PROCEEDINGS OF THE

INDIANA ACADEMY OF SCIENCE

1900

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OF THE

Indiana Academy of Science

1900.

EDITOR, - - Geo. W. Benton.

ASSOCIATE EDITORS:

C. A. Waldo,
C. H. Eigenmann,
V. F. Marsters,
M. B. Thomas,
W. A. Noyes,
Stanley Coulter,
Thomas Gray,
John S. Wright.

INDIANAPOLIS, IND.
1901.

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WM. B. BURFORD, PRINTER,
1901.

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* Publication of the Proceedings of the Indiana Academy of Science began in 1891.

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

[Approved March 11, 1895.]

WHEREAS, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory 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, Preamble.

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

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

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

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 Editing reports. 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.

Disposition of reports.

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.

Emergency.

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.

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

[**Approved March 5, 1891.**]

Birds.

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.

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 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. Permits to Science. Bond. Bond forfeited.

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. Two years.

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. Birds of prey.

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.

TAKING FISH FOR SCIENTIFIC PURPOSES.

Section 2, Chapter XXX, Acts of 1899, page 45, makes the following provision for the taking of fish for scientific purposes: "Provided, That in all cases of scientific observation he [the Commissioner of Fisheries and Game] shall require a permit from the Indiana Academy of Science."

OFFICERS, 1900-1901.

President,
MASON B. THOMAS.

Vice-President,
P. S. BAKER.

Secretary,
JOHN S. WRIGHT.

Assistant Secretary,
E. A. SCHULTZE.

Press Secretary,
GEO. W. BENTON.

Treasurer,
J. T. SCOVELL.

EXECUTIVE COMMITTEE.

M. B. Thomas,
P. S. Baker,
John S. Wright,
E. A. Schultze,
G. W. Benton,
J. T. Scovell,
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, 1900-1901.

PROGRAM.

R. J. Aley, Katherine Golden.

MEMBERSHIP.

A. W. Butler, M. J. Golden, Mel. T. Cook.

NOMINATIONS.

G. W. Benton, C. A. Waldo, M. E. Crowell.

AUDITING.

A. J. Bigney, E. E. Jones.

STATE LIBRARY.

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

LEGISLATION FOR THE RESTRICTION OF WEEDS.

J. C. Arthur, Stanley Coulter, J. S. Wright.

PROPAGATION AND PROTECTION OF GAME AND FISH.

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

EDITOR.

Geo. W. Benton, 525 N. Pennsylvania St., Indianapolis.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, V. F. Marsters, J. C. Arthur,
Donaldson Bodine, M. B. Thomas, 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.

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.

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1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other 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.
P. S. Baker	1893	Greencastle.
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.
J. C. Branner	1893	Stanford University, Cal.
H. L. Bruner	1899	Irvington.
Wm. Lowe Bryan	1895	Bloomington.
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.
A. Wilmer Duff	1896	Worcester, Mass.
C. H. Eigenmann	1893	Bloomington.
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.
O. P. Hay	1893	Washington, D. C.
Robert Hessler	1899	Logansport.
H. A. Huston	1893	Lafayette.
J. P. D. John	1893	Greencastle.
D. S. Jordan	1893	Stanford University, Cal.
Arthur Kendrick	1898	Terre Haute.
Robert E. Lyons	1896	Bloomington.
V. F. Marsters	1893	Bloomington.
C. L. Mees	1894	Terre Haute.
T. C. Mendenhall	1893	Worcester, Mass.
Joseph Moore	1896	Richmond.

* Date of election.

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.
Joseph Swain	1898	Bloomington.
M. B. Thomas	1893	Crawfordsville.
L. M. Underwood	1893	New York City.
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.

M. A. Brannon	Grand Forks, N. D.
D. H. Campbell	Stanford University, Cal.
B. W. Evermann	Washington, D. C.
Charles H. Gilbert	Stanford University, Cal.
C. W. Green	Stanford University, Cal.
C. W. Hargitt	Syracuse, N. Y.
Edward Hughes	Stockton, Cal.
O. P. Jenkins	Stanford University, Cal.
J. S. Kingsley	Tufts College, Mass.
D. T. MacDougal	Bronx Park, New York City.
Alfred Springer	Cincinnati, Ohio.
E. Vane Brumbaugh	Fayette, Iowa.
Robert B. Warder	Washington D. C.
Ernest Walker	Clemson College, S. C.

ACTIVE MEMBERS.

G. A. Abbott	Indianapolis.
Frederick W. Andrews	Bloomington.
George H. Ashley	Indianapolis.
George C. Ashman	Frankfort.
Edward Ayres	Lafayette.
Timothy H. Ball	Crown Point.
J. A. Bergström	Bloomington.

* Date of election.

Edwin M. Blake..............................Lafayette.
Lee F. Bennett..............................Valparaiso.
Charles S. Bond..............................Richmond.
M. C. Bradley..............................Bloomington.
Fred J. Breeze..............................Pittsburg.
O. W. Brown..............................Richmond.
A. Hugh Bryan..............................Indianapolis.
E. J. Chansler..............................Bicknell.
Walter W. Chipman..............................Warsaw.
Howard W. Clark..............................Culver.
George Clements..............................Crawfordsville.
Charles Clickener..............................Tangier.
Mel. T. Cook..............................Greencastle.
U. O. Cox..............................Mankato, Minn.
William Clifford Cox..............................Columbus.
Albert B. Crowe..............................Ft. Wayne.
M. E. Crowell..............................Franklin.
Will Cumback.............................. Greensburg.
Edward Roscoe Cumings..............................Bloomington.
Alida M. Cunningham..............................Alexandria.
Lorenzo E. Daniels..............................Laporte.
Charles C. Deam..............................Bluffton.
Martha Doan..............................Westfield.
J. P. Dolan..............................Syracuse.
Herman B. Dorner..............................Lafayette.
Albert H. Douglass..............................Logansport.
Hans Duden..............................Indianapolis.
Joseph Eastman..............................Indianapolis.
E. G. Eberhardt..............................Indianapolis.
M. N. Elrod..............................Columbus.
Percy Norton Evans..............................Lafayette.
Samuel G. Evans..............................Evansville.
J. E. Ewers..............................
Carlton G. Ferris..............................Big Rapids, Mich.
E. M. Fisher..............................Urmeyville.
Wilbur A. Fiske..............................Richmond.
Austin Funk..............................New Albany.
Charles W. Garrett..............................Logansport.
Robert G. Gillum..............................Terre Haute.
Vernon Gould..............................Rochester.
J. C. Gregg..............................Brazil.
Alden H. Hadley..............................Richmond.
U. S. Hanna..............................Bloomington.
William M. Heiney..............................Huntington.
Victor K. Hendricks..............................Terre Haute.

Mary A. Hickman .... Greencastle.
J. A. Hill .... Peru.
John E. Higdon .... Indianapolis.
Frank C. Higgins .... Terre Haute.
John J. Hildebrandt .... Logansport.
Lucius M. Hubbard .... South Bend.
Alex. Johnson .... Ft. Wayne.
Edwin S. Johonnott, Jr. .... Terre Haute.
Ernest E. Jones .... Kokomo.
Chancey Juday .... Madison, Wis.
William J. Karslake .... Irvington.
D. S. Kelley .... Jeffersonville.
O. L. Kelso .... Terre Haute.
A. M. Kenyon .... Lafayette.
Ernest I. Kizer .... South Bend.
Charles T. Knipp .... Bloomington.
Thomas Large .... Madison, Wis.
John Levering .... Lafayette.
V. H. Lockwood .... Indianapolis.
William A. McBeth .... Terre Haute.
Robert Wesley McBride .... Indianapolis.
Rousseau McClellan .... Indianapolis.
Lynn B. McMullen .... Indianapolis.
James E. Manchester .... Vincennes.
G. W. Martin .... Nashville, Tenn.
Julius B. Meyer .... Lafayette.
O. M. Meyncke .... Brookville.
W. G. Middleton .... Richmond.
John A. Miller .... Bloomington.
W. J. Moenkhaus .... Huntingburg.
H. T. Montgomery .... South Bend.
Walter P. Morgan .... Terre Haute.
J. P. Naylor .... Greencastle.
Charles E. Newlin .... Irvington.
John F. Newsom .... Stanford University, Cal.
E. W. Olive .... Indianapolis.
D. A. Owen .... Franklin.
Rollo J. Peirce .... Logansport.
W. H. Peirce .... Chicago, Ill.
Ralph B. Polk .... Greenwood.
James A. Price. .... Ft. Wayne.
Frank A. Preston .... Indianapolis.
A. H. Purdue .... Fayetteville, Ark.
Ryland Ratliff .... Bloomington.
Claude Riddle .... Lafayette.

D. C. Ridgley	Chicago, Ill.
Curtis A. Rinson	Bloomington.
Giles E. Ripley	Decorah, Ia.
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.
S. N. Taylor	West Lafayette.
Erastus Test	Lafayette.
F. C. Test	Chicago, Ill.
J. F. Thompson	Richmond.
A. L. Treadwell	Oxford, Ohio.
Daniel J. Troyer	Goshen.
A. B. Ulrey	North Manchester.
W. B. Van Gorder	Worthington.
Arthur C. Veatch	Rockport.
H. S. Voorhees	Ft. Wayne.
J. H. Voris	Huntington.
Jacob Westlund	Lafayette.
Fred C. Whitcomb	Delphi.
William M. Whitten	South Bend.
Neil H. Williams	Indianapolis.
Guy Wilson	Greencastle.
Mae Woldt	Indianapolis.
William Watson Woollen	Indianapolis.
A. J. Woolman	Duluth, Minn.
J. F. Woolsey	Indianapolis.
A. C. Yoder	Vincennes.
O. B. Zell	Clinton.

Fellows	51
Nonresident members	14
Active members	137
Total	202

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.

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.

Prof. Christian Frederick Lutken, Copenhagen, Denmark.

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.

Linnean Society of London, London, England.

Liverpool Geological Society, Liverpool, England.

Manchester Literary and Philosophical Society, Manchester, England.

"Nature," London, England.

Royal Botanical Society, 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.
Hon. E. L. Layard, Budleigh Salterton, Devonshire, England.
Mr. Osbert Salvin, Hawksford, Fernshurst, Haslemere, 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.
Prof. Alphonse Milne-Edwards, Rue Cuvier, 57, Paris, France.
Pasteur Institute, Lille, France.

Boutanischer 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.

Kaiserliche Leopoldische-Carolinische Deutsche Akademie der Naturforscher, Halle, Saxony, 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.

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.

The Botanical Society of Edinburgn, 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.

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

Institut Royal Geologique de Suède, Stockholm, Sweden.
Societé Entomologique à 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, Winnepeg, Manitoba.
Dr. T. McIlwraith, Cairnbrae, Hamilton, Ontario.
The Royal Society of Canada, Ottawa, Ontario.
Natural History Society, Toronto, Ontario.
Hamilton Association Library, Hamilton, Ontario.
Canadaian 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.

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.

SOUTH AMERICA.

Argentina Historia Natural Florentine Ameghine, 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

SIXTEENTH ANNUAL MEETING

OF THE

Indiana Academy of Science,

STATE HOUSE, INDIANAPOLIS,

December 26 and 27, 1900.

OFFICERS AND EX-OFFICIO EXECUTIVE COMMITTEE.

D. W. DENNIS, President. M. B. THOMAS, Vice-President. JOHN S. WRIGHT, Secretary.
E. A. SCHULTZE, Asst. Secretary. GEO. W. BENTON, Press Secretary.
J. T. SCOVELL, Treasurer.

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

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 Bates House. 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.

L. J. RETTGER,
SEVERANCE BURRAGE,
Committee.

GENERAL PROGRAM.

WEDNESDAY, DECEMBER 26.

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

THURSDAY, DECEMBER 27.

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

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

PROFESSOR DAVID W. DENNIS,

At 11 o'clock Thursday morning.

Subject: "Photomicrography as It May be Practiced To-Day."

The following papers will be read in the order in which they appear on the program, except that certain papers will be presented "*parri 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 was 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. The Leonids of 1900, 15 m........................John A. Miller.
2. Mosquitoes and Malaria, 10 m........................Robert Hessler.
*3. Outline of a Course of Reading on General Biological Problems, 10 m........................C. H. Eigenmann.
4. A Shell Gorget Found near Spiceland, Ind., 10 m......Joseph Moore.
5. A Harbor at the South End of Lake Michigan, 15 m. .J. L. Campbell.

MATHEMATICS AND PHYSICS.

6. Some Properties of the Symmedian Point, 8 m.......Robert J. Aley.
7. Note on McGinnis's Universial Solution, 5 m.........Robert J. Aley.
8. Graphic Methods in Elementary Mathematics, 10 m..Robert J. Aley.
9. The Automatic Temperature Regulator, 6 m......Charles T. Knipp.
*10. Concerning the Sphere as a Space-Element, 10 m....D. A. Rothrock.
11. The Cayleyan Cubic, 20 m........C. A. Waldo and John A. Newlin.
12. The Use of the Bicycle Wheel in Illustrating the Principles of the Gyroscope, 15 m........................Charles T. Knipp.
13. The Cyclic Quadrilateral, 10 m........................J. C. Gregg.
14. Note on the Determination of Vapor Densities, 5 m.. Charles T. Knipp.

* Author absent, paper not presented.

15. An Improved Wehnelt Interrupter, 15 m., A. L. Foley and R. E. Nyswander.
16. A Method of Measuring the Absolute Dilatation of Mercury, 10 m .... A. L. Foley.
17. The Geodesic Line of the Space $ds^2=dx^2+\sin^2 x dy^2+dz^2$, 10 m .... S. C. Davisson.
18. The Friction of Railway Brake Shoes under Various Conditions of Speed, Pressure and Temperature. 10 m .... Richard A. Smart.
19. Diamond Fluorescence, 10 m .... A. L. Foley.
20. A Theorem in the Theory of Numbers, 10 .... Jacob Westlund.
21. On the Decomposition of Prime Numbers in a Bi-Quadratic Number-Field, 10 m .... Jacob Westlund.
22. Dissociation Potentials of Neutral Solutions of Lead Nitrate with Lead Peroxide Electrodes, 10 m... Arthur Kendrick.
23. Some Observations with Rayleigh's Alternate Current Phasemeter, 10 m .... E. S. Johonnott, Jr.

CHEMISTRY.

24. A Demonstration Apparatus, 10 m .... P. N. Evans.
25. Methylation of Halogenamides with Diazomethane, 10 m .... James H. Ransom.
26. Note on the Apparent Deterioration of Formalin, 2 m. Thomas Large.

BOTANY.

27. Notes on the Examination of Vegetable Powders, 10 m .... John S. Wright.
28. The Staining of Vegetable Powders, 5 m .... John S. Wright.
29. Cryptogamic Collections Made During the Year, 8 m. . M. B. Thomas.
30. Experiments with Smut, 8 m .... M. B. Thomas.
31. The Flora of Lake Maxinkuckee, 15 m .... J. T. Scovell.
32. Generic Nomenclature of the Cedar-Apples, 10 m .... J. C. Arthur.
*33. The Uredineae of Parke County, Indiana, 10 m .... Lillian Snyder.
34. Additions to the Flora of Indiana, 10 m .... Stanley Coulter.
*35. Seed Vitality in Native Plants, 10 m .... Stanley Coulter.

* Author absent, paper not presented.

36. Some Midsummer Plants of Southeastern Tennessee, 10 m .... Stanley Coulter.
37. A Study of the Constituents of Corn Smut, 10 m..... William Stuart.
38. A Bacterial Disease of Tomatoes, 10 m............ William Stuart.
39. Device for Supporting a Pasteur Flask, 3 m.... Katherine E. Golden.
40. Notes on the Microscopic Structure of Woods, 10 m .... Katherine E. Golden.
41. Movement of Protoplasm in the Hyphae of a Mould, 10 m............................ Katherine E. Golden.
42. Description of Certain Bacteria Obtained from Nodules of Various Leguminous Plants, 10 m. Severance Burrage.
43. A Few Mycological Notes for July and August, 1900 —Wells and Whitley Counties, 10 m........... E. B. Williamson.
*44. Notes on a Collection of the Fungi of Vigo County, 10 m., Fred Mutchler.

ZOOLOGY.

45. The Kankakee Salamander, 5 m....................... T. H. Ball.
46. The Eel Question and the Development of the Conger Eel, 10 m.................................. C. H Eigenmann.
47. The Mounting of the Remains of Megalonyx Jeffersoni from Henderson, Kentucky, 10 m............ C. H. Eigenmann.
48. Contribution Toward the Life History of the Squeteague, 10 m.............................. C. H. Eigenmann.
49. A New Oceanic Fish, 10 m...................... C. H. Eigenmann.
49. A New Genus of Oceanic Fishes, 10 m........... C. H. Eigenmann.
50. A New Species of Cave Salamander from the Caves of the Ozarks in Missouri, 10 m................. C. H. Eigenmann.
51. An Addition to the Fishes Occurring in Indiana, 10 m.. L. J. Rettger.
*52. On the Function of the Blood-Sinuses of the Reptilian Head, with Exhibition of Photographs, 10 m....... H. L. Bruner.
*53. Protraction of the Lower Jaw as a Means of Closing the External Nares in Anura, 10 m............... H. L. Bruner.
*54. Some Interesting Peculiarities in the Development of Hybrid Fishes, 15 m......................... W. J. Moenkhaus.

*Author absent, paper not presented.

*55. A Probable Hybrid Darter, 5 m.................W. J. Moenkhaus.
56. Some Observations of the Daily Habits of the Toad, 10 m ....J. R. Slonaker.
57. The Methods and Extent of the Illinois Ichthyological Survey, 5 m...............................Thomas Large.
58. Additions to the Indiana Lists of Dragon-Flies, with a Few Notes, 10 m...........................E. B. Williamson.

GEOGRAPHY AND GEOLOGY.

59. Eskers and Esker Lakes, 20 m........................C. R. Dryer.
60. Spy Run and Poinsett Lake Bottoms, 7., J. A. Price and Albert Shaaf.
61. Abandoned Meanders of Spy Run Creek, 5 m., J. A. Price and Albert Shaaf.
62. The Development of the Wabash Drainage System and the Recession of the Ice Sheet in Indiana, 20 m..Wm. A. McBeth.
63. A Theory to Explain the Western Indiana Bowlder Belts, 5 m................................Wm. A. McBeth.
64. Aids in Teaching Physical Geography, 10 m.........V. F. Marsters.
*65. Geography of Harper's Ferry Sheet (illustrated by model), 10 m................................V. F. Marsters.
66. River Bends and Bluffs, 10 m.....................Wm. M. Heiney.
67. Notes on the Ordovician Rocks of Southern Indiana, 10 m ....Edgar R. Cumings.
68. Some Developmental Stages of Orthothetes minutus N. Sp., 10 m............................Edgar R. Cumings.
†69. The Cold-Blooded Vertebrates of Winona Lake and Vicinity ....E. E. Ramsey.

* Author absent, paper not presented.

† The paper was announced in the program of 1899, but was not completed for publication until recently.

THE SIXTEENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The sixteenth annual meeting of the Indiana Academy of Science was held in Indianapolis, Thursday, December 27, 1900, preceded by a session of the Executive Committee of the Academy, 9 p. m., Wednesday, December 26.

At 9:15 a. m., December 27, President David W. Dennis 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, David W. Dennis, made his address: subject, "Photomicrography as It May Be Practiced To-Day."

At 2 p. m. the Academy met in two sections—biological and physico-chemical—for the reading and discussion of papers. President Dennis presided over the biological section, while Drs. J. L. Campbell and Thomas Gray in turn acted as chairman of the physico-chemical section. At 5 p. m. the section meetings adjourned and the Academy was assembled in general session for the transaction of business.

Adjournment, 5:30 p. m.

THE FIELD MEETING OF 1900.

The Field Meeting of 1900 was held in Terre Haute, Thursday, Friday and Saturday, May 24, 25 and 26.

Thursday evening members of the Executive Committee met in session at the Terre Haute House.

Friday was occupied by an excursion of the Academy to Alum Cave and vicinity. The party left Terre Haute by rail early in the morning, reaching Alum Cave about the middle of the forenoon, where the day was spent in visiting the mines and interesting coal fields of that vicinity. The return to Terre Haute was made in the evening. On Saturday excursions into the field were made in the neighborhood of Terre Haute.

The visiting members of the Academy gratefully acknowledge their indebtedness to the Terre Haute members, the members of the Terre Haute Science Club and their friends for the numerous thoughtful courtesies which made the Field Meeting of 1900 so pleasant and profitable.

PRESIDENT'S ADDRESS.

By D. W. Dennis.

Photomicrography as it May be Practiced To-Day.

The instrument with which my work in photomicrography is at present being done is in a compartment of the office of Dr. C. S. Bond, of Richmond, Indiana: it rests on a solid stone floor; the source of illumination is an arc light fed by a 52-volt alternating current. The tables, the optical bench, the microscope bench and all the illuminating accessories that it carries and the camera were furnished by the Bausch & Lomb Optical Company; the microscope stand and all its accessories were furnished by Zeiss: the stand is the 1899 model. The instrument is shown in Fig. 1. The objectives are the 70, 35, 16, 8, 4, and 2mm; the eyepieces are the 4, 6, and 8 compensating and the 4 projection eyepiece. The microscope stand is the property of the Earlham biological laboratory; all other parts, including the lenses, are the property of Dr. Bond, who not only by his financial assistance made it possible for me to have such an apparatus with which to work, but he has worked with me in all that I have done, and has carried out without regard to expense every suggestion that we could either of us make, with reference to the betterment of the instrument. The "we" which I use in my paper is not the conventional editor's we: it means the doctor and myself.

INTRODUCTORY.

The photomicrography of to-day at its best has been made possible by the growth of several different lines of work. The perfecting of the arc light is one of these: sunlight will do instead of this, but the uncertainty of being able to use it at any particular time is against it; the arc light is always ready; its brilliancy is always the same: photomicrographs of all diameters from 4,000 down can be made with it in from a very few minutes to a small fraction of one second. After one has fully mastered his apparatus and needs to use the light only for adjustment and exposure it is comparatively inexpensive.

The perfecting of the microscope in all its parts was necessary before the work of making photomicrographs of 1,000 diameters and upwards with such ease and certainty as to make them practicable for ordinary purposes was possible. Indeed, the proper focusing of the microscope has been made so easy by Zeiss's latest stand that it may be said that only within a few months past has the use of these high powers been available except in the hands of the foremost experts, and even these consumed so much time and made so many failures to every success that a good photomicrograph was as costly as it was rare; an entire revolution of the micrometer adjustment screw in Zeiss's new 1899 model stand for photomicrography lifts or lowers the tube only .04 of a millimeter, i. e., one-fiftieth of the entire focal distance, and since a movement through less than one degree is entirely practicable, the tube of the microscope can be raised or lowered one nine-thousandth of a millimeter, or one two hundred and twenty-five thousandth of an inch. This is one eighteen thousandth of its focal distance.

How correctly to illuminate the object is again a science in itself; unless this is done, the most complete and costly apparatus constructible or imaginable will not give one correct photomicrograph; if the illumination is nearly right the results will be entirely wrong; the object can be drowned in light or it can be surrounded with halos that will remind the operator of a medieval painting without a suggestion of the piety that should accompany the reminder.

The production of a good photomicrograph requires a working knowledge of photography; the use of the right developer, the right plate, the proper use of reduction and intensification of the negative—all affect details. Three or at least two experts have hitherto been necessary for the production of a good photomicrograph of 2,000 or more diameters—a physicist to illuminate it, a microscopist with a knowledge of the object to adjust and focus the microscope, and a photographer to expose, develop and print it. The introductions to all atlases of this sort that I have seen show that the skill of several men has been enlisted in their production.

Photomicrography has grown then with the growth of microscopy, photography, and optics; it has proposed problems to all these sciences which they have separately taken up and solved in its behalf.

To retrace the steps from Daguerre to the end of the century, from Newton to Abbe, from the Dutch spectacle maker to Zeiss, is the work of books, not addresses; the sacrifices and victories along these journeys may have been elsewhere equaled, they have not been surpassed.

THE APPARATUS IN GENERAL.

The apparatus consists of a table 43 inches long and 15½ inches wide on strong and adjustable iron supports. Upon this table rests the optical bench on four adjustable iron legs which permit it to slide back and forth on two iron tracks. This optical bench carries the arc lights and all other accessories for illumination, except those which are a part of the microscope; these are, naming them from the light forward, first the condenser, which consists of two convexo-concave lenses four inches in diameter mounted at the ends of a nickeled tube; the lens farthest away from the light is adjustable in the carrying tube. Then comes the cooling cell, the ray filters, the shutter, the biconcave lens and the field diaphragm (see Fig. 1); all these parts are carried on two nickeled iron rods, and are adjustable in height from right to left and from before backward on the table. A second table placed at the end of this of the same width and height resting also on adjustable iron supports, is 85 inches long and carries the microscope, which has as substage parts the Abbe with its iris diaphragm and an additional iris diaphragm immediately under the object for use when the Abbe is swung out. It carries also an extensible camera which can be drawn out so as to hold the ground glass and the photographic plate at any distance from the object between 20 and 75 inches.

