) The flora is so crowded that when a predominant species is in flower it frequently gives its tint to the whole landscape, so we have a succession of "color waves" during the year, as the blue of blue vervain, deep purple of *Lythrum alatum*, light purple of swamp milkweed or joe-pye-weed, brown of *Osmunda regalis*, or yellow of tickseed sunflower or *Rudbeckia*.

The tamarack was nearly extinct, but others near by showed probable former flora of *Sphagnum*, pitcher plants and an interesting assortment of heaths and orchids.

Temporary woodland ponds are mostly bare of bottom except for dead leaves and some shrubs and water crowfoot. The temporary ponds in the open are overgrown with *Scirpus cyperineus* and various species of Eleocharis. These temporary ponds are interesting as they contain plants showing *seasonal* dimorphism, an aquatic form during wet seasons and a land form during dry periods of the year. They also contain plants, the lower leaves of which are fitted to submersed life, and the upper to aerial life, as water parsnips and water crowfoot.

Permanent ponds, quaking bogs and bayous are similar to the lake, except that they contain a greater number and variety of duckweeds.

The Ice Ridge is interesting in many ways, but does not contain many plants peculiar to itself.

The Beach contains a mixed flora. Sometimes its flora is of such plants as *Scirpus Americanus* or various *Eleochari*, sometimes it is seedlings of elms, maples, etc., which have been deposited by waves.

The lake has several zones of plants. Near the shore and extending both ways are plants with well marked dimorphism—a well developed land form, and an aquatic form. Among such plants are, spatterdock, white water lily, *Utricularia intermedia*, water plantain, *Heteranthera dubia*, and many others. *Scirpus lacustris* has two well marked forms which frequently grow side by side and form a distinct contrast. At other places what appear to be intermediate forms are found. Many of the *Potamogetons* have emersed leaves dissimilar in form and structure from the submersed ones. Among the various zones of plants are:

(1) The shore plants, as some species of *Eleocharis.*

(2) Aquatic with emersed leaves (or culms) as *Scirpus lacustris,* spatterdock, water lilies and pontederia, also many *potamogetons.*

(3) Short stemmed aquatics; species near shore as *Naias* and species of *Chara* and *Nitella.*

(4) Long stemmed aquatics, in deep water, as various *Potamogetons, Ceratophyllum* and *Myriophyllum.*

(5) Beyond these Phanerogams, and intermixed with them, are the Algae.

The lake disseminates such winged seeds as those of elm and maple, and sows them on the beach.

Various water plants, as *Scirpus* and species of *Potamogeton,* protect the shore from waves. They also serve as points for the attachment of various organisms.

D. The Plant Ecology of Winona Lake.

Lucy Youse.

In the following discussion of plant societies and their distribution about Winona Lake, Warming's system of classification of plant societies will be used. This system of classification, now in general use by botanists, groups plants, except in the case of salt plants, on the basis of their relation to moisture. He distinguishes the following types: Xerophytes, those requiring least moisture; hydrophytes, those requiring most; mesophytes, those of medium moisture conditions; and halophytes, plants of alkaline soil or salt water.

Many things besides climate help to determine the amount of moisture. The quality of the soil has a marked influence upon the water content; clay, for instance, holds water and sand does not. Of all such factors, the topography of the country, since it plays so important a part in determining not only the drainage and the humus content of the soil, but also exposure to the wind, to light and to heat, is held by some to be more important even than surface geology in its influence upon the character of the vegetation. Dr. Henry C. Cowles, in his report upon the plant societies of Chicago and vicinity, has shown this influence to be secondary to that of topography. In his discussion of the same he says: "The flora of a youthful topography in limestone, so far as the author has observed, more closely resembles the flora of a similar stage in sandstone than a young limestone topography resembles an old limestone topography. A limestone ravine resembles a sandstone ravine far more than a limestone ravine resembles an exposed limestone bluff, or a sandstone ravine resembles an exposed sandstone bluff. We may make the above statements in another form. Rock as such or even the soil which comes from it, is of less importance in determining vegetation than are the aerial conditions, especially exposure. And it is the stage reached by the evolution of the topography which determines the exposure."

Much might be said on this subject of the chemistry versus the physics of the soil. It is discussed by both Schimper and Warming, and even the latter says that the chemistry of the soil best accounts for the halophytes. In making observations and recording experiments both sides of the question must be kept in mind if our conclusions are to be accurate.

The soil, or edaphic influence is local, and is in direct contrast to that of climate which is widespread. To the latter are due our pineries of the north and also our own growth of deciduous trees. Beech-maple-hemlock forests, the climax type, toward which, it may be said, everything is tending, are climatic. Oak societies, on the other hand, are a predominant but not permanent feature of Winona Lake, and the conifers of the Atlantic coast are edaphic, being due to soil or local atmospheric conditions. The first plant societies of a region are the result of extreme or pronounced local conditions and are edaphic. Less pronounced conditions gradually obtain and we have climatic types. And even then the types are not permanent, for we have climatic changes. The earth is perhaps gradually growing colder and a period of glaciation may be approaching. Beech fossils in Sweden show the former existence of beech forests in a region which is now too cold for their growth.

It is the purpose of the author to indicate some of the changes which are now taking place in the region under discussion and to show how edaphic are giving way to climatic influences as the territory develops from youth to maturity.

Crustal movements and erosion, with its consequent deposition, must be taken into account. By erosion we have the constant wearing away of hills, which is retarded in no small degree by the vegetation growing upon them and the deposit at a lower level of the material carried away. By this process, which is hastened by the decay of plants, in swamp and lake, xerophytic hills and hydrophytic lowlands both become more mesophytic and a planation called base level is approached. This planation is interfered with by crustal movements. If the movement be upward, the mesophytic development of hills is retarded while that of the swamp is hastened. A downward movement, on the other hand, would hasten the mesophytic development of upland and retard that of the lowland. From this, it will be seen that the ultimate tendency, at least in this climate, is toward the mesophytic condition. Whether the change is slow or rapid is determined by the locality in which it occurs. A granite hill develops much more slowly than a morainic region like that about Winona Lake.

Here we have the "knob and kettle hole" lake and swamp of the terminal moraine. The soil is that attendant upon such a region, a mixture of sand, gravel and clay, with here and there a predominance of sand or clay, the whole being varied by stretches of the muck of the swamp and the sand of the beach.

There are probably three main types of vegetation—the hydrophytic or semi-hydrophytic societies of lake and swamp, the xerophytic or semi-xerophytic of the morainic uplands, and the mesophytic along the streams. In reality we have various combinations of these types and the different plant societies are not limited to the respective topographic forms as indicated, since the region shows marked evidence of development toward the climax type.

1. The Lake.—There are all gradations in the "kettle hole" in the immediate vicinity of Lake Winona, from the lake itself to the various undrained and half-drained swamps scattered here and there about the margin of the lake and representing old ponds which have gradually become filled up by the encroachment of vegetation upon them.

Where the vegetation in the lake is most luxuriant, we find, in the outermost zone, Nymphaea odorata and Nuphar advena (the white and yellow water lilies); next, Pontederia cordata (pickerel weed), and nearer the shore the bulrushes (Scirpus lacustris and Scirpus pungens). A number of species of Potamogetons are found among all of these, in some places reaching far out into the lake. At the mouth of Cherry Creek Potamogeton fluitans predominates, with Potamogentons pectinatus, Potamogeton zosteraefolius and one or two other species nearby, together with Hydrophyllum (water milfoil) and Ceratophyllum (hornwort). In this society Chara has a place by no means unimportant. It is especially prominent in the northwest arm of the lake, which, in its luxuriant growth of vegetation, beautifully illustrates the ultimate fate of the entire body of water. The outlet, which flow from this arm at its southern end, has become so thoroughly choked up with vegetation at its beginning that the water has grown almost stagnant and the lake flora is gradually working its way up the stream. Fig. 1 shows part of this arm in the left foreground and the lilies at the entrance to the outlet. With the exception of this arm the lake vegetation is most luxuriant near the southwest shore

Fig. 1. View across the lake to the east. The general basin form is distinguished. The highlands can be seen in the background. Tongues of land are seen being reclaimed from the lake bottom. On the right is the outlet to the Tippecanoe. Zones of white and yellow water lilies in the foreground, followed by cat-tails and sedges. Zones of willows, Carolina rose and osier dogwood are in the center, while to the right is an oak and hickory forest. On the left is a swamp meadow.

This is perhaps explained by the fact that the winds in this region are from the southwest. The greatest wash of the waves is toward the east and northeast, and here, as we might expect, we find the greatest dearth of plants and plant growth. This southwest beach is overlaid with muck, a natural result of the decay of plants along its margin.

At some places around the lake, notably in the same arm, the bulrushes are followed by the cat-tails (Typha latifolia) with sedges and grasses on the shore beyond. This is shown in Fig. 1, at the left. On the south shore, however, where the land is raised by an ice beach, the lake is bordered by the button bush (Cephalanthus occidentalis), osier dogwood (Cornus stolonifera), Rosa Carolina, Cottonwood (Populus monilifera) and willow. A region similar in vegetation is shown in Fig. 2. This succession of societies is carried a step further on the west shore of the lake southwest of Yarnelle's landing. In addition to the foregoing are swamp white oak (Quercus bicolor), silver maple (Acer dasycarpum),

Fig. 2. View across lake from Yarnelle's landing. The basin effect is more apparent here. The transition in vegetative types is very rapid at this point, owing to the somewhat abrupt rise in the topography. It quickly passes from hydrophytic through the marsh stage to mesophytic. On the shore, zones of the button bush and osier dogwood are followed by those of Carolina rose, willow and, lastly, elm. The coming of this tree means permanent conditions looking to the mesophytic types.

and sycamore (Platanus occidentalis). The land adjoining this on the west, which is slightly elevated and better drained, and which might show a still higher stage of development, has been cleared and cultivated. So we must look toward the south where the hand of man has not interfered with the work of nature. Here, as we might expect, in the same relation as to position, that is a step further from the lake, higher, drier, and well drained, we find the hazel (Corylus Americana), the grape, Mayapple (Podophyllum peltatum), Catnip (Nepeta Cataria), Smilacina racemosa, and the Elder (Sambucus Canadensis). This mesophytic strip forms a zone of tension between the more nearly hydrophytic beach and the semi-xerophytic hill adjoining on the west. At Yarnelle's landing, north of the dredge, where the land rises quite suddenly from the water's edge, joining the hills a short distance beyond, there are comparatively few willows. The sycamores and cottonwoods of the shore are accompanied by the aspens (Populus tremuloides), the elm (Ulmus Americana), black haw (Viburnum prunifolium), the hickory and Sassafras officinale. Closely adjoining are the mayapple, grape, red bud (Cercis Canadensis), and prickly ash (Xanthoxylum Americanum). This evolution of plant societies on the lake shore is perhaps shown even more beautifully in the vegetation of the two long points of land projecting out into the northwest arm. These are shown at the left in Fig. 1, the one in the foreground showing the more advanced stage.

2. The Swamp.—The encroachment of vegetation upon the lake, with its death and decay, makes the water shallower and finally unfits it for the plants themselves. This filling up process is aided by the deposition of material carried in by the streams that feed its waters, and ultimately we have a swamp taking the place of the lake. These may be found in various stages of construction and destruction in the region about Winona which was at one time itself a part of the lake.

One of the youngest of these, near the east shore of the lake and bordering upon Cherry Creek, has its surface covered with duckweed (Lemna, Spirodela and Wolffia) with arrowhead and yellow water lilies near the shore in some places, followed by grasses, the Iris (Versicolor) and sedges (Carex vulpinoidea and Carex lupulina). Surrounding these are the button bush, osier dogwood, willows, swamp white oak and elm and the fern (Aspidium thelypteris). In some places where the swamp is becoming filled up, a dense growth of Polygonum is found in the center.

At many places about the lake is the swamp meadow, a wide stretch of flat land with rich muck soil. One of the most interesting of these lies just north of the lake. Here are grasses, sedges, Salix amygdaloides, the shield fern (Aspidium thelypteris), Potentilla fruticosa (shrubby cinquefoil), Eupatorium purpureum, osier dogwood, Carolina rose, Joe Pye-Weed, Solidago lanceolata, Campanula aparinoides (marsh bellflower), Lycopus lucidus (water horehound), Asclepias incarnata (swamp milkweed), Pycnanthemum lanceolatum (mountain mint), Boehmeria cylindrica (false nettle), Betula pumila (low birch), Steironema longifolium, Osmunda regalis.

Convolvulus arvensis (bindweed), Apocynum androsaemifolium (spreading dogbane), Verbena urticaefolia (white verbena), Rudbeckia hirta (cone flower), and Lythrum alatum (loosestrife), together with the following mesophytic pioneers: Eupatorium perfoliatum (boneset), Pilea pumila (rich weed), and Impatiens.

At places where the swamp is better drained its ultimate tendency is indicated, notably at a point about a quarter of a mile south of the southeast corner of the lake. We see here black oaks (Quercus coccinea tinc-

Fig. 3. View showing rich mesophytic meadow reclaimed from the lake bottom. This area is rapidly becoming more mesophytic and the remaining hydrophytic plants are dying out. In the background, on the morainic upland, is seen an oak-hickory forest, with the white oaks at the base and black oaks on slope. It is probable that the meadow has never been forested.

toria), white oaks (Quercus alba), silver maple (Acer dasycarpum), sycamore (Platanus occidentalis), walnut (Juglans nigra), hickory, poison ivy (Rhus Toxicodendron), richweed (Pilea pumila), Indian turnip (Arisaema triphyllum), May-apple (Podophyllum peltatum), Viola palmata, Viola pubescens. These patches of mesophytic woods are sometimes found in the very center of the swamp at places where the land is somewhat higher. The soil contains a larger amount of moisture than that of the mesophytic woods on the lake shore spoken of above, and the vegetation represents a higher type of mesophytic society.

In the evolution of the swamp of Turkey Lake, the first vegetation is of water plants. These are followed by bulrushes or sedges, and next come shrubs and trees, in some cases those noted above, but in others Cassandra calyculata which is followed by the tamarack (Larix Americana). These swamps are destined to become forests, while in the case of the lake like Lake Calumet, near Chicago, Ill., the destiny of which

Fig. 4. View of a portion of the beach in Cherry Creek Embayment. The slope is gentle, rising from the low channel of the creek on the right to over 20 feet on the left. The soil is very boggy and most of the bogs are associated with mineral springs. Rows of willows in the right center, with sycamores and oaks on left. The rich nature of the soil is apparent in the heavy herbaceous vegetation. Semi-fossilized bivalve shells were found here.

is the prairie, the bulrush stage is followed by grasses. It is suggested by Dr. Cowles that this difference in the ultimate development of the swamp may be due to the depth of the kettle and consequently the depth of the muck, the forest type being found by him to have originated from deep kettles and the prairie type from shallow ones. The muck in the swamps spoken of above is deep and their destiny is evidently forest, as has been pointed out, but there is very little evidence of the Cassandra and the Tamarack stages. There are a few tamarack swamps in the vicinity of Lake Winona containing some of the plants typical of the tamarack stage, such as the pitcher plant (Sarracenia purpurea), and the peat moss, Sphagnum. But in the old Winona Lake bed there are barely three lone tamaracks, standing in the bottom of an old arm of the lake, with nothing to indicate the share they took in the development of the swamp. Further data obtained by a comparison with other specimens of this kind of swamp are necessary before a definite conclusion can be reached concerning its evolution.

Quite an interesting type of swamp is found in a narrow belt of lowland which adjoins the lake and represents an old arm of it, lying like a ditch between the hills there. It contains Ludwigia polycarpa, Ludwigia hirtella, ditch stone-crop (Penthorum sedoides), manna-grass (Glyceria fluitans), Polygonum acre, Polygonum hydropiper, Polygonum sagittatum and Polygonum Muhlenbergii. The flora of the margin is swamp white oak, black alder (Ilex verticillata), sour gum (Nyssa sylvatica), Carolina rose, and the swamp, white or silver maple (Acer dasycarpum). Riccia fluitans carpets the wet soil.

A swamp in the hollow of the hills is filled with Polygonum hydropiper, Iris, skunk cabbage (Symplocarpus foetidus), and Rosa Carolina. Around the margins are dying willows, elm and ash. Fossils of ferns point back to former days when moisture was more abundant. Withering Mnium and flourishing Polytrichum, the relict and the pioneer, show past and future. To the south, the hill has been cleared and xerophytic conditions are being hastened in the margin of the swamp. Dying Iris and vigorous Canada thistle grow side by side. On the east, west and south are the morainic hills covered with oak-hickory forests. The fate of this swamp is gradual filling up by dead vegetation and downwash from the surrounding uplands and the ultimate encroachment of the neighboring plants upon its territory.

3. The Morainic Uplands. The sand-gravel-clay hills are even more numerous about the lake than are the swamp meadows and their vegetation is only slightly varied at different places, this being usually in clearings. The oak-hickory stage prevails. Near the summit of the hill is the black oak (Quercus coccinea tinctoria), with the white oak (Quercus alba), on the lower slopes. These are accompanied by the hickories (Carya alba and Carya sulcata), wild oats (Danthonia spicata), wire grass (Poa compressa), plantain-leaved everlasting (Antennaria plantaginifolia), Polytrichum, New Jersey tea (Ceanothus Americanus) and Silene stellata. At

the base of the hills, on the tension line adjoining the swamp, is the black huckleberry, Gaylussacia resinosa. (See background of Fig. 3.) The oak stage has required so long a time to develop and has been in existence so long that we have only the result and little evidence of what preceded this type. In the north the coniferous forest comes first. Clearings give some intimation of the order of succession, and they are numerous, though somewhat deceptive, as the stages in this case follow one another much more rapidly than they would in a virgin soil in which

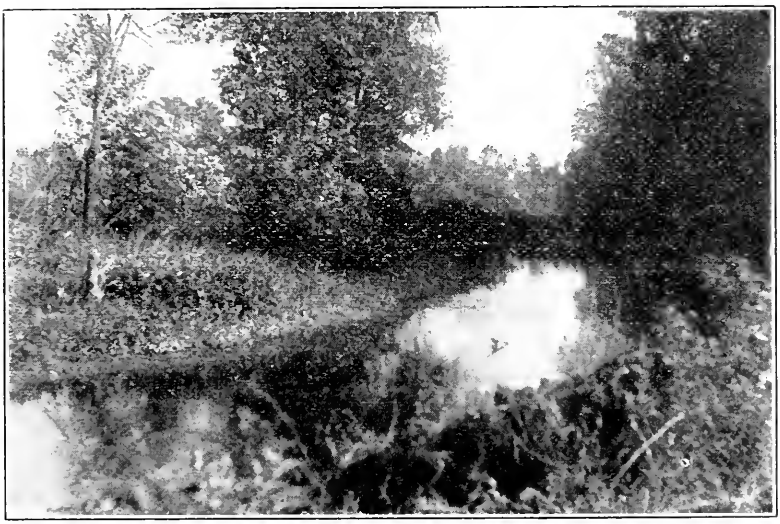


Fig. 5. View of the channel and abutments of the upper or lesser dam. From the condition of the vegetation in the foreground, it is evident that the stream's gradient is small. Upon the left and right the surface rises abruptly to 12 feet, and is covered with heavy mesophytic trees. The soil is sandy. This is a place where vegetation is capable of closing the drainage lines.

there had been no foundation laid for later types. Where the soil has been cleared the first plants that follow, as shown on the north and west sides of the lake, are Xerophytic annuals and perennials, such as poke weed (Phytolacca decanda), mullein (Verbascum thapsus), Canada thistle (Cnicus arvensis), hounds-tongue (Cynoglossum officinale), Leonurus Cardiaca, Arctium lappa, Echinospermum lappula. These seem to be followed by elm and hickory. The beech-maple forest is working its way in so slowly around Winona that at first glance there seems to be no

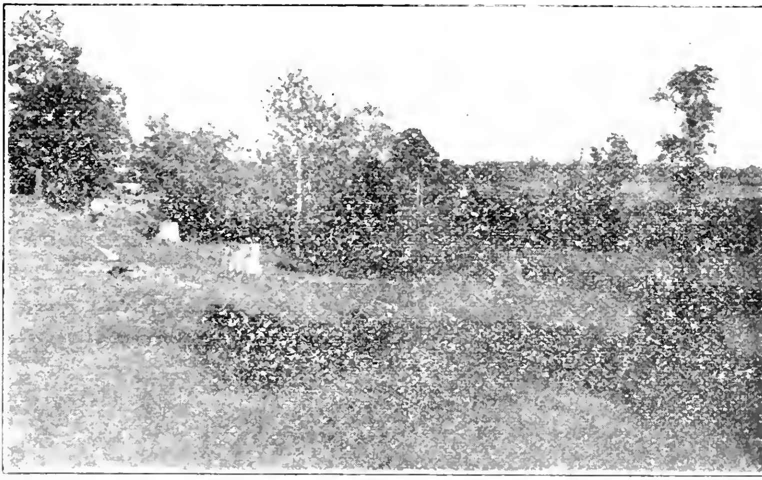


Fig. 6. View across the valley from the left abutment of the lower or greater dam. The width of the valley is here about 165 feet, with the earth walls rising abruptly 22 feet on either side. The soil is a glacial deposit, sand predominating.

Fig. 7. View up the channel of the outlet at the greater dam. The depth of the valley is shown by the altitude of the right abutment in the background. The evidence of the ascending erosion line is in the foreground.

indication of it whatever. It has made its appearance in only one region in the old lake bed, namely, within a mile of the present lake shore around Clear Creek. The beech forest west of the lake is outside of the territory covered by this report. Why this type has lagged so far behind is perhaps due to the large percentage of gravel in the soil, as its development is much slower in gravelly soil than in that in which we have a large percentage of clay. The presence of beeches depends upon the amount of humus in the soil. Then, too, both beech and maple seedlings can grow in the dense shade these trees themselves make or in the lighter forests of oak and hickory. The plants of the latter type, on the other hand, do not flourish in the deeper shade of the beech.

Accompanying the beech (Fagus ferruginea) which is yet somewhat rare in this type of forest about the lake, and the sugar maple (Acer saccharinum) are the tulip tree (Liriodendron tulipifera), the walnut, the pawpaw (Asimina triloba), Hepatica, Trillium, Virginia Creeper, Mayapple, skunk cabbage, various species of ferns, together with the older oaks and hickories, which point back to the past.

4. The Stream.—The territory over which now flows the lower part of the two streams that feed the lake was once the lake bed and is now a flood-plain. Cherry Creek, the largest of these, is a pre-erosion type in what is apparently an erosion valley. Along the lower course of this is a mixture of influences which results in a "hodge podge" of vegetation not easy to unravel. Lake and swamp, spring and stream, all combine their forces to produce this effect. Near the mouth of the stream Potamogeton fluitans is abundant. In that part most often submersed are the rice cut grass (Leersia oryzoides), cat-tails, bulrushes and sedges, among them Scirpus atrovirens, Carex lupulina, and Carex vulpinoidia. Many plants characteristic of springs and spring brooks are found, such as swamp milkweed (Asclepias incarnata), skunk cabbage (Symplocarpus foetidus), Eupatorium purpureum, Eupatorium perfoliatum, Lycopus lucidus (water horehound), and several other species of mint, Lobelia leptostachys and Lobelia syphilitica. Salix longifolia and Salix nigra are common (see Fig. 4), and in the locality west of the creek and bordering upon the lake seedlings of the river or silver maple (Acer dasycarpum) and the aspens (Populus tremuloides) form a marked feature of the landscape. Other plants characteristic of this flood-plain are the ash (Fraximus Americana), the walnut (Juglans nigra), the red-bud (Cercis Cana-

densis), the sycamore (Platanus occidentalis), the mulberry, the hazel (Corylus Americana), the hornbeam (Carpinus Caroliniana), poison ivy (Rhus toxicodendron), Virginia creeper (Ampelopsis quinquefolia), grape (Vitis), greenbriar (Smilax), Indian Turnip (Arisaema Dracontium), ground ivy (Nepeta Glechoma), nettles, blue grass (Poa pratensis), meadow rue, strawberry (Fragaria), Impatiens, Aspidium thelypteris, Onoclea sensibilis and Osmunda regalis.

Looking forward to the future of this stream we expect greater erosion, retrogression toward the xerophytic, and, as the ultimate base level is approached, progression again toward the mesophytic.

Niagara Group Unconformities in Indiana.

Moses N. Elrod, M. D.

Prof. Richard Owen, in the Indiana Geological Survey, 1859-60, calls attention to an unconformity near Huntington, which he supposed to indicate the dividing line between the Devonian and Upper Silurian. He describes the arenaceous limestone of the Devonian as resting unconformably, rate of dip 25 to 40 degrees southeast, on the silicious limestone of the Silurian. Of the Linn's Mill exposure, on Treaty Creek, Wabash County, he says: "Here we again found evidence of the convulsions and unconformable stratification noticed at the Fair Ground quarries of Huntington and in this county. On the west side of the creek, opposite the mill and close to the dam, a hill is formed by an anticlinal axis, the beds dip northward and southward about 43 degrees. But the extreme summit of the hill has evidently been subsequently denuded and abraded by water until a hollow affords a channel for a rippling rivulet, while in the bed of the main stream, beneath the axis, the undisturbed strata are visible." In the light of more recent investigations it is probable Prof. Owen's arenaceous limestone of Huntington and the upper member of his Wabash County unconformities should be correlated with the porous limerock of Prof. Collett, and the picket rock of Messrs. Elrod and Benedict. It should also be noted that the underlying layers of stone, at Treaty Creek, are approximately horizontal, and exclude an uplift as the cause of the distorted bedding.