As to the Support of the Microscope.

It has hitherto been regarded as in principle wrong to have the microscope on the same table with the camera; our experience convinces me that this is a good arrangement, if it is accompanied by the other precautions we now have for keeping the microscope steady. As we received our instrument the microscope bench was clasped by iron clamps to two nickeled iron tubes which extend the entire length of the camera table and carry also the camera. By this arrangement any shaking of the camera was communicated to the microscope directly and rendered the preservation of the focus during the replacement of the ground glass by the plate holder nearly impossible; not one in five of our exposures with this arrangement was successful; something had to be done; we could not put the microscope on a separate table without entirely changing the means of controlling the fine adjustment, which is regulated by a rod, with milled head fastened to the table under the camera and connected by a belt with the micrometer screw; furthermore, this exerted a slight pull on the microscope tube that rendered focusing very difficult; we overcame our difficulties by first placing four adjustable brass pillars under the microscope bench; the bench was now held down to the rods by the binding screws and its distance from the table was made absolutely the same by the brass supports; ordinary sliding of the camera in changing its length or putting in and taking out the plate holder does not in any way damage the focus. To brace the microscope tube against the pull of the focusing belt we supported it two and a half inches behind the milled head of the micrometer screw by an adjustable brass pillar reaching down to the camera table. Since making these additions we have not lost a single plate by change of focus. This result can be brought to pass in other ways, perhaps, but this is one good way and for the following reason is, I believe, the best way: We have fastened also to our camera table a brass rod inside of a brass tube, each provided at the focusing plate end of the camera with milled heads and at the microscope end with separate belts passing around the grooved heads that control the moveable stage, so that the operator six feet away can systematically search a field over, that is three-eighths of an inch in diameter. This is a convenience that comes near to being a necessity; it makes high power work as controllable and as speedy as low; it turns drudgery and annoyance into a pleasure; any one who ever undertook to center an object by giving directions to an assistant at the microscope must know its value. If an object is out of the field, finding it is hopeless in the old way; it is perhaps enough to say for our arrangement that it enables one person to do quickly and exactly what otherwise requires two at a cost of much time, labor and patience. The downward pull on the stage is counterbalanced by an adjustable brass support immediately under the controlling heads of the stage.

MAGNIFICATION.

The linear magnifications possible range from six and a half with the 70mm objective without an eyepiece to 5,500 with the 2mm objective and an 8 eyepiece. The following table shows the magnification at varying lengths of the camera with a few combinations. They were determined in every instance by measuring on the ground glass the projected image of a stage micrometer.

	Objective, 2 mm.			Objective, 4 mm.			Objective, 8 mm.			Objective, 16 mm.			Objective, 35 mm.			16 mm. Objective, Without Eyepiece.	70 mm. Objective, Without Eyepiece.
Camera extension, 25 inches	875	1260	1560	375	500	625	230	325	420	110	153	200	31	42	54	42	9½
Camera extension, 45 inches	1812	2560	3250	750	1062	1375	495	695	875	230	337	430	56	84	112	72	21
Camera extension, 65 inches	2750	3875	5000	1235	1625	2250	730	1062	1375	370	530	675	87	136	166	102	34
Eyepiece	4	6	8	4	6	8	4	6	8	4	6	8	4	6	8		

In will be seen by an inspection of the table that about 35 diameters can be obtained by using the 70mm lens and a camera extension of five and a half feet, or by using a 35mm lens and a 4 projection eyepiece with a camera extension of about 28 inches, or by using the 16mm lens and no eyepiece with a camera extension of 20 inches; each of these methods has of course its advantages, and disadvantages; the first gives a wider field than the last and a deeper focus. Fig. , was made in this manner; with the 16mm lens and no eyepiece only so much of the same object could be taken as lies between the points a and b in Fig. 3. The advantage this arrangement has to compensate for its smaller field and less deep focus is its greater resolving power; this principle holds whatever the combinations that produce any given power.

LEVELING.

The tables and the benches must all be exactly leveled; this is easily done by means of a spirit level and the adjustable feet on which they all rest. The cooling cell and condenser must also be level.

THE ILLUMINATION OF THE OBJECT.

(a) Centering.

It is necessary that all parts of this apparatus be most carefully centered. There are several good ways to do this. One is to place in every piece of the optical apparatus a pinhole diaphragm, which may be cut from black cardboard to fit each separate piece, one for the microscope to be substituted for the eyepiece, one for the Abbe and the field diaphragm, unless these parts are already provided with iris diaphragms, in which case they can be shut to a pinhole; one for the biconvex lens and one for the condenser. The instrument is sufficiently centered when a ray of light passes through this series of holes and falls on the center of the ground glass, when the camera is fully extended; these diaphragms should be saved so that proof of the centering can at any time be quickly made.

(b) The Image of the Light.

In order to make a good photomicrograph with an objective of 8mm focal length or less the image of the light should be thrown into the plane of the object. This can, the books say, "with no great difficulty," be effected by slipping the light and the condensing lenses back and forth on the optical bench; it would be safer to say that it *can* be done; when once a combination has been effected that produces this result the exact position of every optical part should be noted carefully. To facilitate this all makers of photomicrographic apparatus would do well to mark a scale on the tables or on the carrying rods so that all parts can be quickly brought into exactly the same relation to each other and to the object; after many failures and much loss of time in attempting to bring the same state of things to pass that had been previously successful, we had such scales put on our apparatus. Any arrangement of the optical parts will produce an image somewhere; this can be found by carrying a piece of white paper back and forth in the path of the light until the image of the light is found; light and condensers can then be removed until the image rests in the plane of the object to be photographed. In order to have an equally illuminated field it is a good thing to have the size of the equally bright part of the image somewhat larger than the field to be taken; different combinations of the condensers and different positions of these and the light with reference to the object will regulate the size. In work with low powers, 16mm and upwards, this image should fall on the objective instead of the object. If the beginner in his hurry to spoil some plates is satisfied with an approximation to this state of things, or if he lights up and proceeds by the try rule, his time will be lost along with his material.

(c) The Size of the Entering Cone of Light.

Three diaphragms should accompany every complete apparatus: One of these, the field diaphragm, should be placed near the double convex lens, and if possible on its microscope side. This must always be used in every exposure; a second is at the focus of the Abbe nearest the source of light, and need not be used when it is swung out; a third is brought on immediately under the object and is consequently open and not in use when the Abbe is; two of the three are accordingly required in every exposure, namely, the field diaphragm and the one before or the one behind the Abbe.

Only a careful study of the effect on the ground glass will avail in all cases for the regulation of these diaphragms. However, two valuable rules can be given: If the Abbe is not in use the diaphragm immediately under the object must be so closed as to cut off all but the field to be photographed; if the Abbe is being used its diaphragm must in general be large enough for the cone of light entering through it to fill one-third of the central bright portion of the objective; to ascertain whether this is so or not one looks into the microscope tube when the eyepiece is in with a lens such as is often used for focusing on the ground glass; this must be done with every objective used with the Abbe and the exact point to which the diaphragm is opened should be observed on its graduated scale and recorded; if this is not done, and guesses are relied on, hit and miss (mostly miss) results need only be expected. Too wide a diaphragm will drown the details in light; too small a diaphragm will surround all details with diffraction halos that will gain in ugliness as one learns them better.

(d) Ray Filters.

The various colors of white light have differing values for optical and photo-chemical purposes; they do not focus after being refracted at the same place. When the apparatus is so adjusted that the red, orange and yellow rays which mainly affect the eye are in average focus on the ground glass, the blue and violet rays, which mainly affect the sensitive plate, will be in focus enough nearer the object to spoil the picture. One good way to overcome this difficulty is to use a color screen, which cuts out the red and orange rays and at the same time the blue, indigo and violet rays at the other end of the spectrum, leaving the yellow-green waves of approximately the same wave-length to affect both the eye and the plate; without this precaution a good photomicrograph can not be made with daylight or the electric arc; such a color screen is best produced by placing in the path of the light a glass trough with parallel sides and about three-sixteenths of an inch thick, filled with the following solution:

160 grams of dry, pure copper nitrate.
14 grams of pure chromic acid.
125 cc. of distilled water.

This is Zettnow's filter. We have found great advantage, especially in photographing preparations stained with saffrannin or fuchsine, in adding a second trough filled with a dilute solution of Loeffler's methylene blue.

FOCUSING ON THE GROUND GLASS.

Much has been written about the proper focusing of the object. Our experience leads me to conclude that the real difficulty has always been that the machinery of the microscope was not sufficiently accurate, its parts were not sufficiently firm relatively, the microscope itself was not sufficiently supported against damaging strains and jars, and its fine adjustment screw was not sufficiently fine; we need nothing but a fine ground glass and the unaided eye for correct focusing; a plate glass and a focusing lens are generally recommended; they are scarcely a help; the difficulty vanishes with such stable and delicate machinery as puts control entirely in the hands of the one focusing.

POSITION OF THE SENSITIVE PLATE.

A pure scarecrow of the books is the oft repeated necessity of having the sensitive plate take the exact place of the ground glass; some one must have concluded that a want of coincidence in this respect spoiled his plates, and other essay mongers must have copied the conclusions. Doubtless he and they had spoiled plates, but the cause was not here; a variation of a quarter of an inch makes a perceptible difference in magnification, but not in sharpness, and no instrument probably ever varied so much as this.

EXPOSURE.

The time of exposure depends on so many things it is not possible to give any rules: The source of the light, its intensity, the number and character of the condensers, the number and character of the color screens, the width of the diaphragms, the character of the object, the objective and eyepiece used, the sensitiveness of the plate, and the freshness and strength of the developer, all materially affect the time. Any one can find out the time necessary by a few trials provided he understands development and is a good judge of a negative. If he has not these accomplishments he never can tell. Some kind of shutter with which to accurately measure fractions of a second is so useful as almost to be necessary in getting the right exposure; placing a ground glass in the path of the light near its source will multiply the time of exposure some twenty-five times and would be necessary in the absence of a shutter.

PLATES.

It should go without saying, perhaps, that plates giving correct color values should generally be used. We have used Cramer's isochromatic mediums and Carbutt's orthochromatic mediums and have found them satisfactory.

CHEAP APPARATUS.

I can think of no valid plea for cheap apparatus. Some men with cheap apparatus can, to be sure, do better work than others with the costliest. The difference does not lie in the apparatus: this good work is, however, done at an outlay in time, patience and material that renders it so costly in the end as to be impracticable. This is why photomicrography has not been more used in the past. Makers of apparatus are careful to advertise "any microscope stand can be used." This, except for low power work of the simplest character and second grade in quality, is a delusion. Internal reflections from the microscope tube, the objective and its fastenings injure more or less everything: moreover, the trouble necessary to adjust a microscope every time work is wanted is by far the costliest part of the work; a special stand with a large tube from the walls of which reflection is impossible and into which properly constructed objectives can be screwed without a graduating series of collars, mounted firmly on an unshakable foundation, dedicated to this one use, always ready, quickly capable of adjustment for any practicable powers, with a source of light that does not require long-time exposures, immediately adjacent to a properly equipped dark room, is not only the cheapest arrangement; it is the only arrangement that will for any considerable time be used by a busy man. The complete apparatus as I have described it should be supplemented by a firm, permanent, upright stand for copying all such slides as will not permit the microscope to be brought to the horizontal position. This is one exception to my general proposition that cheap apparatus is too expensive. The exception is, however, only apparent, for this is as good an arrangement for this class of work as it will admit of. This sort of camera should be at hand in every laboratory where there is any one competent to use it, for the things for which it is necessary can neither be sent away nor can they await a more favorable hour often. Such apparatus in convenient form has been exhibited and described before this Academy.

LIMITATIONS.

Photography has its limitations. The time of exposure can not be accommodated to a field unequally illuminated. A man ten feet from the camera and a background of forest and hills from a hundred to a thousand feet away can not all be in correct focus at once. Undesirable and immaterial parts of the field will be taken with the same fidelity as the parts wanted. Photomicrography shares all these limitations. With skill they can be reduced to a minimum. By repeated exposures of the same field all parts wanted can be presented in correct focus and together in their true relationship. Fig. 5 was focused for the centrosome in the larger cell; Fig. 6 for the centrosome in the smaller cell. By the use of a special stage, objects can often be tilted so as to bring related points into the same plane. When one side of a field is lighter than the other something can be done by stopping the development at proper stages, washing the negative off and developing the exposed parts by a local application of the developer. Immaterial parts can be cut out by the application of a reducing agent to the negative or the positive, or by matting out in the process of printing. Much has been said against the use of reduction, intensification, retouching or even spotting out, and many inartistic, not to say ugly, prints have been made that might easily and without damage to fidelity have been made tolerable, if not beautiful. By the adjustment of the light, by the kind of light used, by the character of the developer, by the intensity of development, by the time of exposure and by the quality of the plate, two prints of the same object can be made to tell different tales. Photomicrography is not a means of compelling men to tell the truth; no such means has ever been discovered; the usual bounty for veracity is still to be had at the old stand. Clumsily practiced it tells nothing; it is reliable when the photomicrographer is both truthful and capable. There is no more reason why it should be compelled to tell immaterial stories while it is telling material ones than that any other witness on any other stand should be. I have, notwithstanding all this, always followed the rule never to cut out or reduce anything whatever from the material portion of the field. I have often hunted for hours to find a section free from defects which told exactly the same story that another one told, the defects of which I could have removed harmlessly and easily.

ADVANTAGES OF PHOTOMICROGRAPHY.

One great advantage of photomicrography is that it leads to the preparation of better microscopic slides, because, in part, of the rule that does not permit the negative to be altered in its material parts; in part also because the damaging defect can not always be removed. Another advantage is that when correctly carried out it can tell nothing but the truth with reference to the parts in focus. It is maintained by good authority that it sometimes reveals things not visible to ordinary vision. I have often seen things in photomicrographs that had escaped my attention before, but always when I came to observe carefully again I was able to see them. A skillfully prepared photomicrograph shows details more distinctly, with greater contrast, than they have when one observes them through the microscope; I see no reason why if the proper conditions were at hand it may not reveal details beyond the reach of ordinary microscopic vision. A sensitive plate is not blinded by light or tired with long looking. Photomicrography is not here presented as a remedy for all ills; drawings have certain advantages; but every one can not draw, and careful drawings require much more time than photomicrography. The best of both is had when the details of photomicrography are supplemented by a constructive diagram which uites all in one.

In science teaching photomicrography fills a place that nothing else can. Few people comparatively ever use the microscope to any educational purpose; probably not more than a tenth of the students in our colleges and universities are familiar with anything more than its simplest revelations; popular courses are wanted in and out of the colleges; psychology, pedagogy, child study, and all organic studies call for illustrations of biological laws or histological relationships which concern them; for most of them it is photomicrography or drawings or both or nothing; and no one that has ever tried it will hesitate for a moment to say that the photomicrography must not be left out; it makes things real in a way that a diagram can not; it helps the interest, not indeed to the same extent that the microscope does, but to something like the same extent that the microscope would, if the student did not prepare his own object and if all the students could see the same thing at the same time through it and have the view explained while looking. I am sure that the histological lantern slide is with us to stay, and that the histological half-tone shortly will be.

KNOWLEDGE OF PHOTOGRAPHY.

Any one desiring to learn how to make good photomicrographs must procure a camera and learn how to make a good negative; it will not do for him to press the button and let some one else do the rest; he can not learn what a good negative is until he has made many and tested their printing qualities. When any one is a fair judge of the sort of lantern slide or print a negative will make he can then make a good one, and when he can at morning or at noon, on a clear or a cloudy day make a landscape negative and print it on glass or paper so well that his print compares favorably with the best of its class in the market, he may begin to experiment at photomicrography. He generally begins long before this and always produces and often publishes work that he never would have published could he have known what others were doing. Almost every photomicrographer has thrown away crop after crop of negatives which he formerly cherished as the best producible. At this stage he either quits or goes into a thorough study of the principles of photography on the simplest outdoor work; the production of high-power photomicrographs is the most difficult problem in photography and can only be done by good photographers who have had much experience also in low power work.

THE OBJECT TO BE PHOTOGRAPHED.

The photography of diatoms has flourished as a scientific fad for years. It is a special line of photography, calling for special illumination and specially prepared objectives; it calls for resolution, while general histological work requires penetration. It was for a long time a race with instrument makers to see which could resolve the finest striations; diatoms were used for test objects almost exclusively. It was gravely argued that a microscope that was good for diatoms was good also for other things in like proportion. Oblique illumination and blue light were praised for the same reason. The comfortless purchaser was left to reflect—having resolved a pleurosigma or an amphipleura—how few of them he ever cared to resolve, and that blue light concealed what he wanted to see. Every one easily admits, however, now that a diatom can be photographed; and since the publication of Koch's Bakterienkunde in 1889 and 1890 it has been granted that bacteria can be; they can be made to lies so uniformly in one plane. Doubtless it will always remain true that some things can be photographed better than others, and that a good preparation is to be preferred for this purpose to a poor one, that only the best obtainable is to be photographed at all; but we are now in a position to photograph any object better than it is possible to see it by any single focusing of the microscope, and by repeated exposures any object can be photographed as well as it can be seen, so that all at least can be seen in the pictures that can be in the object. Fig. 7 is an egg from the ovary of a cat; the section is so thick that tissue cells lying behind it can be seen through it; and yet all is clear. It goes without saying that all the figures of the accompanying plates are of considerable thickness; one of them, Fig. 16, is an unsectioned blastula of Ascaris; the cavity within is seen through a cell which lies above it, and the light that illuminates it has passed through a cell that lies below, and yet the blastocoele is produced with almost diagramatic clearness.

WHAT THE NEXT STEP IN PHOTOMICROGRAPHY OUGHT TO BE.

The apparatus for the best work in photomicrography is very expensive and always will be. It requires and always will require an expert knowledge to make lantern slides and prints from microscopic preparations that an investigator can not afford to acquire and keep, and time that he could ill afford to spare. Education ought not to lack, it must not, will not lack this means of furthering its ends. We must establish here and there laboratories of photomicroscopy, in connection, preferably, with some of our institutions of learning, at which this work can be done for a considerable number of institutions. By this means negatives would accumulate from year to year until thousands of them might be at the command of all; the cost need not be great for all schools to possess slides of their own from this collection, or slides might be rented at a very small cost; all investigation monograms could thus be illustrated and teaching everywhere could be put in almost immediate touch with the latest that is known, and nothing else so vitalizes the work of the class-room, as every one knows who has tried it. I have tried to get slides from the plates used in works that had been published and copyrighted; I have never been able to do so; there was perhaps no means by which they could be easily made; there should be no other reason; they could only be used for teaching purposes; when one has harvested all the honor and money that can come from his publications I can not see why the good, that it does not impoverish him to part with should not be shared.

A scheme of this kind would furnish opportunity for friendly comparison of work which could not be other than a benefit. A half dozen such laboratories could do the work for the whole country; these could be affiliated and along this one line at least we should be spared the wastefulness of the anarchy of independent effort.

COURSE OF STUDY.

It would immediately come to pass in connection with such laboratories that courses of instruction would spring up. Such courses would be elected without doubt by many students in the various departments of botany and zoology, and as a result the ability to do good work would spread with the demand for it. One year's work in optics with special reference to photomicrography, microscopy and projection, one year in the theory and practice of photography, and two in the theory and practice of photomicrography would fill every requisite, whether of quantity or quality, from the beginning; it would be the work of experience to select finally what is just the best for such a course out of very much that is certainly good.

I have seen none of the literature of photomicrography of value except Neuhaus's "Lehrbuch der Microphotographie." Dr. Neuhaus is a practicing physician of Berlin. He has given us a work of such excellence that one does not need to see another; it contains a bibliography that probably leaves out little that has been written that is worth keeping. It should be translated into English. It was first published in 1890 and a second edition was called for in 1898. It is the first German work that has survived into a second edition.

EXPLANATION OF PLATES.

Except where otherwise stated the following figures have been made with a 2mm. apochromatic immersion objective and a 4 projection eyepiece with a camera extention of 37 inches and a magnification of 1,500. The slides, except where otherwise mentioned, were prepared by Mr. Elwood Mendenhall in the Earlham Biological Laboratory. The ascaris slides were stained by the iron-haematoxylin method. The material was fixed in Fleming's chrom-osmium-acetic fixative. The time of exposure was from 2 to 10 seconds. Zettnow's filter was used in each case, and for the Lilium candidum sections which were stained with saffranin, a Methylene blue filter in addition. No ground glass was used in any instance.

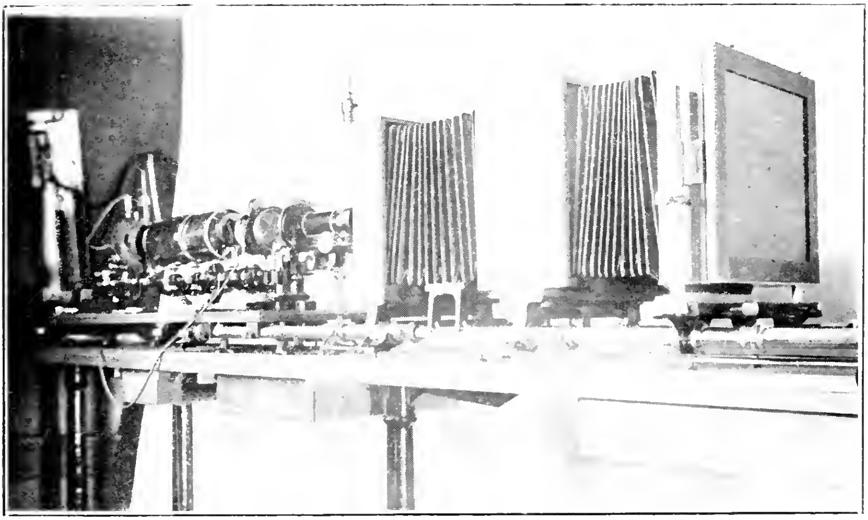
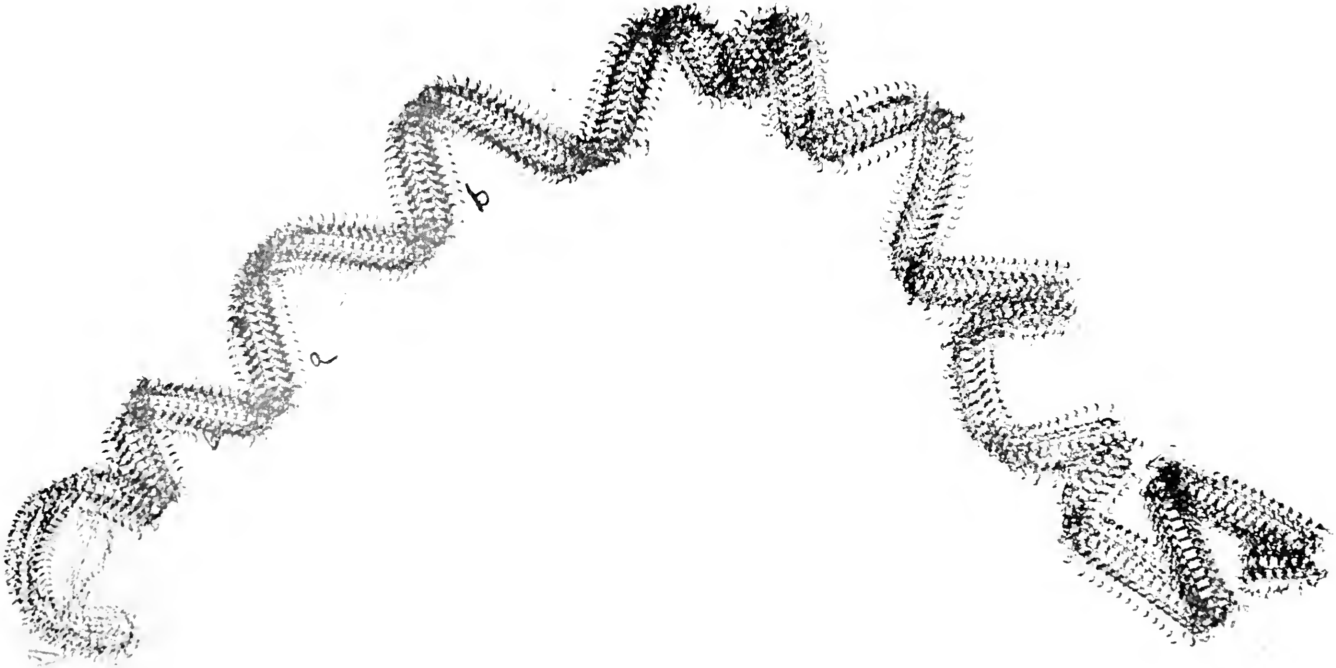


Fig. 1.



TONGUE OF SEA SNAIL.

Fig. 3. 70mm. objective, camera extension of 65 inches. If same magnification had been obtained with 16mm. objective, the field would only have shown portion between *a* and *b*.

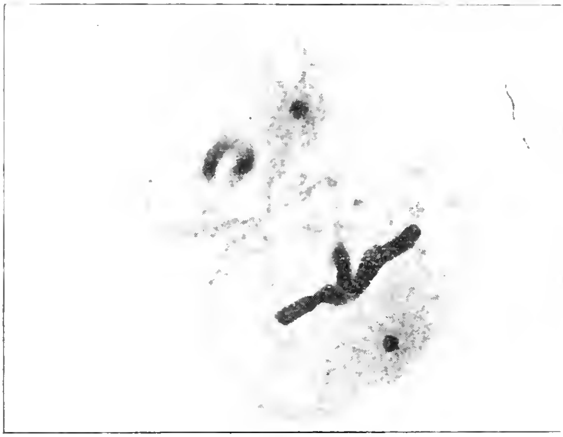


Fig. 5. Ascaris megalocephala, $\frac{1}{12}$ in objective and 4 projection eyepiece; focused for centrosome in larger cell.

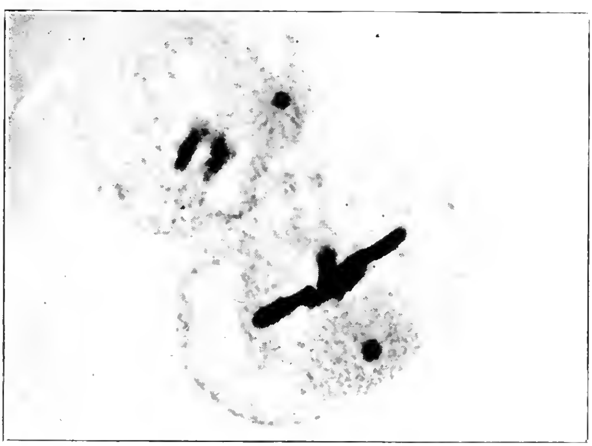


Fig. 6. Same as fig. 5, except it is focused for centrosome in smaller cell.

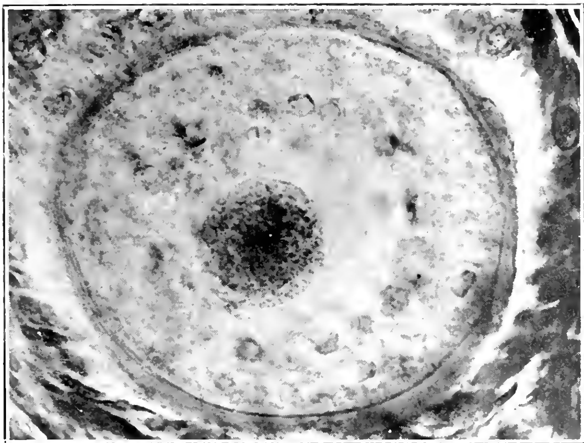


Fig. 7. Egg from the ovary of a cat, multiplied 1,500 times. Slide by Mr. Bertsch.

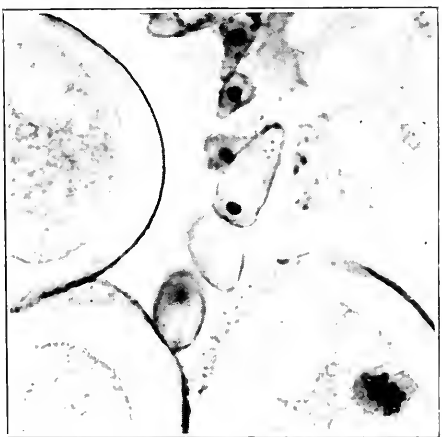


Fig. 8. Sperm cells of ascaris multiplied 825 times. 4mm. objective: 4 eyepiece.

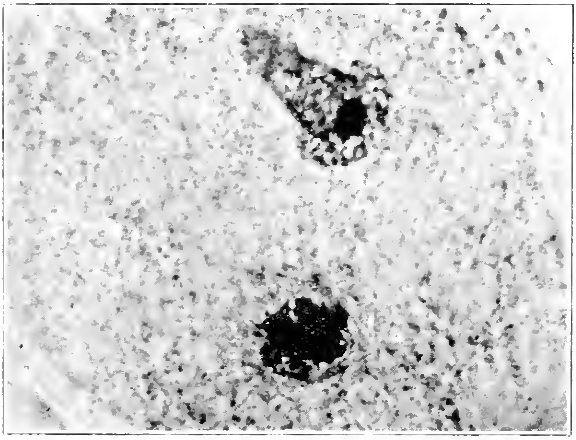


Fig. 9. The sperm cell is entering the egg from above: egg nucleus below multiplied 1,500 times.

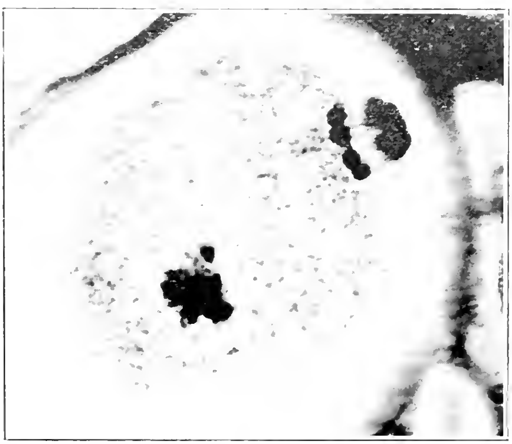


Fig. 10. The formation of the first polar body: sperm nucleus below. Slide by Mr. Irwin

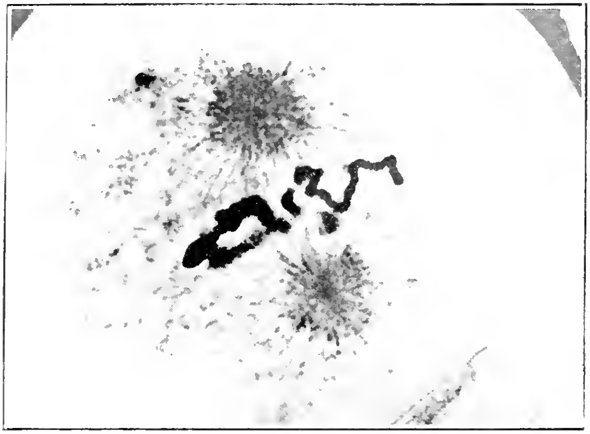


Fig. 11. The mitotic figure is complete.

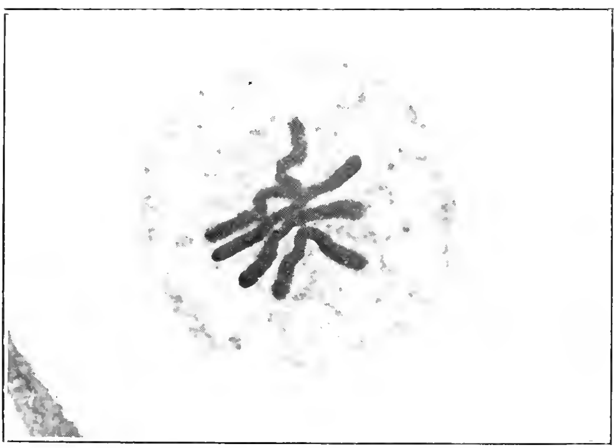


Fig. 12. Chromosomes of the equatorial plate seen from the pole.

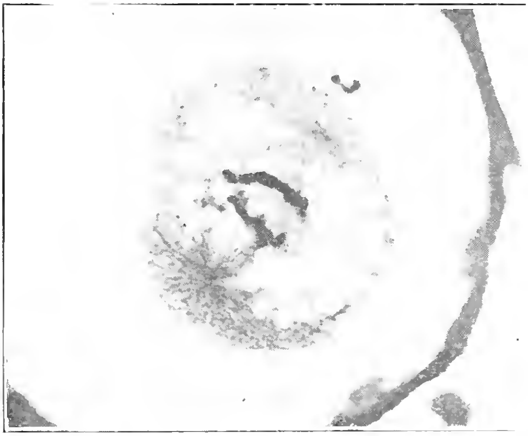


Fig. 13. An early telophase; two centrosomes above; polar bodies outside of egg.

Fig. 14. A somewhat later phase; walls beginning to contract for two-cell stage.

Fig 15. Two-cell stage.

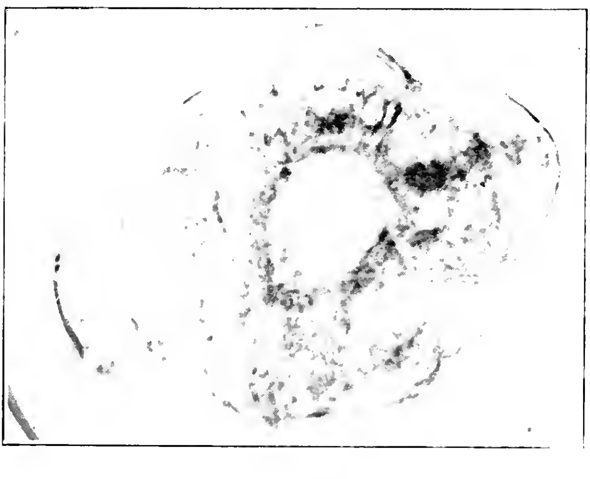


Fig. 16. Blastula of ascaris, multiplied 1,500 times. The specimen is not sectioned; see text.

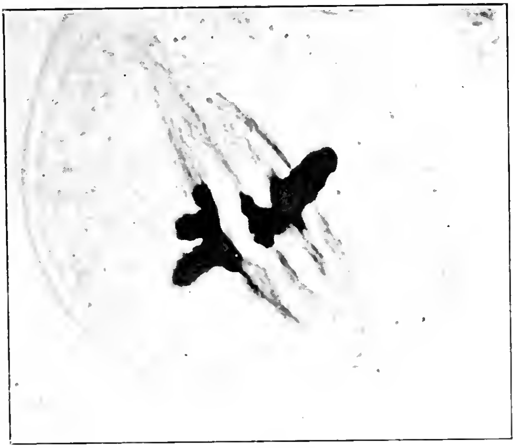


Fig. 17 Pollen mother cell of Lillium candidum: slide by Prof. David M. Mottier, multiplied 1,500 times.

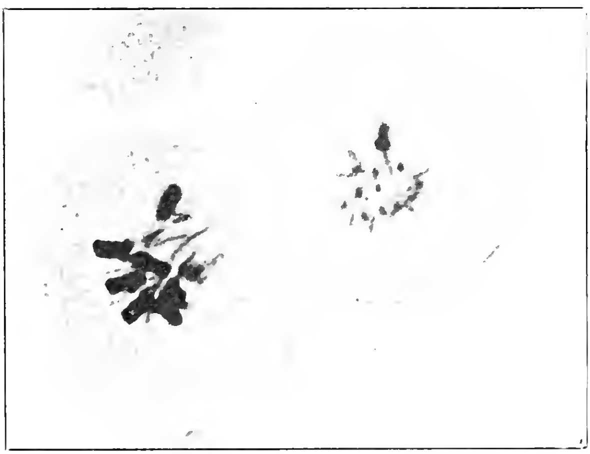


Fig. 18. L. candidum. The right-hand cell is cut at nearly right angles to plane of Fig. 17.

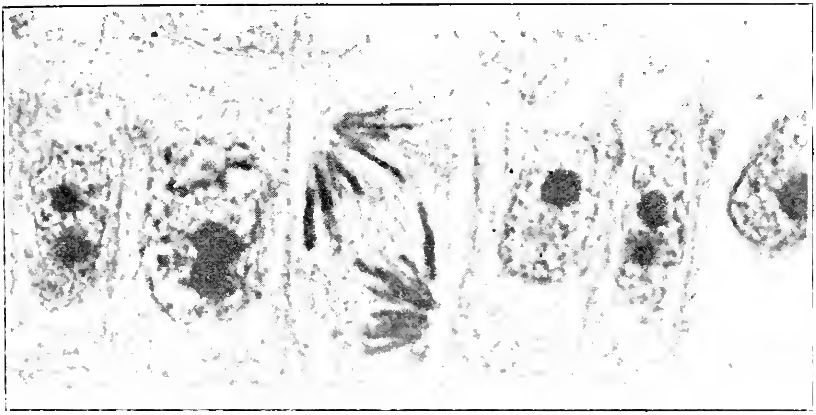


Fig. 19. Onion root; the oblique mitotic figure accommodates itself to the confined cell space.

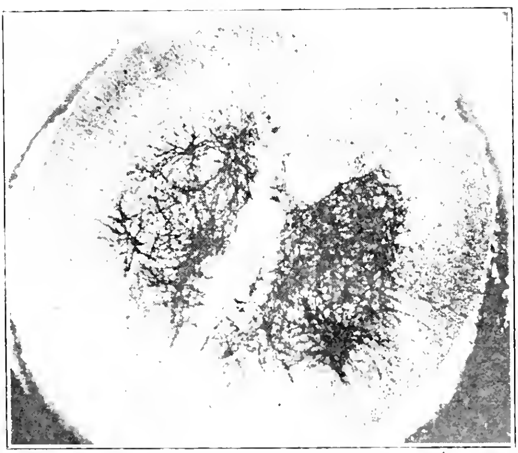


Fig. 20. Spinal cord of embryo pig, multiplied 50 times; Golgi preparation. Slide by Messrs. Warfel and Marshall.

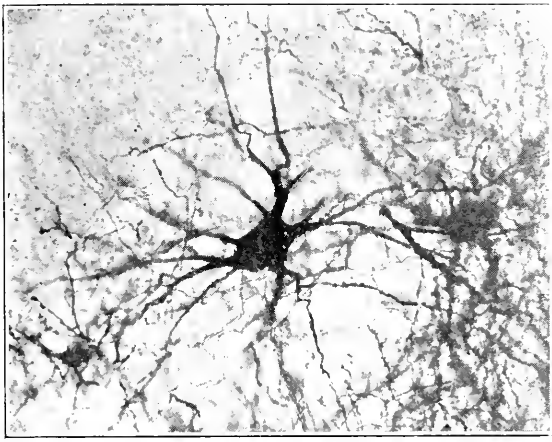


Fig. 21. The upper left-hand cell of fig. 20, multiplied 200 times.

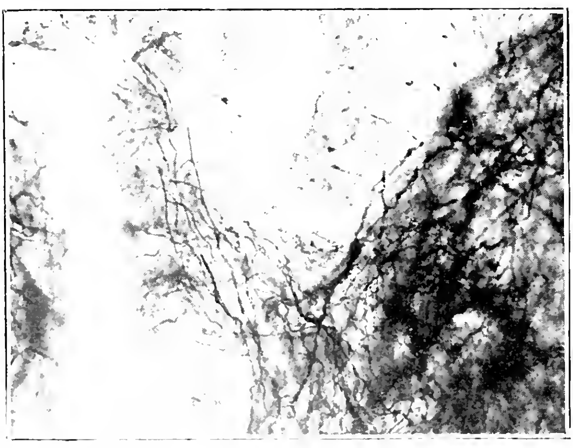


Fig. 22. The Commissure of fig. 20, multiplied 200 times.

The Leonids of 1900.

By John A. Miller.

The number of Leonids observed this year was very much smaller than was anticipated. Doubtless many escaped notice because of the bright moonshine and cloudy weather. Still, bearing these facts in mind, the shower was very disappointing. The *totale* of observations tend to confirm Dr. Johnstone Stoney's prediction that, owing to planetary perturbations, the stream bearing these meteors would not come nearer the earth this year than one and a half million miles.

On the mornings of November 14th and 15th my colleague, Mr. W. A. Cogshall, and myself, aided by our students, observed these meteors in order to obtain data concerning—

(a) The frequency of fall.
(b) The radiant.
(c) Duration of visibility; and
(d) The height at which the meteors appeared and disappeared.

On both mornings the sky was cloudy until three o'clock, and parts of it were overcast even after that time. Hence our observations for frequency are of small value. However, from 3:52 to 4:22 on the morning of the 14th our observers counted thirteen meteors. These came from the neighborhood of Leo, but were probably not all Leonids. At no other time were meteors so frequent as then. It was a source of remark, however, that they seemed to fall in groups two or three. That is, when one appeared one or two others followed at short intervals.

We attempted to obtain a sufficient number of trails of the meteors, photographically, to determine a radiant, but were unsuccessful. Our visual observations for the same purpose were more fruitful. On the morning of the 14th 45 meteor trails were platted; 13 of these were Leonids. On the morning of the 15th 41 were platted: 17 of which were Leonids. The radiant obtained from these paths was at the point whose right ascension is 149° and whose declination is 21°.

A Bergström chronoscope was employed to measure the duration of visibility. This instrument measures time accurately to the thousandth of a second, which is much less than the error introduced by the observer in pressing the telegraphic key which registers the appearance and disappearance of the meteor. The average of the results obtained for the duration of visibility is 0.6 second.

In order to secure the parallax of the meteors observations were made at Bloomington and at Bedford. The co-ordinates of these stations are, for Bloomington, longitude 86° 32′ 11″, latitude 39° 10′; for Bedford, longitude 86° 39′ 10″, latitude 38° 52′. The distance (rectilinear) between the two stations is 33,652 meters, equaling 20.13 miles.

An examination of our charts and recorded times showed that of all the meteors platted only one had been observed simultaneously at both stations.

Using the method of Klinkerfues, we found that the height of the meteor at the time of apparition was 143 miles, and its height at the time of its disappearance was 64 miles.

Mosquitoes and Malaria.

By Robert Hessler.

[Abstract.]

The recently developed theory that mosquitoes are the carriers of malaria from one man to another, which is based on the definitely ascertained cause of malaria, is a question of considerable importance to inhabitants of malarial districts, such as we have, for instance, along the Wabash River.

Speaking of Indiana, especially when compared with former times, it may be said that malaria has lost its terrors. To see what the disease really is requires a visit to such a region as the desolate Roman Campagna, or to the Isthmus of Panama. The ravages of the disease, known about Rome as Pontine fever and at Panama as Chagras fever, is something terrible to contemplate.

Popularly it is generally believed that the drainage of wet areas and of stagnant waters is the cause for the great diminution in the number of cases and of its severity among us.

For a cause, biologists and physicians always want something tangible —a something that can be seen, felt, weighed or measured; a something that appeals to the senses. Many persons are satisfied with a very simple explanation, and frequently a name suffices. The term "malaria" etymologically means "bad air," and was applied to the disease in olden times when bad air or a "miasm" was supposed to cause it.

Now what is malaria? we may ask. What is its cause? How does it get into the body?

Diseases due to a specific cause, to a living organism, spread about over the face of the earth just as we see animals and plants spread. Many with originally restricted habitats have in the course of time attained a world-wide distribution. Some diseases, natives of warm climates, periodically leave their natural boundaries, as yellow fever or cholera, flourish for a short time and then disappear utterly. If a new disease appears in a country and the conditions for its existence are favorable, then the disease remains and is called endemic. The cold of our winters has a destructive effect on many diseases and a retarding influence on others. Some flourish only during the warm months of the year.

The date when a new disease first appeared in a country, or rather an old disease in a new country, is accurately known in many instances, and the gradual spread after its introduction has been carefully followed in some cases. Leprosy, for instance, now so common in the Sandwich Islands, was brought in by the Chinese in 1840.

Malarial fever had a restricted habitat in former times and has gradually spread and still does spread to places where it had never been seen before. Its appearance and spread in the Island of Mauritius in comparatively recent years was attended with a frightful loss of life. It was brought into the island in 1866 by some sick sailors, and an epidemic followed; in the year 1867, 32,000 out of a population of 310,000 died of malaria. In some of the lowly situated districts more than one-fifth of the population perished from fever alone.

The original home of malaria is unknown. Many of the islands of the sea are still free from it. All other conditions may be favorable, but unless the active cause is introduced the disease never appears in a country where it had never been known to occur.

It is now about twenty years since Laveran, a French military surgeon, then stationed in Algiers, discovered and first described the active cause of malaria. This discovery has been verified again and again and is now universally recognized as the cause. It is a minute form of life belonging to the sporozoa and is most commonly known under the name of Plasmodium malariae. To detect this parasite in the blood is the crucial test for malarial fever in these days of laboratory methods of investigating and diagnosing diseases; once found, the application of the remedy for the disease is clearly indicated—this is quinine or one of the alkaloids of the cinchona group. Quinine is a protoplasmic poison to the malarial parasite.

The Plasmodium malariae lives in and at the expense of the red blood corpuscles of human beings afflicted with the disease. It appears first as a minute speck in the corpuscles, gradually enlarges, and about the time the cell is consumed it undergoes a segmentation, each segment being a new and independent being which at once seeks a new host, a fresh corpuscle. Segmentation keeps up the species in the body of the host.

Under suitable conditions a higher development of the parasite can be seen. It is a process of differentiation into gametes, or males and females, and the resulting offspring are concerned in the transmission of the species, and of the disease, be it noted, into a new host.

The role of the mosquito in carrying the disease from one person to another has been worked out during the past two years. The prevailing view of how this is done may be outlined in this wise: When the Anopheles mosquito bites a human being afflicted with malaria, the parasites in the blood are taken into the insect's stomach and here and in the intestines they undergo a certain cycle of existence, or evolution, lasting about a week or ten days, and sporozoids—corresponding to the eggs of higher animals or to the seeds of plants—are formed, and these get into the salivary gland, and when the mosquito bites again they are, along with the saliva, injected into the wound. Once in the human system these sporozoa seek and occupy the red blood corpuscles; gradually they increase in numbers by sporulation, and in the course of a few days, or after one or more weeks, evidence of malaria manifests itself. In this way malaria is transmitted to a new individual.

The life history, or the development of the parasite, can be followed:

First. In the blood of a malaria fever patient by taking a drop of the blood at variable intervals and examining it under a high power of magnification. This will show the sporulating generation.

Second. In blood kept for some time under suitable conditions—warmth and loss of fluid by evaporation—under the microscope.

Third. In the organs, notably the spleen, of persons dying from malaria.

Fourth. In the bodies of mosquitoes after feeding on the blood of a malarial fever patient, the insects being kept at a summer heat.

With the cause definitely recognized, malarial fever may be defined in this wise:

"A specific infectious disease depending upon the presence in the blood of one or more of several species of closely allied parasites (Haemosporidia), which develop within, and at the expense of, the red blood corpuscle of the infected individual, resulting, according to the species and number of the parasites present, in more or less periodic febrile paroxysms or in continued fever."

We may now ask: How does this active cause get into the body? Or, in other words: How do we catch malaria?

When the mosquito theory was first announced it was thought that any and all mosquitoes could transmit the disease. It has since been found that there is only one genus which is now universally suspected.

There are about 250 species of mosquitoes described, and of this number about 30 have been found in the United States. The genus to which the malaria carrying mosquito belongs is that of Anopheles; it may be recognized by its spotted wings and the peculiar position of the body when at rest—the body axis projecting away from the place of support, as a wall. Our common mosquito belongs to the genus Culex and is considered harmless; it has no spots on the wings and the body axis at rest is parallel to the wall. Anopheles is an inhabitant of the country. Culex lives in the city as well as in the country.

Mosquitoes normally live on the juices of plants; the sucking of blood is an acquired habit. The females alone suck blood, the mouth-parts of the males are not adapted for it. They seem to survive our winters; they are often to be seen during warm days in the midwinter months. In the spring the few survivors are ready to repopulate all the country around—and at the same time spread malaria. With us malaria is essentially a disease of warm weather.

There are two chief methods by which the subject can be studied:

First. To search for Anopheles in its usual habitat and then for the malarial fever. Or.

Second. To find the malarial fever and then look for Anopheles.

The blood of man upon which the mosquito has been feeding can readily be studied in thin sections of the insect properly stained. In some of the slides which I will pass around, the distended stomach, filled with blood, can be easily distinguished; under a high magnification any Plasmodium malariae in the corpuscles can be seen.

From the preceding remarks it will be seen that three chief factors are involved in this question:

1. The fever-stricken human being, or, the disease in the body, or, in other words, the reaction brought about by the presence of the active cause.

2. The cause itself, the Plasmodium malariae.

3. The transmitting agent, carrying the active cause from one infected human being to others. This is the Anopheles mosquito.

Now what is to be said on the application of all these discovered facts? Most of us, unless we see a well defined application for newly discovered facts, are not inclined to attach any great importance to such discoveries, and, on the other hand, the more directly we are concerned the greater the value to us. In the field of medicine the value of a discovery is estimated in the light of the relief it gives mankind from disease and affliction.