Prof. John Collett, in the Geological Survey of Indiana, 1872, describes an unconformity seen by him at Calvert's quarry, near Georgetown, Cass County. He found a gray limestone resting unconformably on the "silico magnesia with a small parting of clay." This clay parting, he claims, is general, and is often found in wells some 20 or 30 feet below the surface at Logansport. At a later period the observations of Prof. Collett were confirmed by Mr. A. C. Benedict. Commenting on a section made, near Georgetown, for the report on the Geology of Cass County, 1894, he describes the surface of the first layers under the "gray limestone" as showing evidence, when exposed, "of having been eroded into channels and hummocks before the overlying rock was deposited."

Prof. Collett, under the section of his 1872 report devoted to Wabash County, correlates the "gray limestone seen at Logansport and at a few localities in Miami County" with the "thin-bedded paving stone" of Wabash. The silico magnesian beds of Logansport, he says, "part with the greater portion of the calcareous matter at Peru, becoming argillaceous, while in Wabash this bed is characteristically argillaceous, and in appearance very similar to the hydraulic stone at Louisville." In his general section of Wabash County he places (1) porous limerock at the top, and gives its thickness at from 0 to 40 feet; (2) paving stone, 8 feet; (3) thick-bedded argillaceous limestone, 10 to 20 feet; (4) hydraulic limestone, 10 to 50 feet, and referred the whole series to the Niagara group. The subdivisions adopted by Elrod and Benedict in their report on the Geology of Wabash County, 1891, do not differ greatly from those of Prof. Collett. They placed the quarry stone, the equivalent of his paving stone and thick-bedded argillaceous limestone, at the top of the series. Between the quarry stone and his hydraulic limestone they recognized a local stratum of laminated shale, closely related to the quarry stone, and all below the laminated shale was called cement shale or cement rock. The porous limerock was not given a separate place in the section, because it was the opinion of the writers that it did not form a distinct geologic horizon; but was composed of the changed materials derived from the quarry stone and the underlying formations, but came mainly from the quarry stone layers. The materials were recemented by infiltration, and, as a consequence, the beds have no true stratification planes. For it they adopted the name picket rock, a local term then in common use at Wabash.

These correlations are deemed necessary that the reader may understand the stratigraphic position of the Wabash County unconformities, and the probable relations of the others of the Wabash Valley.

A very remarkable and plain example of unconformity between the quarry stone layers and the blue cement rock may be seen on the east bank of Lagro Creek, one-half mile north of Lagro. Here 30 feet of horizontal quarry stone abuts against a nearly perpendicular wall of cement rock. Below the unconformity, in the creek channel, the cement rock is found to be continuous and connected with the south wall of the unconformity and to pass under the more recent quarry stone. Dip is scarcely appreciable in any of the layers. Other unconformities of great interest are those at the Martin Willis quarry, south of Lagro, on the township line pike, and at Leonard Hyman's quarry, on the Mississinewa River. At these quarries the quarry stone rests on the laminated shale in a valley. On one side of the Martin Willis quarry the shale rises 10 feet above the lowest exposed horizontal layers of quarry stone.

Some convulsion of nature, a local upheaval and subsidence of the earth's crust, was among the theories generally accepted for a time, to account for the false bedding of the Wabash Valley rocks. Prof. Collett, in 1872, was the first to offer an explanation more nearly in accord with recent observations. Of a Delphi locality he writes: "The Pentamerus bed is an irregular deposit, variable in its mode of occurrence and thickness, evidently deposited by currents flowing across irregularities in the surface of the regularly deposited rocks below. It is generally found thrown down upon or against these irregularities, and consequently exhibits remarkable peculiarities of false bedding." But his theory does not account for the uneven surface of the regularly deposited rocks. The most obvious explanation is to suppose that they are due to erosion, and that they indicate the upper surface of the lower member of an unconformity. Especially must this be true where the stratification of the stone, comprising the irregular surface, is found to be level and the layers of uniform thickness. Where the irregularity forming the axis or center of a cone is composed of shale it is not impossible that it may have been formed by currents. The effect of currents on the contour of a shale bed was clearly demonstrated in an example of irregular bedding seen in the quarry of James Lambert at South Wabash. Here an axis of shale had been deposited between the quarry stone layers, which maintain a uniform thickness while conforming to the irregular surface of the shale. Near Lagro, at the Watson Briggs ravine, is a beautiful exposure on a large scale of the picket rock passing over a central axis of a cement shale with the dip in opposite directions. On the flanks of the axis the dip changes from 20 to 12 degrees and the layers become horizontal as they pass over the top. These exposures are supposed to show the primary origin of the false bedding in nearly all cases, and especially so when the distorted layers are of nearly uniform thickness. But in many cases other phenomena are involved and the explanation is not so simple. Irregularities of the underlying surface do not account for the brecciated condition, changed physical characters and the nearly vertical planes of so-called stratification.

The brecciated character of the Indiana stone seems to have been first pointed out by Prof. Orton in the eighth annual report of the United States Geological Survey. Of the Ohio stone, with which he compares the Indiana outcrop, he says: "The layers of limestone appear to have been traversed by joints dividing them into cubical blocks of two or ten inches in diameter, and the separate blocks have been recemented by material of the same sort that composes the substance of the rock. The cause is not obvious, but the phenomena is certainly not referable to uplift and disturbance. It seems more probable that if we were able to trace out the history we should find some modification of the force that produces joints, whatever it may be, as the cause of the phenomena we are considering."

The high angle stylolite planes of the interior conformation of the cones is another feature which should be considered in connection with the brecciated structure. The columnar part of the stylolite seam is peculiar in having its axis lie parallel with the separation plane, and seems to show that the columnar structure is the result of a downward movement of the overlying layer. At the Stauffler quarry, two miles west of South Wabash, and at Rockyway Creek the angle of the separation planes does not exceed 25 degrees, and it is probable that they may be modified bedding planes, something like those described by Mr. T. C. Hopkins in his report, of 1896, on the Bedford oolitic limestone of Indiana.

The exposures at Stauffler's and Rockyway also show that the picket rock gradually changes into even bedded quarry stone, and that the picket rock is a modified form of the other. At the same time the dip changes from an angle of 25 degrees to nearly horizontal.

The high angle stylolite planes are too nearly vertical to have been the result of sedimentation. They evidently grow out of a number of conditions. Briefly, the picket rock cones and ridges rest on a core or axis of cement rock or shale, the latter being the result of erosion. It is probable the layers of stone, overlying the core, were of continuous thickness when deposited, and that the brecciated character and stylolite planes are the result of pressure and unequal resistance to a downward shear.

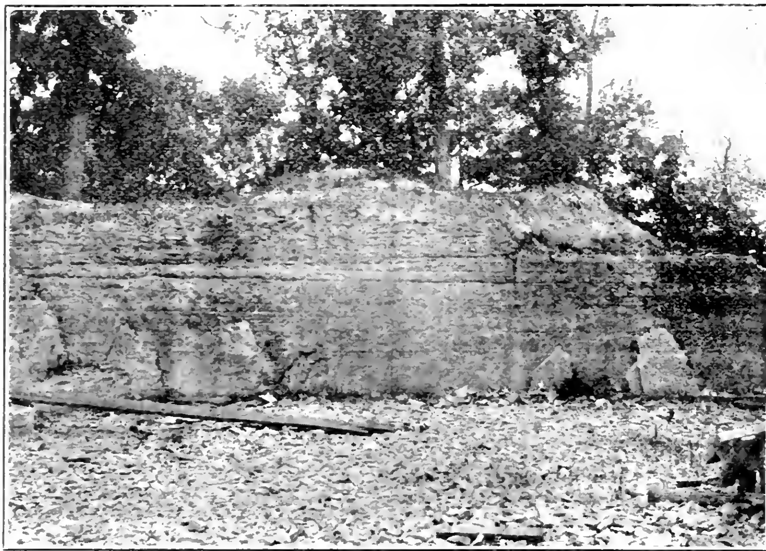
A somewhat similar system of brecciated and irregularly bedded stone extends from the interior of Ohio, across Indiana and into Illinois. Through Indiana and in the vicinity of Chicago high angle stylolite planes are a marked feature of the exposures. In Ohio the distorted bedding is referred to the Waterline formation. In Indiana similar irregularities are supposed to be confined to the Niagara group beds. Dr. A. J. Phinney has been the only Indiana geologist to dissent from this opinion by assigning the Delphi and much of the Logansport exposures to the Lower Helderberg. Prof. Orton, in his report on the Ohio and Indiana gas field, says: "The well-known Wabash flaggings are here counted of Lower Helderberg age." Dr. Phinney, in a report on the natural gas field of Indiana, eleventh United States Geological Survey, dissents from this opinion, and says: "The exposures in the vicinity of Wabash have been considered Niagara limestone, as the fossils are identical with those found at Marion, where the exposure is undoubtedly Niagara.' In the Wabash County report oi 1891 forty species of fossils are tabulated, which were collected from the quarry stone. The most of these were characteristic Niagara fossils. The Illinois geologists have always considered the equivalent beds of that State as of Niagara age.

By some writers great significance is attached to the brecciated structure in determining the age of the stone in which its occurs. However, Dr. Phinney describes the Waterline at Kokomo as "an even-bedded limestone." About Logansport, he says, the Lower Helderberg is a common rock, and "finely exposed," but, so far as known, never shows a brecciated surface. If the Waterline formation is excluded from the Lower Helderberg it is probable no true representative of that period is to be found in Indiana.

Prof. Dana, in the fourth edition of his Manual of Geology, assigns the Waterline formation to the Salina group. And in a bulletin of the Geological Society of America, May, 1900, Mr. Charles Schuchert presents facts to show that all of the Lower Helderberg above the Waterline and Tentaculite limestone should be included with the Devonian. Mr. Schuchert seems to consider the Tentaculite limestone as transitional to the Lower Helderberg. Of twenty-six species found in the Tentaculite beds of New York, only four are known to occur in some higher member of the Lower Helderberg. In Ohio, out of thirteen species described from the hydraulic limestone only four are known to occur in the higher beds. So, then, in view of what is now known, it seems safe to assume that the Wabash County unconformities and pronounced irregularities of bedding were the result of forces in operation near the close of the Niagara epoch, and at all events before the close of the Silurian age.

The subdivisions of the Niagara group in Southern Indiana have been much better defined and correlated than those of the Wabash Valley. The remarkable uniformity in the bedding of the Laurel limestone from Connersville to the Ohio River has been fully described, and the Waldron shale exposures traced from Milroy to Charlestown landing. Slight irregularities of bedding had been noticed in the layers immediately above the

Waldron shale, but nothing worthy the name of an unconformity until Mr. Foerste, in the twenty-second Indiana Geological Report, called attention to the Avery quarry as showing evidence of a period of erosion. Other unconformities on Flatrock and Conn's creeks have been described and illustrated by Messrs. J. A. Price and E. M. Kindle in later reports.



Avery Quarry, Southeast Corner.

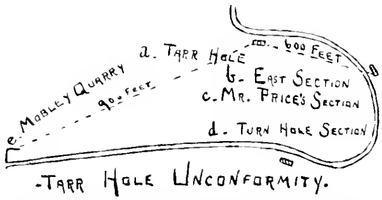
The Avery quarry is located on the east bank of Conn's Creek, one mile south of Waldron. The Louisville limestone, as the workable bed of stone has been called, rests conformably on the Waldron, is 10 feet thick on the north wall and five feet thick in the southeast corner. The layers have a general dip to the north of three degrees. On the south face of the quarry, near the southeast corner, three discontinuous layers are exposed at the top of the Louisville limestone. They aggregate nine inches in thickness at the west end, and thin to nothing before reaching the southeast corner. Immediately under the attenuated strata is a 6½-inch layer which is continuous around the south and east faces of the quarry. From 6½ inches at the southwest end it gradually diminishes to 2½ inches at the northeast corner. Below the continuous layer is a layer which measures 11 inches at the north end; it soon divides into two layers, whose combined thickness is 9 inches at the south end. On the east face two layers, near the top of the wall, were measured, one of which changed in thickness from $2\frac{1}{4}$ to 5 inches in 33 inches, and the other from $2\frac{1}{2}$ to $5\frac{1}{2}$ inches in 21 inches. At the northeast corner of the quarry there is 5 feet of Louisville limestone about the $6\frac{1}{2}$-inch continuous layer, which diminishes in thickness to nothing at the south end. The layers composing this 5-foot stratum do not thin gradually, but by an abrupt ending of the several layers. Twenty feet north of the southeast corner is a slight thickening in the upper layer, which causes a slight dip north and south. These measurements show that the thickness of some layers increase and others decrease with the dip. Below the $6\frac{1}{2}$-inch continuous layer the stone is evenly bedded.

Above the nearly level line of unconformity is from 20 to 48 inches of coarse, sandy-looking limestone in broken layers, with a thin covering of earth above it. Viewed from across the quarry the exposure looks like a broken wall of rubble stone. The results of weathering are very evident, but has not wholly destroyed the lines of continuity, which show irregular bedding.

The color of the Louisville limestone changes from blue or blue-gray at the bottom to a gray near the unconformity. The overlying layers are very nearly brown. The upper Louisville layers change color gradually, and the freshly broken surface of the brown stone can scarcely be distinguished from it, but a marked difference is developed by weathering.

The quarrymen allege that the underlying shale is five feet thick, which is very nearly its average thickness at other places. So far as the thin-bedded shale can be said to have dip it seems to conform to that of the Louisville limestone. If this is true the surface of the Laurel limestone, on which it rests, must be irregular. The exposed Laurel limestone in the bottom of Conn's Creek nearby shows that it has no appreciable dip, nor has it been disturbed by an uplift. Hence it is reasonable to conclude that the irregular surface below the Waldron shale has been the result of erosion which took place after the Laurel beds were deposited and before the Waldron shale came into existence. The inclined position of the Louisville limestone layers is the outcome of irregularities formed during sedimentation.

The unconformities described on Flatrock Creek are minor affairs compared with the Avery quarry locality. The horizon of the Geneva and Louisville limestone unconformities change, and at one place is found between the layers of the "soft, sandy limestone." Generally they appear to be nothing more than lines of irregular bedding, with a slight difference in the structure of the upper and lower members.

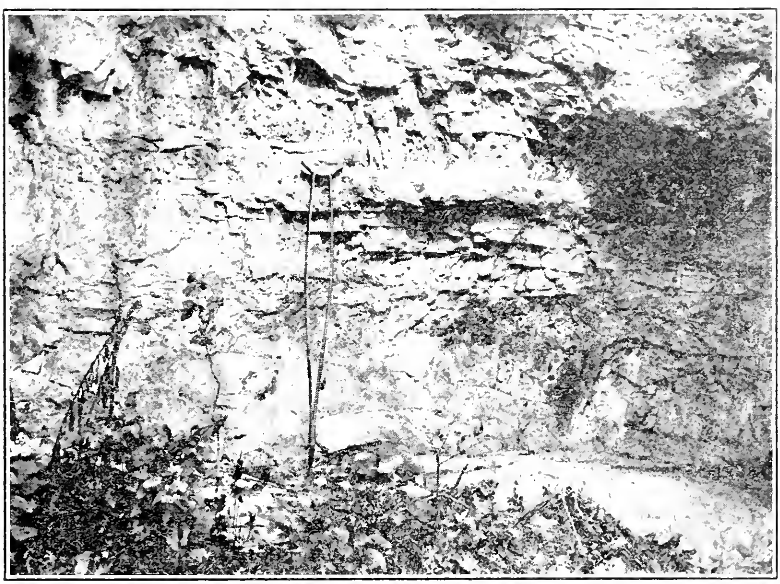


The top of the Waldron shale at *a* is 12 feet, at *b* 17 feet, at *c* 18 feet, at *d* 9 feet above low water; at *e* it is below the surface. The fall in the creek bed from *a* to *e* is 40 inches.

One mile south of Hartsville, in the Tarr hole vicinity, there seems to be conclusive evidence of a period of erosion after the Laurel limestone beds were formed and before the shale beds were deposited. Below the Tarr hole Clifty Creek makes a horseshoe bend within a radius of one-fourth mile. The Tarr hole exposure shows that the top of the Waldron shale is 12 feet above low water, and the shale nearly 7 feet thick. Six hundred feet east the top of the shale is 17 feet above low water and 4½ feet above the same level at the Tarr hole. Near the middle of the bend Mr. Price estimates the shale to be 3 feet thick and its top at from 18 to 21 feet above the bed of the creek. In 1881, when the shale was better exposed than now, a section was made at the Turn hole which showed the top of the shale at 12 feet above low water, and the shale 5 feet and 8 inches thick. After due allowance is made for the decline in the bed of the creek, where it passes over a long riffle, it indicates the surface of the shale is 3 feet below a corresponding level north of it at the Tarr hole. Seven hundred feet west of the last locality is the Jesse Mobley quarry, where a well was put down a few years ago that penetrated the Waldron shale 20 feet below the surface. Twenty feet below the surface, at this place, puts the top of the shale below the bed of the creek. The writer is certain of the position of the shale in this well, as he has a number of the Waldron fossils taken from it at the time the well was dug. Here the top of the shale, after adding 3 feet for decline in creek bed, is seen to be 15 feet below the same level at the Tarr hole, and from 18 to 21 feet below two other points.

Following the bend of the creek on the east side some four or five feet of thin bedded Laurel limestone is exposed, next to the shale, that is not found at the Tarr or Turn holes. The Mobley quarry, since the report on Bartholomew County was written, has developed a number of irregularities of bedding not then visible. There is a slight irregularity on the line dividing the lower grayish stone from the brown layers, and if weathered a few more years might be classed with the Flatrock unconformities.

In lithologic structure and color the Louisville limestone at the Tarr hole and Mobley's quarry very closely resembles the upper and equivalent layers at Avery's quarry. It is probable the quarry stone at both places was deposited under similar conditions, and does not show dip at Mobley's because the quarry is not located over a marked irregularity on the surface of the underlying Laurel limestone. Where investigations have been made it has become evident that all large displays of Louisville limestone are located in an erosion valley or on an anticline connected with a synclinal axis, and that the exposure of the Louisville beds are correspondingly local.



Devonian Exposure, Cave mill Park.

The irregular bedding of the Devonian at Cass, Cass County, is quite marked, and the same is true of the Geneva beds in some parts of Southern Indiana. A fine exposure of mixed bedding is to be seen in the Geneva limestone at the Cave mill park, which presents an eighteen-foot wall of discontinuous, uneven and distorted stratification, overlying what appears to be Louisville limestone. This seems to be the formation from which Mr. Kindle collected a number of Devonian fossils, three-quarters of a mile farther up the creek, opposite Charles' mill, and the equivalent of the Devonian bluffs near Hartsville. According to Mr. Price, irregular bedding is common above the Waldron shale in Rush County. It is probable that further search will reveal many more irregularities that are now obscured by weathering. The irregular bedding of the Louisville and Geneva limestones is probably the result of marine currents, and it certainly is not necessary to invoke a local uplift or convulsion of nature to account for its origin or that of the unconformities.

No unconformities have been reported from the Upper Helderberg, but there is evidence that the Niagara limestone and New Albany black shale are not conformable at Delphi.

By Mr. Foerste and others the Louisville beds are referred to the Niagara epoch, and this may be their place if based on paleontologic evidence. Its horizon, however, can not be established by the existence of a few minor unconformities at the top of Louisville limestone. If unconformities are conceded to have occurred during the Niagara epoch or Silurian age, in the Wabash Valley, they certainly show that the changes in the coast line necessary to their formation, whether submarine or aerial, did not destroy a large per cent. of the fauna in existence before the erosion period began. Of course it is conceded that many of the species found in the Waldron shale are peculiar to that formation, but many of them also came up from the preceding epoch. Therefore, the Upper Niagara and Geneva limestone unconformities have very little significance in determining the age of the formation between which they occur.

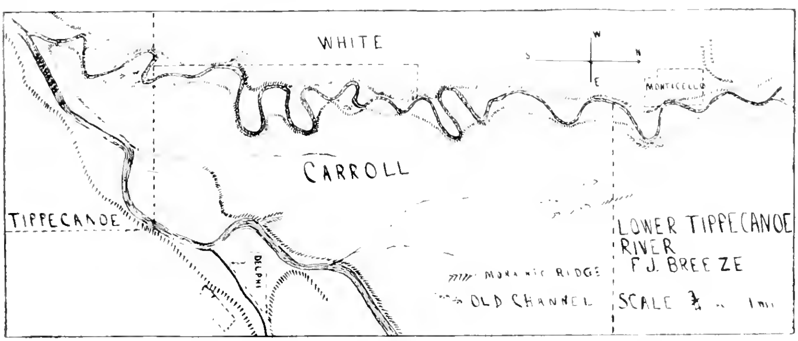
An interesting question arises whether the Waldron shale can be correlated with the quarry stone of Wabash County. Not enough is known to give anything like certainty to what now may be said on the subject, but it may not be improper to call attention to a few observations which indicate that they occupy the same horizon. It is generally known that the Waldron shale is often highly calcareous, with intercallated plates of limestone, and changes to thin layers of limestone as it is traced northward. Frequently on Clifty Creek a stratum of stone below the Waldron shale is seen which very much resembles the hydraulic beds of Wabash County, both in appearance and jointed structure. The laminated shale of Wabash is duplicated by some of the more argillaceous shales of Clifty Creek. The Wabash Valley and Laurel-Waldron unconformities seem to be of the same horizon and lend color to the inference that the quarry stone of Wabash County and the Waldron shale are of the same age.

The Valley of the Lower Tippecanoe River.

Fred J. Breeze.

[Abstract.]

The Tippecanoe River deserves far more attention from the geographer and geologist than has ever been given to it. A careful study of this stream will shed light upon some of the problems of glacial phenomena, and will doubtless yield something of interest concerning stream and valley development. Believing this, the writer has begun a somewhat systematic study of this river. Several days of the last three months have been devoted to the necessary field work in the preparation of a map of



the lower part of the Tippecanoe Valley. This map shows the meanders of the stream and of its valley, and is presented at this time with the hope that it may be some little contribution to the geography and geology of Indiana.

By Lower Tippecanoe is meant that part of the river from the point where it leaves the region of the Glacial Lake Kankakee to its mouth.

A short distance north of Monticello are sandy ridges which doubtless marked the southern limit of the glacial lake, so that this town is near the upper end of this part of the valley, although the gorge-like character of the valley has extended up to the town of Buffalo.

At Monticello the river flows in a valley not over half a mile wide and about eighty feet deep. Farther down the valley widens and deepens so that at some points the valley is a mile wide and the bluffs about one hundred feet in height. The only exposure of bedrock, New Albany shale and Devonian limestone, in this part of the valley is found a short distance above Monticello. Nowhere in the valley were wells found that were cut down to bedrock. The slope is great, the river falling almost 100 feet from Monticello to the mouth.

At this time no explanation as to the causes of the existing features is offered, the writer preferring to present these conditions for interpretation by more competent members of the Academy. This study of the Tippecanoe River will be continued, and some results of this work may be presented at future meetings.

Concerning Well-Defined Ripple Marks in Hudson River Limestone, Richmond, Indiana.

Joseph Moore and Allen D. Hole.

In the Proceedings of the Indiana Academy of Science for 1894, page 53, Mr. W. P. Shannon, under the title, "Wave Marks on Cincinnati Limestone," gives an interesting description of undulations in strata in the southwest part of Franklin County, Indiana. The present paper is a record of similar phenomena in Wayne County, Indiana.

In the spring of 1901 Prof. Joseph Moore observed what appear to be well-defined ripple marks in an exposed stratum of Hudson River limestone. The exposure occurs about five miles southwest from Richmond, Indiana, in the bed of a small tributary of the Whitewater River. The stream at this point flows approximately N. 35° E., and the series of undulations, which will be called "ripple marks" in this paper, are nearly, though not exactly, parallel, and lie in a direction about N. 72° 30′ E. This direction is the mean of the measured direction of several axes. The width of the stream is from ten to fifteen feet, and the ripple marks are exposed more or less plainly for a distance of two hundred feet in the bed of the stream.

The ripple marks have rounded crests and hollows, the slopes on the two sides of a crest being in general symmetrical about the axis. The mean distance from crest to crest is approximately uniform for the series, and the average for twenty such distances is found to be 2.63 feet. The average depth of lowest part of troughs below crests is one and one-half to one and six-tenths inches; total number of crests exposed is forty. The ripple marks in the up-stream portion of the exposed area, constituting the majority of the number named, extend entirely across the bed of the stream; in the down-stream portion, a part of the ripple marks have been worn away by erosion of the stream, leaving the crests only near the margins.

The stratum which has the ripple marks is about three inches in thickness, measured to top of crests; the bottom of this layer is as nearly plane as are the surfaces of the other layers of Hudson River rock in this locality; that is, no indication of the undulations (which are on the upper surface), is found on the lower side of the layer; and this layer containing the ripple marks is not noticeably different in thickness from that of the other layers of the same formation just above or just below it geologically.

The ripple-marked stratum, in the southwesterly (up-stream) direction, disappears beneath other strata of Hudson River limestone. This stratum above, when broken up and removed, showed a layer of blue shale or mud, filling the hollows, and barely covering the crests of the ripples; the ripple marks, however, were as clearly defined where the upper stratum was broken away as in the exposed portion farther down the stream.