How best to apply this new knowledge in reducing the ravages of malaria and in banishing it from the face of the earth is a question on which opinions differ. By some it is held that the best method of procedure is to destroy all the mosquitoes, and thus prevent the transmission from one individual to others. It is claimed by advocates of this class that the malarial parasite may not live exclusively in man, but might be inoculated from lower animals. On the other extreme are men who aim to exterminate malaria by exterminating the malaria germ itself, by properly diagnosing all malaria cases and administering sufficient quinine; by isolating all such patients and protecting them from mosquito bites. They blame the mosquito less than the infected blood upon which the insect feeds. It would be impossible, they argue, to get rid of all the mosquitoes in any community, much less of those in the whole world. Their reliance is quinine and screens.

Besides these extreme views there is what may be called a compromise, that is: To reduce the number of breeding places of the mosquito to a minimum, by drainage and drying up all wet places and pools of stagnant water; by isolating the sick and protecting them from the bites and by the administration of quinine. With the breeding places reduced and the sick isolated there will be a constantly diminishing number of malarial fever cases.

A number of experiments have already been made along these lines. Former éfforts, as those of the Italian government in planting Eucalyptus trees, have been futile because founded on imperfect data. Of the Eucalyptus it should, however, be said that it does have a slight influence, the leaves containing a volatile oil offensive to the mosquito, and on this account they do play a slight part in lessening the ravages of the disease among those living in a grove of the trees.*

Quite different are the results of experiments made this year. From the Eucalytus theory of a generation ago to the mosquito theory of to-day is a step far in advance, and results based thereon are equally significant.

The Italian railways—with their lonely stations in the plains and valleys—were the first to take advantage of the new theory in adopting prophylactic measures against mosquito infection of malaria by protecting their buildings and those occupied by their workmen by mosquito netting. The tests have been regarded as conclusive. Of 104 railway employes protected from mosquito infection not one contracted the disease. On the other hand, out of 359 persons not thus protected but otherwise living under similar conditions, only seven or eight escaped the fever.

A more elaborate test was made at Paestum, in a fearfully infected region to the southeast of Naples. The houses had wire screens over every opening—doors, windows, chimneys, etc., and persons going in and out after dusk were obliged to wear veils and closely woven, thick gloves. One hundred three persons were thus protected and of this number only three showed symptoms of malarial infection. The difficulty of inducing ignorant persons to fully comply with directions for protecting themselves accounts for the exceptions. No quinine was used by the party. Out of the population of 307 souls living in that region and not protected, all but five contracted malaria—these five being sons of the soil who seem to have been immune to a considerable extent. Where the protected party took no quinine, the exposed persons, on the other hand, during the same period, took six pounds.

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*The specimens of Eucalyptus here shown are, one from Battipaglia, north of Paestum, in a terribly devastated region of Italy; the other from the Roman Campagna above the Callistus catacombs.

It is now proposed to isolate all fever patients in the malarial districts and to protect the dwellings by screens—a tremendous undertaking with an area of 20,000 square miles and with a population, much of it very ignorant, of 2,500,000.

CHANGES IN INDIANA.

In regard to the changed condition in Indiana—the former prevalence of malaria, especially in the Wabash bottoms, even only two or three decades ago, and its comparative rarity at the present time: It seems to me that the explanation is to be sought chiefly in the fact that proper medication, the taking of sufficient quinine, is resorted to promptly nowadays, resulting in the rapid disappearance of the disease, or disease symptoms, in the afflicted individual, and thus keeping the number of foci from which the disease could be disseminated at a minimum, and at the same time shortening the period of existence of such foci, or, in other words: The fewer individuals there are in any neighborhood the less the liability for the healthy to contract the disease.

In former times quinine was a very costly remedy, used as a last resort and usually in insufficient doses; to-day quinine is very cheap and by many used for any suspicious malarial symptoms.

Then, too, mosquitoes were, no doubt, more abundant in former times than at present, owing to the greater number of wet places where the animals could breed; stagnant water being one of the essentials in the life history of the insect. Drainage is restricting such breeding places more and more, thus indirectly reducing the number of mosquitoes. Now that the proper relationship of malaria to swamps and pools is known, it becomes a comparatively easy matter to still further diminish the progeny of the "skeeters" still among us. The simplest method, except drying up wet places, is to spread a film of oil over all bodies of stagnant water—the larvae as they come to the surface to breathe get the oil in the respiratory system and quickly perish. The necessity of isolating and properly protecting all malarial fever cases is self-evident.

SUMMARY AND CONCLUSIONS.

Malaria is a disease which once had a restricted distribution, but which in the course of time has been distributed over the face of the earth; it is most common in warm climes; it is due to a specific cause, the Plasmodium malariae, a minute organism living in and destroying the red blood corpuscles. The parasites are transmitted from one person to another by the mosquito. A certain cycle of the life history of the malarial parasite takes place within the body of the mosquito and the spores are injected from the salivary glands into and under the skin in biting.

Certain species of mosquitoes are the carriers to and fro of the infect-ing organisms. They may in a general way be recognized by their spotted wings and by their peculiar position when at rest.

The prevalence of malaria can be diminished by guarding against mosquito bites; by isolating malarial fever patients, giving them sufficient quinine and protecting them from being bitten; by reducing the number of breeding places of the mosquitoes by drainage.

Individual prophylaxis is best attained by avoiding the bite of the mosquito.

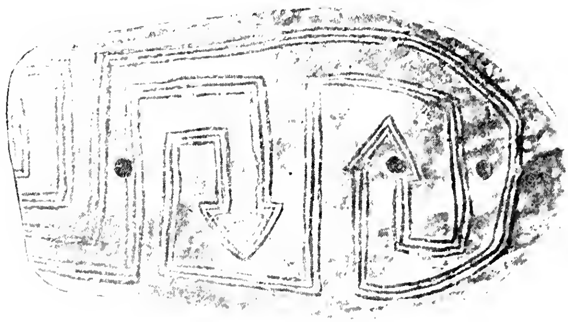
A Shell Gorget Found Near Spiceland, Indiana.

By Joseph Moore.

All I propose to do in this brief paper is to give a history of the object represented by the accompanying photograph, leaving it for others to tell the meaning of the engraved design and also its relation to other specimens of prehistoric art. About half a mile north of Spiceland, Henry County, while some men were loading gravel and sand, they came to some graves from which were taken two or three badly decayed human skeletons, the skull of a groundhog and the gorget which is the subject of this report. One of the human skulls is well preserved and the other sufficiently so to indicate its character. They represent rather a fine type of head.

The photograph herewith presented is very nearly one-half the size of the original, which is in length five and three-fourths inches. The greatest breadth toward the wider end is three and one-eighth inches, and that of the narrower end is two and one-half inches.

It has been wrought by dressing off the borders of a very large specimen of fresh water mussel, a species of Unio. It is evident both from the incompleteness of the original tracing on its concave surface and from the natural form of that species of shell that one-fourth, more or less, of the entire length of the original ornament has been broken off while yet in use, and the broken edge dressed to improve its appearance.



There are four perforations. As to the design, it has been engraved by a steady hand, and the fine grooves afterwards neatly stained with dark paint.

The photograph would probably represent the original somewhat more perfectly had not the finder varnished it, supposing it would otherwise be likely to crumble, as did the larger part of the two skeletons. It was, however, well preserved.

Professor Holmes of the Smithsonian Institute and Professor Warren K. Moorehead both regard it as an interesting find, and one or both of them will probably tell us more about what it is supposed to mean. So far as I have yet been able to learn, inscriptions on shell are more common further south, say in Tennessee and the Gulf States, than in the latitude of central Indiana.

This design is in some respects allied to what may occasionally be found among the ruins of Central America, judging from pictures observed in archeological reports.

I am indebted to David Newby of Spiceland for the specimen and to Professor Collins of Earlham for the photograph.

A Harbor at the South End of Lake Michigan.

By J. L. Campbell.

The northern boundary intended for Indiana by the act of Congress, July 13, 1787, and also the boundary designated in the act introduced December 27, 1815, by Mr. Jennings, the territorial delegate for the admission of Indiana as a State, was an east and west line through the southern extreme of Lake Michigan.

But an amendment to the original bill was adopted removing this boundary line ten miles to the north, and in this form the act was passed April 19, 1816.

This ten-mile line was marked on the early maps of the State, and has been the subject of curious inquiry by many who are ignorant of this item of State history.

By this amendment there was added to the territory of the State nearly one-half of the present counties of Steuben, Lagrange, Elkhart, St. Joseph and Laporte.

By the original line the State would have been cut off entirely from the great northern chain of lakes, and Michigan and Illinois would have cornered at the extreme southern limit of the lake.

The ten-mile strip gives to the State a lake front of forty miles between Michigan and Illinois, and makes Lake, Porter and Laporte counties parts of the border of our great inland sea.

I do not know who deserves the honor of securing the ten-mile strip, but I would be glad to erect two monuments to his memory, one where our shore line touches Illinois and the other to mark the line between this State and Michigan.

From the period of the admission of the State in 1816 until the present our wisest statesmen and best engineers have manifested great interest in the improvement of our lake front.

Michigan City was laid out in 1831, and in 1836 Congress made an appropriation of $20,000 for the beginning of a harbor at that place.

The site is a good one—the growth of the city has been satisfactory, a fair degree of liberality has been shown by the general government for the harbor, and the results prove that the expenditures have been wise.

It merits and should continue to receive the most generous support. But the new conditions around the head of Lake Michigan require improvements and advantages on a much greater scale than the continued support of a single harbor.

The village of 1830 at the mouth of Chicago River has become the second city of importance in the United States.

Its traffic by rail and water has become so great that relief and enlargement are most pressing, and these must be provided along the Indiana lake front.

The shore line along the lake is made up of loam and sand, which, although not the best material for harbor building, are of comparatively easy manipulation.

With other sites for a new harbor I ask attention anew to the mouth of the Calumet River, and particularly to the feasibility of using the strip of low land or lakelet east of the river and extending possibly into Porter County.

Between the sand hills or ridges, which are shown on the government survey, and the nearest railway line there is a strip of marsh land called, on the old maps, Long Lake.

If on examination it should be found practicable to dredge out this lake to the proper depth and connect it with the mouth of the Calumet the desired harbor would be easily constructed.

This site is specially commended on account of the protection afforded by the sand ridges on the north, thereby making it a haven as well as a harbor, and because it would interfere least with the railways along the lake shore.

The commercial advantages to the State are of the greatest importance.

All the railways running southeast and east from Chicago would use this new port for transfers between rail and water—and possibly also between railways west and north of Chicago on account of less expensive terminal facilities—so that the co-operation and support of the great railway interests would be secured.

Here would be the point of minimum cost between the Lake Superior iron ores and the block coal of central Indiana and the greatest stimulus offered to the development of all kinds of manufacturing industries.

The cheapening of transportation for oolitic limestone would be no small factor in favor of this new outlet.

Hammond and other flourishing cities in the northwest part of the State would experience the most direct benefits by the increase of business and manufacturing facilities and consequent increase in population.

The proposition is worth at least a passing thought and is commended to the State and general governments for further consideration.

Some Properties of the Symmedian Point.

By Robert J. Aley.

Monsieur Emile Lemoine, at the Lyons meeting of the French Association for the advancement of the Sciences in 1873, called attention to a particular point within the triangle, which he called the center of antiparallel medians. Since that time a number of mathematicians have studied the point and have discovered many of its properties. The point is such an interesting one that a brief collection of its more striking properties may be of some value. No claim is made to completeness.

DEFINITIONS OF THE POINT.

1. The point of concurrency of the bisectors of all lines antiparallel to the sides of the triangle.

2. The point of concurrency of the lines isogonal conjugate to the medians of the triangle: that is, the point of concurrency of the symmedians of the triangle.

3. The point within the triangle, the sum of the squares of whose distances from the three sides is the least possible.

4. The point within the triangle, whose distances from the sides is directly proportional to the sides.

NAMES OF THE POINT.

1. Center of antiparallel medians, proposed by Monsieur Emile Lemoine.

2. Symmedian point (symédiane, from symétrique de la médiane), proposed by Monsieur Maurice d'Ocagne. The English form "symmedian" was suggested by Mr. R. Tucker in 1884.

3. Minimum point, suggested by Dr. E. W. Grebe.
4. Grebe's point, proposed by Dr. A. Emmerich.
5. Lemoine's point, proposed by Professor J. Neuberg.

METHODS OF CONSTRUCTING THE POINT.

1. Draw the medians AM_a, BM_b of the triangle ABC. Then draw AK'_a, BK'_b, making the same angle with the bisectors of angles A and B, respectively, as are made by AM_a and BM_b. The intersection of AK'_a, BK'_b is K, the symmedian point.

2. Draw antiparallels to BC and CA. Join A and B, respectively, to the midpoints of these antiparallels, and the intersection of these joining lines is K, the symmedian point.

3. To the circumcircle of the triangle draw tangents at B, C and A, and let these intersect in X, Y, Z, respectively. Then AX, BY, CZ concur at K, the symmedian point.

SOME PROPERTIES OF THE POINT.

1. K is the point isogonal conjugate to G, the centroid.

2. If K_a, K_b, K_c are the feet of the perpendiculars from K to the three sides respectively, then

$$\left.\begin{aligned} KK_a &= \frac{2\Delta a}{a^2+b^2+c^2}. \\ KK_b &= \frac{2\Delta b}{a^2+b^2+c^2}. \\ KK_c &= \frac{2\Delta c}{a^2+b^2+c^2}. \end{aligned}\right\}$$

Where Δ is the area of the triangle ABC, and a, b, c are three sides of the same triangle.

3. Area of $\triangle$ BKC $= \dfrac{a^2}{a^2+b^2+c^2}$

Area of $\triangle$ CKA $= \dfrac{b^2}{a^2+b^2+c^2}$

Area of $\triangle$ AKB $= \dfrac{c^2}{a^2+b^2+c^2}$

$\triangle BKC : \triangle CKA : \triangle AKB = a^2 : b^2 : c^2$.

4. Antiparallels to sides of the triangle through K are equal. Such antiparallels cut the sides of the triangle in six points which lie on a circle whose centre is K. This circle is called the *Cosine* Circle.

5. K is the median point of the triangle $K_aK_bK_c$.

6. The line KM_a (M_a is the mid point of BC) passes through the mid point of the altitude AH_a.

7. The sides of the K-pedal triangle $K_aK_bK_c$ are perpendicular to the medians of ABC, respectively.

8. The sides of the G-pedal triangle $G_aG_bG_c$ are perpendicular to the symmedians AK, BK, CK, respectively.

9. $a . GA . KA + b . GB . KB + C . GC . KC = a . b . c.$

10. If the symmedian lines AK, BK, CK meet the circumcircle of ABC in A′, B′, C′, then the triangles ABC and A′B′C′ are co-symmedian, that is they have the same symmedian point K.

11. K and M (M is the circumcentre of ABC) are opposite ends of a diameter of Brocard's Circle.

12. Parallels to the sides of ABC through K, determine six points on the sides which lie on the Lemoine Circle.

13. If points A′, B′, C′ be taken on KA, KB, KC so that $KA' : KB' : KC' = KA : KB : KC =$ constant, then antiparallels to the sides through A′, B′, C′, respectively, determine six points on the sides of the triangle which lie on a Tucker Circle.

14. If $A_1 B_1 C_1$ is Brocard's first triangle, then

A_1 K is parallel to BC.

B_1 K is parallel to CA.

C_1 K is parallel to AB.

15. AK, BK, CK produced meet Brocard's circle again in A″, B″, C″ respectively, and these points form Brocard's second triangle A″ B″ C″.

16. If KA, KB, KC, meet the sides of ABC in X_1, X_2, Y_1, Y_2 and Z_1, Z_2 respectively, then the sides of the triangle $Z_1 X_1 Y_1$ are parallel to A Ω, B Ω, C Ω respectively, and the sides of $Y_2 Z_2 X_2$ are parallel to A Ω′, B Ω′, C Ω′ respectively, where Ω and Ω′ are the Brocard points of ABC. Ω and K are the Brocard points of $Z_1 X_1 Y_1$ and Ω′ and K are the Brocard points of $Y_2 Z_2 X_2$.

17. The point of concurrency D of AA_1, BB_1, CC_1 is the point isotomic conjugate to K.

18. The line MK is perpendicular to and bisects the line ΩΩ′.

19. The Simson line of Tarry's point is perpendicular to MK.

20. $\text{Cot} \angle KBC + \cot \angle KCA + \cot \angle KAB = 3 \cot \omega$ where ω is the Bocard angle.

21. If the symmedian AK cut BC in K'_a and the line MM_a in Q then (AK'_a, KQ) is a harmonic range.

22. If from K'_a perpendiculars p and q are drawn to CA, AB respectively, then

$$\frac{p}{b} = \frac{q}{c} = \frac{2}{a^2 + b^2}$$

23. $AK : KK'_a = b^2 + c^2 : a^2$

24. $BK'_a : K'_a C = c^2 : b^2$

$CK'_b : K'_b A = a^2 : c^2$

$AK'_c : K'_c B = b^2 : a^2$

$$BK'_a = \frac{ac^2}{b^2 + c^2} \text{ etc}$$

25. The tangent to the circumcircle at A, and the symmedian AK are harmonic conjugates with respect to AB and AC.

26. The angles AMK, BMK, CMK are equal respectively to the angles (BC, B_1C_1) (AC, A_1C_1), (AB, A_1B_1), that is the respective angles between the sides of Brocard's first triangle and the corresponding sides of the fundamental triangle.

27. The sides of the $\triangle K_aK_bK_c$ are proportional to the medians of the $\triangle$ABC, and the angles of the $\triangle K_aK_bK_c$ are equal to the angles which the medians make with each other.

28. The sum of the squares of the sides of $K_aK_bK_c$ is less than the sum of the squares of the sides of any other triangle inscribed in ABC.

29. The ratio of the area of ABC to that of its co-symmedian triangle A'B'C' (See No. 10) is $(-a^2+2b^2+2c^2)(2a^2-b^2+2c^2)(2a^2+2b^2-c^2):27a^2b^2c^2$.

Note On McGinnis's Universal Solution.

By Robert J. Aley.

The full title of the book is, "The Universal Solution for numerical and literal equations by which the roots of equations of all degrees can be expressed in terms of their coefficients, by M. A. McGinnis, Kansas City, Missouri, the Mathematical Book Company, 1900."

In his preface the author announces that the book appears at "the request of many able mathematicians, teachers and scholars throughout the United States." He also modestly states that the imaginary is for the first time put upon a true basis, that bi-quadratics are more thoroughly treated than in any prior work and that it is the only work in which general equations beyond the fourth degree are solved. It is also the only book that shows the fallacies in Abel's proof that equations of higher degree than the fourth can not be solved by radicals.

That the book is interesting goes without saying. No one who promises so much can fail to write in an interesting manner. One follows breathlessly to see the kind of a paradox that will be produced.

A number of simple theorems in the theory of numbers and the theory of equations are stated as though they were new.

On page 53, article 164, we read: "The roots of quadratics represent the sides of *right triangles* when Real Quantities; the sides of *isosceles triangles* when *Real Imaginaries;* and when *Pure Imaginaries* may be represented by *lines.*" His argument for the latter part of the statement, it is needless to say, is not convincing.

A number of special numerical problems in equations of various degrees are solved. In many of these some very ingenious special methods are exhibited.

One chapter is devoted to the discussion of Wantzel's modification of Abel's proof of the impossibility of an algebraic solution of equations of higher degree than the fourth. The character of the discussion can be best understood by quoting the conclusion. "If we should accept his (Wantzel's) demonstration as true, we would be forced to the conclusion that the general equation of a degree higher than four was destitute of roots. The concluson of Wantzel that the roots can not be indicated in algebraical language is equivalent to saying that there are no roots, since it is absurd to say that finite quantities exist which can not be expressed in any function of other finite quantities, which are themselves symmetrical functions of the first, however complicated."

The author's notion of the imaginary is summed up in a general theorem, as follows: "An Imaginary Quantity is the indicated square root of the difference of the squares (with its sign changed) of the bases of two right triangles having a common perpendicular which is the radius of a circle; two of such triangles lying wholly within the semicircle, and two partly within and partly without the semicircle." What the theorem or the demonstration means would be hard to tell.

Of his so-called universal solution I will consider only that of the sixth degree. He assumes that—

$$x^6 + mx^5 + nx^4 + bx^3 + px^2 + tx + q = 0$$

$$\left\{x^2 + \frac{m}{a}x + y\right\}\left\{x^2 + \frac{m}{b}x + z\right\}\left\{x^2 + \frac{m}{c}x + w\right\} = 0$$

He then puts

$$(1)\quad n - \frac{m^2}{A} = \frac{A_0}{2m} - \frac{m^2}{2A^2} = y + z + x$$

$$(2)\quad p - \left\{\frac{m^2n}{B^2} - \frac{m^4}{B^3}\right\} = \frac{Bt}{m} = yz + yw + zw.$$

$$(3)\quad q = yzw$$

$$(4)\quad oA^3 - 2mnA^2 + 2m^3A - m^3 = 0$$

$$(5)\quad tB^4 - mpB^3 + m^3nB - m^5 = 0.$$

From (4) and (5) find A and B

Then x, y, z are found from 1, 2, 3 by means of a cubic equation.

The author incidentally remarks that the proper combination of the three values of A, and the four values of B are easily determined by a little practice. The author also says that it is evident that by comparing coefficients the values of 1 a, 1 b, 1 c can be obtained. The novice will find some difficulty in doing it. The real point of difficulty, however, is that we have eight unknown quantities, viz., a, b, c, x, y, z, A, B, and nine equations to be satisfied, viz., five by equating coefficients, and four from (1) and (2). So that the boasted solution is after all only a solution when there is some condition placed on the roots.

Graphic Methods in Elementary Mathematics.

By Robert J. Aley.

The Automatic Temperature Regulator.

By Chas. T. Knipp.

(Published in the Physical Review, Vol. XII, No 1, January, 1901.)

The Cayleyan Cubic.

By C. A. Waldo and John A. Newlin.

The Use of the Bicycle Wheel in Illustrating the Principles of the Gyroscope.

By Chas. T. Knipp.

(Published in the Physical Review, Vol. XII, No. 1, January, 1901.

The Cyclic Quadrilateral.

By J. C. Gregg.

PROBLEM.

The opposite sides of a quadrilateral FGHI inscribed in a circle, when produced, meet in P and Q: prove that the square of PQ is equal to the sum of the squares of the tangents from P and Q to the circle.—No. 80, page 470, Phillips and Fisher's Geometry.

SOLUTION

(See Fig. I.)

On PO and QO as diameters draw circles (centers S and T) and cutting circle O in C, D, E and K. QK and PD are tangent to O. Through the points Q, F and G draw a circle cutting PQ in A. Then $\angle PHG = \angle GFI = \angle QAG$ $\therefore$ $\angle PAG$ is the supplement of $\angle PHG$ and PAGH is cyclic, and

$PQ.PA = PF.PG = PD^2$ and

$PQ.QA = QH.QG = QK^2$ and adding these two equations

$\overline{PQ}^2 = PD^2 + QK^2$ — Q. E. D.

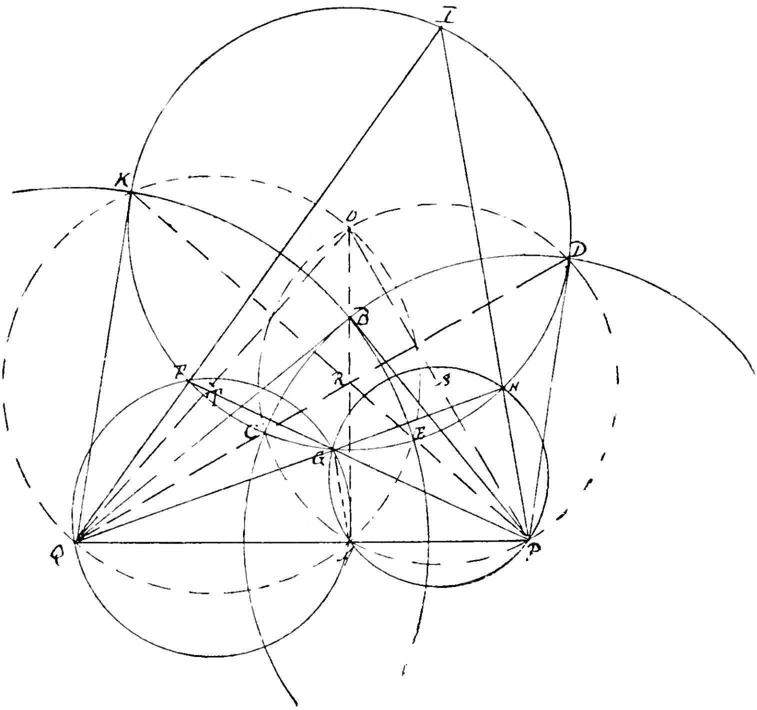


Fig. I.

DISCUSSION.

(1) With P and Q as centers, and PD and QK as radii draw two arcs meeting in B. Then PBQ is a right angle, and PB is tangent to arc EBK, and as the tangents PD and PB to circle O and arc EBK are equal, P must be on the common chord KE produced; and in the same way DCQ is a straight line.