The right bank of the stream is steep and higher than the left bank; and here the Hudson River rock outcrops up to a height seven or eight feet above the water; the upper stratum of Hudson River rock in this vicinity is estimated at forty feet above the ripple-marked stratum. The left bank is a part of a flood-plain. At one point a trench was dug back from the water's edge on this side. When soil, sand and gravel were removed, the ripple marks were found clearly defined as far as the digging extended, some of the blue shale being found adhering to the surface.

The under side of the ripple-marked stratum is paved in nearly every square inch with well-preserved fossils, consisting in far the greater part of *Leptaena sericea*. These are associated with *Rafinesquina alternata*, *Orthis occidentalis*, *Rhynchotrema capax*, and a very few other brachiopods.

Let it be understood all the time that the under surface of this layer is entirely flat. The upper, or rippled surface, is very smooth and shows almost no fossils in form to be identified, but only small fragmental and finely comminuted shells very firmly compacted. This triturated and very compact character of the rippled surface is not confined to the surface, but extends to a slight depth, gradually shading into coarser shell fragments.

The first layer below the stratum bearing the ripples contains substantially the same fossils, with possibly a still larger proportion of *Leptaena sericea*, and an occasional specimen of each of the following, viz.: *Zygospira modesta*, *Orthis testudinaria*, and *Crania scabiosa*. This layer indicates a somewhat agitated condition of the water in which it was deposited.

Above the layer of tough, pasty blue clay which covers the rippled surface, lies a consolidated layer consisting of whole and fragmental fossils cemented by hardened clay. The shells and fragments are, so far as examined, pitched at all angles and crowded together in a way to indicate an agitated condition of the waters during their deposition. There appear to be few, if any, species in this upper layer different from those already named.

We conclude that the undulations referred to in this paper are ripple marks for the following reasons:

1. The axes of the series in general are parallel, yet with some variation in direction and continuity such as is seen in ripple marks formed on sandy bottoms now.

2. The crests of the entire series are spaced with approximate uniformity; that is, there is no increase or decrease in distance from crest to crest in passing from one edge to the other of the exposed area, which might be the case if the undulations were beach marks.

3. The fragments composing the surface of this stratum are much finer than those found in the bottom, and finer than most of the fragments in the strata lying above and below.

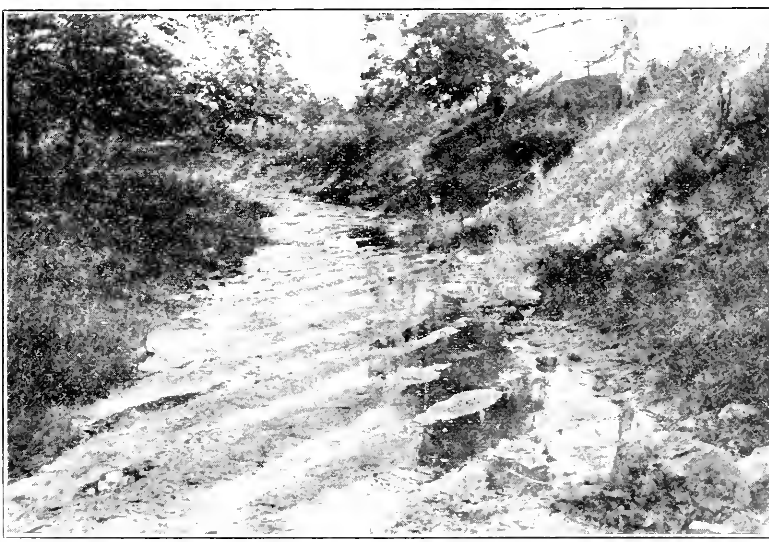
4. The arrangement of fragments in the strata lying next above and next below give evidence of considerable agitation of the water at the time those strata were being deposited.

The accompanying plates show the appearance of the ripple marks. Plate I. is from a photograph, up-stream view; Plate II., the down-stream view; Plate III., a small portion of bed of stream, looking downwards from the high right bank of stream.

PLATE I.

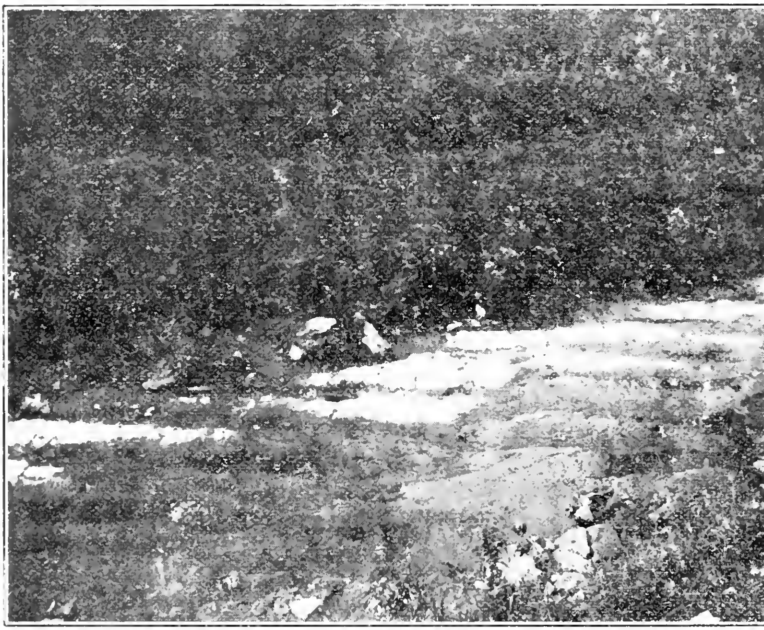
Ripple Marks—Up-stream View.

PLATE II.



Ripple Mark—Down-stream View.

Plate III.



Ripple Marks—View from Right Bank.

Note on the Variation of the Spires in Seminula argentia (Shepard) Hall.

J. W. Beede.

[Abstract.]

Owing to the systematic importance and the rarity of good material of the brachial framework of the brachiopods, any light on the extent of individual variation of these parts is of considerable importance. In examining several specimens of *Seminula argentia* (Shepard) Hall, which show the position and form of the spiralia, some remarkable results were obtained.

Both valves of this species are quite convex, old specimens always being very ventricose. However, the species is very variable in form. Four of the thirteen specimens were somewhat compressed, but it so happens that three of these approach the normal type very closely, while the fourth does not vary from it greatly. Those showing greatest variation have not been subject to any visible external deformation.

The normal position of the spire is with the apex pointing to the side, near the margins of the valves, at or a little in front of the middle of the shell, which is also its widest part. In the central part of the cavity of the shell the edges of the spire nearly or quite meet. Anteriorly they flare apart leaving a subcircular opening. For convenience in this paper this opening will be referred to as the frontal aperture of the spiralia.

A specimen from the Topeka limestone, Upper Coal Measures, shows the spires with the apex of one of them pointing almost directly forward toward the anterior end of the shell, turned through an angle of about 90 degrees from its normal position; while, as nearly as can be determined from the ground specimen, the apex of the other is directed toward the median line of the pedicle valve just in front of the hinge. This specimen was selected and ground nearly to the center because it was one of typical form and perfect exteriorly. The remaining specimens are all from one horizon in the Permian of Cowley County, Kansas. One of these has the spire turned through an angle of 45 degrees or more in a vertical direction (when held brachial valve up and hinge away from observer) pointing near the middle of the right side of the brachial valve, while the opposite spire points toward the middle of the opposite side of the pedicle valve. Another specimen from the same locality is intermediate between this and the normal form. There are other specimens showing a similar variation and several are normal. The frontal aperture varies from subcircular to a mere slit.

The form of the spire varies from a fairly well-developed spiral cone with flaring base and acute apex to a form approximating a disk with very obtuse apex. The most disk-like form observed belongs to a shell less ventricose than the average and the spire is turned from the normal position. The number of whorls in the spires seems to vary slightly, though the material at hand does not admit of certain determination in this respect. Unfortunately the crural attachments of the spires are not shown in any of the specimens. However they must have been somewhat modified to accommodate the twisted position of the spires, unless, in the specimens examined, the spires which are abnormal had broken loose in the shell prior to fossilization, which I believe is improbable.

The above variations, except in the case cited, do not seem to accompany any particular form of shell. There is nothing visible in the specimens to show the cause of their abnormality.

It is dangerous to generalize much on the observations based on a single species. All that I suggest is that the foregoing seems to indicate that in those spire-bearing brachiopods, particularly the Athyridae, where the form of the shell does not govern the form and position of the spire, i. e., those which approach a spherical form, the spiralia may be subject to a considerable variation both as to the form of the spire and its position.

Topography and Geography of Bean Blossom Valley, Monroe County, Indiana.

V. F. Marsters.

In Monroe County, Indiana, and others lying to the southwest (Owen, Greene, Martin, Dubois, Pike and Gibson) occur a number of preglacial river valleys the present topography and content of which unmistakably suggest the existence of a temporary period of laking. Inasmuch as the attenuated edge of the Illinoian till plain passes diagonally through the above counties and crosses the mouths of many of the southern tributaries to the west branch of White River, which present evidence of arrested drainage near the limit of the till plain, it seems probable that the laking was consequently connected with the glaciation of the immediate region.

In Monograph XXXVIII, U. S. G. S., Mr. Frank Leverett has mapped and given a brief description of the probable preglacial drainage, the areal extent of the laking and the final adjustment of the postglacial drainage within the counties mentioned above. For the discovery of a few of the cases described, Leverett is indebted to Mr. C. E. Siebenthal, who furnished much of the data relative to the laked valleys found in Monroe and Owen counties. Mr. Siebenthal has also referred to this same topic in a paper published in the annual reports of the Indiana State Geological Survey. It is to one of these cases that I wish to devote the main part of the description and discussion presented in this paper.

Bean Blossom River takes its rise in the northern tier of townships in Brown County, flows a little south of west to Monroe County, reaching the northwest corner of Bloomington Township, where it turns rather sharply and continues in a due northwest course to the White River, into which it empties at a point about one mile below Gosport, Owen County. The topographic features of this rather picturesque valley, which are regarded as giving the key to its geographic history, are, briefly, these: First—The steepness of the valley sides and its persistence in close contact with the valley floor, together with its peculiar variations in direction. Second—The predominance of a broad flat floor, sometimes a mile or more in width, now occupied by a small meandering stream which for the greater part of its course insists upon keeping to the south or southwest side or edge of the valley floor. Third—The occurrence of both isolated and attached hummocks and ridges, the former usually located near the middle of the valley floor, the latter standing in rather close proximity to the valley slope. The rock content of these striking bits of relief is precisely the same as that which composes the upland on either side of the valley, namely, the subcarboniferous limestone and underlying sandstone locally known as the "knobstone." Fourth—The occurrence of a series of benches or so-called terraces rimming the valley slopes at various points and ranging in height above the valley floor from thirty to seventy feet. These consist of mixtures of sandy material and clay which have been derived from the rock formations as appear on the surface of the upland. Fifth—The development of V-shaped valleys just scarring the valley sloped to the present valley floor and not extending beneath it.

In attempting to unravel the geographic history of a river valley whose drainage has been subject to arrest by the invasion of an ice sheet, we find that the story of its life resolves itself into three fundamental parts.

First, what were the topographic characteristics of the valley before the laking stage; in other words, what was its preglacial history. Second, what happened to the valley during the laking stage, its glacial history. Third, what has happened since the disappearance of the lake, its post-glacial history.

DESCRIPTION OF TOPOGRAPHIC FEATURES.

Valley Slopes. While the average slope of the valley side is somewhere between twenty-five and thirty degrees, it very rarely falls as low as fifteen and in many places attains a slope as high as forty degrees. The variation in the slope bears a direct relation to the minuteness of dissection, or the spacing of the streams crossing it. Observation bears out the conclusion that the closer the streams to each other, the more subdued the slope. For a number of stretches along the valley sides very few streams crossed them, and there the slope was invariably found to assume the steepest angle. Moreover, the trend of the slopes appear to have a peculiar and persistent variation in direction, considered with reference to the general direction of the valley. It is believed that these features afford certain criteria by which something of the early history of Bean Blossom may be determined.

Valley Floor. The greater part of the valley is remarkably smooth and flat. There is, however, some systematic variation from an absolute plain. If we should construct a cross-section of the relief of the valley, especially in the central or upper parts, we should find that its systematic departures from a plain are such as to suggest that such aggrading as occurred in the valley was governed to a very large degree, at least on the present surface, by fluviatile agencies and not to the promiscuous distribution of sediments over its bottom during a period of laking.

It should also be noted that the present river channel throughout a large part of its course persists in keeping to the south and west side of the valley floor. Only at a few points within the limits of Monroe County do we find that the present Bean Blossom succeeds in meandering across the entire width of the valley floor. In other words, this river is not appropriate to and does not fit the broad valley which it now occupies.

The monotonous plain of the valley is broken at various places within the limits of Monroe County by the projection of conical hills and elongate ridges through its floor. In nearly all the cases examined in detail it was found that they were made up of the same rock as compose the uplands, sheeted over with a thin soil, and not of the same sort of incoherent mass of silts, clay, etc., constituting the valley floor.

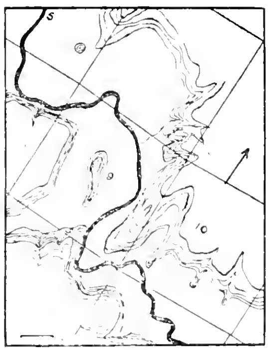
The slopes vary between twenty and forty degrees and usually maintain a sharp angle with the valley floor as did the valley sides. They vary in size and shape from conical hills with almost circular bases one or two hundred feet in diameter, to ridges a half mile long, one to four hundred yards in width. Their tops fall a little short of the general level of the upland. They invariably lie either with their longer axis parallel to the trend of the valley or with their outer ends pointing diagonally across and down stream. In the latter case the trend of their slopes bears some linear arrangement and relation to the valley slope adjacent to it.

These elevations or "islands," when isolated, stand out well towards the middle of the valley; when, however, they happen to approach the valley slope, they are usually *attached* to the valley slope. Their nearness or remoteness to the valley slope determines the comparative elevation of the connecting part or extension of the valley slope to the outstanding bit of relief, or "island."

Terraces or Benches. Rimming the valley slopes are to be found a number of benches of variable widths, with surfaces sometimes as flat as a floor or with an exceedingly gentle decline valley-ward, with outer edges lobate in shape and descending with a marked angle to the level of the valley floor. These occur at various points within the limits of Monroe County, invariably situated on the north and east side of the valley, and varying in elevation from twenty feet in the lower part of the stream to seventy or more feet in the upper part of the valley near the east line of Monroe County. In all the cases examined they were found to be composed of mixtures of clay and sand undoubtedly derived from the disintegrated rock formations constituting the surface of the uplands. No glacial debris of any sort was found either on the surface or in any of the sections or cuts in the benches noted within the limits of Monroe County.

PREGLACIAL HISTORY OF BEAN BLOSSOM.

Inasmuch as the greater part of the clay and silt occupying the valley floor is precisely the same in kind as that covering the unglaciated uplands and valley slopes, it is evident that this filling simply represents the wash and soil-creep from the slopes and uplands on either side. Moreover, the rate of filling was so far in excess of the ability of the stream to carry off its load that the preglacial valley became clogged with the waste to such a degree that the stream now occupying the valley floor is for much of its course quite unable to spread its meanders over the entire width: only at the narrowest sections does Bean Blossom succeed in occupying the entire valley from slope to slope, as seen in sketch map No. 1.



Sketch Map No. 1. Section 9, Bean Blossom Township.

Inasmuch as the filling of Bean Blossom at its mouth and for some little distance up stream is covered over by a patchy film of glacial sand associated with boulders, composed partly of crystalline rocks, the underlying clays, silts, etc., antedate the glacial coating. Moreover, the occurrence of benches (to be associated with the glacial history) resting upon the valley filling also point to the same conclusion, that the present filling of the valley, less the benches and the glacial sands, etc., near the mouth of the valley, is preglacial.

The question then arises, what was the topographic expression of Bean Blossom before it was aggraded. There are a number of observations which throw some light on its early history, but much more data should be gathered over the adjacent area before a detailed analysis can be given.

That the preglacial Bean Blossom valley *was very much* narrower than the present one, is attested to by the occurrences of various knobs and remnants of ridges protruding through the aggraded floor. Some of these are subcentrally located, suggesting that the prefilled valley must have been confined between the slopes of the half-covered ridges and the opposite valley slope, thus decreasing the average width of the pre-filled valley by nearly one-half its present cross-section within the limits of Bloomington and Bean Blossom Townships, Monroe County.

There are also certain features which suggest that Bean Blossom must have been at grade at a time antedating the completion of the filling of the preglacial valley.

At a number of points within the limits of Monroe County are to be found curved valley sides extending for a half mile or more, with steep slope, making an angle with the valley floor of thirty-five to forty degrees. Such regularly curved slopes and at such steep angles at once suggest a *meander-cut* slope.

Moreover, there is no evidence that these slopes have been cut by a meandering stream on the *present floor*. We must conclude, then, that they antedate the present surface of the valley floor, and if meander-cut in origin, as the topographic relief very strongly suggests, Bean Blossom must have been at grade before the present filling, at least completed, because a meandering habit is not begun until the stream has already finished its vertical cutting, or, in other words, has cut down the slope of its channel to such a gentle descent that it could not be lessened. Then it was that Bean Blossom must have begun its side cutting and carved the curved slopes, only remnants of which are now seen projecting above the level of the *present* valley floor.

Another set of facts also points toward the conclusion that the preglacial Bean Blossom had reached grade and become a mature stream long before the laking or the completion of preglacial filling of the valley.

A small tributary (Jack's Defeat) running northeast from Steinsville presents some features evidently of interest in connection with the geographical history of Bean Blossom. This stream, now rather diminutive, runs upon a flat floor, and hence at grade. The topography, however, of the valley slopes reveals incised meanders. The present slopes are steep and sharp cuspate points now project into the valley on either side. Such only could have been produced by a stream that had at some time reached grade after the incision of its meander. The crests of the meander-cut slopes now stand some 80 to 100 feet above the valley floor. If this view be correct, it would seem altogether probable that the main stream, Bean Blossom, inasmuch as both flow over the same kind of rocks with the same structure and texture, had also passed through the same stages as did its tributary.

But so deeply has the valley been filled after grade was reached that such meander-cut slopes as were developed have been largely buried beneath the present filling. Either, then, Bean was early at grade and widened its valley by meandering, or after it came to grade was compelled to incise its meanders, nearly all of which have been subsequently buried beneath its present valley floor.

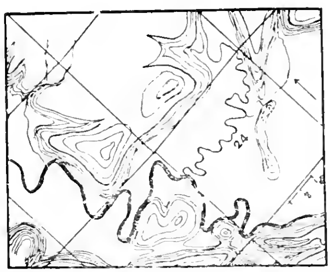
Moreover, so deeply has Bean Blossom been aggraded that many of the tributary valleys are also aggraded for some distance up stream. This wholesale filling would necessarily force the slopes to rapidly retreat at the junction of the tributary with the main stream, so that, as a result, the trend of the valley sides would assume a systematic angularity. The consequent narrowing and broadening is well exhibited in the lower ten miles of Bean Blossom.

LOST RIDGES AS EVIDENCE OF AGGRADING.

It is evident, should a valley be refilled, in part, with waste from the uplands, that any relief left between its valley slopes, as well as the dissected slopes included, would lose relief in proportion to the amount of filling brought into the valley. In such a case we should expect to find many successive stages of burial of the dissected slopes, according as they were near or remote from the center of the prefilled valley. Many of these stages are well shown in the lower portion of Bean Blossom.

In the middle of Bean Blossom valley occur a number of illustrations in which the inter-stream spaces of moderate relief have been so deeply buried that the uppermost portion of the same now stands above the valley floor, as isolated ridges or "islands," with very steep side slopes, extending to and beneath the present floor of the valley. These are locally spoken of as "lost ridges," a term quite appropriate to their geographical history. Such islands are shown in a number of sketch maps. In sketch map I a small subcircular knob (Section 5, Bean Blossom Township) stands in line with a point standing between White River on the left and Bean Blossom on the right. Its position suggests that it is the *buried* end of this point (see Plate No. 1).

About one mile up the valley is another elongate ridge about one-third of a mile in length, some three or four hundred yards in width and with an elevation of some eighty feet above the valley floor. This is found in section 9, Bean Blossom Township, and illustrated in sketch Map No. I, and by the photograph plate II. The same topographic feature is again duplicated in section 24, Bean Blossom Township. This illustration is locally known as Lost Ridge. This case is not so centrally located as the former one, but lies close to the east side of valley—but still separated from it by a hundred yards or more of flat floor. As in other cases, the trend of its slopes and that of the adjacent valley slope shows such an alignment as to strongly suggest attachment beneath the present valley floor. See sketch map No. II. Photograph plate III gives some idea of

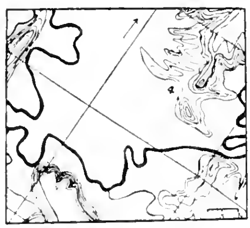


Sketch Map No. II. Section 24, Bean Blossom Township.

steep slopes, presented by an end view of the Ridge. Other cases of the same thing might be enumerated, but the above are sufficient to show the type of relief consequent upon the more complete stages of burial of the spurs near the central part of the preglacial valley.

As a further test of partially aggraded valley, we should also expect to find as additional criteria, spurs of variable relief but attached to the valley slopes by narrow necks, still above the present level of the valley floor. Moreover, various stages of the tied-on knob or ridge ought to be in evidence if the present width of Bean Blossom is due to aggrading. Such additional stages are fairly well shown in contour sketch map No. I, where three small cases of attached knobs may be seen. A still better case is shown in the pen sketch, which occurs in section 32, Washington Township. A photograph of one, the south knob, is shown in Plate IV. Variation in the widths and elevation of the necks connecting the partially buried spur is well illustrated in the sketch.

In map No. III, section 4, Bloomington Township, is shown another illustration of special interest. This occurs at the rather abrupt turn of Bean Blossom Valley, on the northeast side, where the upland forms a point projecting into the valley. The point shows the same sort of topography (see Plate No. V) as noted in other cases—the rounded tops, increasingly steep slopes, descending to the valley floor, and the neck connecting it with the upland on the north. This case attains additional interest, as just to the west and opposite the gap or sag between the knob and the upland, is a bench varying in elevation above the valley floor from twenty to forty feet, and flanking the slopes of the projecting headland and spur. The geographical significance of the benches will be observed in another part of the paper.



Sketch Map No. III. Section 4, Bloomington Township.

In the center of the valley floor and just opposite (or to the south of) the last named spur, and also up stream for some two and one-half miles, still more evidence of valley filling is apparent. To the southeast of the point occurs a rather subdued ridge, somewhat irregular in relief, extending up stream for three-quarters of a mile, or thereabouts. A portion of this is shown in sketch map No. III. Bean Blossom flows close to its northern edge. On the south side of the elevation flows Muddy Fork Creek from the southeast, and reaches Bean Blossom some distance beyond its west end. So full has Bean Blossom, and its tributaries, as well, been filled with waste that the aggraded floor of both valleys have for some distance up the respective streams from their junction merged into *one* broad flat floor.

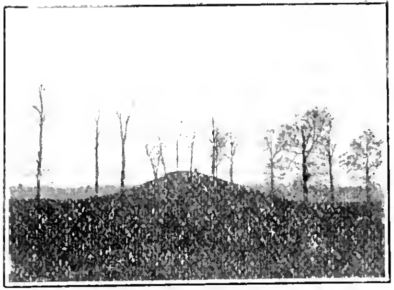


Plate I.

Plate III.

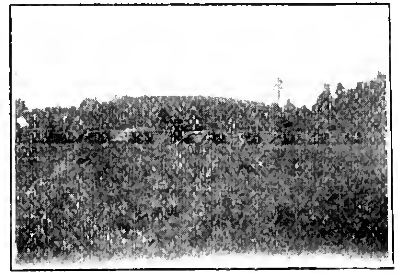


Plate IV.

Plate V.

Plate VI.

There is still another case of the same thing in section 3, Bloomington Township, which touches the almost covered spur last mentioned on the east and extends to Dolan, east side of section 3. The little village of Dolan lies in the gap, or sag, between the knob and the spur of upland separating Bean from Muddy Fork. Had the valley floors of these respective streams been aggraded some twenty-five feet above their present level, the attached spur would have passed into the "island" type, as the floors of the two valleys would in that case have been confluent.

Additional illustrations might be appended, but the above series is sufficient to bring out the variations in topographic relief which furnish a key to this particular stage in the history of the valley.

In a word, then, we may say these various phases of topographic relief are not confined to a limited part of the valley within Monroe County, but are prominent features throughout its entire course. Moreover, they exist as inevitable consequences resulting from processes of aggrading and hence may be used as legitimate and trustworthy criteria by which to determine a part of the life history of the respective valley.

GLACIAL HISTORY OF BEAN BLOSSOM.

That Bean Blossom and the adjoining uplands near its mouth have been occupied by an ice sheet is attested to by a series of observations. The occurrence of glacial boulders, gravel and fine sand near the mouth (section 9, Bean Blossom Township) and patches of sand with occasional boulders as far up stream as section 24, near Lost Ridge, warrant this conclusion. From section 24 Mr. C. E. Siebenthal has traced the edge of the till plain to the northeast, it being found to follow along the line of Indian Creek, and passing out of Monroe at Godsey into Morgan County, but returning again to Monroe some two miles east, where Hacker's Creek crosses the north line. From this point to the southeast the edge of the till is exceedingly difficult to trace. Patches of sand and gravel, however, occur in the head waters of some of the northern tributaries to Bean Blossom, in northeastern Monroe and Brown counties. Furthermore, glacial gravel and pebbles are known to occur within the limits of Bean Blossom itself, not far from the east line of Monroe; but whether this was ice or water-laid has not been determined. Enough facts, however, are at hand to show that the heads of northern tributaries of Bean must have

Plate II.

been invaded by the ice sheet, and at the same time the drainage was held up by the interference of the ice sheet at the mouth of Bean Blossom.

The evidence of the arrest of drainage at the time of ice invasion is found in the occurrence of a series of benches, inaptly termed terraces by some writers, rimming the eastern and northern slope of the valley at various points within the limit of Monroe County and are reported to occur with increased frequency in Brown.

In all the sections and cuts found in the benches, only clay and sandy materials appeared. No limestone and sandstone exposures, such as make up the valley slopes, were found in the benches; their contents are undoubtedly made up of the wash and soil-creep brought into the valley from the uplands, the clay portion being derived from the decomposed limestone and the sand constituency from the underlying knob stone.

The benches vary much both in form, areal extent and elevation above the valley floor. They are invariably attached to the slope, and exhibit in most instances a remarkably flat or sometimes gently sloping surface towards the outer edge. The outer rim is usually lobate in form, with narrow, young valleys extending towards the rock slopes, and sometimes, so far, as to traverse the entire width of the bench. The slope of the outer edge is usually steep and well defined. In some cases the tops of the benches are slightly undulating or rolling. Those, however, seldom attain the elevation of the flat-topped ones. In Marion and Washington Townships they may be traced continuously for three or more miles, and attain a width of something over half a mile. They also vary much in elevation above the valley floor, attaining a maximum height in Marion Township, sections 19 and 20, of seventy or more feet, and decreasing gradually down stream, until in section 32, Washington, they are found to be some twenty-five to thirty feet above the valley floor.

That these benches must have been deposited in water is attested to by various criteria. The flat tops, steep angle on the front, and stratification show that they are delta-like accumulations brought in during the arrest of the drainage and not terraces in technical sense, although they appear very much like the latter so far as form is concerned.

The various elevations attained in different parts of the valley may be due to different levels at which the laked valley stood during the laking period, or it may be accounted for in part, at least, to the larger contribution of residual materials from uplands to the upper part of the valley by the northern tributaries, than by similar streams emptying into Bean

Blossom nearer its mouth, so that only in the upper part were the benches built up to the highest level, while in the lower part the amount contributed was insufficient to bring them up to similar altitudes.

If the laked Bean Blossom stood at different levels during the laking stage, we should expect to find somewhere in the valley a lower lying bench corresponding in elevation to the successive lake levels and adjacent to the higher bench. Nothing of this sort was found. I am therefore inclined to attach more importance to the former interpretation, namely, that irregularity of height above the valley floor is largely due to the variation in amount of the residual material brought into the valley. The tributaries bringing the least amount of material constructed the smaller and lower benches.

Another interesting feature is associated with two of the largest northern tributaries to Bean Blossom, namely, Buck and Wolf creeks. Beside the portion of each creek, wriggling across the valley bottom, are rather long and narrow strips or delta-like accumulations similar in content to the benches already described, and extending from the valley slope to within a few yards of the Bean Blossom channel which hugs the south slope of its valley. The surface does not attain the characteristic flatness of the rimming benches, but is slightly irregular in relief and increasingly so towards the slope to which it is attached. This is especially true for the Buck Creek case, but not for the Wolf Creek. The increasing irregularity may be in part due to the nearly complete burial of a projecting spur, whose top is barely coated over with the delta deposits now spread almost across the entire width of Bean Blossom; but it must be said that no outcrops of limestone or sandstone, such as make the slopes of the valley, have been discovered within its limits. On the other hand, the irregularity of relief may have been produced by the piling up of the great load of silt within Bean Blossom by the tributary, but did not succeed in building it up to the lake level; in other words, it is an incomplete delta, or bar.

The Wolf Creek case differs from the former only in having a moderately flat top, or at least the higher flats on it attain about the same level, thus suggesting that it was built up nearer to water level, and hence more even and uniform in relief. These differ from the rimming benches only in that they *extend across the valley floor*, while the former, being made by smaller streams close to each other, have built a series of small benches or deltas which have become confluent, and hence continuous *along the valley side*.

The pen sketch plate No. 1 gives some idea of the appearance of one of these benches (see pen sketch section 32, Washington Township). Plate VI shows beyond the trees a side view of one of the spur-like extensions of a bench occurring in section 4, Bloomington Township. (See contour map No. III, which also shows position of the partly buried headland.)

No. 1. Pen Sketch of Attached Spurs and Benches. Section 32, Washington Township.

Post-glacial History. Since the close of the laking stage Bean Blossom River has developed a meandering course on its broad floor. Only in the narrowest sections of the valley has it succeeded in spreading its meander belt across the entire floor. For the most part it keeps to the west or south side of the valley, and yet still assumes a meandering habit for considerable stretches. In other words, the stream does not fit the *present* dimensions of the broad valley, which accordingly must have been brought about by other conditions than that resulting from lateral cutting, by a mature stream. Cross sections of the valley at its broadest places reveal a slight curvature of surface in the center and occasional abandoned meandering channels. This slight variation from a plain surface suggests flood plain construction. Whether this constructive work antedates the glacial episode of Bean Blossom is not certain, but it would seem from the data at hand, that the present post-glacial Bean Blossom has not had time or the ability to do much constructive work since pleistocene time.

Young Valleys. Traversing the steepest slopes of Bean Blossom, are to be found numerous V-shaped valleys, with remarkably steep channels, ending their lower course at the point of intersection of the valley floor with the adjacent slope. In all cases small alluvial fans are built on the valley floor with their apex projecting but a few feet or yards at most beyond the mouths of the young valleys. In none of the observed cases was it found that the level of the valley floor would extend into the mouth of the young valley. It is therefore believed that the greater part of the cutting of these young valleys may date subsequent to the preglacial filling. The fact that alluvial fans and not deltas with steep outer edges and flat tops occur at their mouths, suggest that they have been constructed since the laking of the valley, and hence are regarded post-glacial.

Note. For a portion of the data used in the preparation of the contour maps, the author begs to acknowledge the assistance of Mr. E. R. Cumings and Mr. J. W. Beede, Instructors, Department of Geology, Indiana University, and Mr. J. W. Frazier, student, Indiana University.

Wabash River Terraces in Tippecanoe County, Indiana.

William A. McBeth.

General Description.—The Wabash Valley, in Tippecanoe County, Indiana, embraces an area of about eighty square miles. Its average width is about three miles. It is much wider below LaFayette than above, and it is less wide at that place than elsewhere within the county below the mouth of Tippecanoe River. The width of this valley above the city averages at least two miles, while below it is not less than four.

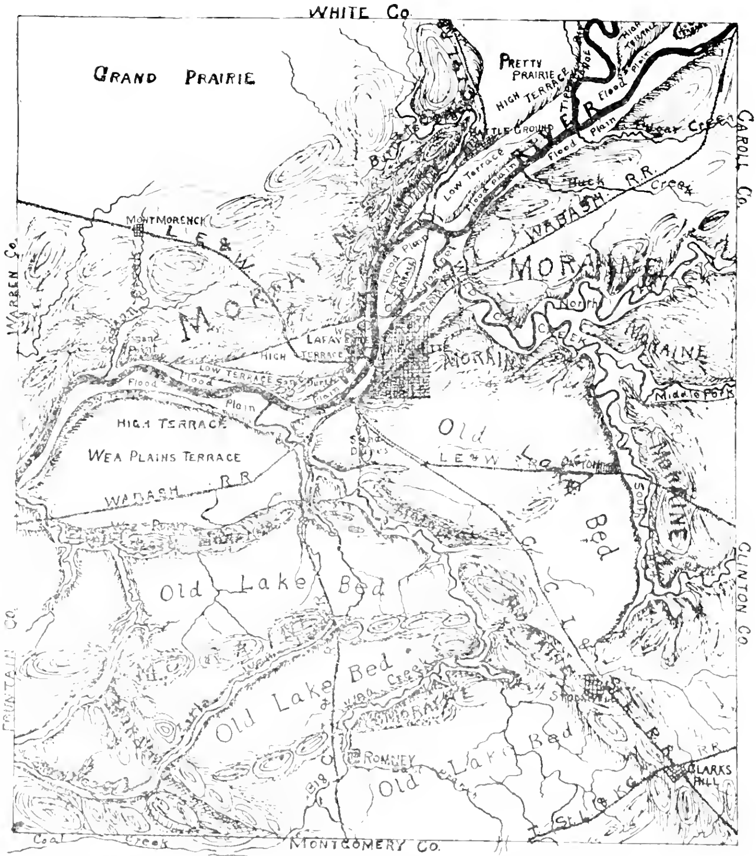
The valley comprises a broad, shallow trench, cut by a deeper and narrower trench, into the bottom of which is carved the river channel.

The general surface is about seven hundred feet above sea-level, and the bottom of the river channel is about two hundred feet below this. The inner valley or flood-plain tract averages about one mile in width and along this rise the terrace fronts from one hundred to one hundred and fifty feet above the stream. The inner valley is quite uniform in width throughout the county, but the terrace areas are much more conspicuous below LaFayette than above.

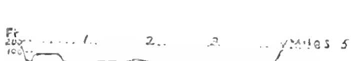
The outer valley is quite straight compared with the inner valley, which meanders from side to side, while the river crossing from side to side of this flood-plain meanders most.

The Terraces.—The terraces begin a few miles below Delphi, on the west side of the river, an island in the Deer Creek Prairie flood-plain comprising the farthest up-stream area so far observed.

The point between the Tippecanoe and the Wabash, where it rises above the flood-plain near the junction, is of this formation. Below the mouth of the Tippecanoe the terraces become conspicuous. On the west side of the stream the region called Pretty Prairie descends gently from the Grand Prairie and terminates in a bluff front which runs parallel with the Wabash at an average distance of a mile from it.

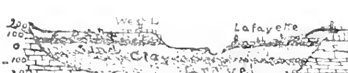


A MAP OF TIPPECANOE COUNTY, INDIANA.
To Show Terraces, Flood plains, Moraines & Drainage
Scale 0 1 2 3 4 5 Mi. By W. A. McBeth.



Cross profile at Battle Ground

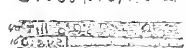
Cross profile at Lafayette



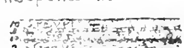
Cross section at Lafayette (Ideal.

Cross profile at mouth of Indian Creek

Cross profile at Independence.



Near Pyrmont



3 mi. South of Lafayette

Sections showing interstratification

This is of terrace structure to an unknown distance back from the river and is not limited on the west by a perceptible bluff. At Battle Ground the level of the prairie is continued south to the point where the river swings across the valley against the foot of the west bluff. This part of the high terrace is nowhere more than one-fourth of a mile wide. The Tippecanoe battle field occupies its entire width of a few rods between the lower terrace on the east and the valley of Burnett's Creek, which separates it from a high bluff on the west.

The low terrace just mentioned averages about one mile in width and its border along the flood-plain takes the form of a distinct ridge, apparently a sand-bar, higher than the general surface of the terrace. This surface is ten to fifteen feet above the flood-plain.

Below the westward bend of the river the flood-plain occupies the full width of the valley separating the terrace tracts below from those above. This flood-plain surrounds a detached section of low terrace which evidently was cut off from that on which LaFayette stands by a former course of the river. This channel was later the lower course of the Wild Cat Creek and still contains a chain of ponds. The creek was by some means deflected and now joins the river several miles farther up stream than formerly.

The LaFayette terrace slopes gently from flood-plain level back one mile to the bluffs. It corresponds in elevation to the detached area in the flood-plain and the low terrace above the bend. It is about four miles long and is slightly higher at the upper end than at the lower.

The West LaFayette terrace is two miles wide in its greatest width and eight miles long. Opposite LaFayette it presents a bold bluff to the river and lies at an elevation of one hundred and twenty to one hundred and fifty feet above it. Two miles below a low terrace begins and extends between the higher terrace and the flood-plain nearly to the mouth of Indian Creek.

The most extensive area is the beautiful region embracing the Wea Plains, southwest of LaFayette. This great terrace begins just below the city and extends ten miles to the west line of the county. Its width averages at least four miles. Its height agrees with that of the West LaFayette terrace, the narrow strip between lower Burnett's Creek and the bluffs and Pretty Prairie. This correspondence in elevation seems to indicate a former continuous surface of these terraces throughout the valley at a height of one hundred to one hundred and fifty feet above the present river channel.

The Pre-glacial Valley.—As the stream flows on a valley floor of rock at Delphi, eighteen miles above LaFayette, and again at Black Rock, at the west line of the county, fourteen miles below, the nature of the intervening depression, its shape, direction and extent have been and are still matters of interesting speculation. It is probably a section of the valley of the pre-glacial Wabash. This valley bottom is sixty or eighty feet above the bottom of the filled valley at Terre Haute and the two sections possibly are connected by a buried valley somewhere near the present stream line.

There are signs that its former course was north of its present course from the west line of Tippecanoe County into the immense pre-glacial valley of Kickapoo Creek, opening into the Wabash Valley at Attica. Cates' Pond, a traditionally bottomless kettle hole pond or lake, about two miles northwest of Independence, Warren County, is a good link in the evidence of such a former course.

The abrupt drop of two hundred feet from the valley bottom at Delphi to the rock floor beneath LaFayette indicates that the part of the stream above Delphi is not in the old valley. The north fork of Wild Cat Creek perhaps more nearly represents the pre-glacial drainage line. The little creeks between this creek and the Wabash show rock in their channels, while Wild Cat does not cut down to bed-rock at any place in Tippecanoe County, so far as I know, although its valley is one hundred feet or more in depth as far up as the county line.

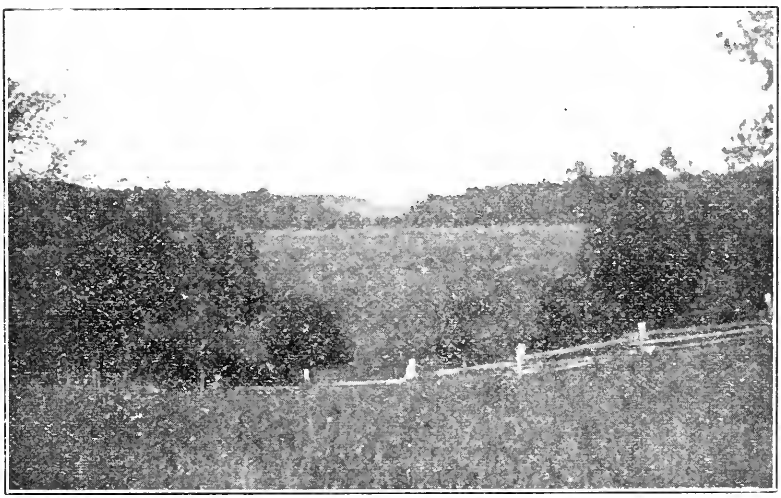
Rock outcrops in the bed of Indian Creek near Porter's Station, in the bed of Little Wea Creek at the Monon Railway crossing and along Flint Creek for four or five miles above its mouth.

Borings are few and not many are deep. A well driven forty or fifty feet below the bed of the Big Wea Creek, where it is crossed by the moraine about five miles south of LaFayette, passed through gravel hardpan and into quicksand, producing a constant flow of water.

Materials and Structure of the Terraces.—The terraces and the whole valley region are composed of sand, gravel and bowlders with interposed beds of clay. The whole deposit is of great depth, in places as much as three hundred or four hundred feet. The channel of the river at LaFayette is two hundred feet below the general surface of the county and one hundred and fifty feet above the bed-rock, giving total depth of three hundred and fifty feet of deposits.

The material is bedded in layers that lie at a high angle, such as is seen in delta structure; the dip is in a general direction down stream. Ample opportunities for observation occur in gravel pits and stream sections.

The streets in West LaFayette are improved by opening pits in the street lines and afterward filling them with the top-soil and graveling over them. These excavations uniformly show steeply inclined beds. The railroad cuts through the terraces on both sides of the river show this structure. The valley of the Wea through the gravel deposits shows the same thing. In the Wea Valley a layer of conglomerate is a conspicuous



Cates' Pond, a kettle hole two miles northwest of Independence, Ind.

feature, dipping toward the creek on the north side and from it on the south side.

The conglomerate stratum is formed of the sand and gravel of the deposit cemented with carbonate of lime. It lies apparently at a uniform horizon and is of uniform thickness. The cement is so abundant in some places as to fill completely the interstices in the mass of sand and gravel. Indeed, a block left in a yard fronting on State Street in West LaFayette has its upper flat surface completely covered with a layer of pure carbonate of lime a half inch thick.

An interesting feature of these deposits is the occurrence of beds of bowlder clay interstratified with the sand and gravel. This is noticeable more particularly about the east end of the Wea Plains along ravines opening into the Big Wea Creek. An exposure 3.5 miles south of LaFayette shows a deep layer of false bedded fine sand overlaid by three feet of very dense till, above which is ten feet of sand and gravel. This interstratification of materials appears even more strongly marked along the Wild Cat Creeks. At the bridge across South Fork near Monitor are two beds of clay differing in color and overlaid by twenty feet of sand and gravel. Near Pyrmont, on the north fork, ten feet of dark alluvial clay appears above the waters of the creek, above this ten feet of coarse gravel, and above this forty feet of gray bowlder clay.

Allied Topography.—The topography of the county about the border of the terrace deposits is interesting and suggestive. A moraine ridge containing much gravel, some of it water laid, extends along the entire south side of the Wea Plains. A heavy moraine lies along the north side of the valley from Battle Ground south, bending away from the river just above West LaFayette. Stream sections in the mass of this moraine show compact till as deep as they extend. At the mouth of Indian Creek the upper hundred feet of the bluff is a layer of fine sand resembling the dune sand of Lake Michigan, and the sand ridges of northern Indiana. This may be the source of the sand built into the ridges and dunes a mile further up the valley. The bluffs back of LaFayette are of till and are possibly a section of the moraine west of the river extending east in the direction of Monitor.

Explanation.—An attempt at explanation would revert immediately to the glacial period. The great valley was obstructed somewhere to the west, probably in the region of the great bend, by an ice sheet moving east or south. This may have been a result of one of the earlier ice invasions. The obstructed valley forming a lake has been filled by the deltas of streams flowing into it. The high angle of the layers indicate this. The layers of till represent movements of the ice sheet over the delta plain. These may have been minor advances and recessions of the same ice sheet. The material has been assorted out of the drift sheet overlying the basins of the streams traversing the region. The lime cement in the conglomerate is easily explained as being derived from the Niagara limestone region lying immediately to the east.

The problems in detail are of such complexity that any attempt at explanation is made with extreme diffidence. There are good reasons for believing that the valley was over-ridden by ice from the east and also from the north at various times during the accumulation of the deposits. The sheets of till found at different depths in the terrace gravels indicate this. The moraine extending along the south side of the Wea Plains as far east as the Little Wea Creek is composed of hills and ridges of gravel, while farther east it becomes a ridge of till.

This may indicate that after the valley had been filled nearly to its present level the ice swept over it from the north, transporting the gravel from the valley and depositing it in the moraine.

The arrangement of the moraines on either side of the river at LaFayette, together with the narrowness of the valley at that point, may indicate that the front of the ice sheet lay across the valley while the moraines were deposited.

The terminal drainage may have spread gravel deposits over the surface of the Wea Plains much as the Yahtse River is building its delta below its outlet from the Malaspina Glacier in Alaska. This may have been a line of interlobate drainage between lobes from the Lake Erie and Lake Michigan basins, and much of the material may have been furnished by the slow, but long-continued creep of the glacier toward the stream line.

The height of the terraces was determined by the height of the rock surface crossed by the river between the west line of the county and Attica. The terraced arrangement is continued here, but the upper valley has been made by the removal of the drift from the surface of the rock, while the inner valley has been cut through the rock (mainly shales) since the gravel was deposited above. The excavation of the inner valley through Tippecanoe County proceeded as the channel through the rock sill below was cut down. The stream that did this work carried the waters of the melting sheet of ice as it retreated slowly to the north and east. Its width probably corresponded to that of the inner valley.

The Tippecanoe River and Wild Cat Creek were streams of great volume as the size of their valleys show, and this volume was doubtless maintained through a long period of time.

The sand dunes southwest of LaFayette along the eastern edge of the Wea Plains Terrace, those on the terrace edge on the north side of the river opposite the mouth of Wea Creek, and the deep deposit on the crest of the bluff above the mouth of Indian Creek were probably gathered and piled up from the surface of the Wea Plains by the southwest winds, while, after the recession of the ice, the surface remained bare.

History of the Wea Creek in Tippecanoe County, Indiana.

William A. McBeth.

The Wea Creek has two principal forks, known as Big Wea and Little Wea. These both rise near the south line of Tippecanoe County and flow roughly parallel with each other five or six miles apart, first to the northeast through nearly half their course, then bending to the northwest, they gradually approach each other and unite.

The course below the junction continues northwest to the Wabash. The Big Wea receives a tributary which joins the main stream near the elbow-like bend, coming from the southeast near the south line of the county.

These branches all rise in marshy meadows or prairies now generally drained. These marshy tracts are usually long, narrow sags or shallow valleys extending across the divide.

Streams flowing to the south and southwest rise near the heads of the Wea Creeks. In the map of Tippecanoe County, on page 238, it will be noticed that Shawnee Creek rises near the source of Little Wea Creek, Coal Creek near the head of Big Wea Creek and a tributary of Sugar Creek near the source of the east fork of Big Wea Creek.

The upper course of Little Wea Creek follows a valley with gently sloping sides twenty to thirty feet in depth and one-fourth of a mile wide. Just below where it is crossed by the Chicago, Indianapolis & Louisville Railroad, near its abrupt bend, this valley widens out and comes to an end. For two or three miles the creek flows through a flat prairie with a channel just large enough to carry its flood waters. This channel is forty or fifty feet wide and five or six feet deep. For two or three miles above its junction with the Big Wea Creek it again follows a valley of about the same width as its upper valley but having much steeper bluffs and a more level bottom.

The upper seven or eight miles of the Big Wea Creek flows in a channel three or four feet deep and ten to twenty feet wide, over the smooth, gent'y sloping prairie. Near Romney it flows from the smooth prairie into a valley one-fourth of a mile wide and twenty to thirty feet deep. The tributary from the southeast joining the Big Wea near its abrupt bend has its upper course without a notable valley, but enters one of considerable size near its mouth. After the main stream bends to the northwest, its valley within

Channel of Wea Creek, one mile south of Romney, Ind. The stream here flows through an old lake bed.

Valley of Wea Creek, one mile north of Romney, Ind. The stream has cut this part of it valley deep and drained the lake bed shown above.

a few miles becomes much shallower. The bluffs become low and for some distance on the east side entirely disappear at a wide gap opening into an extensive prairie to the east. Just below this the northeast bluff becomes considerably higher than the one on the opposite side of the stream. About two miles below a deep broad valley begins and continues to the Wabash flood-plain. The lower course of the Wea for several miles, is cut through the Wea Plains terrace and the Wea Valley itself is terraced. The levels of parts of the terrace farthest up stream conform apparently to the surface of the Wea Plains.

The peculiarities of valley and course noticed in these streams invite an attempt at explanation. This is found in the interpretation of the glacial features of the region.

By reference to the map it will be noticed that several moraines cross the county south of the Wabash River. The one forming the divide between the Wea system and the streams to the southwest extends southeastward across the southwest corner of the county. Another extends east along the south side of the Wea Plains terrace to a point nearly south of LaFayette, where it bends to the southeast and continues to the southeast corner of the county. Between these ridges others trend east and west. All the ridges together thus form a complex network. Enclosed by the ridges are tracts of level prairie formerly marshy over large areas but now generally drained.

The creeks cross these flat prairies, cut through some of the ridges and follow along the sides of others. The Wea streams are entirely post-glacial in their origin and history. Their channels are cut in the beds of glacial drift that overlies the country, the underlying bed-rock being reached and exposed for a distance of a few rods in only one place in all the Wea system. This is in the bed of Little Wea Creek where it enters the Wea Plains terrace.

The retreat of the ice sheet from this region uncovered the basin of the Wea Creeks before it did the present course of the Wabash River. It may be that melting of the ice between the Michigan and Erie lobes occurred across the course of the Wabash River and along the Tippecanoe River, while the Wabash, farther west, was still obstructed to a much later period. This caused the waters of the melting ice to gather along the front of the ice border until they covered the whole Wea basin and flowed out at the sags across the divide where the heads of the Wea Creeks are so near the heads of Shawnee, Coal and other creeks. This would have made a lake of all of southern Tippecanoe County. This lake would have been about one hundred and fifty feet deep at Dayton, in the east part of the county. Some of the moraines were entirely covered with water. The broad upper valley of Little Wea was probably made by a stream flowing in the opposite direction to that of the present stream from where it is crossed by the Chicago, Indianapolis & Louisville Railroad. Some part of the valley of the Big Wea below Romney may have been made by a stream afterward reversed. When the Wabash was uncovered the lake covering nearly the whole south part of the county fell to a much lower level and the general course of the present Wea streams was laid out. As the water fell the tops of the moraines appeared and the waters flowed across their crests at the lowest places. But the streams were not continuous as now. The region was nearly covered by several smaller lakes held in by bordering moraines and the streams connected the lakes and formed the outlet of the lowest. The deep valleys show the parts of the streams that flowed across the moraines from lake to lake. As the streams deepened their valleys, the lakes were gradually drained, leaving their smooth, muddy bottoms exposed to become the level marshy prairies found at the settlement of the country. As the lakes fell to lower and lower levels, the streams were extended across the lake beds, where they now meander in sluggish courses in narrow, shallow channels.