(2) Since PK.PE=PF.PG=PQ.PA, the point A is in the circumference T, and OA is perpendicular to PQ, and A is also in the circumference S.

(3) PQ.PA=PF.PG=PI.PH. ∴ the points A, Q, I, H are concyclic, and in the same way A, P, I, F are also concyclic.

(4) PK and QD are respectively perpendicular to QO and PO, and R is the orthocenter of the triangle POQ, and AO passes through R.

(5) The three arcs DEC, EBK and DBC cut orthogonally, two and two, and the common chord of any two of them passes through the center of the third.

(6) (See Fig. II.)

$\angle GPA + \angle GQA = \angle HIF$ (supplement of $\angle PGQ$).

$\angle GPH = \angle GAH$.

$\angle GQF = \angle GAF$ and adding these three equations

$\angle QPI + \angle PQI = \angle HAF + \angle HIF$, or

$180° - \angle HIF = \angle HAF + \angle HIF$.

$180° - 2\angle HIF = \angle HAF$. But $\angle HOF = 2\angle HIF$.

$\therefore 180° - \angle HOF = \angle HAF$ and H, A, F, O, are concyclic.

(7) We have now shown the following points to be concyclic:

A, G, F, Q,—center M.

A, G, H, P,—center N.

A, O, K, Q,—center T.

A, P, D, O,—center S.

A, P, I, F,—center S′.

A, Q, I, H,—center T′.

A, H, O, F,—center O′.

And we will show that X is the center of a circle through A, G, O, I.

(8) CD, OA and HF are the three common chords of circles O, S and O′, and must meet in a point. Hence HF, the diagonal of FGHI, passes through R.

(9) Since APIF is cyclic $\angle QAF = \angle QIP$; and for the same reason $\angle PAH = \angle QIP$. $\therefore \angle QAF = \angle PAH$ and $\angle OAF = \angle OAH$.

(10) Since the circles S′, O′ and M pass through the points A and F, their centers S′, O′ and M are in the same line perpendicular to AF. For a similar reason N, O′, T′ are in the same line perpendicular to AH, and S′, S, N and T′, T, M are respectively in the same lines perpendicular to PQ or TS. Also T′S′, TS and MN respectively bisect AI, AO, and AG at right angles. Now the angles SO′S′ and SO′N have their sides respectively perpendicular to the sides of the equal angles OAF and OAH. $\therefore \angle SO'S' = \angle SO'N$ and SN = SS′, and in the same way TM = TT′. Hence the lines T′S′ and MN will meet TS at the same point X, and XA = XG = XO = XI and X is the center of the circle through A, G, O, I.

(11) Now HF, OA, and GI are the three common chords of the circles O, O′ and X and must meet in a point. Hence GI the other

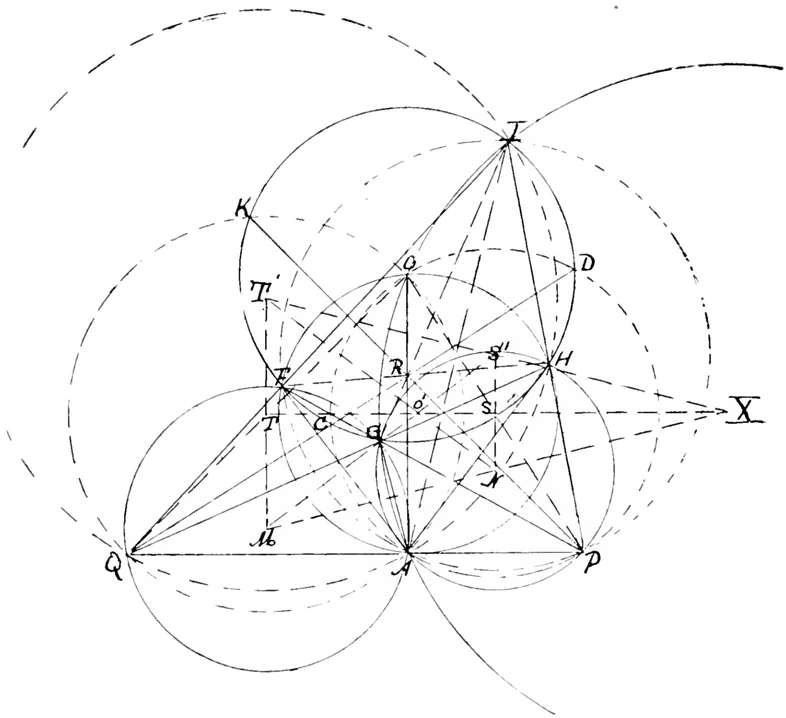


Fig II.

diagonal of FGHI also passes through R, and we have established the following

Theorem.—The diagonals of an inscribed quadrilateral meet in the orthocenter of the triangle whose vertices are the center of the circle, and the points where the opposite sides meet.

(12) (See Fig. 1.) Since QK, QE, PC and PD are tangents to circle O, the following theorem holds: If the diagonals of an inscribed quadrilateral meet in R, and its opposite sides meet in P and Q, and PR and QR be drawn cutting the circle in E, K, C and D, then PD, PC, QK and QE are tangent to the circle.

(13) The diagonals of *any* quadrilateral inscribed in circle O, and whose opposite sides meet in P and Q, will pass through R.

(14) If any point I, in circle O be joined to P and Q and cutting the circle in F and H, PF and QH will meet on the circumference as at G.

Note on the Determination of Vapor Densities.

By Chas. T. Knipp

The object of this note is to describe briefly a method of determining vapor densities which was suggested to the writer last year while making observations on the surface tension of water at high temperatures.

The principle used is that the buoyancy of vapor increases as the density increases. An iron core *mn* (Fig. 1), carrying a sphere *S* at its lower end is lifted by the sucking action of a coil in which a current is flowing. The lifting coil and core with sphere attached are contained in a steel vessel of sufficient strength to withstand high pressures. Three insulated circuits are run through the plug closing the vessel. The scheme

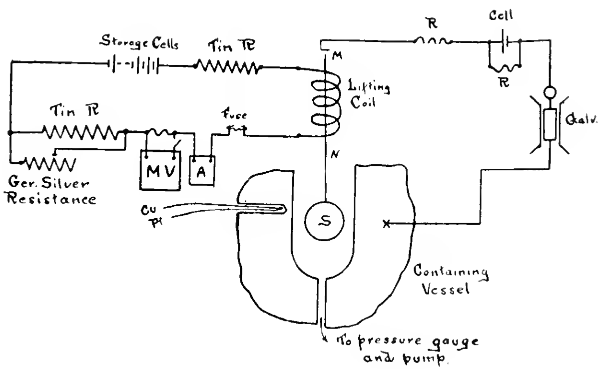
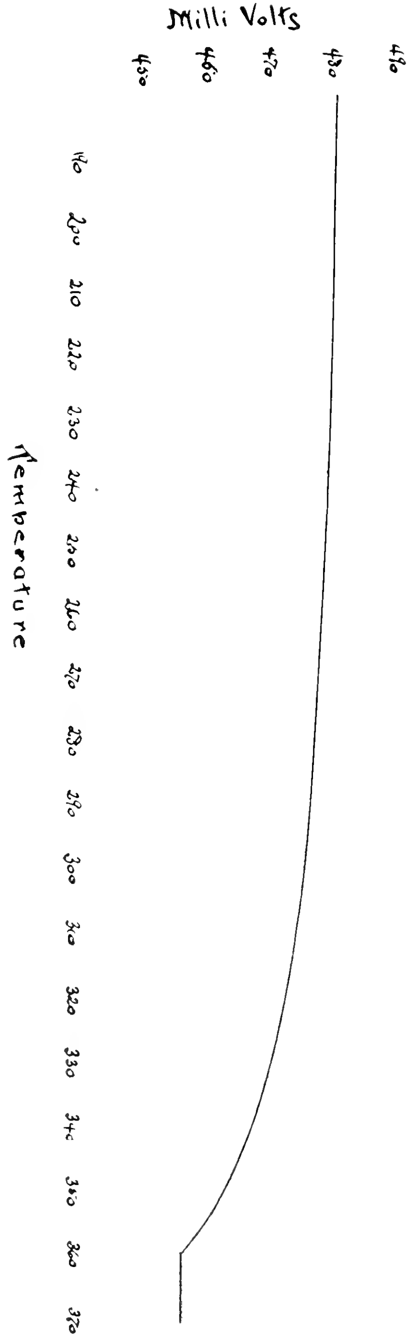


Fig. 1.

of connections is shown in Fig. 1. The lifting current is supplied by a number of storage cells, the current being adjusted by tin resistances until the sphere is lifted. At that instant contact is made at *M*, closing the signal circuit, shown to the right in the figure. The temperature is read by means of a Cu-Pt thermo-junction. This is placed in a hole drilled in the containing vessel to within 2mm of the inner cavity. The vessel communicates with a pressure gauge and pump. The current required to lift the sphere is read by means of a milli-volt meter looped around a .03-ohm coil.



Milli Volts
490
480
470
460
450
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
Temperature

Fig. 2.

As yet only a few readings have been made, and these were obtained incidentally while conducting the investigation referred to above. A curve was platted (Fig. 2) in which temperatures are abscissas, and the corresponding currents are ordinates. Only the upper portion of the curve is shown in the figure. The density increases very slowly at first, and becomes constant when the critical temperature is passed.

This method furnishes a means of determining the critical temperature and critical pressure, as well as the critical volume of a liquid.

An Improved Wehnelt Interrupter.

[**Abstract**]

By Arthur L. Foley and R. E. Nyswander.

The chief difficulties encountered in working with the ordinary type of Wehnelt Interrupter are that the glass tube which holds the platinum wire is continually breaking and that the length and size of the projecting platinum wire can be changed only by constructing new tubes.

In the improved interrupter a lead vessel serves as electrode and to contain the electrolyte. The platinum wire is held in a brass tube having its lower end slotted and conical. A collar, sliding on the conical end, serves to press the jaws together and to clamp the platinum wire. The projecting end of the wire may be about 1 cm. long; the remainder of the wire may extend up the inside of the tube.

The lead vessel should be filled half full of the electrolyte and over this should be poured a layer of coal oil 2 or 3 cm. deep. The brass tube is gradually lowered until the platinum point extends to the desired depth in the electrolyte. The remainder of the platinum wire and the brass tube are entirely protected by the oil. The oil serves also to decrease the spray and fumes from the electrolyte. A platinum loop instead of a point is preferable in many cases. The action of the interrupter is made more constant.

Many other electrolytes may be used besides the usual 10 per cent. solution of sulphuric acid and water. As a matter of fact for high or low voltages some other electrolytes are superior. The following tables gives some data concerning a few of many electrolytes that have been used with this form of interrupter:

Solution (in water).	Voltage.	Spark.	Remarks.
1% sulphuric acid	40- 50	Short and thin	Fairly constant.
5% sulphuric acid	25- 40	Short and thin	Fairly constant.
10% sulphuric acid	20- 50	Strong	Fairly constant on high voltage.
20% sulphuric acid	20- 30	Very strong	Unsteady. Will not work on high or low voltage.
5% sulphuric acid 5% nitric acid	12- 20	Average	Fairly constant.
5% caustic potash	40- 50	Average	Stops frequently but, s arts again without interruption.
10% sodium sulphite	75-115	Very heavy	Quite constant. High frequency. Used on 115 circuit without resistance.
10% sodium hyposulphite	40- 90	Strident	Ceases if short circuit is made on secondary.
10% acetic acid	....	....	Will not work on any voltage.
10% potassium sulphate	70-115	Average	Fairly constant.
10% ammonium nitrate	35- 85	Strong	More constant if secondary short circuited.
10% potassium nitrate	90-115	Very heavy	Not constant when t increased.
5% nitric acid (glass vessel and platinum sheet electrode)	30- 50	Strong and strident	Steady.

A Method of Measuring the Absolute Dilatation of Mercury.

[Abstract.]

By Arthur L. Foley.

The forms of apparatus used by Dulong and Petit, and Regnault, in determining the absolute dilatation of mercury are open to one or both of the following objections: (1) Some parts of the mercury columns are exposed and so the temperature can not be exactly the same throughout; (2) the heights of the columns must be measured from some assumed point of equilibrium in a horizontal connecting tube. The method proposed in this investigation is entirely free from both these objections.

The two arms of a vertical U tube are jacketed in the usual way, except that the jacketing tubes are of glass to permit the heights of the mercury columns to be taken with a cathetometer, at any level. Into the tube is poured a quantity of mercury sufficient to stand several centimeters high in each arm. When the required temperature has been attained the two heights are carefully measured. More mercury is added and under the same temperature conditions the heights are again measured. The differences in the heights before and after adding the mercury, together with the temperature difference of the two arms, are all the data required. Many independent determinations may be made by adding or removing mercury. As the readings are in every case difference readings any effects that might come from capillary and convection currents in the horizontal tube are eliminated. Two of my students, J. G. Gentry and O. A. Rawlins, have obtained remarkably consistent results by this method, though the coefficient of dilatation obtained by them is slightly less than that obtained by Regnault.

The Geodesic Line of the Space $ds^2 = dx^2 + \sin^2 x dy^2 + dz^2$.

By S. C. Davisson.

The Friction of Railway Brake Shoes Under Various Conditions of Pressure, Speed and Temperature.

By R. A. Smart.

Information concerning the friction of unlubricated rubbing surfaces is, unfortunately, limited in quantity, and it is believed that the data presented herewith, although relating particularly to the friction of brake shoes for railway cars, may be properly offered to the Academy as a contribution to the general subject.

The brake shoe is an important factor in the chain of mechanism popularly known as the air brake. It is not, strictly speaking, a part of the air brake, but is the immediate agent through which the air brake accomplishes the stopping of the train. It is the block of metal which is pressed against the tread of the car-wheel and which creates, in contact with the wheel, the friction which brings the wheel and hence the train to rest. It will at once be seen that the effectiveness of the whole air brake system on our railways is dependent directly upon the efficiency with which the brake shoe does its work. For instance, we can conceive of the brake shoe being made of some substance like glass, so hard that its friction would be practically nothing, in which case the air brake would be powerless to stop the train.

In fact, so important is the brake shoe in the eyes of railway officials that the Master Car Builders' Association has caused to be built an elaborate machine to be used exclusively for the testing of brake shoes. The need of such a machine will be understood when it is stated that the tendency of brake shoe manufacturers is, in order to be able to guarantee long life for their shoes, to make them so hard as to seriously impair their frictional qualities.

The Master Car Builders' Brake shoe testing machine, which has been deposited by them in the engineering laboratory of Purdue University, consists of a heavy revolving weight whose kinetic energy at any speed is equal to that of one-eighth of a loaded 60,000-pound freight car. On the same shaft as this weight and revolving with it is an ordinary car wheel. By a series of weighted levers, the shoe to be tested is pressed against the moving car wheel, thus bringing the wheel and, hence, the revolving weight to rest. When it is remembered that the freight car has eight wheels, each fitted with a brake shoe, it will be seen that the machine reproduces the conditions surrounding one-eighth of a freight car, so far as the forces involved in stopping the car are concerned. The machine provides a complicated recording mechanism by which the performance of the shoe while under test may be determined.

The present tests were undertaken to determine the effect upon the coefficient of friction of variations in three factors, viz.: The normal pressure between the shoe and the wheel, the speed of the wheel at the time the shoe is first applied, and the temperature of the rubbing surfaces. The effect of the first two variables was determined by making stops from various initial speeds and under different braking pressures, and calculating for each test the mean coefficient of friction for the stop. The limits of the variable elements under which the tests were made were as follows: Initial speed, 10 to 65 miles per hour; normal pressure, from about 2,800 pounds to about 10,700 pounds, these limits being the ones found in ordinary road service. In making a stop, the method of procedure is as follows: The weight and car wheel are brought to the desired speed of rotation by an engine. The engine is then disconnected from the revolving weight by a clutch and the brake shoe is brought in contact with the car wheel with the desired braking pressure. As the car wheel and weight are being brought to rest under the action of the brake shoe, the recording mechanism attached to the latter draws an autographic record of certain elements in the performance of the shoe, from which the mean coefficient of friction during the stop may be calculated.

The effect of the third variable mentioned above, namely, the temperature of the rubbing surfaces, was more difficult to determine. The temperature of the shoe only was observed, and this was found by imbedding in each end of the shoe the thermo-electric joint of a Le Chatelier pyrometer. This joint, in connection with a D'Arsonval galvonometer, gave continuous readings of the temperature of the face of the shoe near each end. The tests were made by making continuous runs at constant speed and noting simultaneously the temperature of the shoe and the coefficient of friction. The limits of temperature under which the tests were made were from about 60° F. to about 1500° F.

The results from the tests may be summed up as follows:

1. The coefficient of friction of brake shoes decreases with increase of pressure. The values are approximately as follows:

Soft cast-iron shoe.

Slow speed.

Pressure increasing from 2,700 pounds to 10,700 pounds.

Coefficient of friction decreasing from 37 per cent. to 20 per cent.

Soft cast-iron shoe.

High speed.

Pressure increasing from 2,700 pounds to 10,700 pounds.

Coefficient of friction decreasing from 25 per cent. to 15 per cent.

Hard cast-iron shoe.

Slow speed.

Pressure increasing from 2,700 pounds to 10,700 pounds.

Coefficient of friction decreasing from 33 per cent. to 18 per cent.

Hard cast-iron shoe.

High speed.

Pressure increasing from 2,700 pounds to 10,700 pounds.

Coefficient of friction decreasing from 17 per cent. to 12 per cent.

2. The coefficient of friction of brake shoes decreases with increase of initial speed. The values are approximately as follows:

Soft cast-iron shoe.

Light pressure.

Speed increasing from 10 to 65 miles per hour.

Coefficient of friction decreasing from 37 per cent. to 25 per cent.

Soft cast-iron shoe.

Heavy pressure.

Speed increasing from 10 to 65 miles per hour.

Coefficient of friction decreasing from 27 per cent. to 20 per cent.

Hard cast-iron shoe.

Light pressure.

Speed increasing from 10 to 65 miles per hour.

Coefficient of friction decreasing from 33 per cent. to 20 per cent.

Hard cast-iron shoe.

Heavy pressure.

Speed increasing from 10 to 65 miles per hour.

Coefficient of friction decreasing from 25 per cent. to 12 per cent.

3. The coefficient of friction of cast-iron brake shoes is practically constant with variations in temperature of shoe and wheel within the limits of the experiments.

Diamond Fluorescence.

[**Abstract.**]

By Arthur L. Foley.

A year ago I presented to the Academy an account of an experiment with a diamond and a photographic dry plate (Proceedings of Academy, 1899, p. 94). Later experiments have confirmed the theory presented. It has been found that a low temperature is favorable to the success of the experiment.

A Theorem in the Theory of Numbers.

By Jacob Westlund.

Let n be any prime number and let

$$S_k = 1^k + 2^k + 3^k + \ldots\ldots\ldots\ldots + (n-1)^k.$$

Then

$S_k \equiv 0$, mod n, when $k \not\equiv 0$, mod $(n-1)$ and $S_k \equiv -1$, mod n, when $k \equiv 0$, mod $(n-1)$.

Proof. Consider the congruence.

$$x^{n-1} - 1 \equiv (x-1)(x-2)\ldots\ldots\ldots\ldots(x-n-1), \text{ mod } n.$$

This congruence is evidently satisfied by the n — 1 incongruent numbers.

$$1, 2, 3, \ldots\ldots\ldots\ldots \ldots (n-1).$$

But the congruence is of the degree $n - 2$, since it may be written

$+ a_1 x^{n-2} - a_2 x^{n-3} + a_3 x^{n-4} \dots\dots\dots\dots - a_{n-1} - 1 \equiv 0$, mod n, where

$a_1 = 1 + 2 + 3 + \dots\dots\dots + (n-1)$

$a_2 = 1 \cdot 2 + 1 \cdot 3 + \dots\dots\dots + 2 \cdot 3 + \dots\dots\dots$

$a_3 = 1 \cdot 2 \cdot 3 + 1 \cdot 2 \cdot 4 + \dots\dots\dots$

. . . .

$a_{n-1} = 1 \cdot 2 \cdot 3 \dots\dots\dots (n-1)$.

Hence, since the number of roots of a congruence with prime modulus can not be greater than the modulus, the given congruence must be identical. Hence,

$a_1 \equiv 0$, mod n.

$a_2 \equiv 0$, mod n.

$a_{n-2} \equiv 0$, mod n.

$a_{n-1} \equiv -1$, mod n.

But from the theory of symmetric functions we have the following relations:

$S_1 - a_1 = 0$.

$S_2 - S_1 a_1 + 2a_2 = 0$.

. . . .

$S_{n-2} - S_{n-3} a_1 + \dots\dots\dots - (n-2) \cdot a_{n-2} = 0$.

$S_{n-1} - S_{n-2} \cdot a_1 + \dots\dots\dots + (n-1) \cdot a_{n-1} = 0$.

$S_n - S_{n-1} \cdot a_1 + \dots\dots\dots + S_1 \cdot a_{n-1} = 0$.

. . . .

Hence,

$S_1 \equiv 0$, mod. n.	$S_{2n-3} \equiv 0$ mod. n.
$S_2 \equiv 0$, mod. n.	$S_{2n-2} \equiv -1$ mod. n.
. . . .	$S_{2n-1} \equiv 0$ mod. n.
$S_{n-2} \equiv 0$, mod. n.	. . . .
$S_{n-1} \equiv -1$ mod. n	
$S_n \equiv 0$, mod. n.	
. . . .	

or

$S_k \equiv 0$, mod n, when $k \not\equiv 0$ mod $(n-1)$ and $S_k \equiv -1$, mod n, when $k \equiv 0$ mod $(n-1)$.

On the Decomposition of Prime Numbers in a Biquadratic Number-Field.

By Jacob Westlund.

Let

$$x^4 + ax^2 + bx + c = 0$$

be an irreducible equation with integral co-efficients, whose discriminant Δ we suppose to be a prime number. Denote the roots of this equation by $\Theta, \Theta', \Theta'', \Theta'''$, and let us consider the number-field $k(\Theta)$, generated by Θ. Then since the fundamental number of $k(\Theta)$ enters as a factor in the discriminant of every algebraic integer in $k(\Theta)$, it follows that Δ is the fundamental number of $k(\Theta)$ and

$$1, \Theta, \Theta^2, \Theta^3$$

form an integral basis, i. e., every algebraic integer α in $k(\Theta)$ can be written

$$\alpha = a_0 + a_1\Theta + a_2\Theta^2 + a_3\Theta^3$$

where a_0, a_1, a_2, a_3 are rational integers.

The decomposition of any rational prime p into its prime ideal factors is effected by means of the following theorem: If

$$F(x) = x^4 + ax^2 + bx + c$$

be resolved into its prime factors with respect to the modulus p and we have

$$F(x) \equiv \{P_1(x)\}^{e_1} \{P_2(x)\}^{e_2} \ldots\ldots \pmod{p}$$

where $P_1(x), P_2(x) \ldots$ are different prime functions with respect to p, of degrees $f_1, f_2, \ldots$ respectively, then

$$(p) = \{p, P_1(\Theta)\}^{e_1} \{p, P_2(\Theta)\}^{e_2} \ldots\ldots\ldots$$

where $\{p, P_1(\Theta)\}$, $\{p, P_2(\Theta)\}$ ..... are different prime ideals of degrees f_1, $f_2, \ldots$ respectively. (1)

In applying this theorem to the factorization of p we have two cases to consider, 1st when $p = \Delta$ and 2nd when $p \neq \Delta$.

Case I. $p = \Delta$.

Suppose

$$(p) = A_1^{e_1} A_2^{e_2} A_3^{e_3} A_4^{e_4}$$

where $A_1, A_2 \ldots$ are different prime ideals of degrees $f_1, f_2, \ldots$, respectively. Then, since the fundamental number of $k(\Theta)$ is divisible by $p^{f_1(e_1-1) + f_2(e_2-1) + \cdots}$ (1), we have

$$f_1(e_1 - 1) + f_2(e_2 - 1) + f_3(e_3 - 1) + f_4(e_4 - 1) = 1,$$

(1) Hilbert: "Bericht über die Theorie der Algebraischen Zahlkörper," Jahresbericht der Deutschen Mathematiker-Vereinigung (1894-95), pp. 198, 202.

and also

$$f_1 e_1 + f_2 e_2 + f_3 e_3 + f_4 e_4 = 4.$$

From these two relations we see, remembering that $\triangle$ is divisible by the square of a prime ideal [2], that the required factorization of p is either

$$(p) = A_1^2 . A_2 . A_3$$

where A_1, A_2, A_3 are prime ideals of first degree, or

$$(p) = A_1^2 A_2$$

where A_1 is of first degree and A_2 of second degree.