Paleontology of Bartholomew County, Indiana, Mammalian Fossils.

J. Jep. Edwards, M. D.

1. *Mastodon americanus* (Blum.).

This animal is represented in this county by two specimens.

a. *Os sacrum.*

Weight of fossil, eight pounds and nine ounces. Found in 1898 upon a sand-bar in White River, one mile east of Wailesboro; identified by Dr. M. N. Elrod. It is in a fair state of preservation, with foramina and tuberosities well defined. In possession of the writer. A brief account of the find appeared in the *Indianapolis News* of January 15, 1901, and the Columbus (Ind.) *Daily Herald* of same date.

b. Tooth. Found in Ohio Township, Bartholomew County, in 1900. Have been unable to see it.

2. *Elephas primigenius.*

The only known specimen found in the county was a tooth unearthed in a gravel pit one-half mile south of Wailesboro in 1898. It was covered with seven feet of soil and gravel. Weight, nine pounds. It was destroyed by fire in the office of Dr. Webster Peek, at Frankton, Indiana. Identified by the writer. See Columbus, Ind., *Home Advocate* of September 9, 1898.

3. *Cariacus americanus* (Harlan).

Extinct elk. Post pliocene fossil. The specimen is the *Os frontis* to which is attached the antler with two branches. Present length two feet, weight five pounds. When found it measured over seven feet in length and was then incomplete. By handling it has crumbled to its present length. Found in White River one mile east of Wailesboro. Identified by the writer. A meager description appeared in the *Columbus Herald* of January 15, 1901.

4. *Cervus virginianus.*

Virginia deer. Sub-fossil. Specimen is the right frontal appendage (antler). Found in Wayne Township in 1898. Identified by the writer.

Organic Acid Phosphides.

P. N. Evans.

Phosphorus in the organic phosphines shows such a perfect analogy to nitrogen in the amines, that it seems strange that we should not be familiar also with the phosphorus analogues of the acid amides—which we may appropriately call *phosphides*. Of this class of bodies no mention is made in most books on organic chemistry, and an examination of the literature shows only two of these substances to have been prepared and very superficially investigated, namely, mono- and tri-chlor-acetyl phosphides, dating back to the seventies.

With a view to preparing other representatives of this class and examining them, the methods used to make the acid amides were considered as to their applicability; the reaction between hydrogen phosphide (PH_3) and acid chlorides seemed to be the most promising by which to attempt to prepare new acid phosphides.

Preliminary experiments were made several years ago with some of the simpler acid chlorides, but the very imperfect absorption of the phosphine, and the formation of solid hydrogen phosphide seemed to make the attempts unpromising, and the subject was dropped for a time.

A year ago, with Charles E. Vanderkleed, the subject was taken up again, and dichlor-acetyl chloride selected as the acid chloride to experiment with first, since the reaction had been shown to take place with the chlorides of mono- and tri-chlor-acetic acids. The reaction proceeded satisfactorily, though slowly, and the originally liquid chloride gradually thickened to a thick, yellow, transparent mass, from which by solution in alcohol and precipitation by ether a fine crystalline powder was obtained, giving on analysis figures for phosphorus and chlorine corresponding to the phosphide expected, $CHCl_2COPH_2$.

This substance is extremely soluble in alcohol, insoluble in ether, chloroform, and petroleum ether, insoluble in but soon decomposed by water, especially on warming, with the formation of hydrogen phosphide (PH_3) and dichlor-acetic acid, judging by the odor. It is quite stable in dry air and chars without melting at about 200° centigrade. Its behavior is what might be expected from a comparison with the amides, especially its greater tendency to decompose with water, on account of the more weakly basic character of phosphine compared with ammonia.

Experiments are being now made by Miss Frances M. DeFrees on the preparation and properties of benzoyl phosphide, $C_6H_5COPH_2$, and a crystalline compound has been obtained, charring without melting, and showing similar solubilities and decompositions to those of the dichlor-acetyl phosphide.

Adsorption of Dissolved Substances.

P. N. Evans.

The term "adsorption" is used for the attraction exerted by a solid surface on gases or dissolved substances. With regard to gases, the effects are familiar in the action of porous solids, such as charcoal, which seem to condense gases within the pores as if under considerable pressure; the action is a selective one, however, for in the case of charcoal some gases, ammonia for instance, are very much more affected than others. The numerous chemical reactions taking place in the presence of such porous solids as platinum sponge may probably be attributed to this surface attraction.

That solids in contact with solutions concentrate the dissolved substances on their surfaces, has been assumed in many cases, and some very superficial quantitative experiments carried out. It is commonly accepted by analysts that the first portion of the solution passing through a filter should be rejected in volumetric work on account of a possible change in concentration due to the action of the filter, but little experimental work has been done to learn how general this effect is among solids and among solutions, and very little to ascertain the magnitude of the change produced. The results obtained by different observers are difficult to harmonize; most of the experimenters simply show that adsorption takes place between certain solids and certain solutions; a few attempt a quantitative examination but omit to report factors essential to the drawing of general conclusions; a very few investigate the influence of concentration—with more or less contradictory results. One claims that the adsorbed quantity, that is, the weight of the solute close to the solid surface in excess of that in the same volume of other parts of the solution, is not dependent on the concentration in the strict sense of Henry's Law, but that dilution always lowers the quantity of the dissolved substance in the solution more markedly than that of the adsorbed substance; another, that Henry's Law applies throughout approximately; still another ascribes the results to chemical union and not physical attraction.

About four years ago the writer, with Donald Davidson, carried out a series of experiments to learn how general the adsorbing action of solids on solutions might be, and the magnitude of the effect. The details of the experiments would be out of place here, and some factors now realized to be essential to their interpretation were not recorded, but briefly, the experiments showed the following facts:

Twentieth-normal tartaric acid showed a loss of nearly 12 per cent. by contact with filter paper; twentieth-normal potassium hydroxide about the same with filter paper; 2.6 per cent. sucrose solution with animal charcoal was reduced to 1.9 per cent.; fiftieth-normal acetic acid with silica gave over 5 per cent. loss; fiftieth-normal hydrochloric acid with silica 2.5 per cent. loss; fiftieth-normal hydrochloric acid with cotton cloth 4 per cent. loss; fiftieth-normal ammonia with cotton cloth about 15 per cent. loss. All of these experiments showed, then, a positive adsorption of from 2.5 to 15 per cent. of the dissolved substance. Several others, however, showed no effect whatever: 2.5 per cent. sucrose with charcoal made from sugar, with lampblack, with sand; tartaric acid with cloth; tenth-normal sodium thiosulphate with silica.

Some experiments with sodium chloride and filter paper seemed to indicate negative adsorption, that is, the concentration of the solution was increased, possibly by adsorption of the solvent, and the same result has been reported in some cases by another observer, but in this instance it was found to be due to chlorides in the paper, none of the laboratory supply of filter paper being really free.

The weights of adsorbing substances and volumes of the solutions were unfortunately not recorded in these experiments.

The conclusion from this series of experiments is that while adsorption may be very marked in some cases, it is not shown by all solids and all solutions.

Later, experiments were carried out with Miss Frances DeFrees with a view to ascertaining the relation between adsorption and concentration. The adsorber selected was filter paper, and the dissolved substance copper sulphate. The same quantity of the solution was allowed to stand in contact with a fixed weight of paper in every case, and titrations were made with potassium cyanide solutions of suitable concentrations on this copper solution and the same solution not treated with paper. The figures obtained showed the interesting facts that above a certain concentration—about fifth-normal—no adsorption took place; that is, the concentration of the solution underwent no change by contact with the paper. As the concentration was decreased from this point the effect became more and more marked, the amount of copper removed by the paper increasing in absolute quantity up to about twelfth-normal and then decreasing with the concentration to about two-hundred-and-fiftieth-normal, farther than which it could not be followed. The decrease in concentration of 100 c. c. of this solution by contact with 5 grams of paper amounted to over 25 per cent.

To learn whether both parts of the copper sulphate were equally affected a number of determinations were made on the sulphuric acid and showed a very close agreement with the copper results, an evidence that the adsorption is of the non-ionized electrolyte and not of the ions independently.

As to the time required for the action to complete itself, the same results were obtained after a few minutes and after several days, showing that the equilibrium is very quickly established.

A similar series of experiments carried out with potassium chloride and filter paper gave analogous results, the adsorption, however, beginning at twentieth-normal, and only rising to something over 5 per cent. of that present at five-hundredth-normal concentration.

The work is being continued and promises further interesting results.

The Determination of Manganese in Iron and Steel.

W. A. Noyes and G. H. Clay.

The process proposed involves no new principle, but is a combination of several old methods.

REAGENTS.

Ferrous ammonium sulphate.—Dissolve 8.56 g. crystallized ferrous ammonium sulphate in water containing 40 cc. of dilute sulphuric acid (25 per cent.) and make up to one liter.

Potassium permanganate.—A standard solution of such strength that 1 cc. is equivalent to about 0.001 g. Fe. The manganese equivalent for the present method is found by multiplying the iron equivalent by $\frac{55}{112}$

Sodium acetate.—Thirty grams of crystallized sodium acetate, 30 cc. of acetic acid (30 per cent.) and 170 cc. of water.

Bromine water.—A saturated solution.

PROCESS.

Dissolve 1.5 grams of the sample in 20 cc. of nitric acid (1.20) and 5 cc. of hydrochloric acid (1.12). Heat till dissolved, transfer to a 300 cc. flask, add a solution of sodium carbonate till nearly neutral and then zinc oxide slowly till the precipitate of ferric hydroxide forms. After two minutes add an excess of zinc oxide.

Make up the volume to 300 cc., mix by pouring back and forth into a dry beaker and filter through a dry filter. Take 200 cc. of the filtrate, add 20 cc. of the sodium acetate solution and 40 cc. of bromine water.

Heat nearly to boiling, stirring occasionally and adding more bromine water, if necessary, till the precipitate of manganese dioxide separates. Filter and wash. The precipitate adhering to the beaker need not be removed, but the beaker must be rinsed thoroughly. Place the beaker under the funnel containing the precipitate and drop upon the latter, from a burette, the solution of ferrous ammonium sulphate till solution is complete, breaking up the precipitate occasionally with a fine stream of water from a wash bottle. Unless the manganese exceeds 0.4 per cent., not more than 20 cc. of the solution need be used. Wash out the filter and titrate the filtrate with the standard permanganate solution. The difference between the number of cc. of permanganate used and the amount which would have been employed if no manganese dioxide had been dissolved in the ferrous ammonium sulphate, multiplied by the manganese equivalent of the solution, will give the amount of manganese in one gram of iron.

The method was tested with solutions containing known amounts of manganese and gave accurate results. The method avoids the evaporation to dryness required by Volhard's method and also gives a very sharp end reaction, while the end reaction of Volhard's method is very difficult to see.

The paper is published in the Jour. Amer. Chem. Soc., 24, 243.

A New Hydroxy-dihydro-alpha-Campholytic Acid.

W. A. Noyes and A. M. Patterson.

Dihydro-alpha-campholytic acid was prepared by W. M. Blanchard and one of us last year. From this the alpha-brom. derivative, $C_8H_{14}{-CO_2H \atop -Br.}$ and the corresponding hydroxy acid, $C_8H_{14}{-CO_2H \atop -OH}$, have been prepared. When the latter is warmed with lead peroxide and dilute sulphuric acid a ketone is formed which should be identical with the 2–3.3 trimethyl cyclopentanone, prepared synthetically by one of us, if the Perkin-Bouveault formula for camphor is correct. From the melting point of the oximes the two ketones appear to be different, and the formula for camphor referred to seems to be no longer tenable. The rejection of that formula, however, compels us to suppose a transfer of a methyl group from one carbon atom to another in reactions which take place readily at ordinary temperatures under the influence of sulphuric or hydrobromic acid.

Some Drug Adulterants of Note.

John S. Wright.

[Abstract.]

Phytolacca decandra L.—The leaves, inflorescence and young fruiting racemes were found mixed to the extent of about thirty per cent. in bales of belladonna leaves received in Indianapolis from Germany, December, 1898. Since then the writer has not found them as an adulterant, though many other lots have been carefully searched. The presence of Phytolacca was first betrayed by the abundance of young flowering and fruiting racemes. Deprived of these, Phytolacca leaves make a very clever adulterant for belladonna leaves, as the two resemble in many particulars, especially when dried and crushed or compressed in the manner customary for shipment. Critical examination, however, reveals many differences of odor, texture, color, size, shape and other gross characters.

Since this report was made, in December, 1901, the writer has found that Dr. C. Hartwich [Schweitz. Wochensch. f. Chem. u. Pharm., 1901, p. 430] gives an account of a similar discovery. Furthermore, Dr. Hartwich points out some of the histological differences between the two, so that, according to established rules, he deserves the credit of priority.

*Genista tinctoria L.—The flowering and leafy stems of this plant have been recently offered, unmixed and neatly baled, on the American markets as "flowering" Scoparius—Cytissus Scoparius (L.) Link. When baled, Genista bears a superficial resemblance to the official Scoparius; however, the purchaser who accepts it as such is certainly a very careless or incompetent inspector of drugs. The botanical characters of the two are too well known to need mention here. Medicinally they are unrelated.

Rhizome and stipes of fern—species undetermined—are frequently offered for the official *male fern* or *Aspidium*. The official drug should consist of the recent rhizomes and stipes of Dryopteris Filix-mas (L.) Schott, and D. marginalis (L.) Gray, deprived of all non-green tissues. The spurious rhizome is smaller and structurally very unlike the true drug. It has never been observed in the recent state by the writer; contains practically no extractives, and may be regarded as worthless. So far, neither its geographical nor its botanical source has been learned. At times the market offerings would indicate that it constitutes about one-half of the available supply of so-called male fern.

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* An examination of the authorities disclosed but one reference to it as an adulterant: "Do not confuse with Scoparius."—King's Am. Disp., Revision by Lloyd and Felter.

Notes on Apple Rusts.

H. H. Whetzel.

The following notes on the apple rusts of Crawfordsville and vicinity are presented with the hope that they may prove helpful to those interested in this group of fungi. The observations recorded here are the results of three years' study of these plants. No systematic classification of our forms has been attempted, but the species studied is probably Tremella Juniperi-Virginianae (Schw.), as listed by Arthur in his Generic Nomenclature of Cedar Apples. This is the most common one in our locality. Special work on the anatomy of the cedar apple and the various forms in which this fungus occurs is now under way and will be ready for presentation soon.

GENERAL PREVALENCE OF THE PARASITE THROUGHOUT THIS DISTRICT.

The general prevalence and abundance of this pest throughout this section of the State is to be attributed to two causes: First, the occurrence of cedars throughout the timbered tracts of this region in such numbers and so generally distributed as to insure a universal infection of the orchards of the district; second, the prevailing ignorance of the farmers and apple growers in regard to the relation of the galls of the cedar to the Roestelia of the apple. Most farmers have planted cedars about their yards, either for ornament or protection, and as the orchards are always in close proximity to the house, the fungus is placed in a position for easy dissemination and perpetuation. One farmer not far from Crawfordsville alternated a row of apple trees with one of cedars throughout his orchard for protection from winds. Another gentleman, in the city, planted a row of cedars through his orchard along either side of the path that led from the street to his house. The result in both cases, of course, is evident. Almost every lawn in the outskirts of the city supports one or more cedars to the detriment of every susceptible apple tree in the neighborhood.

PHENOMENAL ABUNDANCE OF THE FUNGUS DURING 1900 AND ITS MARKED SCARCITY THE FOLLOWING SEASON.

The phenomenal abundance of the cedar apples and the very marked ravages of the rust on the apple trees of the city during 1900 aroused the interest not only of those acquainted with the parasite, but also very generally of the citizens of the city. On a field trip in November, 1899, we noticed the extraordinary abundance and great size of the galls that infested the cedars in yards and pastures. In commenting upon this Prof. Thomas said that never before had he seen them in such numbers and of such large size, some of them being at that time as large as walnuts. The infection was very general. Every cedar from the small seedling to the tall tree was fairly loaded on every twig and branch with the chocolate-brown galls. Just what caused this unusual abundance is not so easily discovered, but perhaps the following record of the weather for July and August and the first days of September, 1899, may throw some light on the matter. From observations made the following year it was found that the aecidiospores began to ripen about July 26. Beginning, then, with July 28, we have the following:

July 28, 1899	Rain
August 2, 1899	Rain
August 5, 1899	Rain
August 8, 1899	Rain
August 25, 1899	Rain
September 6, 1899	Rain

Six heavy rains, followed by intervals of from three to sixteen days of warm, fair weather, as shown by the weather reports kept in the city, the very best conditions for the distribution and germination of the aecidiospores on the cedar. What other factors may have entered into this general infection we are unable to say.

The conditions the following spring (1900) bore out fully the promises of the previous fall. The warm rains of the latter part of April and throughout May brought forth the yellow gelatinous masses of teleutospores in abundance. So numerous and large were the galls that the limbs of the trees bent beneath the burden and the large yellow masses could be seen for long distances. The warm sun of the days following the rain dried up the gelatinous masses, causing the teleutospores to germinate and produce countless numbers of sporidia, which were carried far and near to the apple trees of the city and surrounding country. How perfect the weather conditions of that spring were for the dissemination of this fungus, the following record will show:

April 17, 1900	Rain
April 20, 1900	Rain
May 6—8, 1900	Rain
May 18—19, 1900	Rain
May 23, 1900	Rain
May 28—29, 1900	Rain
May 31, 1900	Rain

Here were heavy rains with longer or shorter periods of fair, warm days between them, the thermometer standing on an average at from 68 degrees to 70 degrees F.

Under conditions so favorable to the fungus, infection of the apple trees was very general and the ravages of the Roestelia stage of the rust were most severe. Late in July the aecidiospores began to ripen, the leaves of the infected apple trees, already discolored by the numerous yellow spots that had begun to appear during the latter part of May, now grew brown and dropped off, so that by the middle of August some trees were nearly bare and the ground beneath them was covered with dead leaves. Most of the young trees put forth a second growth of leaves. Many of the old trees, seemingly unable to meet the unusual demand, either made a feeble effort or entirely refused to put out new leaves and remained bare until the following spring. Of course, some perished. We recall several such trees that were cut the next summer. The apple crop suffered accordingly. Almost no fruit was produced and the little that did mature was knotty and worthless. While the farmers of the northern part of the State, where cedars are very scarce, were selling apples at fifty cents to one dollar a bushel, grocers in the city of Crawfordsville sold them "three apples for five cents" and proportionately per bushel. This failure of the apple crop of this vicinity, while perhaps due in part to the dry weather of the latter part of July, August and the first of September, was largely because of the ravages of the apple rust. Comparison of this district with other apple producing sections of the country, where the drought was equally severe but where the cedar does not occur, confirms this statement.

The general scarcity of the apple rust the following year (1901) was as striking as had been its general prevalence the previous season. So scarce were the galls in the spring of 1901 that it was with difficulty that we obtained specimens enough to supply a class of nine students. The tree which the previous year had bent to the ground with its weight of galls now yielded, after careful search, but five or six scrawny specimens. Not only were the galls few in number, they were very small and produced comparatively few spores. In many cases they consisted only of new growths on the sides of the old galls and occasionally even the old galls bore a second crop of teleutospores. To what, then, shall we attribute this marked decrease in gall production? Certainly not to a deficiency in aecidiospore supply, for we have already seen that the supply of aecidiospores during the summer of 1900 was unusually large; not, indeed, to any mishap that may have befallen the galls during the winter of 1900 and 1901, for upon field trips during October and November, 1900, the general scarcity of the galls was very noticeable. The fact remains, then, that the galls were not formed. To us it seems that the cause is to be found in the weather conditions of the latter part of July, August and early September of 1900, the period during which the large crop of aecidiospores was ripened and disseminated and when under favorable conditions very general infection of the cedars should have occurred. The weather reports for the period indicated are as follows:

July 24, 1900.......................................Rain
August 12—15, 1900..................................Rain
August 17—18, 1900..................................Rain

Only three rains, practically only two, with long periods of from eighteen to thirty days of warm, dry weather between (there was no rain after August 18 until September 19), with the thermometer averaging about 80 degrees F. A comparison of the above with conditions during the same period in 1899 shows about one-half the number of rains as occurred during the last mentioned time.

The Roestelia, while not so abundant during the past summer (1901) as in 1900, have still been plentiful enough to aid materially in the destruction of the remaining apple trees of the city and country. The dry weather of the latter part of the past summer (1901) has had its effect on the infection of the cedars. Galls, while present, are not numerous, and a repetition of the ravages of 1900 are not to be expected. Weather conditions for this period are as follows:

July, 1901, no rain; average temperature, 90 degrees F.
August 14, 1901, rain; average temperature, 80 degrees F.
August 18, 1901, rain; average temperature, 80 degrees F.
September 11, 1901, rain; average temperature, 80 degrees F.

AN EXPERIMENT.

For the past three years we have had occasion daily to pass the home of Mayor Elmore, of Crawfordsville. On the lawn in front of his house stands a large cedar and just southeast of it, about three rods distant, is a small apple tree, about seven years old. During the spring of 1900 we noticed the great abundance of the cedar apples which infested this cedar and later in the summer the great number of leaves of this apple tree that were covered with the Roestelia. That the cedar galls were responsible for the attacks on the apple tree seemed quite evident, but we decided to test it by an experiment the following spring, and also to determine if by exclusion of the spores of the cedar galls the apple tree might not be protected from the ravages of the Roestelia. Accordingly on April 24, 1901, one of the limbs of the apple tree was enclosed in a sack of cheesecloth. The apple leaves were just bursting from the buds and the teleutospores had as yet not ripened on the cedars. About May 1, just after a hard rain, the first gelatinous stalks with their teleutospores made their appearance on the cedar apples, and on the following day sporidia in abundance were produced. On May 27 the first indication of the Roestelia, in the form of yellow spots or patches, appeared on the exposed leaves of the tree. Examination of the protected leaves showed only a very few spots. By July 3 no aecidia had ripened, although spermagonia in abundance had been produced. July 27 the first aecidia matured. The sack had been removed June 25 and the protected leaves showed only about one-half as many spots as the unprotected. No more spots appeared on any of the leaves during the remainder of the season. The last crop of sporidia were produced about the last of May, at least a month before the sack had been removed.

It was also observed that the west side of the apple tree, which was directly exposed to the cedar, bore more clusters of aecidia per leaf than the east side. This fact, together with the results in the protected branch, seems to prove conclusively that the sporidia of the teleutospores on the cedar had produced the infection of the apple leaves. The failure of the sack to exclude all of the sporidia was due to their minute size and the openness of the cloth. The experiment will be repeated next spring with cloth of a firmer texture. The fact that infection took place through the cheesecloth proves that the sporidia and not the teleutospores are carried to the apple leaves, since the openings in the cloth were too small to allow the latter spores to pass through. This fact seems to have been overlooked in many published reports on this fungus.

GERMINATION OF TELEUTOSPORES.

Many attempts at the germination of teleutospores were made in the laboratory. Most of these were more or less successful. The only things brought out worthy of note were: First, that in general our results confirmed the work done by H. M. Richards and recorded in his paper in the Botanical Gazette for September, 1889; and second, that best results were obtained when the teleutospores were germinated, not in an abundance of water, but rather on simply moist slides placed in the sunlight under bell jars. This allowed the spores to dry slowly, thus affording natural conditions for sporidia production.

Several gelatinous galls were allowed to dry in the sunlight on the window sill. An abundance of sporidia were produced which covered the sill beneath and about the galls, while wet material showed upon examination no sporidia. This strengthens the statement previously made that the sporidia and not the teleutospores are disseminated by the wind, since evidently the teleutospores never leave the gall before germination.

THE GALLS PERENNIAL.

As already mentioned, it was observed that many of the galls of the spring of 1901 were but outgrowths on the sides of old galls and that in many cases these old galls bore a second crop of teleutospores. Although no further investigation has been made, there appears to be but one solution to the problem, and that is that the mycelium had summered in the old galls, producing the new outgrowths and the second crop of spores in the spring. As far as we have found, no record of such a condition has been made, and while evidence seems to show that the mycelium is perennial, we wish to investigate further before making a definite statement and only offer this observation as a matter for consideration by those who may be working on this fungus.

SUSCEPTIBILITY AND IMMUNITY OF DIFFERENT SPECIES OF APPLES.

Some observations were made in different parts of the city to determine the susceptibility and immunity of different species of apples. In the experiment already described the apple tree infested was of the Milum variety. In the same yard in which this tree stood was another apple tree that was never infected by the rust. It was a fall apple, variety unknown. In another yard in another part of the city stood two apple trees with interlocking branches; one was of the Bellflower variety, a winter apple, the other was a large fall apple, variety unknown. Across the street to the west stood two cedars that usually bore a few galls. The Bellflower always suffered severely from attacks of the pest, while the other tree remained free from it. The difference in the appearance of these two trees by the middle of August was most striking. The Bellflower, with its sickly, yellowish foliage, mottled with the dark clusters of Roestelia, presented a striking contrast to the dark, healthy green of its neighbor's. The effect was also very noticeable in the apples of the two trees. Those of the Bellflower were small, knotty and not numerous, although the branches had been loaded with blossoms during the spring. The apples of the other tree were large, perfect and plentiful. More extended observations regarding this point will be made next spring.

The selection of immune varieties seems to be the only solution of the problem of the extinction of the fungus, at least in this vicinity. Not only do cedars occur in the natural forests of the region, but they have been very generally planted by farmers for protection and decoration so that the only other method, the destruction of the cedars, is quite out of the question, as so many not concerned in apple growing would not destroy their cedars, and the absolute destruction of every red cedar would be necessary to exterminate the fungus.

Notes on the Genus Stemonitis.

H. H. Whetzel.

During the past summer and fall we have made a careful study of the genus Stemonitis, as represented by the species occurring in the vicinity of Crawfordsville, Ind. This study has brought out several striking and interesting conditions regarding the development of some structures of this genus. The study was made in the laboratories of Wabash College.

and the specimens examined represent the collections of three years from this vicinity. Many species were from the campus and the shade trees along the streets of the city.

Great care was taken in collecting. The exact place of its occurrence, the date and other important data were preserved with the material. The best specimens of each species were mounted for future reference, while the remaining material was preserved for study. On each collecting trip every specimen of slime mould was taken and subsequently identified to insure thoroughness in the local work. This was necessary, as many species could be determined only by extended study and comparison with other material. Several species that appear exactly alike to the naked eye vary greatly in minute structure.

Besides this, very careful mounts were made, both in balsam and glycerine jelly, from fresh specimens. The spores were removed from those mounted in balsam, in order to show capillitium structures; others to show spore markings were mounted in jelly, containing a small amount of potassium hydrate to swell the spores. Careful measurements of spores were kept and records preserved of their color *en masse* and under the microscope. Fresh material was always used for color records, as the spores change with age, and the entire sporangium with its spores changes color several times during the process of fruiting. The following record kept of S. maxima will illustrate this:

June 25, 7 p. m., plasmodium, pearly white.
June 26, 6 a. m., fruited (still wet), purple black.
June 26, 10 a. m., brownish, dark.
June 27, 3:30 p. m., lighter brown.
July 20, spores shed, purple brown, pale.

This specimen grew on an old charred stump convenient to the laboratory, and we examined it several times each day to note any changes of color. Records of color variation of species of other genera also show this striking change of color during and after fruiting.

For determination of species, Macbride's North American Slime Moulds were used, while Lister's Mycetozoa was used for reference and comparison.

Before the presentation of the conclusions based upon a study of sporangium and spore structure, the following miscellaneous notes and observations may be of some interest:

The number of species occurring in this vicinity, so far as collections up to the present show, are six of the twelve listed by Macbride. Besides these, a seventh form was found differing quite materially from any other species collected, and not corresponding with any description of species listed by Macbride or any other author consulted. This form is very common, and its distinctive characteristics are so much unlike those of closely related individuals that it is doubtless a new species.

Very hot days following heavy showers seemed to present conditions best suited for the development of the fruiting stage of Stemonitis, and from early in the spring until late in the fall such conditions were sure to bring forth beautiful sporangium clusters in abundance. A hot morning following a thunder shower is particularly favorable. Examination of old trees and stumps early in the morning often revealed the pearly white plasmodia pushing forth upon the surface. As far as we have observed, all plasmodia of this genus are of a pearly white. Repeated attempts to bring these plasmodia to the laboratory to fruit always resulted in their distortion, partial development or decay. In no case were there normal fruits produced, although conditions seemed to be favorable.

A careful review of the particular habitat of each species revealed no special place for each. We have found them almost everywhere, although perhaps most frequently on the decaying trunks and stumps of the Red Maples that line the streets of the city. One stump of Red Maple has produced for three successive years the most beautiful specimens of S. Webberi; several fruitings being produced each season. Three were noted this year. Usually an area six inches in diameter on the side of the stump was completely covered with rich brown tufts. Board piles, posts and sides of old buildings yielded many fine specimens. Some species fruited on grass blades and leaves, which were in close proximity to the old logs in which the plasmodia grew. Some of the best specimens we obtained came from an old charred stump on the campus. The sporangia almost always occur in very exposed places. This, together with their large size and abundance, makes the discovery of them comparatively easy.

Many and careful attempts were made at germinating the spores of the different species. None was successful, although several kinds of media were used. Besides water, concoctions of rotten wood, on which the specimens grew, were tried, but all without success.

CONCLUSIONS DRAWN FROM THE SYSTEMATIC STUDY.

Comparison of this genus with others of the order has lead us to believe that Stemonitis represents the most perfect differentiation and specialization of the Stemonitaceae. Next in order below it stands Comatricha, from which the former is not very easily separated, as its lowest forms are much like the higher forms of Comatricha, only its one characteristic structure, the superficial net, serving to distinguish it.

This superficial net is peculiar in several respects. In the first place, it is almost the only example of such a structure occurring among the slime moulds, although a slight indication of such a structure may be noted in the higher forms of Comatricha. In the second place, its gradual development and perfection in Stemonitis is indeed very remarkable. Besides, this gradual perfecting of net structure is found to correspond with a like perfecting of spore markings, so that in a species presenting the best development of this superficial net we find the most specialized forms of spore marking. Another and almost equally interesting gradation in structural development, parallel to the above, is to be seen in the inner or supporting network of the capillitium. Although presenting some exceptions, this shows on the whole a tendency to a steady reduction in the number of threads of the inner network and a thickening of the resulting ones. In the species we have studied there was noted, corresponding to the differentiation just described, a gradual increase in the height of sporangia. An examination of Macbride's listed species present some interesting exceptions. A wide variation in height of sporangia of the same species is common. But in general we think it may be safely said that the tendency is toward taller and larger sporangia, with the increase in complexity of the contained parts. There are other structures that upon future investigation will probably reveal a like gradation.

Upon the discovery of this gradual and parallel development of certain structures, it occurred to us that a classification of the species of this genus, upon the basis of the development of some of these structures, would not only be the most convenient, but might, at the same time, represent the natural sequence of the species in the genus. Of course that structure which showed this development, and at the same time proved most constant in the different species, was the one to be chosen as the primary basis of classification. Careful investigation of a large number of individuals of each species showed that spore markings primarily, with size and color secondarily, was the structure to be selected.

The specimens were then gone over most carefully, and the following classification prepared, including only the species that have come under our observation, although a review of the remaining six species listed by Macbride showed that they would fit into and complete most perfectly the classification which we had worked out. For convenience, the species have been placed in three groups.

CLASSIFICATION OF THE SPECIES OF STEMONITIS.

Generic character—the superficial net.

Basis of species classification—spores; their markings, size and color.

Other structural characters important in separation of species—inner and outer net structures of capillitium; height of sporangia, and general color.

a. Epispore smooth or only slightly warted, with low, scattered warts. Spores small, light colored or colorless.

1. Stemonitis pallida Wingate.

   Spores nearly or quite smooth, 4-5μ, pale reddish brown; capillitium, inner network dense; outer net meshes small, 6-13μ; height of sporangia, 4 mm., brownish purple, becoming pallid with age.

2. Stemonitis axifera (Bull) Macbr.

   Spores with low, scattered warts, 5-6¼μ, pale reddish brown; capillitium as in S. pallida; height of sporangia 5-10 mm., ferruginous, with purple tinge after spore dispersal.

3. Stemonitis Smithii Macbr.

   Spores minutely warted, 5μ, pale dusky brown; capillitium more open than in S. axifera, outer net meshes 6-15μ; height of sporangia, 5-12 mm., bright yellowish brown, rusty, paler after spore dispersal.

4. Stemonitis ——— 64 (collection number).

   Spores smooth, or nearly so, 5μ, pale dusky brown, not reddish; capillitium, inner network open, outer net with small meshes 10-25μ, height of sporangia 10 mm., dark purple brown, like S. maxima.

b. Epispore distinctly warted, warts spinose; spores larger and darker than in a.

5. Stemonitis Morgani Peck.

Spores densely but minutely warted with spinose warts, 7-8μ, reddish brown, dark with purple tinge; capillitium, inner network loose, few branches, outer net large meshed 15-40μ; height of sporangia, 15-18 mm., rich reddish brown, dark with purple tinge.

6. Stemonitis Webberi Rex.

Spores densely and very distinctly warted, 8-9μ, reddish brown; capillitium, inner net open, outer net large, coarse, irregular meshes 50-125μ; height sporangia 18 mm., rusty brown.

c. Epispore reticulate, large, dark, violaceous never brown.

7. Stemonitis maxima Schw.

Spores reticulate, 7-8μ, dark violaceous; capillitium, inner net of medium density, outer net meshes 8-40μ; height of sporangia 5-10 mm., dark purple brown, becoming pallid with age.

The Vegetation of Abandoned Rock Quarries.

Mel T. Cook.

The study of the encroachment of plants on waste land and the order of their succession becomes especially interesting in the case of the abandoned rock quarries because of the very small amount of soil.

The following observations were made from the study of three limestone quarries in Greencastle, Indiana, and vicinity. It is impossible to give the exact ages of these quarries; a small amount of rock is still taken from them. Rough estimates will be given in the following descriptions:

Quarry A.—A small quarry, about ten or fifteen years old; about two-thirds of the floor covered with water, which drains in from a small area; no natural outlet.

Quarry B.—A much larger quarry, about fifteen or twenty years old; very long and narrow and extending east and west; the first work done in the western end; small stream runs the entire length from east to west; another much smaller stream from a spring enters on the north side, spreads out fan-shaped and joins the main stream. A small marsh in one part of quarry. Heavy woodland on the south.

Quarry C.—Very little larger than B and about twenty or twenty-five years old. Extending north and south; first work at north end; small stream runs through north end; large pond in south end. Almost surrounded by thin woodland.

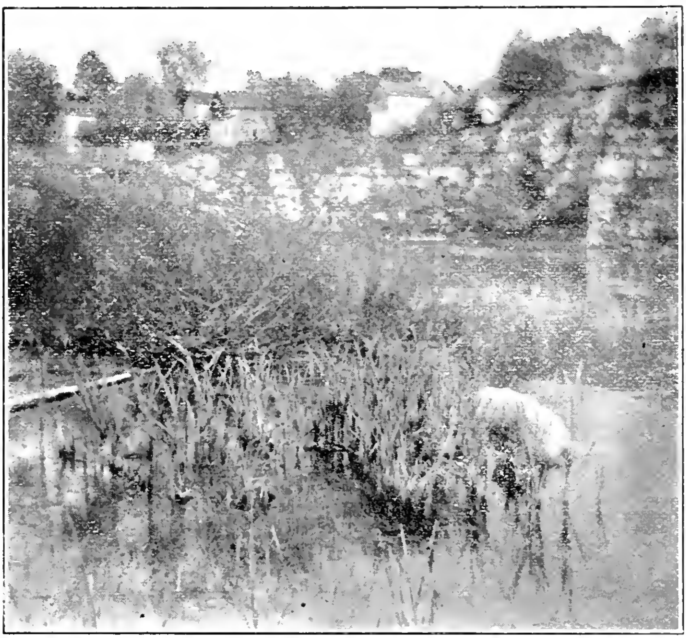

Fig. 1.

There is no soil in these quarries except the small amount incidentally carried in by the workmen, by the wind, by the streams; and the powdered limestone soil, the result of blasting and crushing.

Although there may be many factors bringing seeds into the quarry, the two principal ones are wind and water.

The order in which the plants appear in these quarries is as follows: Algae, lichens, mosses, scouring rushes, monocotyledons and dicotyledons.

The water naturally brings in the algae, which grow in great variety and abundance. Lichens are not very abundant and are usually found in the higher parts. The peculiar soil formed from powdered limestone forms a muck in which a few species of mosses grow, but not in great abundance. A few very poor specimens of Equisetum arvense were found in quarry B, having come in from the gravel bed of the railroad which runs on the north bluff of this quarry.

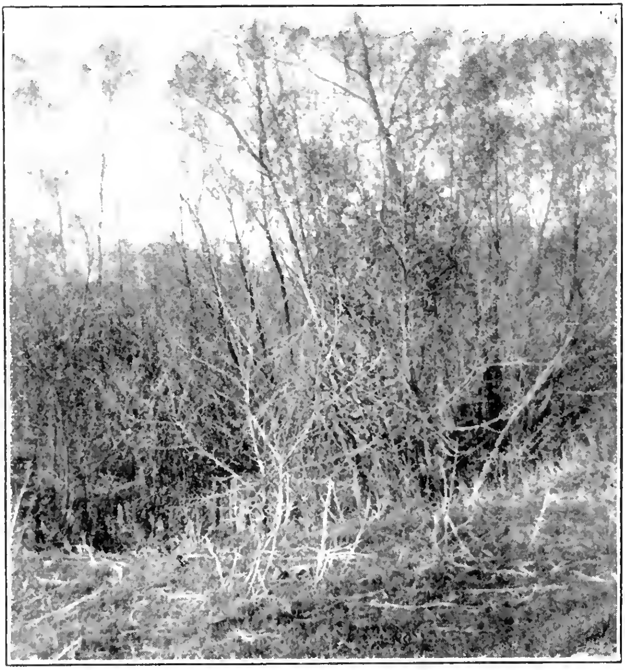

Fig. 2.

Of the Spermatophytes the monocotyledons are the first to appear, the hydrophytes leading and invading the ponds. Of these the most showy is the Typha latifolia L. (Fig. 1), which was very abundant in all three quarries. Around the margins of these ponds the sedges were very abundant, gradually giving way to the grasses a little farther back.

Of the dicotyledons, the willows (Salix sp.) and sycamore (Platanus occidentalis L.) were the most conspicuous (Figs. 1 and 2). The willows were always in great abundance along the streams and on the margins of the ponds. The sycamores were by far the most interesting growth and were found abundantly in quarries B and C. They were more abundant and much larger in the old parts of the quarry and seemed especially well adapted to this peculiar soil: in fact, they seemed to be able to grow with little or no soil except the limestone powder in the crevices. Fig. 3 shows a tree about eight inches in diameter growing out of the apparent solid

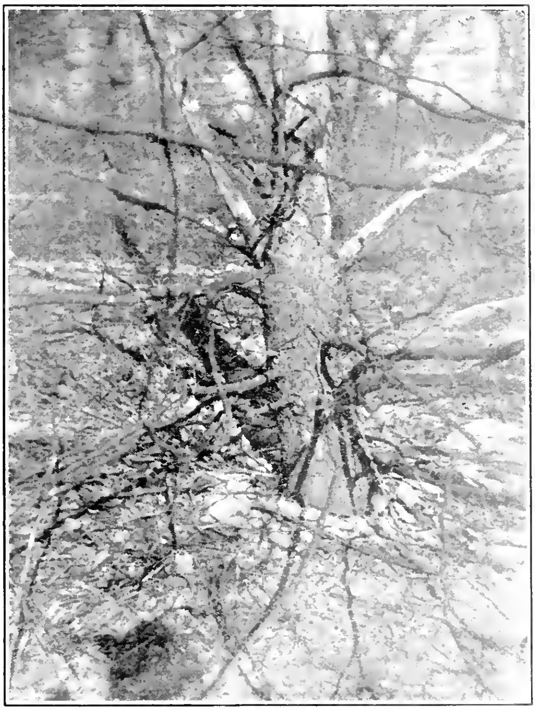

Fig. 3.

floor of quarry C. Fig. 4 shows a tree of about four inches in diameter growing out of a crevice between strata in the wall of the same quarry.

In the older parts of the quarry and around the margins, where considerable amounts of surface soil has been carried in, the dicotyledonous plants are very abundant.

The common watercress (Roripa nasturtium L.) was abundant in quarry B, having been carried in by the little stream from the north. Its spread, however, was very slow, seemingly dependent on the amount of surface soil carried in by the stream, since it did not thrive in the limestone soil.

A few plants of the button bush (Cephalanthus occidentalis L.) were found around the pond in quarry C.

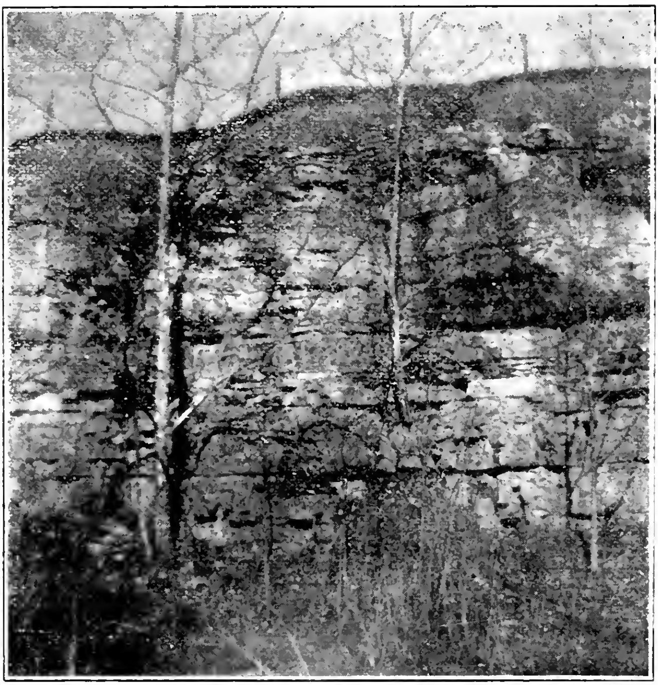

Fig. 4.

A summary gives the following conclusions: (1) the first plants are the algae in great variety and abundance. (2) A very few lichens. (3) A few mosses. (4) Equisetum very rare; the soil not suited to its growth. (5) Typical hydrophyte societies in the ponds, the Typha latifolia being most conspicuous. The ponds slowly encroached upon by the sedges and grasses: These plants form a soil for the many dicotyledons which are found in the older parts of the quarry. (6) The willows and sycamores are the first trees, both being specially well adapted to the thin soil.

The following census of plants was made from quarry B by Mr. Guy Wilson:

1. Typha latifolia L.
2. Alisma Plantago aquatica L.
3. Panicum dichotomum L.
4. Muhlenbergia sp.
5. Phleum partense L.
6. Agrostis alba L.
7. Cyperus sp——.
8. Carex sp——.
9. Ixophorus glaucus (L.) Nash.
10. Juncus effusus L.
11. Juncus tenuis Willd.
12. Juncus nodosus L.
13. Salix sp——.
14. Ulmus Americana L.
15. Rumex crispus L.
16. Polygonum sp——.
17. Roripa nasturtium (L.) Rusby.
18. Draba Caroliniana Walt.
19. Platanus occidentalis L.
20. Potentilla monspeliensis L.
21. Pyrus sp. (cultivated).
22. Melilotus alba Desv.
23. Trifolium partense L.
24. Trifolium repens L.
25. Acalypha gracilens A. Gray.
26. Euphorbia nutans Lags.
27. Rhus radicans L.
28. Impatiens sp——.
29. Onagra Oakesiana (A. Gray) Britton.
30. Daucus carota L.
31. Asclepias incarnata L.
32. Verbena urticifolia L.
33. Scutellaria lateriflora L.
34. Prunella vulgaris L.

35. Hedeoma pulegioides L.
36. Lycopus rubellus Moench.
37. Mentha piperita L.
38. Mimulus alatus Soland.
39. Plantago major L.
40. Micrampelis lobata (Michx.) Greene.
41. Lactuca Scariola L.
42. Lactuca Canadensis L.
43. Ambrosia trifida L.
44. Xanthium strumarium L.
45. Vernonica sp——.
46. Eupatorium perfoliatum L.
47. Solidago Canadensis L.
48. Erigeron Philadelphicus L.
49. Bidens laevis (L.) B. S. P.
50. Bidens frondosa L.

The Germinative Power of the Conidia of Aspergillus Oryzæ.

Mary F. Hiller.

Former investigations of the mould, Aspergillus oryzae, have resulted in many practical suggestions which have determined this mould to be of interest to the commercial as well as to the scientific public.

In 1876 Ahlburg, the first investigator of the mould, described the fungus and named it Eurotium oryzae. Cohn, in 1883, in his study of moulds as industrial factors, called it Aspergillus oryzae. Büsgen, in 1883, gave the first complete description of this mould, and in 1893 Wehmer attempted a structural study. From this time many investigators were at work in many different laboratories working out the life history of the fungus. It was Takamine, a Japanese chemist, who introduced Aspergillus oryzae into the laboratories of this country.

The careful experiments of many investigators, among whom are Jörgensen, Hansen, Klocher, also Atkinson and Hoffman, who have treated it from the industrial standpoint, have resulted in suggesting for this mould many interesting properties, such as the claims that the mycelium, in developing, secretes a diastatic ferment and that under certain conditions of growth the mould is convertible into yeast. These two properties alone would establish its value to the commercial world aside from its scientific interest.

The object of the following experiments is to study the germinative power of the conidia of Aspergillus oryzae, the plan being to test the conidia of various ages in different media.

This study was suggested by a statement of Wehmer's to the effect that neither the age of the inoculating material, nor the medium upon which it has been grown, affect the germinative power of the conidia.

The material used in these experiments was taken from cultures germinated upon the following media: Wort (obtained from the brewery, unfermented, but after having been hopped), wort-gelatine (wort fortified with ten per cent. gelatine), dextrose, rice, bran, also some of the so-called original material which had been obtained from Takamine. These cultures, which were seventeen in number, covered the dates of March 29, 1897, to November 26, 1898.

A new series of cultures were made from these seventeen cultures, which varied in age from two years and eleven months to four years and seven months, the testing medium being wort. Upon examination of these cultures the following results were obtained: Cultures obtained from the six, grown originally upon wort, and which varied in age from two years and eleven months to three years and seven months, had been germinated and the mould was in a vigorous and advanced stage of growth. Those cultures taken from bran, rice, wort-gelatine and the original material failed to show any signs of germination.

In the second series of cultures the medium of germination used was wort-gelatine. Upon examination of these cultures at various dates, it was found that the six taken from the wort cultures had germinated and the mould had grown vigorously, while those cultures taken from bran, rice, etc., had failed as in series number one.

Pasteur solution was the medium used in the third series of cultures. The results obtained were the same as the results from series one and two, the six cultures taken from wort having germinated and all others having failed.

The fourth series, the testing medium bouillon, gave the following results: Six cultures taken from wort grew, also one taken from bran, which was four years and six months of age, the cultures from wort-gelatine, rice and the original material having failed.

For a fifth series of cultures gelatine was added to beef broth, and the results of these cultures were the six from wort grew, the fungus being in a vigorous state, also one from wort-gelatine, which was three years of age, the growth not being vigorous; cultures from bran, rice, original material and the remaining four of wort-gelatine failed.

The series of moist chambers in which a drop of wort was used was then made, and the following were the results obtained: Germination had taken place in cultures obtained from rice three years and nine months of age, one from wort-gelatine three years of age and the six from wort. Those failed which had been obtained from cultures on bran, dextrose, original material and the remaining four on wort-gelatine.

A series of cultures was also made using Pasteur solution and alcohol to normal solution, but no results at all were obtained, germination having failed in every culture.

New cultures were made in wort from the original cultures which had germinated in just one or two testing media and were as follows: One from wort-gelatine which was three years of age and had germinated in beef broth and gelatine; one from rice three years and eight months of age, which had germinated in the moist chamber, wort having been used; one from bran four years and six months old, which had germinated in bouillon; one from wort-gelatine three years old. It had germinated in the moist chamber. These four cultures failed to give any sign of germination. From this result it is suggested that the cutting off of the air supply had permitted the conidia to germinate in wort in the moist chamber where the test tube cultures in wort failed to promote germination.

A microscopical examination was made of the conidia from cultures of various media and dates, the following being the conidia examined: Those from original cultures in wort, wort-gelatine, dextrose, from cultures of Series I, in which wort was the medium; Series III, Pasteur solution the medium; Series IV, bouillon the medium. In these examinations the conidia showed no apparent difference.

The tabular form of these experiments and the results obtained from them suggests the following conclusions:

First.—The germinative power of the conidia of Aspergillus oryzae is dependent upon the medium upon which the inoculating material has been grown.

Second.—The age of the inoculating material in these experiments varied from two years and eleven months to four years and seven months, and from results obtained the germinative power lessens with age.

Third.—(a) Some media are decidedly favorable to the fungus in retaining its vitality. Example 1: Wort, all cultures from it having germinated in each of the six testing media. (b) Other media are favorable under certain conditions. Example: Wort-gelatine. Out of five cultures one grew in one of the testing media. (c) Still other media are decidedly unfavorable. Example: Dextrose, cultures from it having failed throughout the experiments.

Fourth.—Alcohol is not stimulating to the conidia of Aspergillus oryzae.

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Spore Resistance of Loose Smut of Wheat to Formalin and Hot Water.

William Stuart.