Hence the factors of F(x) are either

$$F(x) \equiv \left\{ P_1(x) \right\}^2 P_2(x) \, . \, P_3(x) \qquad (\text{mod. } p),$$

where $P_1(x)$, $P_2(x)$, $P_3(x)$ are prime functions of first degree, or

$$F(x) \equiv \left\{ P_1(x) \right\}^2 P_2(x)$$

where $P_1(x)$ is of first degree and $P_2(x)$ of second degree.

In order to find the prime ideal factors of p we have thus to resolve F(x) into its prime factors with respect to the modulus p. To do this we set

$$X^4 + ax^2 + bx + c \equiv (x + l)^2 (x^2 + mx + n) \quad (\text{mod. } p)$$
$$\equiv x^4 + (m + 2l)\, x^3 + (n + l^2 + 2ml)\, x^2 + (ml^2 + 2ln)\, x + nl^2. \quad (\text{mod. } p.)$$

Hence, for determining l, m, n we have the congruences

$$\left.\begin{array}{l} m + 2l \equiv o \\ n + 2ml + l^2 \equiv a \\ ml^2 + 2ln \equiv b \\ nl^2 \equiv c \end{array}\right\} (\text{mod. } p).$$

Eliminating m and n, we get

$$\left.\begin{array}{l} 4l^3 + 2la \equiv b \\ 3l^4 + al^2 \equiv c \end{array}\right\} (\text{mod. } p),$$

which give

$$2al^2 \equiv 3bl - 4c \quad (\text{mod. } p).$$

Having thus obtained the values of l, m, and n, we set

$$X^2 + mx + n \equiv (x + r)(x + s) \quad (\text{mod. } p)$$
$$\equiv X^2 + (r + s)\, x + rs. \quad (\text{mod. } p).$$

Hence,

$$\left.\begin{array}{l} r + s \equiv m \\ rs \equiv n \end{array}\right\} (\text{mod. } p).$$

or

$$(r - s)^2 \equiv -4\,(a + 2l^2) \quad (\text{mod. } p).$$

---

(1) Hilbert, p. 201. (2) Hilbert, p. 195.

1. If $\left(\frac{-(a+2l^2)}{p}\right) = -1$, then $x^2 + mx + n$ is irreducible and we have

$$F(x) \equiv (x+1)^2 (x^2 + mx + n) \pmod{p}$$

and hence

$$(p) = (p, \theta + 1)^2 (p, \theta^2 + m\theta + n).$$

2. If $\left(\frac{-(a+2l^2)}{p}\right) = +1$, then let $r - s = k$ be a solution of $(r-s)^2 \equiv -4(a+2l^2) \pmod{p}$ and we get r and s from the congruences

$$\left.\begin{array}{l} r + s \equiv m \\ r - s \equiv k \end{array}\right\} \pmod{p}.$$

We have then

$$F(x) \equiv (x+1)^2 (x+r)(x+s) \pmod{p}$$

and hence

$$(p) = (p, \theta + 1)^2 (p, \theta + r)(p, \theta + s).$$

Case II. $p \pm \triangle$.

In this case we have the two relations

$$f_1(e_1 - 1) + f_2(e_2 - 1) + f_3(e_3 - 1) + f_4(e_4 - 1) = 0.$$
$$f_1 e_1 + f_2 e_2 + f_3 e_3 + f_4 e_4 = 4.$$

Now since $\triangle$ is the only prime which is divisible by the square of a prime ideal, the relations given above show that p can be factored in one of the following ways:

1. $(p) = A_1 . A_2 . A_3 . A_4$ where A_1, A_2, A_3, A_4 are all of 1st degree.
2. $(p) = A_1 . A_2 . A_3$ where A_1 is of 2d degree and A_2, A_3 of 1st degree.
3. $(p) = A_1 . A_2$ where A_1 and A_2 are both of 2d degree.
4. $(p) = A_1 . A_2$ where A_1 is of 1st degree and A_2 of 3d degree.
5. $(p) = A_1$ where A_1 is of 4th degree, in which case (p) is a prime ideal.

Hence F(x) can be factored in one of the following ways:

1. $F(x) \equiv P_1(x) . P_2(x) . P_3(x) . P_4(x) \pmod{p}$.
2. $F(x) \equiv P_1(x) . P_2(x) . P_3(x) \pmod{p}$.
3. $F(x) \equiv P_1(x) . P_2(x) \pmod{p}$.
4. $F(x) \equiv P_1(x) . P_2(x) \pmod{p}$.
5. $F(x) \equiv P_1(x) \pmod{p}$.

where $P_i(x)$ is a prime function of the same degree as the corresponding A.

In order to decompose $F(x)$ into its prime factors with respect to the modulus p we set

$$x^4 + ax^2 + bx + c \equiv (x + l)(x^3 - lx^2 + mx + n) \pmod{p}.$$
$$\equiv x^4 + (m - l^2)x^2 + (n + lm)x + ln \pmod{p}$$

hence,

$$\left.\begin{aligned} m - l^2 &\equiv a \\ n + lm &\equiv b \\ ln &\equiv c \end{aligned}\right\} \pmod{p}.$$

from which we get

(1) $l^4 + al^2 - bl \equiv -c. \pmod{p}.$

A) If (1) has one solution only, then the prime factors of $F(x)$ are $(x+l)$ and $(x^3 - lx^2 + mx + n)$ and the required factorization of p is

$$(p) = (p, \theta + l)(p, \theta^3 - l\theta^2 + m\theta + n).$$

B) If (1) has two solutions l and l'. Then $F(x)$ contains two factors of 1st degree and one of 2d degree and we have

$$F(x) \equiv (x + l)(x + l')(x^2 + sx + t) \pmod{p}.$$

where

$$\left.\begin{aligned} s &\equiv -(l + l') \\ t &\equiv a - l^2 - l'^2 - ll' \end{aligned}\right\} \pmod{p}.$$

and hence,

$$(p) = (p, \theta + l)(p, \theta + l')(p, \theta^2 + s\theta + t).$$

C) If (1) has three solutions in which case it evidently must have four solutions $l, l' l'' l'''$, then

$$F(x) \equiv (x + l)(x + l')(x + l'')(x + l''') \pmod{p}.$$

and hence,

$$(p) = (p, \theta + l)(p, \theta + l')(p, \theta + l'')(p, \theta + l''').$$

D) If (1) has no solution, $F(x)$ has no factors of 1st degree. Then we set

$$F(x) \equiv (x^2 + mx + n)(x^2 - mx + n') \pmod{p}.$$
$$\equiv x^4 + (n + n' - m^2)x^2 + m(n' - n)x + nn' \pmod{p}.$$

Hence,

$$(2) \qquad \left.\begin{aligned} n + n' - m^2 &\equiv a \\ m(n' - n) &\equiv b \\ nn' &\equiv c \end{aligned}\right\} \pmod{p}.$$

If the system (2) is soluble we have

$$F(x) \equiv x^2 + mx + n)(x^2 - mx + n') \pmod{p}.$$

and hence,

$$(p) = (p, \theta^2 + m\theta + n)\ (p, \theta^2 - m\theta + n').$$

If (2) is insoluble, F(x) is irreducible and hence (p) is a prime ideal.

As an application we give a table of the prime ideal factors of certain rational primes in the number-field generated by a root θ of the equation

$$x^4 + x + 1 = 0.$$

Here $\triangle = 229$ and we get

$$(229) = (229, \theta - 75)^2 (229, \theta^2 - 79\theta - 71)$$
$$(2) = (2)$$
$$(3) = (3, \theta + 2)(3, \theta^3 + \theta^2 + \theta + 2)$$
$$(5) = (5, \theta + 2)(5, \theta^3 + 3\theta^2 + 4\theta + 3)$$
$$(7) = (7)$$
$$(11) = (11, \theta + 4)(11, \theta^3 - 4\theta^2 + 16\theta + 3)$$
$$(13) = (13)$$
$$(17) = (17, \theta - 3)(17, \theta^3 + 3\theta^2 - 8\theta - 6)$$
$$(19) = (19, \theta - 2)(19, \theta^3 + 2\theta^2 + 4\theta + 9)$$
$$(23) = (23, \theta + 4)(23, \theta + 5)(23, \theta^2 - 9\theta - 8).$$

Dissociation-Potentials of Neutral Solutions of Lead Nitrate with Lead Peroxide Electrodes.

[Abstract]

By Arthur Kendrick.

To determine if in such solutions and with lead peroxide electrodes electrolytic action takes place at voltages lower than that required for the separation of lead and lead peroxide with platinum electrodes, the method developed by Nernst[1] and Le Blanc[2] was made use of.

Two platinum wires coated with a thick, firm crust of lead peroxide were first used as electrodes. The current-potential curves obtained showed sharp bends at about 0.4 volt. To determine at which electrode the action at this voltage took place an electrode was made of a platinum wire projecting 1mm from a sealed glass tube. This point was coated with the lead peroxide before use each time. The other electrode con-

1. W. Nernst, Bericht. d. deutschen ch. Gesel. 30, p. 1547, 1897.
   L. Glaser, Zeit. für Electrochemie, 4, p. 355, 1898.
   E. Bose, Zeit. für Electrochemie, 5, p. 153, 1899.
2. LeBlanc, Zeit. für ph. Chemie, 12, p. 333, 1892.

sisted of a piece of platinum foil of several square c. m. area, coated with lead peroxide. Thus the two areas were vastly different; and nearly the whole of the polarization occurred at the point electrode, which was used successively as anode and as kathode.

When used as anode the current-potential curves showed the bend at about 0.4 volt. But used as kathode, the several curves were not in as good mutual agreement, and do not clearly indicate a particular voltage at which action at that electrode begins. The general indications are that the lead appears at a voltage considerably less than that required to separate lead on a platinum kathode, and that the peroxide is reduced. The irregularities that may mask the critical voltage seem to be due to local concentration changes around the electrode.

PbO_2 seemed to form at the anode at the voltage 0.4.

Some Observations with Rayleigh's Alternate Current Phasemeter.

By E. S. Johonnott, Jr.

This instrument in the field of alternate current measurements takes a place similar to that of the galvanometer in direct current measurements; with some advantages, and also with some disadvantages. For example, its indications may represent either current or electromotive force, and the angle of lag and true watts in a circuit may be obtained by a simple calculation. However, its indications, as in all other alternate current meters, vary as the square of the current; hence its range of sensibility is limited.

The principal feature of the instrument is the ease with which it gives the angle of lag of the current in a circuit behind the electromotive force impressed at its terminals. Also when once calibrated it gives all the quantities needed to determine the energy absorbed in a conductor.

Similar to the tangent galvanometer it consists of an iron magnet suspended in the field of the current whose value is required.

Fig. I is a horizontal sectional view of the form used by Lord Rayleigh. *M* represents the current coil, and is connected in series with the conductor on which the measurements are desired to be made. *S* represents the E.M.F. coil and is shunted across the terminals of the conductor.

Between the coils, *M* and *S*, with its center on their common axis, a piece of soft iron wire is suspended at an angle of 45° to the axis of the coils.

In the instrument with which the following observations were made, the coil *M* consisted of 72 turns of No. 22 copper wire wound in two sections having 48 and 24 turns respectively. *S* was similarly wound with No. 28 manganin wire and had a resistance of 668 ohms. Each was made adjustable along their common axis for a distance of 13 centimeters.

The needle was suspended with a fine phosphor-bronze torsion fiber. The deflections were measured with mirror and scale.

If an alternating current is sent through either of the coils, the needle becomes a magnet acted upon by a couple depending upon the instantaneous value of the current. The couple will be in the same direction whatever the direction of the current. In short, it will vary as the sine of twice the angle theta and as the mean of the square of the current values.

Since the couple varies as the sine of twice the angle theta, it will be a maximum for theta = 45°. Here also will be the position for the least sensitiveness to change in the zero.

In order to use the instrument as a phasemeter, readings of the deflection produced by the current in *M*, and the fall of potential in *S* are taken independently. Then, usually, two readings of the deflection produced by the currents in both coils simultaneously are taken—one in which both couples act in the same direction, the other when they act in opposite directions. The values of these two latter readings depend upon the angle of lag, and together with the reading for the currents, independently, give sufficient data for its computation.

The calculation may be made in two ways:

(1) Analytically.

(2) Graphically.

In the first method,

$$C_1{}^2 = A^2 + B^2 + 2AB \cos \phi$$

$$C_2{}^2 = A^2 + B^2 - 2AB \cos \phi$$ when

A^2 is the deflection with M acting independently.

B^2 is the deflection with S acting independently.

C_1^2 and C_2^2 is the deflection with M and S acting simultaneously.

ϕ may be found from either equation.

In the second method, two triangles are laid off with their sides proportional to the square roots of the readings. The angle of lag, ϕ, is given in either case as shown in Fig. II.

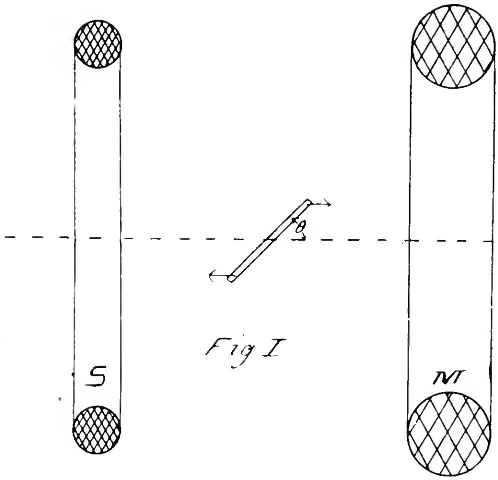


Fig I

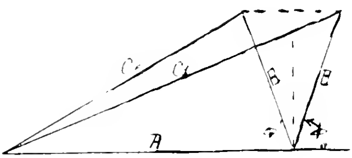


Fig II

$$C_1^2 = A^2 + B^2 + 2AB\cos\phi$$
$$C_2^2 = A^2 + B^2 - 2AB\cos\phi$$

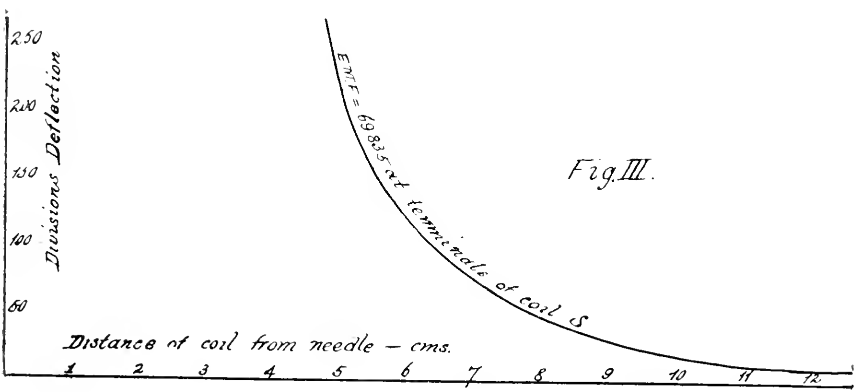


Fig. III.

Considerable range in sensibility for both coils is obtained by adjusting them at different distances from the needle. Some idea of this range may be obtained through inspection of the curve given in Fig. 3.

This was taken with the coil *S*, having a constant E.M.F. of 69.835 volts at its terminals. The abscissae represent the distances of the coil from the needle: the ordinates, the corresponding value of the deflections on the scale.

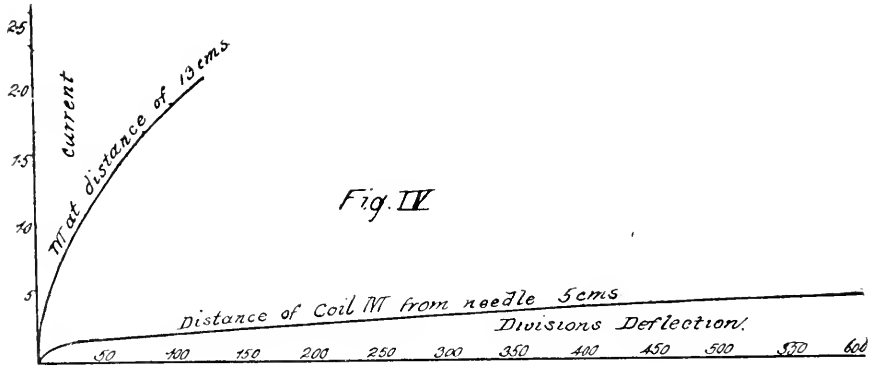
Both coils were calibrated at different distances from the needle with the Thomson balances. Fig. 4 represents curves taken with the coil, *M*, and shows no appreciable departure from the law of the squares.

In order to facilitate taking the readings, compensating coils, *M′* and *S′*, Fig. 5, were arranged in the circuit for *M* and *S* respectively, so that the conditions within the conductor on which the observations were being made remained the same when either *M* or *S* was cut out. This obviated removing either coil when the reading due to the current in the other was desired.

In Fig. 5 is shown a diagram of the connections used in making an observation for the angle of lag in a circuit which is here shown to be a coil, *X*, on a split anchor ring. *X* and *M* are connected in series in the secondary of a one-to-one transformer, in order to have no appreciable impedance in the circuit, other than *X*. The electrical conditions in this circuit were then controlled by the resistance and choking coil in the intermediate circuit. One commutator was arranged in the shunt circuit to reverse the current in *S*, another to substitute the compensating coil *S′* for *S*.

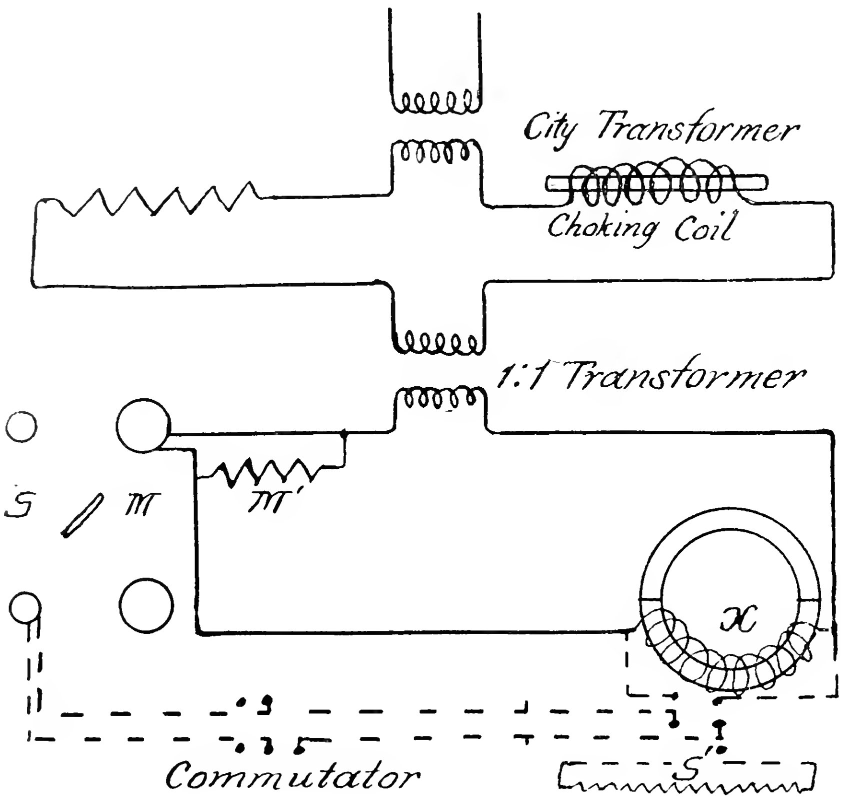
One of the greatest difficulties encountered in measurements of this character is due to unsteadiness in the source. Particularly is this true when all the readings can not be taken simultaneously. This may, however, in a measure, be overcome by arranging an auxiliary voltmeter similar to the E.M.F. coil, S, with its terminals connected across the terminals of the secondary of the city transformer. The phasemeter readings are then taken when the deflection due to their auxiliary coil is constant.

With respect to accuracy the phasemeter as a current meter is perfectly similar to the galvanometer.



current
M at distance of 13 cms
Distance of Coil M from needle 5 cms
Divisions Deflection.
2.5
2.0
1.5
1.0
.5
50
100
150
200
250
300
350
400
450
500
550
600

Fig. IV



City Transformer
Choking Coil
1:1 Transformer
S
M
M'
X
Commutator
S'

Fig. V.

Some measurements on hysteresis and the effect of iron in the magnetic circuit have been undertaken. It would, however, be too premature to take up their description at this time.

The instrument which has been described was built, largely, by Mr. Edwin Place, formerly connected with the Institute. He made many observations similar to those above recorded.

I should like to take this opportunity to thank Dr. Gray for his many suggestions and for the removal of a number of stumbling blocks.

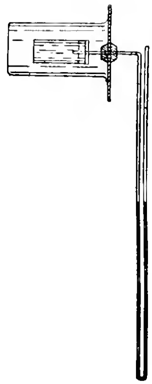
A Demonstration Apparatus.

By P. N. Evans.

The apparatus is a simple modification of that commonly used to compare, by diffusion, the density of another gas with air. It consists of a porous battery-cell placed horizontally and fitted by a stopper to a glass tube bent downwards at right angles a few inches from the stopper, and then upwards again to its original height. This U-shaped manometer is about two feet long and half filled with a dark-colored liquid; the limbs are close enough together to make a slight difference of level easily seen, against a white background fastened to the tube. To further increase the sensitiveness of the instrument a perforated glass plate or heavy card is secured between two corks on the horizontal part of the tube close to the cell, so that the cylinder or beaker of gas to be examined may be pressed lightly against this, and thus largely prevent loss of the gas before sufficient time has elapsed to show the maximum deviation in the manometer.

While the ordinary apparatus is recommended for demonstration only with gases differing considerably from air in density, this modification has given very satisfactory results with hydrogen sulphide, and even oxygen, with densities of 1.18 and 1.11 respectively, a difference in level of at least an inch being observed in the latter case. A slight effect, clearly visible to the manipulator, though not satisfactory for demonstration purposes, was obtained with nitrogen—density 0.972.

Still greater delicacy may be obtained by slanting the whole apparatus, giving the manometer a decided inclination.



Methylation of Halogen Amides with Diazomethane.*

By Jas. H. Ransom.

Since the classical work of Hofmann on the rearrangement of the halogen amides to derivatives of the isocyanates the mechanism of this reaction has been the subject of numerous investigations. Hoogewerff and van Dorp extended the work of Hofmann and pointed out the probability of a similarity in this reaction and that known as the "Beckmann rearrangement" of the oximes. After some more recent work on the brom-amides by Lengfeld and Stieglitz, the latter, with his pupils, studied the influence of the amide hydrogen atom on the rearrangement. He found that when this hydrogen was replaced by an alkyl radical no rearrangement took place in the sense of the Hofmann reaction, and suggested as the simplest and most reasonable explanation, that at some early stage of the reaction, under the influence of the alkali, the molecule

*This work was undertaken during the past summer, at the University of Chicago, in company with Dr. Julius Stieglitz.

lost hydrobromic acid, leaving monovalent nitrogen, which, by its reactivity, drew to itself the radical originally attached to carbon. As Stieglitz has pointed out, this explanation would account for the Beckmann rearrangement, and for that of the acid azides.

It seemed not without interest, therefore, to determine experimentally the position of the amide hydrogen in the halogen amide molecule. The two possible positions of this atom, R CO—N H/Cl and RC—(OH)=N Cl, correspond to the two classes of alkyl derivatives, chlor alkyl acid amides, R CO N R/Cl, and chlorimido acid esters, whose properties are now known. But the fact that the salts of such a molecule may have a different constitution from that of the free acid would make quite uncertain any conclusions drawn from the results obtained from the usual methods of introducing an alkyl radical.

Von Peckmann has shown that substances of an acid character react readily with diazomethane, forming a methyl derivative of the substance, the methyl entering where the hydrogen was attached. As the reaction is carried out with the free acid in absolute ethereal solution the probability of a rearrangement of the molecule during the process of methylation is reduced to a minimum. Ransom has shown, also, in two cases, that this method of methylation can be used to advantage in deciding delicate questions of constitution.

With these ideas in view, the following work was undertaken: Benzchloramide is best made by adding a solution of chloride of lime to a cold saturated solution of benzamide, which had previously been acidified with acetic acid, and extracting the oil which is formed with ether. On drying the ethereal solution with calcium chloride and evaporating the ether in vacuo without heating, a crystalline residue results which after recrystallizing from benzol was found to be 98.1 per cent. pure. The purity was determined by finding the percentage of active chlorine in the substance, by adding potassium iodide to a dilute alcoholic solution and titrating the free iodine with sodium thiosulphate. An ethereal solution of diazomethane was then prepared and some of the benzchloramide, suspended in a little ether, added to it until the yellow color of the diazomethane had nearly disappeared. Nitrogen was evolved in large quantities. When the action had ceased the ether was evaporated and there was left an oil with a peculiar but not unpleasant ethereal odor. The oil did not solidify even in a freezing mixture. Some of it was dissolved in ligroin and dry hydrogen chloride passed into the solution.

Chlorine was evolved and a white solid separated which was very soluble in water. The aqueous solution after standing some time gave off a distinct odor of benzoic ether ($C_6H_5COOCH_3$). Caustic soda separated from the solid an oil which had the characteristic odor of benzimido ether ($C_6H_5C{\scriptsize \begin{matrix}-OCH_3\\=NH\end{matrix}}$). A quantity of the salt was heated in a bath to 118°. A gas (CH_3Cl) was evolved which burned with a green flame, and in the tube there remained a crystalline substance which proved to be benzamide. Some of the methylated chloramide was suspended in water and reduced with hydrogen sulphide. When the oil had become dissolved the solution was poured from the free sulphur and distilled with a concentrated solution of caustic soda, the distillate being collected in hydrochloric acid. This distillate was evaporated to dryness, and the residue extracted with absolute alcohol. Very little dissolved in the alcohol and no trace of methyl amine could be detected, nor of aniline by using either the delicate Jacquemine test or the isocyanide reaction. The properties of this substance therefore and its reactions correspond in every detail with what would be expected from the constitution,

$$C_6H_5C{\scriptsize \begin{matrix}-OCH_3\\=NCl\end{matrix}}$$

Besides, benzchloramide is a fairly strong acid, as its alcoholic solution can be titrated against standard caustic alkalis, using either phenolphthalein or litmus as indicator. This acidity is not due to hydrolysis, thus forming free hydrochloric acid, since it gives with silver nitrate, even on standing, only a trace of silver chloride. A solution of the substance therefore contains hydrogen ions, a thing not to be expected on the supposition of an amide hydrogen. We may conclude therefore that benzchloramide contains an hydroxyl group.

Attempts were made to extend the investigation to other amides, viz., m—nitrobenzamide and anisic acid amide. The chloramide of the former however was found to be so unstable even at 0° that work on it was discontinued for the time. Anisic acid chloramide is also unstable, but at —5° enough of it was obtained to try the action of diazomethane upon it. The bleaching powder method was the one used to make the chloramide, but it always contained some of the dichloride, which was then converted into the monochloride by dissolving in caustic soda and reprecipitating it with acetic acid. As the least excess of acid decomposes it completely, the yields are very poor. A small amount of the substance, about 90 per cent. pure, was methylated as described above.

An oil was obtained which, when dry hydrogen chloride was passed into its solution, evolved chlorine, and deposited an oily solid salt. At 115°-120° it lost methyl chloride and there remained a crystalline substance which, however, was not the amide and contained chlorine. This was saponified with caustic soda, but the acid formed melted at 205°-210° and still contained chlorine. It is evident that at some stage the benzene ring became chlorinated. But the fact that methyl chloride was evolved on heating indicates that the methyl was united to oxygen.

A little preliminary work was done with the brom-amides, they being more easily prepared pure than the corresponding chlor derivatives. While the results were not conclusive, they indicated that either methylation occurred on the nitrogen atom or that a rearrangement of the amide to the amine had taken place. For a distinct isonitril odor was observed when the saponified product was boiled with chloroform and caustic potash. Besides when m-nitro benzbromamide was methylated a substance was obtained with quite different properties from those in the former cases. It contained a large amount of bromine, though almost inactive. A small amount of the substance gave a distinct test for formaldehyde (resorcin and sulphuric acid). This might indicate that a molecule of the brom amide had added itself to the methine (CH_2) group, thus:

$$R\,Co\,N{\begin{matrix}H\\Br\end{matrix}} + CH_2 = R\,Co\,NH - CH_2\,Br.$$

This on saponification would give a derivative of formaldehyde and would contain inactive bromine.

The work will be extended in this and other directions as soon as opportunity offers.

Note on the Apparent Deterioration of Formalin.

By Thomas Large.

Attention of chemists and naturalists is called to the following facts: A stock of formalin, purchased from a prominent firm, for 40 per cent. formaldehyde, was kept at the Biological Station of Illinois for three years, where it was subjected to winter temperatures. When temperature was low a precipitate of white paraform (?) appeared, and was redissolved with higher temperatures. In the past summer some difficulty was experienced with it in preserving larger fishes in warm weather. A sample of the formalin was submitted to Dr. Palmer, Professor of Chemistry in the University of Illinois, for examination. The following is his report on it: "We find that it contains 38½ per cent. of formic aldehyde. This is practically the quantity that is supposed to be contained in commercial formalin, i. e., 40 per cent. formic aldehyde. I find that nearly one-half of the formic aldehyde is polymerized, i. e., about 18½ per cent. is in the form of the polymer tri-oxymethylene. I am not sufficiently familiar with the use of the formalin as a preservative to be able to state whether this polymerization will interfere with the use of the formalin as a preservative, but would suggest that possibly the formalin has proved unserviceable because nearly half of the constituent which is expected to do the work is in the form of the polymer, and probably unserviceable."

Notes on the Examination of Vegetable Powders.

By John S. Wright.

[Abstract.]

Brief accounts were given of the methods employed in preparing vegetable powders for microscopical studies, especially through the use of clearing and other microchemical reagents. References were made to the work previously done along this line and to the literature of the subject. Histological characters of vegetable powders were discussed, particular attention being paid to the value of the microscope as a means of identifying and detecting adulterations in granulated and powdered drugs and spices.

The Staining of Vegetable Powders.

By John S. Wright.

[Abstract.]

The use of differential stains to aid in the study of the histological elements of vegetable powders is in many instances important. If in

the study of a powder it may be stained differentially to correspond with the staining which can be employed upon various sections made of the original crude material, it becomes much easier to refer the minute granules and fragmentary elements to the tissues from which they originated.

There are two ways by which we may produce differentially stained powders for microscopical examination. The first and simplest is to make thick (½-¼mm) transverse sections of the tissues to be studied. These may then be stained in the usual manner, after which they are triturated in a mortar to a No. 60, 80 or 100 powder, as the case requires. Such powders are differentially stained in a satisfactory manner, but the fragments and cell masses often show truncated ends, due to sectioning, which are not found in powders produced wholly by grinding.

While the above process is an aid to the proper understanding of powders it is not of direct service in the great number of cases in which the microscopist is required to determine the identity and purity of powders. In such instances any staining method to be of service must enable the operator to differentially stain the powders directly. This may be accomplished by placing about ¼ or ½ gm. of the powder in a glass tube (50 to 60mm long and 10 to 15mm in diameter), one end of which has been closed by tying over it a piece of closely woven white silk cloth. Resting on this cloth bottom the powder may be treated with the various bleaching fluids, washed, double stained, dehydraded and cleared for mounting by allowing the tube to stand in watch glasses into which the stains and reagents have been poured. In this way a number of powders each in a separate tube may be treated at the same time. Owing to the great capillarity of fine powder it may often be necessary to promote the drainage and washings by blowing on the free end of the tube with the mouth; in this way it is possible to make rapid transfers from one reagent to another.

Cryptogamic Collections Made During the Year.

By M. B. Thomas.

During the past year some very interesting collections of cryptogams have been made in the local flora of Montgomery County.

These have been studied with special care and added to our already very complete list of the plants of the local flora. Very careful notes have been secured as to the distribution, variations and other important questions connected with the plants as collected.

During the early part of the year, in connection with the work in forestry, a collection was made of the fungi injurious to timber in our locality. The number of species was not as large as could reasonably be expected, and it seems that most of the devastation by fungi in our native forests is produced, in the main, by a very imited number of species.

Some additions have been made to our list of algae and a few to the collection of mosses. The latter list now includes 39 species.

Our most important contribution to the State flora is in the slime moulds.

During the past summer two students, Messrs. H. H. Whetzel and A. A. Taylor, devoted much time to this group. The result is an addition of 31 species to our list presented to you two years ago by Mr. Olive. This now gives us a total of 77 myxomycetes in Montgomery County. In addition to this we now have on hand some material not yet worked over, and doubtless several species in this are not included in our list. This is all the more interesting when we consider that our county is not particularly adapted to these forms of plant life and that the number reported is nearly two-fifths of the whole number found thus far in the United States.

The additions to the list are as follows. The classification used is the one presented by Lister in his Mycetozoa.

Order *Ceratomyxaceae.*

Ceratomyxa mucida Schroet.

Order *Physaraceae.*

Plysarum polymorphum var. *obrusseum* Rost.

Physarnm calidris Lister.

Physarum newtoni Macbride.

Physarum compactum Lister.

Physarum globuliferum Pers. (Bull).

Physarum galbeum Wingate.

Chondrioderma spumarioides Rost.

Order *Didymiaceae.*

Didymium dubium Rost.

Didymium farinaceum Schrader.

Order *Stemonitaceae.*

Stemonitis tenerrima B. and C., Morg.

Stemonitis smithii Macbride.

Stemonitis webberi Rex.

Stemonitis confluens Cook and Ellis.

Comatrichia obtusata Preuss.

Comatrichia persoonii Rost.

Comatrichia laxa Rost.

Lamproderma arcyrionema Rost.

Order *Reticulariaceae.*

Enteridium rozeanum (Rost) Wingate.

Order *Heterodermaceae.*

Lindblandia tubulina Fries.

Order *Lycogalaceae.*

Lycogala exiguum Morg.

Lycogala flavo-fuscum Rost.

Order *Arcyriaceae.*

Arcyria incarnata Pers.

Arcyria oerstedtii Rost.

Arcyria digitata (Schw) Rost.

Arcyria ferruginea Sauter.

Arcyria cinerea (Bull) Pers.

Order *Trichiaceae.*

Hemitrichia intorta Lister.

Hemitrichia karstenii (Rost) Lister.

Trichia rubiformis Pers.

Experiments with Smut.

By M. B. Thomas.

On two previous occasions I have reported to the Academy some special progress made with experiments with formalin as a fungicidal agent.

The first report included the results of a series of experiments upon the effects of formalin in different strengths of solution, with varying periods of time, on the germinating power of a number of cereals.

The second report was the result of a practical field experiment based on the facts discovered by the earlier investigations. The conditions of this field experiment were not as trying or severe as might be desired, and although the results were highly gratifying, yet they did not seem as conclusive as we could wish. Accordingly, the past summer, another field experiment, on a somewhat larger scale, was tried in a part of the State where the smut of oats has been very destructive.

The trial was conducted on the farm of Chas. Baker, Noble County.

The last week in April three acres of oats were sown in three plats, the seed being treated respectively 40, 60 and 90 minutes in a solution of one part of commercial formalin to 200 parts of water. The seed was scattered broadcast without drying. Alongside of these areas was sown a field of untreated seeds. All of the seed used was from a previous crop of smutty oats that was very much infested.

No difference was noted in the time of germination of the several lots, but the treated seeds produced plants that were more uniform and better developed than those from the untreated ones.

At the time of cutting the difference between the two fields was very striking. Fully 15 per cent. of the heads of the untreated seeds were smutty, while not one stalk of the plants from the treated seeds showed any signs of smut. The whole experiment was conducted by the owner of the place from directions and material furnished by the department and the results were examined by one of our students. Of the three separate lots of treated seeds the ones soaked for 60 minutes seemed to be the best, and that time is recommended as safe and efficient for treatment. Comment on this experiment is unnecessary, and it is hoped that these facts may increase the use of this fungicide to the improvement of our production of oats

The Flora of Lake Maxinkuckee.

By J. T. Scovell.

Lake Maxinkuckee is situated in Marshall County, Indiana. It occupies parts of sections 15, 16, 21, 22, 27, 28 and 34 of Township 32 north of Range 1 east of the second principal meridian. The lake is a little more than two and one-half miles long from north to south and about one and one-half miles wide, having an area of nearly 1,900 acres. The surface of the lake is about 735 feet above tide. It is 150 feet above Lake Michigan, but 130 feet below the summit of the divide between Lake Michigan and the Wabash River. The lake is 15 feet above the Tippecanoe River five miles south, and about 75 feet above English Lake, 20 miles west. These elevations show that the lake is on a slope that descends gently toward the south and west. The lake is near the southwestern angle of the Saginaw moraine. The country about the lake is quite varied. There are hills and valleys, broad undulating plateaus, wet marshes and boggy swamps. The soils are sand, gravel, boulder, clay and swamp muck. There are more hills and clay and boulders on the east, more sand and gravel, more marshes and swamps on the west. On the east the surface rises somewhat abruptly to a general level of 75 or 80 feet above the lake, some hills reaching an elevation of about 140 feet. On the west there is a narrow divide 25 to 30 feet above the lake, then low land and swamp. The confused mingling of sand, gravel, clay and boulders, the irregular hills and the numerous kettle holes indicate that the surface features about the lake are of glacial origin. Just east of the center of the lake there are 15 or 20 acres of water that is from 85 to 90 feet deep. This deepest water is part of some 300 acres of deep water that forms the central portion of the lake. Fully one-half the area of the lake is shallow, the water being ten feet or less in depth.

Wells drilled from 75 to 150 feet through sand, gravel and clay, without reaching bed rock, indicate that the lake bed is wholly composed of morainic materials. In fact it seems to occupy a cluster of kettle holes, one long and deep, surrounded by several of lesser size and depth. The region drained into the lake is quite limited, being scarcely more than three times its area. "The Inlet" enters the lake from the southeast, Aubeenaubee Creek from the east, and Culver Inlet, with one branch from the north and one from the east, enters the northeastern part of the lake. These four streams, each rising within two miles of the lake, each largely fed by springs, are the principal inlets. Several very small streams, the outlets of springs, bogs, flowing wells and little swamps, contribute something to the waters of the lake. "The Outlet" is a sluggish stream which flows from the west side of the lake southerly into the Tippecanoe River. About 80 rods from the lake the outlet expands into a pond or lake, having an area of about 60 acres. This body of water is shallow, at no place more than 12 feet deep. The greater part of its bed is muddy, and two-thirds of its outline is marshy. The ordinary variation in the level of the lake during the year is less than two feet. Such variation does not materially change the area of the lake or appreciably modify the various forms of life that inhabit its waters.

Perhaps one-eighth of the outline of the lake is low ground, marshy, swampy or boggy. But in general the muck or black mud is shallow, seldom more than two or three feet in depth, and it rests on a bed of hard sand or gravel. From the shore out to a depth of six or eight feet the lake bed is of hard sand or gravel, even along the low ground. At the mouths of the southeast and northeast inlets there are considerable areas of shallow mud over the sand, and at the mouths of the lesser inlets there is always a little soil. But for long distances along the steep banks of clay or gravel there is no fine soil, just sand or gravel. On the north, west and south this bed of sand and gravel supports an abundant growth of Chara, which is generally of small size and thickly crusted with calcic carbonate. This bed is also the home of immense numbers of bivalve mollusks. The chara and shells of dead mollusks yield considerable quantities of calcic carbonate. At first one would expect to find this material making deposits over the bed of this shallow water. But this calcic carbonate and other fine material is swept away and deposited in deeper water, where it helps to form the extensive marl beds of the lake. During the summer there are more winds from the east than from any other quarter, but during the year there are more westerly winds, and in general the westerly winds are stronger. There are also many northerly winds and many southerly winds, so that during the year there are numerous winds from each quarter. These winds pile up the water along the shores toward which they blow. This causes more or less of an undercurrent toward the deep water which carries with it all the fine material of the shallower water. As the westerly winds are more numerous and stronger these undercurrents are stronger on the east, carrying the fine material into deeper water, the marl beds commencing in eight to ten feet of water instead of in six to eight feet of water as on the other sides of the lake. The marl forms a rich soil which shades off into darker material under deeper water. During the winter ice forms to a thickness of from 15 to 25 inches. As the ice expands it crushes against the banks with great force. Where the shores are low the ice often pushes great quantities of sand and other materials up into ridges, sometimes two or three feet high. These ridges or ice beaches are generally washed away by the high water common in spring, but sometimes they remain, making a distinct and somewhat peculiar plant region. Along the steep banks, the boulders that have fallen to the beach during the summer are crowded against the bank by the ice, making in some places quite extensive stone walls. With such a variety of soils as occur in and about Lake Maxinkuckee, a varied flora may be expected. In the waters of the lake there are great quantities of microscopic life, called *plankton*. Of the microscopic plants, protococcus, rivularia, oscillaria, diatoms, desmids and others are common everywhere in the open lake, but were most abundant among the higher vegetation along the shores. Occasionally rivularia would occur in such quantities as to be conspicuous to the naked eye. Spirogyra, vaucheria, oedogonium, hydrodiction, stigeoclonium, nostoc, cladophera, zygnema, chetophora, and others often occurred in masses in the shallow water. Chara and nitella were very abundant.

Nitella sp? A tall, slender plant, was abundant between 18 and 22 feet, ranging from 12 to 25 feet. In water from 20 to 25 feet deep we seldom found anything beside nitella.

Nitella sp? A small, delicate plant found in shallow water, common in the marshes and in the lake out to a depth of two feet.

Chara sp? A slender, rank-growing plant quite free from lime. Was abundant between 10 and 14 feet, ranging from eight to 24 feet. In some localities this chara was the only plant found between 10 and 14 feet.

Chara sp? A stout plant, seldom more than eight inches high, was thickly coated with lime. It was most abundant at a depth of from eight to 10 feet, often forming a thick mat of vegetation to the exclusion of other plants.

Chara sp? Much smaller than the above mentioned, quite abundant in shallow water, often the only vegetation. It was usually thickly coated with lime.

There are doubtless other species of chara and nitella about the lake, but the ones mentoned are the most abundant.

Potamogeton natans L. This plant was more common in the southwestern portion of the lake, growing in water from four to six feet deep.

P. amplifolius Tuckerm. This plant was abundant in water from five to eight feet deep, but ranged from two to 24 feet. On the Sugar Loaf bar, it was abundant and rank from nine to 24 feet.

P. lonchites Tuckerm. This pond-weed was common everywhere in shallow water. A cluster of rank potamogetons growing in eight to ten feet of water on Weed Patch bar I called lonchitis, but do not feel quite sure that I was correct.

P. heterophyllus Schreb. This plant was quite common out to a depth of four feet.

P. lucens L. This plant, sometimes called perch weed, was widely distributed, growing most commonly in water from six to eight feet deep.

P. praelongus Wulf. Not very common, growing in water from eight to 12 feet deep.

P. perfoliatus L. Not common, but quite abundant in a few localities in the south part of the lake. More common in water from eight to 12 feet deep.

P. zosteraefolius Schum. Quite common. More abundant between 10 and 16 feet, but ranging from two to 26 feet.

P. friesii Ruprecht. Widely distributed, more abundant between 12 and 16 feet, but ranging from eight to 25 feet.

P. pusillus L. More common in the southeastern portion of the lake in deep water, ranging from 10 to 24 feet.

P. pectinatus L. Forming thick masses, excluding other vegetation in water 10 to 16 feet deep, also in shallow water one to three feet deep. It often stands at the head of a steep slope.

P. robbinsii Oakes. Very common in the shallow waters of the Little Lake, but in the large lake more common in water from 10 to 18 feet deep, ranging from two feet to 24 feet.

Naias flexilis (Willd) Rost and Schmidt. Very abundant, ranging from one to 24 feet. Most common in the northeastern part of the lake.

Naias flexilis robusta Morong. This plant, while not common, was found in several localities

Sagittaria graminea Michx. In the shallow water of the Little Lake.

Philotria canadensis (Michx.) Britton. Very abundant in a few localities in shallow water, as near the head of the outlet. It is widely distributed in deep water, ranging from one to 22 feet.

Vallesneria spiralis L. Called Eel-grass. Said to be the wild celery of Chesapeake Bay. The plants bearing pistillate flowers grow in shallow water. I saw none deeper than two or three feet. The male plant was most abundant in water from eight to 18 feet deep. We found it as deep as 24 feet. The pistillate flower is carried to the surface of the water by a long thread-like scape. After fertilization the scape forms a spiral of several coils, drawing the ovary several inches under water, where the seeds ripen. The staminate flower has a short peduncle. When the pollen is mature, the flower separates from the plant and rises to the surface. The pollen, escaping from the anther, floats away to the pistillate flowers. The buds or stolons formed in the fall, on the male plant, are highly prized by mud hens and ducks as food. They will dive 10 or 15 feet for it. The shores are often thickly covered with the leaves they break off while getting these dainty bits of food.

Eleocharis interstincta (Vahl.) R. and S. In shallow water in both lakes, often forming large patches.

E. mutata (L.) R. and S. Abundant in shallow water near the mouth of the southeast inlet.

E. palustris (L.) R. and S. Found along the southern shore of Lake Maxinkuckee.

Scirpus americanus Pers. Common in the shallow water of both lakes.

S. lacustris L. Common in the western and southern portions of the lake out to a depth of seven or eight feet. Specimens from 10 feet to 13 feet long often occur.

Spirodela polyrhiza (L.) Schleid. Common in quiet waters about the lake shores.

Lemna trisulca L. Common in the outlet and in the southeastern inlet.

L. minor L. Often found with *Spirodela*.

Wolffia columbiana Karst. In the southeastern inlet and in the outlet.

Eriocaulon septangulare With. In Lake Maxinkuckee, but not common.

Brasenia purpurea (Michx.) Casp. Very abundant in the outlet, only occasionally found in the lake.

Nymphaea advena Soland. Common.

Castalia odorata (Dryand) Woods and Wood. Abundant in the outlet and in the Little Lake. Only occasionally found in the larger lake.

Ceratophyllum demersum L. Common everywhere to a depth of 21 feet.

Abundant in shallow water and quite plentiful between 14 and 20 feet.

Batrachium trichophyllum (Chaix.) Bossch. Abundant in the southeastern part of the Little Lake.

Roripa nasturtium (L.) Rusby. Abundant in the northeastern inlet and in other places.

Myriophyllum spicatum L. Abundant in the Little Lake and in the outlet. In water from two to eight feet deep.

Myriophyllum verticillatum L. Found in both lakes. Not deeper than 14 feet.

Utricularia purpurea Walt. In the outlet.

U. vulgaris L. In the outlet and Little Lake.

U. intermedia Hayne. In the outlet and Little Lake.

U. minor L. In the Little Lake and outlet.

U. gibba L. In the outlet.

U. biflora Lam. In the Little Lake.

Bidens beckii Torr. Found in both lakes. Not very abundant, but ranging from two to 20 feet in depth.

Peltandra virginica (L.) Kunth. Found in shallow water of both lakes, often in the mud along shore.

Pontederia cordata L. Common in shallow water of both lakes, often above water line along shore. Both of these plants, after fertilization, bend over, thrusting the ovary into the water or mud, where the seeds ripen.

On the marshes below the level of high water we found—

Dryopteris thelypteris (L.) A. Gray.

Equisetum fluviatile L.

Typha latifolia L.

Alisma plantago-aquatica L.

Sagittaria latifolia Willd.

Dulichium arundinaceum (L.) Britton.

Eleocharis ovata (Roth) R. and S.

Scirpus smithii A. Gray.

Acorus calamus L.

Xyris flexuosa Muhl.

Juncus effusus L.

Salix discolor Muhl.

Polygonum sagittatum L.

Decodon verticillatus (L.) Ell.

Mimulus ringens L.

Lobelia syphilitica L.

Cephalanthus occidentalis L.

Nyssa sylvatica Marsh.

Polygala cruciata L.

Spiraea tomentosa L. And more than sixty others, largely sedges and grasses.

In addition, along the beach, between low and high water, we found—

Panicum crus-galli L.

Muhlenbergia sylvatica Torr.

Cyperus diandrus Torr.

Polygonium pennsylvanicum L.

Impatiens biflora Walt.

Teucrium canadense L.

Lycopus virginiana L.

Mentha piperita L.

Mentha canadensis L.

Xanthium canadense Mill

Eclipta alba (L.) Hassk.

Bidens connata Muhl. And more than fifty others. In all making over two hundred plants in and about Lake Maxinkuckee growing below high water mark.

I desire to call attention specially to the following facts: First, that the bed of the lake is comparatively barren under water from two feet to six or eight feet deep; second, that there is an abundance of rank vegetation under water from eight feet to 20 feet deep; third, that we found no vegetation below a depth of 26 feet in Lake Maxinkuckee.

Generic Nomenclature of Cedar Apples.

By J. C. Arthur.

In a communication made to this society at a former meeting (December, 1898) the writer gave some account of recent studies in the nomenclature of plant rusts, especially as applied to species occurring in the State of Indiana.* At that

*Arthur, J. C.—Indiana plant rusts, listed in accordance with latest nomenclature. *Proc. Ind. Acad. Sci. for 1898:* 174–186.

time no extended study of the generic nomenclature of this group of fungi had been attempted, and the conclusions of Dr. Kuntze (*Rev. Gen. Pl. III*) were accepted as the most satisfactory at hand. Since then the ground has been gone over to some extent, and some questions worth public discussion have arisen. Among the most interesting of these is the correct appellation of the cedar apples.