The comparative absence of any definite knowledge of the spore resistance of the loose smut of wheat to formalin and hot water, and the lack of any efficient method of preventing losses to the wheat crop from it, seem to invite some attention to this phase of the question. In a measure the work which has been performed is simply a continuation of some investigations begun during the season of 1898, and reported in the Academy Proceedings for that year, pp. 64-70. At that time work was undertaken with both wheat and oats smut, but on account of the fact that the wheat smut spores did not remain viable under laboratory conditions this portion of the work had to be abandoned. Further opportunity for study of the wheat smut did not present itself till last summer. A considerable quantity of smutted heads was collected from last year's wheat crop just after the grain headed out, and before the spores were blown or washed off the rachis. This material was kept in the laboratory until needed for use. Spores mounted in hanging drop cultures over moist cells showed good germination in distilled or tap water at the time the material was collected, but in the course of two or three weeks failed to germinate. As these results corresponded with those of 1898, it was decided to try germinating them in some nutrient solution. Accordingly a Pasteur sugar solution was substituted for the water, with the result that a vigorous germination was obtained.

In order to insure a uniform lot of spores for the culture experiments, a sufficient quantity of them were jarred from the smutted heads, and after removal of the detritus by screening, they were thoroughly mixed and collected in a receptacle from which fresh supplies were drawn as desired.

Treatment of the spores.—The spores were treated in muslin sacks, one corner of which was weighted with a small quantity of shot in order to carry the sacks down into the solution and maintain them in proper position while being treated.

In treating the spores, especially in the formalin solutions it was found absolutely essential that only a minute quantity of spores be taken, otherwise they were apt to collect in masses, and in this way the solution did not readily permeate the whole mass. Whenever this occurred, in the shorter periods of treatment, spores taken from the interior of these masses would invariably show germination.

Formalin treatment.—The strength of formalin solutions used were .18, .25 and .5 per cent. The periods of treatment to which the spores were subjected in these solutions were one-quarter, one-half, one, and two hours, the four lots of spores being treated at the same time, each being successively removed without in any way disturbing the remaining ones. The treated spores were mounted as soon as possible after removal from the formalin solution, and, after a microscopic examination, were placed in a moist chamber, the moist chamber being used in order to obviate the necessity of using vaseline to cement the cover slips to the glass cell. Better results seemed to be obtained when the culture had free access to moist air.

The data obtained from the formalin treatment which is given in Table I, shows that the quarter-hour treatment in the weaker solutions were apparently not effective. In the .18 per cent. solution with the quarter-hour treatment every culture made showed good germination, while in the .25 per cent. solution eight out of twelve showed germination in the quarter-hour treatment and one out of twelve in the half-hour.

TABLE I.

Germination Tests of Spores Treated With Formalin.

Strength of Solution.	Length of Treatment.	Number of Cultures.	Cultures Showing Germination.	Percentage of Same.
.18	¼ hour.	4	4	100
.18	½ hour.	4	0	.....
.18	1 hour.	4	0	.....
.18	2 hours.	2	0	.....
.25	¼ hour.	12	8	67
.25	½ hour.	12	1	8.3
.25	1 hour.	4	0	.....
.25	2 hours.	4	0	.....
.50	¼ hour.	3	0	.....
.50	½ hour.	3	0	.....
.50	1 hour.	3	0	.....
.50	2 hours.	3	0	.....
Not treated.	....	10	10	100

The latter germination is probably accidental, owing to the fact that the half-hour treatment in the .18 per cent. solution showed no germination. Treatment in the .5 per cent. solution proved effective in all cases.

In order to note the action of the formalin upon the smut after their removal from the solution, cultures were made of the spores at different periods after their removal, varying from a quarter to one and a half hours. The data obtained, which is presented in Table II, shows conclusively that the formalin proved effective in the quarter-hour treatments if given sufficient time to act upon the spores before mounting them in the liquid media. Spores treated a quarter hour in the weakest solution and mounted one hour after showed no germination.

TABLE II.

Germination of Spores Treated 1 4 Hour in Formalin Solution, Mounted Some Time After.

Time elapsed after removal from Formalin Solution.	Strength of Solution.	Number of Cultures.	Cultures Showing Germination.	Percentage of Same.
1 hour.	.18	2	0	....
1½ hours.	.18	2	0	....
¼ hour.	.25	2	2	100
½ hour.	.25	4	2	50
¾ hour.	.25	2	0	....
1 hour.	.25	3	0	....

In the quarter per cent. solution the treatment was effective if the spores were not mounted for three-quarters of an hour after their removal from the formalin. It would appear, therefore, that under ordinary conditions of farm practice in which the seed is allowed to dry before being planted, treatment with either strength of solution should prove effective. In actual practice, however, such a treatment does not prove effective. This has been amply demonstrated by some experiments which were reported by Dr. Arthur in the Thirteenth Annual Report of the Indiana Experiment Station, p. 21, January, 1901, in which seed treated a half hour in a .45 per cent. solution of formalin at an average temperature of

124.5 degrees F., showed over one per cent. of smutted heads in the resultant crop.

Hot water treatment.—Only two periods of treatment were tried with hot water; these were for five and ten minutes. The range of temperature tried was from 130 degrees F. to 100 degrees F. The highest temperature used was considered the lowest point at which the treatment of wheat seed could be expected to prove effective, and it was therefore taken as the starting point in the work. As this temperature proved effective in killing the spores, a lower one was tried and so on until the lower limit of effectiveness was reached. The results of the work, which are presented in Table III, show that the lower limit of effective treatment was 110 degrees F. for five minutes and 105 degrees F. for ten minutes.

TABLE III.

Germination of Spores Treated With Hot Water.

Temperature of Water.	Length of Treatment.	Number of Cultures.	Cultures Showing Germination.	Percentage of Same.
130° F.	5 minutes.	2	0	....
130° F.	10 minutes.	2	0	....
125° F.	5 minutes.	2	0	....
125° F.	10 minutes.	2	0	....
120° F.	5 minutes.	4	0	....
120° F.	10 minutes.	4	0	....
115° F.	5 minutes.	4	0	....
115° F.	10 minutes.	4	0	....
110° F.	5 minutes.	6	0	....
110° F.	10 minutes.	6	0	....
105° F.	5 minutes.	8	4	50
105° F.	10 minutes.	6	0	....
100° F.	5 minutes.	2	2	100
100° F.	10 minutes.	4	4	100
Not treated.	....	19	19	100

The unusually low temperature at which the viability of the spores were impaired seems all the more remarkable when we take into account the fact that a treatment of the seed wheat for ten minutes at a temperature of 130 degrees F. is not effective in removing all the smut from the ensuing crop. The results obtained from both the formalin and hot water treatments would seem to indicate that the spores are easily killed, in weak solutions of formalin and in comparatively low temperatures of water, when brought in direct contact with these agencies.

The lack of success in treating the seed for smut seems to be due to the inability of the agency used to reach all the smut spores. This is probably due to the fact that the seed coat is somewhat impervious to liquid solutions; hence, all spores that are held in the interstices of the seed coat are reached with difficulty, if at all. Assuming this explanation to be correct, it would appear that a different treatment should be accorded wheat than that advocated for oats. Some preliminary treatment should be given with the object of softening the seed coat, to such an extent as to permit of the ready action of whatever disinfecting agency it is desired to employ. With this idea in view a series of experiments were undertaken in which the seed, intended for treatment either with formalin or hot water, was given a preliminary soaking in water at about 70 degrees F. The length of time in which the seed was allowed to soak in water varied somewhat inversely to the time in which it was to be treated in formalin and hot water. For example, in the formalin treatments in which four lots of seed were treated, the first lot was soaked a half hour in the water and two hours in the formalin solution, whereas the fourth lot was soaked three hours in the water and only a quarter-hour in the formalin solution. In the hot water treatment, somewhat the same method was followed, except that a shorter period of treatment was given.

Germination tests were made of the treated seed in a Geneva germinator. The treatment of the seeds and the data obtained from the germinator tests which are presented in Tables IV and V, show that the formalin treatments injured the viability of the seeds somewhat more than that of the hot water. In neither case, however, was the seed appreciably injured.

TABLE IV.

Germination of Seed Wheat Soaked in Water, Then Treated With Formalin.

Soaked in Cold Water.	Treated in .18% Formalin.	Per Cent. of Germination in					Total Per Cent. Germination.
		1 day.	2 days.	3 days.	4 days.	5 days.	
½ hour.	2 hours.	35.5	74	82.5	86.—	87.—	87
1 hour.	1 hour.	22.5	67	80.5	85.5	....	85.5
2 hours.	½ hour.	36	76.5	84.5	87	88	88.—
3 hours.	¼ hour.	34	81	81	85.5	87.5	87.5
Untreated.	....	0	36.5	72.5	81.5	95.—	95.—

TABLE V.

Germination of Seed Wheat Soaked in Water, Then Treated in Hot Water.

Soaked in Cold Water.	Treated in Water at 120 F.	Per Cent. of Germination in					Total Per Cent. Germination.
		1 day.	2 days.	3 days.	4 days.	5 days.	
1 hour.	½ hour.	10.5	64.5	92	....	93	93
2 hours.	¼ hour.	31.5	76	93.5	....	94	94
3 hours.	10 minutes.	45.5	81.5	91.5	....	..	91.5
4 hours.	10 minutes.	46	92	94.5	....	97	97.—
Untreated.	....	....	....	....	....	..	95

The delayed germination of the untreated seed was due to the fact that it had not been soaked in water previous to putting it in the germinator, hence it took some time to absorb sufficient moisture for germination.

In the formalin treatment seed soaked three hours in water and then treated a quarter-hour in an .18 per cent. solution of formalin, was not materially injured, there being but 7.5 per cent. less germination than from the untreated. That soaked one hour in water and one hour in the formalin solution showed slightly more injury than any of the others.

For the hot water treatment a temperature of 120 degrees F. was chosen, on the supposition that though considerably lower than that used in ordinary practice it was nevertheless sufficiently high to insure killing all spores with which it came in contact. Four lots of seed were treated, for periods varying from one to four hours in the cold water and from ten to thirty minutes in the hot water. The highest germination obtained was from seed which had been soaked four hours in cold water and ten minutes in the hot water.

SUMMARY.

A careful consideration of the evidence at hand would seem to indicate that in themselves smut spores are easily destroyed by either formalin or hot water treatments.

Owing to the somewhat impervious nature of the seed coats of wheat, and the not improbable fact that spores find lodgment in the interstices of them, it is difficult to reach and kill all the spores with any ordinary method of treatment.

To render the seed coats of wheat susceptible to such agencies as are commonly employed for the prevention of smut, it appears to be necessary, even imperative, that they should be soaked for some time in cold or tepid water prior to treatment.

A three hours' soaking in cold water and a quarter-hour treatment in an .18 per cent. formalin solution did not materially injure the viability of the seeds.

Seeds soaked four hours in cold water and then treated ten minutes in water at 120 degrees F. gave slightly better germination than the untreated seeds.

Some Additions to the Flora of Indiana.

William Stuart.

The accompanying list of flowering and fungous plants are some which have been collected by the writer during the past two seasons. In the flowering plants, out of a list of five, three are far removed from the range to which they are accredited.

In presenting the list it has been thought desirable to append a few notes under each species, giving the locality and soil in which they were collected, together with such other observations as might be deemed of interest.

FLOWERING PLANTS.

1. Agropyron occidentale Scribn. (A. Spicatum L. & L.) Colorado Bluestem. Tippecanoe County.

This species is not listed in Britton and Brown, but may be found in the revised edition of Bulletin 17 of Division of Agrostology, United States Department of Agriculture, p. 298, 1901. According to Scribner it is found "in dry or moist soil, Wisconsin to Iowa, and westward to Washington, Texas and Arizona." It was found in abundance by the writer along the Wabash and Monon railroads south of Lafayette, in dry, gravelly soil. Its introduction into the State is doubtless due to the railroads.

2. Sporobolus neglectus Nash. (S. vaginaeflorus Vasey.) Small Rushgrass. Tippecanoe County.

Found growing in abundance along sidewalks in West Lafayette. No other station noted.

3. Chenopodium murale L. Nettle-leaved Goosefoot. Tippecanoe County. Collected along sidewalk in Lafayette.

4. Astragalus Tennesseensis Asa Gray. Tennessee Milk Vetch. Tippecanoe County.

This plant was collected in sandy bottom land along the Wea Creek, about four miles south of Lafayette, and some two hundred yards down stream from the Wabash railroad bridge. It is probable that it owes its introduction into the State to the railroad. Not very abundant. Of this plant Britton and Brown say: "On hillsides, Tennessee to Alabama and Missouri, March to May." It was collected in fruit the latter part of May.

5. Psoralea tenuiflora Pursh. Few-flowered Psoralea. Tippecanoe County.

Found growing along the Wabash railroad south of Lafayette. Not abundant. Collected in fruit July 7, 1901. Britton and Brown give the range as follows: "Prairies of Illinois and Minnesota to Texas and Sonora west to Colorado and Montana, May to October."

PLANT RUSTS.

6. Puccinia vexans Farlow. On Bouteloa curtipendula (Michx.) Fon. Tippecanoe County. II, III, collected July 20, 1900.

7. Puccinia panici Dietl. On Panicum virgatum L. Tippecanoe County. III, collected May 30, 1901. (Teleutospores of previous season.) II, collected June 22.

This rust was collected on an isolated clump of Panicum virgatum, in the same region as that in which P. vexans was found. The date of the formation of teleutospores was not obtained owing to the destruction of the grass by fire.

8. Aecidium Pammelii Trelease. On Euphorbia corollata L. Tippecanoe County.

This aecidium was collected June 9, 1901, on plants of E. corollata, which were growing in close proximity to the clump of P. virgatum that was affected with the rust P. panici. The absence of any other aecidium suggested to the writer that possibly this was the aecidial stage of P. panici. Accordingly some of the affected Euphorbia leaves were collected and inoculations made upon potted plants of P. virgatum in the station greenhouse. Leaves of these plants were inoculated June 11 and 14, the latter being made with freshly collected material. In each instance well-developed uredosori were obtained in eight days from the time of infection. As both inoculations were entirely successful, it would appear reasonably certain that A. Pammelii on E. corollata is the aecidial stage of P. panici on P. virgatum.

9. Aecidium physalides Pk. On Physalis heterophylla Nees. Tippecanoe County. Collected May 22, 1901.

The writer wishes to acknowledge his indebtedness to Dr. Arthur for the determination of the rusts.

Effect of the Composition of the Soil Upon the Minute Structure of Plants.*

Herman B. Dorner.

The growth and distribution of plants are dependent upon four factors, namely, light, temperature, moisture and soil. Under moisture are included both that of the soil and that of the atmosphere. Soil and moisture may well be treated together, since the one is greatly dependent upon the other. In the work carried out, the only factor which was varied was that of the soil.

The changes occurring in plant structures, due to the variation of any of these factors, may be divided into two groups. These may be con-

*An abstract from a thesis presented to the Faculty of Purdue University for the degree of Master of Science.

veniently called *permanent* and *temporary* changes. By permanent changes are meant those which have become fixed in the plant and are due to generation after generation being subject to the same conditions. By temporary changes are meant those which have taken place for only a generation or two and which have not become impressed upon the plant to such an extent but that it will again revert to the normal on being placed under the former conditions. To this latter group belong the temporary reduction of leaf surfaces, stunted growths, and other similar changes. It is only this latter group which can possibly figure in the work carried on.

The study of the gross changes, due to the variation of soil conditions, has always been one of great interest to the botanist. These changes may be seen in nature all about us and often the vegetation of a region will give, to the trained eye, the conditions of the soil. The soil is now studied, not by chemical analysis, but by what will grow upon it.

The object of the experiment has been to determine whether these variations in the soil have given other than gross changes. Although the minute differences were the main object in view, all gross changes, which occurred, were noted in order to trace their connection with the minute ones.

The soils used in the experiment were a good, dark loam, a good yellow clay, and a clean pit sand.

The loam used contained only a very small quantity of sand and was taken from a field which had been under cultivation for a number of years, but to which little or no manure had been added for some time. It contained a large amount of silt and humus.

The clay also contained a very small quantity of sand and was secured only a short distance from a brickyard. The soil, however, was a little too light for brick-making.

The sand was a clear pit sand, not over sharp or very coarse. On washing it showed very little silt or foreign substances.

The other three conditions, temperature, light and moisture, were kept, as nearly as possible, uniform for all.

In watering, great care was taken to keep them in the best growing condition. The plants were only given water when they required it, so that in no case were they overwatered or allowed to dry out more than possible.

The plants were grown in a greenhouse with a day temperature of about 21 degrees C., and a night temperature of about 16 degrees C. However, on bright, sunny days, the temperature went as high as 27-30 degrees C.

The plants were arranged upon the bench with enough distance between them to allow them to receive light from all sides. This was necessary in order to avoid distortions due to overcrowding.

In selecting the plants, an attempt was made, as far as possible, to select only those which were representatives of large families. Those used were the carnation, chrysanthemum, geranium, bean, corn, and the onion. At the same time they also represent three modes of reproduction: namely, by seeds, by bulbs, and by the ordinary cutting or slip.

In making a study of the gross difference the following points were noted: The size of the plant, the length of the petiole, size and color of the leaves, diameter of the stems, length of the internodes, and size and abundance of the roots. For the minute differences, the structures of the leaf, stem, and roots were studied.

In counting the number of stomata sections were taken from various parts of the leaves. The sections were then placed under the microscope and a spot chosen at random. Twenty counts were made for each side of the leaf and the average taken.

The bulbs of the onion and the seeds of the corn and bean were planted directly into the five-inch pots in which they were to remain. On the other hand, the rooted cuttings of the carnation, chrysanthemum, and geranium were first planted in two and one-half-inch pots and later transferred to four-inch pots, in which they were allowed to remain.

A close study of the changes in the gross structure, due to the variations in the soil, show that the effect of a heavy clay upon a plant is almost the same as that of a sand. This may be partly explained by the fact that although a clay soil is very rich in plant foods, the roots find such difficulty in penetrating it that the greater part of it is unavailable. Hence, the plant suffers in the same manner as when grown in sand, which is poor in plant foods.

A change in soil was found to result in:

First.—A decrease in size from the loam to the sand. In all cases the sand produced a dwarfed growth.

Second.—A decrease in leaf surface from loam to sand. In no case was the leaf surface in the sand over one-half that of the loam.

Third.—A variation in color. The clay soil gave a very dark green leaf, while that in the sand was always of a sickly, yellowish green.

Fourth.—A decrease in length of petioles from loam to sand.

Fifth.—A decrease in the diameter of the stem from loam to sand.

Sixth.—A decrease in the length of the internodes from loam to sand.

Seventh.—A decrease in the mass of roots from the loam to the sand with the exception in the case of the onion. However, when the size of the plant is taken into consideration, the mass of roots of the plants in sand was always relatively the greatest.

As a result of these numerous variations, the plants in the sand have a stunted growth above soil and an increased growth in the soil. This is also true of the clay, but not to such a great extent as in the sand.

The changes in the histological structure are not so general. Those which do take place are more for specific rather than general cases. The changes which are general may be summed up as follows:

First.—A decrease in the transpiring surface from the loam to the sand.

Second.—A decrease in the relative size of the woody tissues of the root from the loam to the sand. This decrease was due to a variation in the number of cells rather than to their size.

Third.—A larger number of crystals for the clay soil than either of the other two. This was true in the two plants in which the crystals were found, the carnation and the geranium. These crystals were found both in the stems and the leaves.

Fourth.—A greater wood development in the loam than in either of the others. This increase was not due so much to an increase in the size of the cells as to their number.

There was quite a variation in the number of stomata, but these variations were specific and not general. In some cases the loam had the highest average, in others the clay, but in most cases the greatest number were in the sand. In one case, the corn, the loam showed the greatest average for both sides of the leaf. In the bean, the clay gave the greatest average, while in the onion, carnation and geranium the sand gave the most. (See table.)

In five cases out of the six, the loam gave the thickest leaves. In the sixth case, that of the carnation, the clay gave the greatest average. This increase in thickness was caused by a general increase in thickness of all the tissues of the leaf.

In those plants bearing trichomes it was found that those growing in the loam had the smallest number.

An interesting fact was noted in connection with the development of wood in the carnation. The loam here gave the greatest wood development and the clay the least, while on the other hand the clay showed a heavy band of hard-bast. A decrease in the amount of woody tissue seems to have been followed by an increase in the amount of hard-bast. In the clay specimens where there is such a large amount of hard-bast, the wood is merely represented by a few large vessels and a few wood cells.

In conclusion, it may be said that as a result of the variation of soils, there are more marked changes in the gross than in the minute structure. The changes in gross structure are general for all the plants studied, while the changes in the minute structures are more for specific than for general cases.

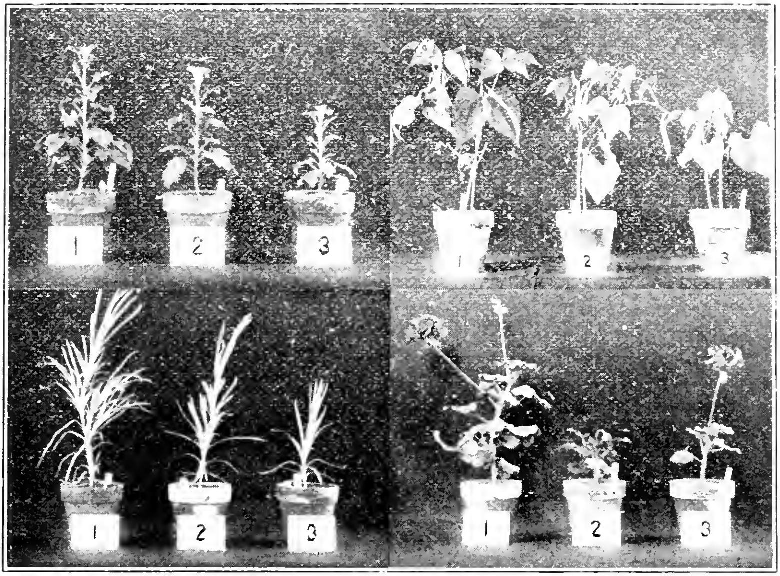
TABLE SHOWING NUMBER OF STOMATA PER SQUARE MM.

	Upper Side.			Lower Side.			Average for Both Sides.		
	Sand.	Clay.	Loam.	Sand.	Clay.	Loam.	Sand.	Clay.	Loam.
Bean	7.2	1.6	3.6	342.8	382.8	162.4	175.0	192.2	133.0
Corn	34.0	32.0	43.6	72.8	63.2	72.0	53.4	47.6	57.8
Onion	....	....	....	85.6	53.2	53.6	.....	.....	.....
Carnation	87.2	88.2	74.6	73.8	69.4	67.6	80.5	78.8	71.1
Geranium	62.4	42.4	35.2	209.8	177.0	195.6	136.1	109.7	115.4
Chrysanthemum	....	....	....	81.6	97.4	88.2	....	.....	.....

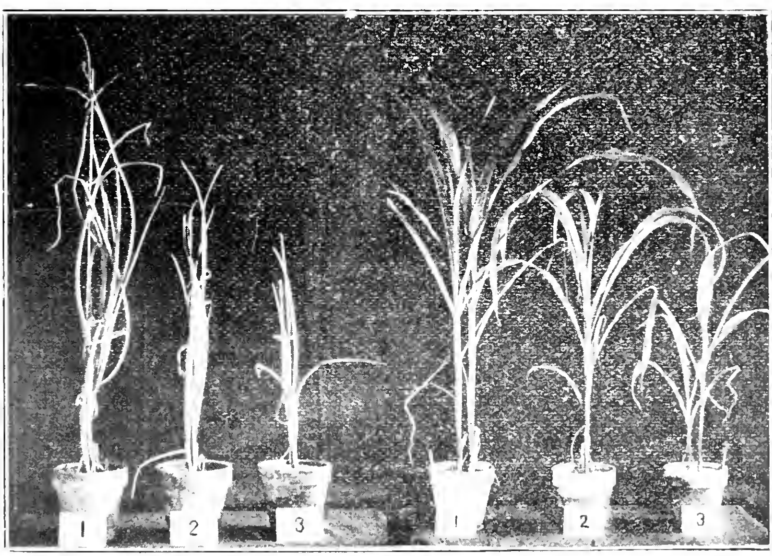
*No count was made for the upper side, as it was impossible to remove the epidermis.

EXPLANATION OF PLATES.

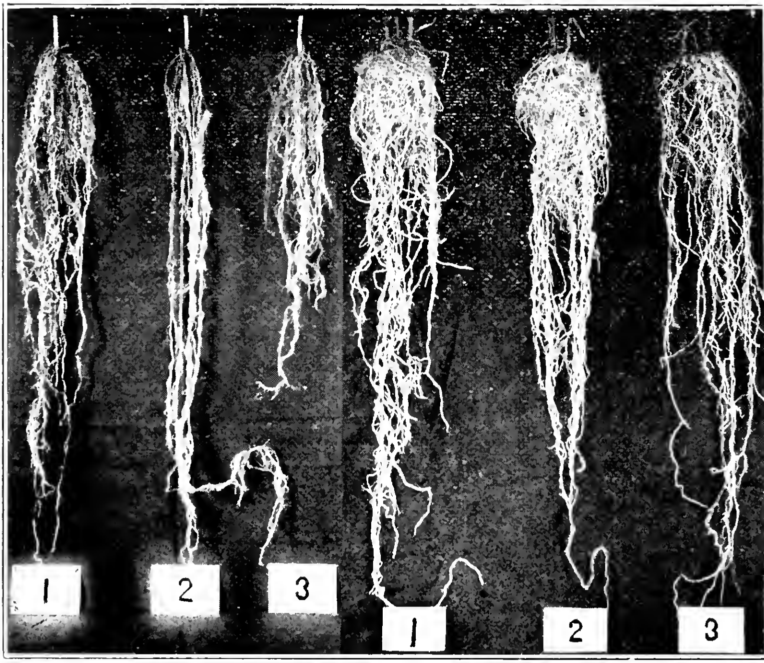
In the illustrations, 1 always represents those plants grown in loam; 2, those in clay; and 3, those in sand.



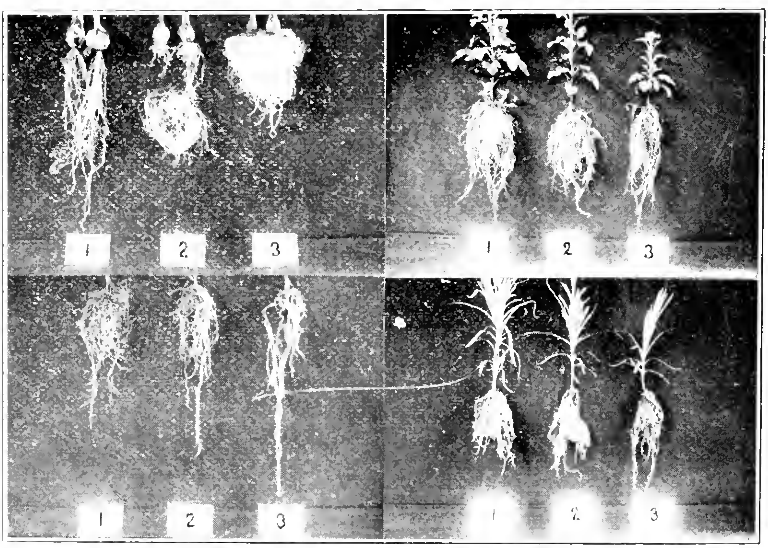
Chrysanthemum. Bean.
Carnation. Geranium.



Onion. Corn.



Bean. Corn.



Onion.
Geranium.

Chrysanthemum.
Carnation.

A Collection of Myxomycetes.

Fred Mutchler.

This collection was made during the month of October, 1901, in the neighborhood of Bloomington, Ind. Lister's "Mycetozoa" was used in classifying them and the names given therein have been observed in this list.

Amaurosporales. (Spores violet.)

I. *Calcarinea.* (Sporangia containing lime.)

Order I. Physoraceae. (Lime in granules.)

4. Fuligo septica Gmelin.

Order II. Didymiaceae. (Lime in crystals.)

12. Didymium nigripes Fries.
Didymium Xanthopus Fries.

II. *Amaurochaetineae.* (Sporangia without lime.)

Order I. Stemonitaceae.

15. Stemonitis splendens Rost.
Stemonitis fusca Rost.
Stemonitis fusca, var. confluens Rost.
Stemonitis ferruginea Ehrenb.

Lamprosporales. (Spores other than violet.)

I. *Anemineae.* (No capillitium.)

Order I. Heterodermaceae.

24. Dictydium umbilicatum Schrader.

II. *Calonemineae.* (Capillitium present.)

Order I. Trichiaceae.

33. Trichia fallax Pers.
Trichia affinis De Bary.
Trichia favoginea Pers.
Trichia contorta Rost.
Trichia persimilis Karst.
Trichia botrytis Pers.
Trichia scabra Pers.
Trichia varia Pers.

34. Oligonema nitens Rost.

35. Hemitrichia rubiformis Lister.
Hemitrichia leocarpa Lister.

Hemitrichia clavata Rost.
Hemitrichia intorta Lister.
Hemitrichia Karstenii Lister.
Hemitrichia stipata Mass.

Order II. Arcyriaceae.

37. Arcyria pucinea Pers.
Arcyria stipata List.
Arcyria digitata McBr.
Arcyria albida Pers.
Arcyria incarnata Pers.
Arcyria nutans (Bull.) Grev.
Arcyria ferruginea Sant.
Arcyria flava Pers.
Arcyria insignis Kalchbr. and Cooke.

39. Perichaena variabilis Rost.
Perichaena chrysosperma List.

Order III. Margaritaceae.

41. Dianema depressum List.

Order IV. Lycogalaceae.

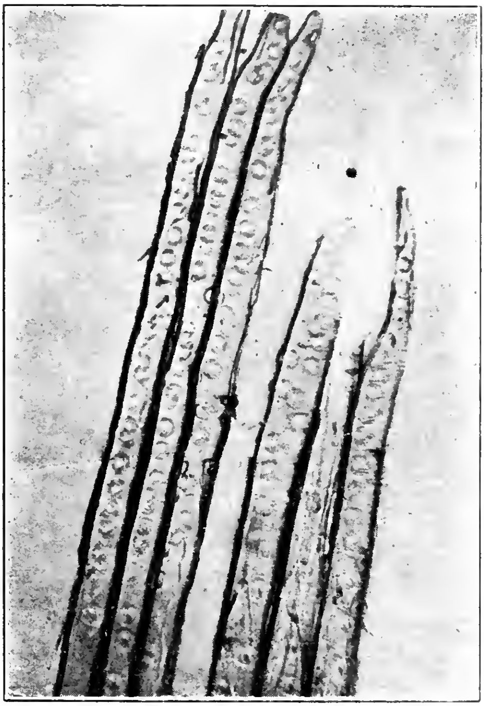
43. Lycogala miniatum Pers.
Lycogala exigium Morg.
Lycogala flavo fuscum Rost.

A Study of the Histology of the Wood of Certain Species of Pines.

Katherine E. Golden.

The conifers grow in thickness similarly to the dicotyledons, but their wood differs very considerably, particularly the secondary wood, in which wood vessels are entirely absent. In the first-year wood a few vessels are developed close to the pith, but the after-growth is composed entirely of tracheides. The tracheides are fibre-like elements with peculiar bordered pits, and are very similar in their appearance in the different species, and yet the wood, taken as a whole, differs very materially, varying from the very soft, light wood of the white pine to the hard, dense wood of the long-leaf pine.

In order to determine, if possible, what peculiarity of structure produced such variations in the wood, since the wood itself is formed entirely of similar elements, and there is not the chance for variations in structure that appear in the dicotyledonous wood, certain species of the pines were examined microscopically, by means of sections and by maceration of the wood, by the latter method separating the elements. Thirteen species were examined. The wood varied in age from seven years in Pinus glabra to over fifty years in Pinus elliottii. In order to compare



Pine Tracheides. X 145.

the elements in the different species, and also the spring and summer wood of the same species, camera lucida drawings were made of the tracheides. These were then measured, so as to determine the actual length, width, and the thickness of the walls of the spring and the summer woods.

The tables give the results of the measurements, the characteristics of the woods as obtained from sections studied with the microscope, and also the properties of the wood in bulk.

NAME.	Length in Mm.		Width in μ.		Ratio Between Length and Width.		Thickness of Walls in μ.		Ratio Between Width and Thickness.	
	Spring.	Summer.	Spring.	Summer.	Spring.	Summer.	Spring.	Summer.	Spring.	Summer.
Pinus strobus	3.7000	3.6000	17.97	21.21	77.11	169.73	5.42	6.81	8.85	3.31
Pinus monticola	4.3330	1.9333	12.95	34.09	100.88	141.71	4.73	8.11	9.08	4.18
Pinus flexilis	2.7333	2.9250	34.09	15.90	80.17	183.96	5.68	6.25	6.00	2.54
Pinus resinosa	2.0250	2.0500	44.69	27.27	45.31	75.17	4.16	6.81	10.74	4.00
Pinus torreyana	3.5333	3.1333	41.66	32.57	84.81	96.20	7.19	11.55	5.78	2.81
Pinus ponderosa	3.2833	3.0222	18.48	35.22	67.72	85.80	3.78	10.03	12.82	3.51
Pinus ponderosa scopulorum?	3.2880	3.0000	25.37	18.18	129.60	164.40	2.46	3.97	10.31	4.57
Pinus contorta	2.9666	3.0333	19.62	35.60	59.78	85.20	4.92	9.46	10.08	3.85
Pinus tæda	6.1444	6.7250	56.06	33.33	114.95	201.77	4.51	10.60	12.35	3.14
Pinus rigida	2.4000	3.0583	42.80	32.95	56.07	92.81	3.03	9.46	14.12	3.48
Pinus glabra	2.2222	2.6055	46.96	26.13	47.32	99.71	4.54	9.84	10.34	2.65
Pinus palustris	4.1555	4.8533	43.56	40.90	102.28	118.66	6.43	13.63	6.77	3.00
Pinus elliottii	5.2590	4.9440	59.09	43.16	89.00	114.55	8.71	16.09	6.78	2.68

NAME.	Spring Wood.	Summer Wood.	Tyloses.	Resin Ducts.	Medullary Rays.
Pinus strobus	Nearly all	Thin ring, indistinct		Single, promiscuous	1 row of cells, obscure.
Pinus monticola	Nearly all	Thin ring, indistinct	Present	Single, pairs, promiscuous	1 row of cells, widens, then narrows, obscure.
Pinus flexilis	Large amount	Small amount, distinct	Present	Single, pairs, promiscuous	1 row of cells, rarely more, conspicuous.
Pinus resinosa	About $\frac{2}{3}$	About $\frac{1}{3}$, indistinct	Present	Single, promiscuous	1 row of cells, rarely 2 or 3, obscure.
Pinus torreyana	About $\frac{4}{5}$	About $\frac{1}{5}$, distinct	Present	Single, promiscuous	1 row of cells, rarely more, obscure.
Pinus ponderosa	Nearly all	Thin ring, indistinct		Single, pairs, in summer wood	1 row of cells, obscure.
Pinus ponderosa scopulorum	About $\frac{1}{4}$	About $\frac{3}{4}$, not dense		Single, pairs, in summer wood	1 row of cells, obscure.
Pinus contorta	About $\frac{2}{3}$	About $\frac{1}{3}$, distinct	Present	Single pairs, promiscuous	1 row of cells, rarely more, obscure.
Pinus tæda	About $\frac{1}{2}$	About $\frac{1}{2}$, distinct		Single, promiscuous	1 row of cells, widen into more, obscure.
Pinus rigida	About $\frac{3}{4}$	About $\frac{1}{4}$, indistinct		Single, in summer wood or close to it	1 row of cells, widen to 3 or 4, obscure.
Pinus glabra	About $\frac{9}{10}$	About $\frac{1}{10}$, distinct		Single, promiscuous	1 row of cells, rarely 2, obscure.
Pinus palustris	About $\frac{2}{3}$	About $\frac{1}{3}$, distinct		Single, in summer wood, near spring	1 row of cells, rarely more, conspicuous.
Pinus elliottii	About $\frac{1}{3}$	About $\frac{2}{3}$, distinct	Present	Single, in spring and early summer	1 row of cells, rarely more, conspicuous.

NAME.	Weight.	Strength.	Density.	Grain.
Pinus strobus	Light	Not strong	Soft	Straight, fine.
Pinus monticola	Light	Not strong	Soft, compact	Straight.
Pinus flexilis	Light	Not strong	Soft, compact	Close.
Pinus resinosa	Light	Moderately strong	Hard, compact	Coarse.
Pinus torreyana	Light	Not strong	Soft, compact	Rather close.
Pinus ponderosa	Heavy	Strong	Hard, compact	Not coarse.
Pinus ponderosa scopulorum	Heavy	Strong	Hard, compact	Not coarse.
Pinus contorta	Light	Strong	Hard	Coarse.
Pinus tæda	Light	Not strong	Not hard	Very coarse.
Pinus rigida	Light	Not strong	Soft	Coarse.
Pinus glabra	Light	Not strong	Soft	Very coarse.
Pinus palustris	Heavy	Very strong	Very hard, compact	Coarse.
Pinus elliottii	Heavy	Very strong	Very hard, compact	Coarse.

NAME.	Color.		Quality.
	Heartwood.	Sapwood.	
Pinus strobus	Light brown or red	White	Good quality.
Pinus monticola	Light brown or red	Nearly white	Inferior quality, resembles P. strobus.
Pinus flexilis	Light yellow, red on exposure	Nearly white	Inferior quality.
Pinus resinosa	Yellow	Nearly white	Tough, elastic, does not shrink, warp in seasoning.
Pinus torreyana	Light red	Light yellow	Brittle.
Pinus ponderosa	Light red	White	Brittle, not durable, vary considerably.
Pinus ponderosa scopulorum	Light red	White	Brittle, not durable, vary considerably.
Pinus contorta	Brown, reddish	Nearly white	Brittle.
Pinus tæda	Light brown	Orange to white	Brittle, not durable, inferior.
Pinus rigida	Reddish	Yellow or white	Rigid, durable.
Pinus glabra	Light brown	Nearly white	Brittle, not durable.
Pinus palustris	Light red or orange	Nearly white	Tough, durable.
Pinus elliottii	Dark orange	Light orange	Tough, durable.

In examining the figures obtained it is seen there are six species in which the spring wood tracheides are longer than those of the summer, while seven species have the summer tracheides the longer. The species in each group show variations in hardness and strength, so that taking the length of the tracheides as a factor by itself nothing can be deduced in regard to the quality of the wood, but taking the length and comparing it with the width of the cells, and again comparing the width and the thickness of walls together, and the amount of the spring and summer wood, the strength can be determined within limits in each species.

For instance, in P. ponderosa scopulorum the spring tracheides are 129.6 times as long as they are wide, and the summer tracheides 164.4 times their width, the thickness of their walls is not nearly as great as that of many of the others, but when the thickness is compared with the width of the cells, it is found to be fairly thick, and as about two-thirds of the annual ring is summer wood, we have an explanation of the strength of the wood.

Taking any of these factors alone, it does not mean anything, as the length of the elements may be very considerable, but the width may be also; then, again, the elements may have rather thin walls, if the thickness of the wall alone were considered. But when the size of the cell as a whole is taken into consideration along with the thickness, the proportion of wall may be greater than the figures representing the thickness indicate.

Contributions to the Flora of Indiana.

Stanley Coulter.

The notes included in this contribution are based, partly, upon a critical study of certain species and partly upon reports and materials submitted by those interested in perfecting our knowledge of the flora of the State. They are presented in the hope that they may prove of interest and value to the botanical workers of the State.

Pinus Strobus L. White Pine.

From Mr. C. F. Very, of New Albany, I have received abundant specimens of the leaves and cones of this species with the following notes. The specimens are from trees planted by the father of Mr. Very some seventy years ago, and one of them is about sixty feet in height, with a trunk diameter of eighteen inches: "They came from that native grove of white pine in the northeastern part of Floyd County, near the line of Clark. At the time my father got them, about seventy years ago, there was quite a grove of the white pines there, one of them being quite an old tree, which would throw them back of the time of white men. The Knobs in that region are now covered with old field scrub pine" (P. Virginiana Mill). The note is interesting as extending the local range of the white pine.

Eriophorum gracile Koch, as given in the State Flora, page 655, becomes *E. paucinervium* (Engelm.) A. A. Eaton, as will be seen by reference to Britton's Manual, page 182, and the latter name should replace it.

Eriophorum gracile Koch, of Britton's Manual, but not of the Illustrated Flora, has been collected by Mr. C. C. Deam, of Bluffton, in Wells County. The determination of the form was made by E. S. Steele, Assistant Botanist, Department of Agriculture, Washington.

E. paucinervium, therefore, replaces *E. gracile* of the State Flora, and *E. gracile* of Britton's Manual is to be added to the Flora.

Quercus Texana Buckley.

In Britton's "Manual of the Flora of the Northern States and Canada," page 333, it will be seen that this species becomes *Quercus Schneckii* Britton (*Q. Texana* Sargent, in part, not Buckley). Under the former name it was reported in the "Catalogue of the Flowering Plants and of the Ferns and Their Allies Indigenous to Indiana,"[1] as occurring in Gibson, Posey and Knox Counties, upon the authority of Dr. J. Schneck. The statement was also made that it would be found to extend farther northward along the Wabash River. Specimens have come into my hands since that report from Vermillion County, where it occurs in considerable abundance. While closely allied to *Q. palustris* DuRoi, with which it is doubtless often confused, it is also liable to be mistaken on casual inspection for *Q. rubra* L. In addition to the leaf characters which serve to separate the forms, I have found the shape of the buds and color of the twigs of value. The buds are more sharply conical and apparently much more compactly built than in either *Q. rubra* or *Q. palustris*. The twigs are of a lighter, more definite gray than in the other forms and have in addition a peculiar dusty appearance, because of their being slightly tomentulose. A reference to Britton's Manual as cited above will give leaf and fruit characters. I submit with this specimens in flower and fruit, labelled *Q. Texana* Buckley,

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[1] Report of State Geologist, p. 710.

which were collected in low bottoms two miles east of Mt. Carmel, Ill., by Dr. J. Schneck. In the Catalogue of the State Flora, therefore, *Q. Schneckii* Britton should replace *Q. Texana* Buckley, and Vermillion County be added to the range there assigned.

Quercus ellipsoidalis E. J. Hill. Hill's Oak.

Mr. Hill informs me that this oak occurs in the northwestern counties of the State. The range as given in Britton's Manual, page 334, is Illinois, Michigan and Minnesota. It is a tall tree with drooping lower branches, close, gray bark, the innermost layer being yellowish. The leaves are oval to obovate-orbicular in outline, from 6-15 cm. long when mature, deeply 5-7 lobed, with rounded sinuses; shining above, glabrous or nearly so beneath; base broadly cuneate to truncate; petioles 2.5-5 cm. long. Acorn ellipsoid to subglobose, 1-2 cm. long, 1-1.5 cm. thick, 1-2 times as long as cup. (Britton's Manual, *loc. cit.*) The species should be added to the flora.

Quercus pagodaefolia (Ell.) Ashe.

It will be recalled that last year[2] I expressed the opinion that the above form was "so well marked in our area as to seem entitled to varietal, if not, indeed, to specific rank." I further stated, after reviewing the history of the species, that in my judgment "it should be written *Q. digitata pagodaefolia* Ell., and given a place in the flora."

In Britton's Manual, page 334, it appears as above, with the following leaf and fruit description:

"Leaves oval to oblong in outline, cuneate to truncate at base, 2-3 dm. long, deeply 5-11 lobed, persistently white-tomentulose below, dark green above, the lobes narrowly triangular, spreading or somewhat ascending, usually entire; twigs tomentose; petioles 3-6 cm. long; cup sessile, shallow, its bracts appressed; acorn globose, about 1 cm. in diameter; about one-half enclosed in cup."

The tree, which is from 100-110 degrees high in its maximum development, is usually found in wet or moist soil. In the southwestern counties, Dr. J. Schneck. I submit for your inspection specimens collected by Dr. Schneck near East Mt. Carmel, Ind.

Q. pagodaefolia (Ell.) Ashe is, therefore, to be added to the flora, having a place between *Q. digitata* (Marsh) Sudw., and *Q. Marylandica* Muench, being given the range assigned above.

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[2] Proceedings Indiana Academy Science, Vol. 11, p. 142.

Quercus Alexanderi Britton. (Manual of the Flora of the Northern States and Canada, page 336.)

To this species is to be referred the forms cited in the State Catalogue, page 713, under *Q. Prinus* L.

Q. Alexanderi is closely allied to *Q. acuminata* (Michx.) Houda, including really what were formerly regarded as broad-leaved forms of the latter species. The description is as follows:

"A tree similar to the preceding species (*Q. acuminata*), but the leaves broadest above the middle, obovate or oblong-obovate; cup cupulate, short-stalked or sessile, shallow; acorn ovoid, 1.5-2 cm. long, 2-3 times as high as the cup; bark; especially that of the old trees, flaky."

Probably fairly distributed throughout the State in the same situations as *Q. acuminata*.

In some respects, notably the venation of the leaf and the acorn, the form closely approaches *Q. Prinus*. The catalogue should, however, be corrected to read as indicated by this paragraph. Specimens of the leaves are herewith presented.

Sisymbrium altissimum L.

This species, adventive from Europe, is reported by Dr. Robert Hessler as growing along the State Line Railroad, east of Lake Cicott, Cass County, June 7, 1901; Lake Maxinkuckee, Marshall County, H. W. Clark. The species is easily distinguished from the other members of the genus by its height, from 6-9 dm.

Vicia angustifolia Roth.

"Growing plentifully along the old Eel River railroad in the northern portion of Logansport. I had not noticed it in former years and it must have been introduced recently." (Robert Hessler.)

Britton, in his manual, page 566, gives the range of the species from Nova Scotia to Florida. This record is a western extension of the range. The inflorescence being axillary, separates it readily from the other members of the genus except *V. sativa* L. and *V. sepium* L.; from both of which it is easily distinguished by the character of the leaflets.

Scrophularia leporella Bicknell.

"Lake Cicott, June 7, 1901, in flower; Lake Maxinkuckee, July 21, 1901, in fruit. Plants are more upright and bloom much earlier than the other species, at least by the end of May." (Robert Hessler.) Also collected at Lake Maxinkuckee by H. W. Clark.

The form is further separated from *S. Marylandica* L. by its leaves being "incised dentate" instead of sharply serrate; the mostly alternate instead of opposite bractlets; the sharply contracted throat of the corolla, and the corolla being dull instead of shining within.

An examination of the specimens in the Purdue Herbarium show that all of the specimens collected in flower in May and June are to be referred to this species, which will probably be found generally distributed throughout the State.

The following additions are also reported by Mr. H. W. Clark, but as specimens have not been seen they are included only tentatively:
Saraslana odorata (L.) Scribn. Holy Grass. Seneca Grass.

Lake Maxinkuckee, Marshall County. This locality would be a southward extension of range in the central United States, the recorded range being "south to Wisconsin."

Lilium umbellatum Pursh. Western Red Lily.

Lake Maxinkuckee, Marshall County. The only objection to this reference seems to lie in the fact that it is a dry soil plant, and the further fact that the majority of Mr. Clark's Maxinkuckee collections were in the marginal zones near the lake. The leaf character and arrangement would, however, seem sufficient to separate it readily from any related forms.

The following species are to be added upon the authority of Britton's "Manual of the Flora of the Northern States and Canada." I have not as yet had opportunity to examine Herbarium specimens to verify the references, but have no reason to doubt their accuracy.

Lycopodium porophilum Lloyd and Underw. Rock Club-moss.

Britton's Manual, page 1037. "Differs from *L. lucidulum* in its nearly linear entire leaves and smaller size, and from *L. Selago* in the bases of its leaves, which are flattened. On sandstone rocks, Wisconsin, Indiana and Alabama." The familiarity of Dr. Underwood with the Pteridophytes of the State places this reference beyond question.

Talinum rugospermum Holzinger. Rough-seeded Talinum.

Britton's Manual, page 1047. "Similar to T. teretifolium and confused with that species. * * *T. teretifolium* differs in having short, blunt style-lobes, oblong anthers and smooth, black seeds. In dry soil Indiana to Wisconsin and Minnesota." In *T. rugospermum* the seeds are pale and roughened.

The following additional stations are reported by Dr. Robert Hessler and indicate work of a character that would much simplify the labors of the Biological Survey if it could become more general:

Xyris flexuosa Muhl. Slender Yellow-eyed Grass.

Low places along Lake Cicott, Cass County, August, 1901. Previous reported stations are Laporte, Lake and Kosciusko counties.

Veratrum Woodii Robbins. Wood's False Hellebore.

Found several miles southeast of Logansport, Cass County. No flowers developed, probably on account of the extreme dryness of the season.

Trillium nivale Riddell. Early Wake Robin.

On rocky, shaded hillsides, rare. This species is also found in abundance in Tippecanoe County, on the grounds of the Germania Club south of LaFayette.

Jeffersonia diphylla (L.) Pers. Twin-leaf.

A patch on a shady hillside east of Logansport, Cass County.

Hamamelis Virginiana L. Witch Hazel.

On limestone cliffs along the Wabash River, near Logansport.

Floerkea proserpinacoides Willd. False Mermaid.

In low, moist woods at the Northern Indiana Hospital for Insane, Cass County. A large patch in bloom, May 2, 1901.

Oenothera laciniata Hill. Sinuate-leaved Evening Primrose.

Along the Eel River railroad, about two miles east of Logansport, Cass County. Spreading rapidly along the right of way of the railroad. Previous records for the State are Vigo, Daviess and Fayette counties.

Lysimachia quadrifolia L. Whorled Loosestrife.

In sandy soils about Lake Maxinkuckee, Marshall County.

Naumburgia thyrsiflora (L.) Duby. Tufted Loosestrife.

Wet places about Logansport, Cass County.

Asclepias amplexicaulis J. E. Smith. (*A. obtusifolia* Michx.) Blunt-leaved Milkweed.

A cluster found in a sand field near Lake Cicott, only a short distance from the railroad.

The following forms are spreading with extreme rapidity in locations indicated:

Camelina sativa (L.) Crantz. False Flax.

In Logansport, along the right of way of the Wabash railroad.

Micrampelis lobata (Michx.) Greene. Wild Balsam Apple.

Sicyos angulatus L. Star Cucumber. One-seeded Bur Cucumber.

"These vines, formerly rarely seen in Cass County, are now very common along the margins of the Wabash River, covering shrubs and small trees profusely and often crowding out small plants." (R. Hessler.)

Should the nomenclature of Britton's Manual, 1901, be generally adopted, many new species would be added to the flora of the State, since in that work any recognizable plant segregate is given specific rank. No sweeping changes should be made, however, until there has been sufficient time to judge as to whether the species there announced are possible of recognition except by the comparative methods of a great herbarium.

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