Two species of cedar apples occur in Indiana; both forming swellings, or pseudo-apples, on the branchlets of red cedar in one stage of growth, and so-called rust spots on the leaves of various apples and thorns in the alternate stage. These were placed under the genus *Puccinia*, following the authority of Dr. Kuntze, one being *Puccinia globosa* (Farl.) Kuntze (*Gymnosporangium globosum* Farl. and *Roestelia lacerata* Fr.), and the other being *Puccinia Juniperi-Virginianæ* (Schw.) Arth. (*Gymnosporangium macropus* Lk. and *Roestelia pyrata* Thax.).

The development of the concept, now embodied in the genus containing the cedar apples and apple rusts, is an interesting one. Many of the earlier systematists placed the cedar apples among the algæ, and even after becoming fully recognized as fungi, it was long before their close relation to the other *Uredineæ* was firmly established. The apple rusts have been confounded with the cluster-cups of other genera, even quite recently, although it has now been nearly forty years since their connection with the cedar stage was first established. However, it is not with the development of the concept of the genus that this paper has to deal, but with the unfolding of its nomenclature.

Reviving the ancient usage of the generic name *Puccinia* in order to have it replace the familiar name *Gymnosporangium* was done in the interest of a stable nomenclature. The result shows, however, that a stable nomenclature is not to be obtained at a single dash, even when the principles are recognized and accepted that are to govern the procedure. Dr Kuntze (*Rev. Gen. Pl.*, Vol. 3, p. 507) gives Haller, 1742 (*Enum.*, Vol. 1, p. 17), the credit of founding the genus *Puccinia*, but Magnus (*Bot. Centr*, Vol. 77, p. 4) has clearly shown that Haller's type material could not have belonged to the *Uredineæ*. The next subsequent author mentioned by Kuntze is Adanson, 1763. In accordance with the Rochester Code, Haller is excluded from consideration on account of antedating 1753, the initial date for priority, but Adanson might be accepted. This author presents an abbreviated diagnosis derived wholly from Micheli's classical work *Nova Plantarum* of 1729. It runs as follows: "*Puccinia* ***Mich.*** *t.* 92. *Tige élevée cilind, simple ou rameuse. Coriace. Toute la plante est formée de piramides ou filets en massues, couchés comme autant de rayons les uns sur les autres*" (*Familles des Plante*, Vol. 2, p. 8). Turning to Micheli, we find that he describes and figures two species under his genus, one evidently belonging to the *Uredineæ* and the other not. According to Magnus this lack of singleness invalidates the name for replacing that of the De Candollean genus *Gymnosporangium.* It does not do so, however, in the writer's opinion, but it makes it necessary to decide which of the two species included is to be accepted as the type of the genus.

The idea of definite and unchangeable types is of comparatively recent growth. The type of a species is the individual plant to which the name is first given, and the type specimen is therefore an important adjunct in fixing the name and character of the species. In like manner the type of a genus should be the species mentioned under it, if there is but one given, but if more than one be given, and the author has neglected to designate the one to be accepted, it would seem to require for the sake of uniformity and stability that the first species named under the genus be assumed to be the type. This method in whole or in part has been ably advocated by Underwood, Cook, Jordan, Coville, Ward, Greene and others. Up to the present time it has been put into rigid practice to a limited extent only, the revision of American ferns by Prof. Underwood being the most conspicuous example, but it seems to the writer that the general acceptance of the rule will go far toward furnishing a stable basis for taxonomic nomenclature. To one who has watched the course of the present movement for a nomenclature that stands squarely upon priority, guided by uniform procedure rather than by individual judgment, the rule of types here set forth must seem a necessity that will inevitably be adopted sooner or later. It is for the sake of lending a hand in bringing about so desirable an end that the study of the cedar apple nomenclature is here presented.

If the rule of taking the first species mentioned under a genus as its type is applied, there can be no question that Adanson's genus *Puccinia* is to be accepted as a name antedating *Gymnosporangium*, and we may waive the discussion of the exact determination of the type, brought forward by Magnus. But this does not settle the matter.

In Linnaeus' *Species Plantarum* of 1753, which is accepted as the beginning of valid nomenclature, only two species occur belonging to the *Uredineæ* ; one is *Lycoperdon epiphyllum*, now called *Puccinia epiphylla* (L.) Wettst., and the other is *Tremella juniperina*, known to be unquestionably *Gymnosporangium juniperinum* (L.) Wint. Linnaeus' genus *Tremella* contains seven species, the one just mentioned being the first, while the six which follow do not belong to the *Uredineæ*. The first species is characterized as follows (p. 1157) :

> "Tremella sessilis membranacea auriformis fulva. *Fl. suec.* 1017.
> Byssus gelatinosa fugax, junipero innascens. *Fl. lapp.* 531.
> Habitat in Juniperetis primo vere."

Turning to Linnæus' flora of Sweden (*Fl. suec*, 1745, p. 368), where this species is the first named under the genus *Tremella*, and to his flora of Lapland *Fl. lapp.*, 1737, p. 370), it will be found that these lines are the descriptive names used in those works respectively, both works antedating the introduction of binomial names.

In Engler & Prantl's *Nat. Pflanzenfamilien* (Vol. 1, p. 92) Lindau has credited the genus *Tremella* to Dillenius, as has also Saccardo in his *Sylloge Fungorum* (Vol. 7, p. 780). Both these authors undoubtedly are following Fries in his classical work, *Systema Mycologicum*, of 1823 (Vol. 2, p. 210). The reference is clearly to Dillenius' *Historia Muscorum* of 1741, where we find seventeen species listed under *Tremella*, but strangely enough not one of these is a fungus. The first species, which we must consider the type, is characterized as "*Tremella marina vulgaris, Lactucæ similis*, Oyster Green or Laver." This is certainly a marine alga. In Linnæus' *Species Plantarum* of 1753 (p. 1163) we will find this species given, with direct citation of Dillenius, under the name *Ulva Lactuca*, as the fifth of the nine species under the genus *Ulva*. It is certainly evident that Linnæus did not found his genus *Tremella* upon that of Dillenius, and that the twenty or more species of fungi now generally listed under *Tremella* as a Dillenian genus are not correctly referred.

It seems certain, if the method of types is accepted, that *Tremella* replaces *Gymnosporangium* as a genus of *Uredineæ*, and that the usage to which the name has generally been applied by modern systematists is erroneous. The same method of procedure shows eight generic synonyms of *Tremella*, which will be given without further comment, together with their type species and their respective hosts.

There are fifteen described species of cedar apples, of which eight occur exclusively in North America, two in both North America and Europe, three wholly in Europe, one in India and one in China and Japan. In order to show their status in the genus *Tremella*, and also for convenient review, they are here listed.

1753. TREMELLA *Linnæus.*

(*T. juniperina* on *Juniperus sp.*)

1763. *Puccinia* Adans. (*P. non ramosa* Mich. on *Juniperus sp.*).
1791. *Æcidium* Pers. (*Æ. cornutum* on *Sorbus aucuparia*).
1804. *Rœstelia* Reb. (*R. cancellata* on *Pyrus communis*).
1805. *Gymnosporangium* Hedw. f. (*G. conicum* on *Juniperus communis*).
1809. *Podisoma* Lk. (*G. fuscum* DC. on *Juniperus sp.*).

1826. *Centridium* Chev. (*C. Sorbi* on *Sorbus aucuparia*).

1826. *Ciglide* Chev. (*C. calyptratum* on *Pyrus communis*).

1877. *Hamaspora* Kœrn. (*H. Ellisii* on *Cupressus thyoides*).

1753. T. JUNIPERINA *L.* (Sp. plant. : 1625) Europe and North America.

I. On Sorbus, Aronia and Amelanchier. (*Rœst. cornuta* (Pers.) Fr.)

III. On Junip. communis and J. nana (*Gym. juniperinum* (L.) Wint.)

1785. T. SABINÆ *Dicks.* (Pl. Crypt. Brit. : 14.) Europe.

I. On Pyrus. (*Rœst. cancellata* (Jacq.) Reb.)

III. On Junip. Sabina and other sp. (*Gym. Sabinæ* (Dicks.) Wint.).

1788. T. CLAVARIIFORMIS *Jacq.* (Collect. **2** : 174.) Europe and North America.

I. On Cratægus (*Rœst. lacerata* (Sow.) Mer.)

III. On Junip. communis. (*Gym. clavariiforme* (Jacq.) DC.)

—— T. PENICILLATA (*Müll.*) *n. n.* (1780. *Lyc. penicillatum* Müll. Fl. Dan. t. 839.) Europe.

I. On Malus and Sorbus (*Rœst. penicillata* (Müll.) Fr.)

III. On Junip. communis. (*Gym. tremelloides* A. Br.)

—— T. MESPILI (*DC.*) *n. n.* (1815. *Æcid. Mespili* DC. Fl. France. **6** : 98.) Europe.

I. On Mespilus, Cydonia, Pyrus and Cratægus (*Rœst. Mespili* (DC.).

III. On Junip. Sabina (*Gym. confusum* Plowr.)

—— T. JUNIPERI-VIRGINIANÆ (*Schw.*) *n. n.* (1822. *Gym. Juniperi-Virginianæ* Schw. Schr. Nat. Ges. Leipz. **1** : 74.) North America.

I. On Malus. (*Rœst. pyrata* (Schw.) Thax.)

III. On Junip. Virginiana. (*Gym. macropus* Lk.)

—— T. BOTRYAPITES (*Schw.*) *n. n.* (1834. *Caeoma* (*Rœst.*) *Botryapites* Schw. Proc. Am. Phil. Soc. **4** : 294.) North America.

I. On Amelanchier. (*Rœst. Botryapites* Schw.)

III. On Chamæcyparis thyoides. (*Gym. biseptatum* Ellis.)

—— T. CLAVIPES (*C. and P.*) *n. n.* (1871. *Pod. Gym. clavipes* C. and P. Jour. Quek. Cl. **2** : 267.) North America.

I. On Amelanchier. (*Rœst aurantiaca* Pk.)

III. On Junip. Virginiana (*Gym. clavipes* C. and P.)

—— T. ELLISII (*Berk.*) *n. n.* (1874. *Pod. Ellisii* Berk. Grev. **3** : 56.) North America.

? I. On Aronia. (*Rœst. transformans* Ellis.)

III. On Chamæcyparis thyoides (*Gym. Ellisii* (Berk.) Farl.).

—— T. SPECIOSA (*Pk.*) *n. n.* (1879. *Gym. speciosum* Peck. Bot. Gaz. **3** : 217.) North America.

? I. On Amelanchier alnifolia. (*Roest. Harknessiana* E. and E.)

III. On Junip. occidentalis. (*Gym. speciosum* Peck.)

—— T. GLOBOSA (*Farl.*) *n. n.* (1880. *Pod. fuscum globosum* Farl. Gym. of U. S. : 18.) North America.

I. On Malus, Crataegus, Sorbus and Cydonia. (*Roest. lacerata* Am. Auct.)

III. On Junip. Virginiana. (*Gym. globosum* Farl.)

—— T. BERMUDIANA (*Farl.*) *n. n.* (1887. *Æcid. Bermudianum* Farl. Bot. Gaz. **12** : 206.) North America.

I. On Junip. Virginiana. (*Æcid. Bermudianum* Farl.)

III. On Junip. Virginiana. (*Gym. Bermudianum* Earle.)

—— T. CUNNINGHAMIANA (*Barcl.*) *n. n.* (1889. *Gym. Cunninghamianum* Barcl. Mem. Med. Off. India **5** : —.) India.

I. On Pyrus, Cotoneaster (*Æcid. Cunninghamianum* Barcl.)

III. On Cupressus. (*Gym. Cunninghamianum* Barcl.)

—— T. NIDUS-AVIS (*Thax.*) *n. n.* (1891. *Gym. Nidus-avis* Thax. Bull. Conn. Sta. No. 107 : 6.) North America.

I. On Amelanchier. (*Roest. Nidus-avis* Thax.)

III. On Junip. Virginiana. (*Gym. Nidus-avis* Thax.)

—— T. KOREAENSIS (*Henn.*) *n. n.* (*Roest. koreaensis* Henn. Monsunia 1 : —.)

I. On Pyrus, Malus and Cydonia. (*Roest. koreaensis* Henn.)

III. On Junip. Chinensis. (*Gym. Japonica* Syd.)

ADDITIONS TO THE FLORA OF INDIANA.

BY STANLEY COULTER.

Since the publication of the "Catalogue of the Flowering Plants and of the Ferns and their Allies Indigenous to Indiana" numerous reports of additions have come to my hands. These reports have been examined with great care, in many cases the specimens themselves being submitted with the report. As a result quite a number of species are to be added to the flora of the State. It is gratifying to note, however, that the majority of these additions are to be found in the grasses and sedges, groups that have been largely neglected by collectors. Another considerable number includes extra-regional plants the occurrence of which within our bounds is to considered as exceptional, and which, while members of the flora are only local or occasional. A third class includes escapes from cultivation, the inclusion or exclusion of which is largely a matter of individual judgment. The number of species added is much smaller than I had reason to expect in view of the fact that the original catalogue was based almost wholly upon accessible herbarium specimens, it being felt that in the absence of such verifying material the enumeration would lose much of its value. This rule led to the temporary exclusion of some of the forms which are now definitely reported and verified by accessible material.

SPECIES TO BE ADDED TO CATALOGUE.

Dryopteris spinulosa (Retz.) Kuntze. (Aspidium spinulosum Sw.)

Reported from Wells County by C. C. Deam, and from Wabash County by J. N. Jenkins. In fruit June 11.

Panicum sphærocarpon Ell. Round-fruited Panicum.

Porter County (E. J. Hill).

Panicum flexile (Gattinger) Scribn. Wiry Panicum.

Lake County (E. J. Hill).

Panicum verrucosum Muhl. Warty Panicum.

Porter County (E. J. Hill).

Bromus tectorum L. Downy Brome Grass.

Lake County (E. J. Hill). This seems to be the western limit of this form, which in favorable localities becomes a troublesome weed.

Agropyron repens glaucum (Desf.) Scribn. (A. glaucum R. and S.)

Lake County (E. J. Hill).

Cyperus Houghtoni Torr.

Lake and Porter Counties (E. J. Hill).

Eleocharis Robbinsii. Oakes.

Porter County (E. J. Hill).

Psilocarya nitens (Vahl) Wood. Short-beaked Bald-rush.

Porter County (E. J. Hill).

Psilocarya scirpoides Torr. Long-beaked Bald-rush.

Porter County (E. J. Hill). Britton and Brown give the range of this plant "In wet soil, Eastern Massachusetts and Rhode Island." The above citation extends the range of the plant far to the west. I have not seen the plant, but admit it because of the well known discriminative accuracy of Mr. Hill.

Fuirena squarrosa Michx.

Porter County (E. J. Hill).

Rhynchospora corniculata macrostachya (Torr.) Britton. (R. macrostachya Torr.)

Porter County (E. J. Hill).

Scleria reticularis Michx.

Porter County (E. J. Hill).

Scleria Torreyana Walp.

Porter County (E. J. Hill).

Scleria pauciflora Muhl.

Porter County (E. J. Hill).

Carex oligosperma Michx. Few-seeded Sedge.

Lake County (E. J. Hill). A species somewhat northern in its mass distribution, seeming to have its southern limit in the station just cited.

Carex limosa L. Mud Sedge.

Wells County (C. C. Deam). "Found on low borders of a small lake in Jackson Township. Scarce."

Carex glaucodea Tuckerm.

Lake County (E. J. Hill).

Carex decomposita Muhl. Large-panicled Sedge.

Wells County (C. C. Deam). "Growing in bunches of moss in bogs made dry by draining."

Xyris Caroliniana Walt. Carolina Yellow-eyed Grass.

Porter County (E. J. Hill). A species found in its mass distribution near the Atlantic coast.

Juncus bufonius L. Toad Rush.

Wabash County (J. N. Jenkins), Kosciusko County (C. C. Deam). "Low, sandy shore of Goose Lake, Kosciusko County."

Juncus articulatus L. Jointed Rush.

Lake County (E. J. Hill). A species decidedly northern in its distribution. Admitted upon the authority of Mr. Hill.

Juncus diffusissimus Buckley.

Crawford County (C. C. Deam). "Valleys about Wyandotte Cave." Britton and Brown give the range of this species, "Southeastern Kansas to Mississippi and Texas." The conditions surrounding Wyandotte Cave are such as to preclude the possibility of the form being introduced along highways or railways. The station given stands as the recorded eastern limit of the species. The determination was made by Mr. M. L. Fernald of the Gray Herbarium, Harvard University.

Stenanthium robustum S. Wats.

Wabash County (J. N. Jenkins). In some of the material examined the pedicels were elongated in fruit, but the form without question is to be referred as indicated above.

Quercus nigra L. Water Oak.

Crawford County, near Wyandotte Cave (C. C. Deam). By error this species was not included in the catalogue. It is fairly well distributed throughout the State, growing near streams and swamps, though sometimes found in upland regions.

Asarum reflexum Bicknell.

Lake County (E. J. Hill). This species was described in Bulletin Torrey Club, Vol. 24, p. 533, pl. 317, 1897. It is distinguished from *A. Canadense* by its smaller flowers, calyx tube white within, *lobes of the calyx limb early reflexed*, purplish-brown, 4″–5″ long, about as long as tube, *triangular*, with a straight obtuse tip 1″–2″ long. (Britton and Brown, Vol. 3, 513.

Mr. Hill reports that all the Asarums he has examined, growing about Chicago, prove to be of this species. None of the sheets in the Purdue herbarium, however, can be so referred. The Asarums should be carefully examined by collectors in order that the distribution of this form within our area may be determined.

Cycloloma atriplicifolium (Spreng) Coulter. (C. platyphyllum Moquin.)

Kosciusko County (C. C. Deam). "In sand pit near Eagle Lake."

Atriplex hastata L. (A. patulum hastatum Gray.)

Wells County (C. C. Deam). "Waste places and cultivated fields."

Allionia hirsuta Pursh. Hairy Umbrella-wort. (Oxybaphus hirsutus Sweet.)

Wabash County (J. N. Jenkins). This form has an assigned range to the west and northwest. Abundant material, however, places the reference beyond question.

Brassica campestris L.

Wells County (C. C. Deam). "Waste places."

Cardamine Pennsylvanica Muhl.

Wells County (C. C. Deam). "Five miles north of Bluffton, May 25, 1899."

Cleome serrulata Pursh. Pink Cleome. (C. integrifolia T. & G.)

Wells County (C. C. Deam). "On prairies south of Bluffton." The species has, perhaps, its eastern limit in Indiana, the assigned range being Illinois and westward.

Fragaria Americana (Porter) Britton. American Wood Strawberry.

Wells County (C. C. Deam). "In woods June 13, 1897."

Agrimonia hirsuta (Muhl) Bicknell.

Wells County (C. C. Deam).

Crataegus cordata (Mill) Ait. Washington Thorn.

Gibson County (J. Schneck, M. D.). An eastern, chiefly mountain form in Gibson County "on the higher hills."

Crataegus macracantha Lodd. Long-spined Thorn. (C. coccinea macracantha Dudley.)

"Along open bottoms in southwestern counties." (J. Schneck, M. D.)

"Banks of Wabash river, Wells County." (C. C. Deam.)

Prunus nigra Ait. Canada Plum, Horse Plum.

"In Woods," Wells County (C. C. Deam). The range of this species is well to the north of Indiana, but the abundance of material shows the above reference to be correct. In flower April 17, 1898.

Trifolium incarnatum L. Crimson, Carnation or Italian Clover.

Wells County (C. C. Deam). Somewhat widely escaped from cultivation within the last few years, but apparently not long persistent.

Oxalis cymosa Small. Tall, Yellow Wood-sorrel.

"Hill near Wyandotte cave, Crawford County, July 11, 1899." (C. C. Deam.)

Lechea tenuifolia Michx. Narrow-leaved Pin-weed.

Crawford County (C. C. Deam). "On hill near Wyandotte cave, July 11, 1899."

Vincetoxicum Shortii (A. Gray) Britton. (Gonolobus Shortii A. Gray.)

Crawford County (C. C. Deam). "On hill near Wyandotte cave, July 12, 1899."

Salvia lanceolata Willd. Lance-leaved Sage.

Gibson County (J. Schneck, M. D.). "On a sandy knoll in low river bottoms." An extreme western form having as its assigned range, "on plains, Nebraska and Colorado to Texas, Arizona and Mexico." The specimens submitted undoubtedly belong to this species, being easily separated from related forms by leaf characters and lobing of the connective. This eastern extension of range is extremely difficult of explanation, especially when the character of the station is taken into account.

Lonicera glaucescens Rydb.

Wells County (C. C. Deam). On bank of creek in Jackson Township, May 28, 1899.

Leontodon autumnale L. Fall Dandelion. Lion's Tooth.

Wells County (C. C. Deam). In yards at Bluffton, introduced in grass.

Helianthus petiolaris Nutt. Prairie Sunflower.

Lake County (E. J. Hill). A western prairie form occasionally found in dry, waste places eastward. Probably introduced into Indiana along east and west railway lines leading into Chicago.

Senecio Balsamitæ Muhl. (S. aureus Balsamitæ T. and G.)

Wabash County (J. N. Jenkins). The range of variation in *S. aureus*, so widely distributed throughout the State, is the only ground for questioning the above citation. The material submitted seems to bear out the description of the species *Balsamitæ*. It is therefore included in the list.

Centaurea Jacea L. Brown or Rayed Knapweed.

Lake County (E. J. Hill.) A form fugitive from Europe, usually found in waste places north, or in ballast about seaports.

Wolffiella Floridana (J. D. Smith). Thompson.

Marshall County, near Culvers (H. Walter Clarke). The abundant material furnished by Mr. Clarke leaves no room for questioning the accuracy of the reference. The range of the species by this citation is sharply extended northward, its assigned limits heretofore being "Georgia and Florida to Missouri, Arkansas and Texas.'"

Wolffia papulifera Thompson. Pointed Duckweed.

Gibson County (J. Schneck, M. D.). "Two miles east of Mt. Carmel, Ill., in Indiana. This is another decided extension of range, in this case eastward, the recorded range of the species being, "Kennett and Columbia, Mo." (Britton and Brown, Vol. 3, p. 510.)

SPECIES ESCAPED FROM CULTIVATION.

Pinus resinosa Ait. Canadian Pine. Red Pine.

Wabash County (J. N. Jenkins). A northern form which will probably not maintain itself in our area.

Populus balsamifera candicans (Ait.) A. Gray. Balm of Gilead.

Gibson County (J. Schneck, M. D.). Specimens of this form were in the Purdue herbarium at the time of collating the catalogue, but it was not included, being considered as an escape, and there being no record of its persistence.

Broussonetia papyrifera (L.) Vent. Paper Mulberry.

Gibson County (J. Schneck, M. D.). An evident escape from cultivation. The inclusion of the species should depend upon the persistence of the form in the wild state.

Malus Malus (L.) Britton. Apple.

"Along Wabash and White Rivers" (J. Schneck, M. D.). This form was excluded because regarded as an escape. The history of its persistence for many years in several different parts of the State has come into my hands since the publication of the catalogue. It should in all probability be included in the State flora.

Paulownia tomentosa (Thunb.) Baill. (P. imperialis S. and Z.)

Gibson County (J. Schneck, M. D.).

Tragopogon porrifolius L. Oyster Plant. Salsify.

Wells County (C. C. Deam).

Koelreuteria paniculata Laxm.

Gibson County (J. Schneck, M. D.).

These plants have undoubtedly escaped from cultivation in the locations cited. Whether or not they should be included in the State flora is a matter of personal judgment. Evidently fugitive plants which appear but for a single season in a single station can scarcely be regarded as entitled to place. That a plant escaped from cultivation should be listed as a member of the State flora in my judgment should require evidence, first, that it had maintained itself for at least three years; second, that in these years it was more than holding its own, in other words was making gains, however slight, in its new situation. For these reasons, in my opinion, the above plants, with perhaps the exception of the apple, should not be included in the flora. The list, however, is given for the benefit of those whose judgment would add them to the Catalogue list.

A few critical notes may perhaps find a proper discussion in this paper.

Quercus pagodæfolia Elliott.

Reported by Dr. Schneck as belonging to the flora of the southwestern counties. The question turns upon the point as to whether the form is to be regarded as a distinct species or merely as a variety. This form originally appeared as *Q. falcata* Michx., var. *pagodæfolia* Elliott, being separated from the type by "larger leaves, 11–13 nearly opposite and spreading lobes." Sargent includes it under *Q. falcata* Michx., and Britton and Brown under *Q. digitata* (Marsh) Sudw. In neither of these cases is it given even varietal rank. The form in our area is so well marked that it certainly seems entitled to varietal, if not, indeed, to specific rank. In my judgment, the form should be written *Q. digitata pagodæfolia* Ell., and given a place in the flora.

Quercus Phellos L. Willow Oak.

This form has been recorded as found in Gibson, Posey and Knox Counties. Concerning the occurrence of this species in this region, Dr. Ridgway says: "This species I give with some doubt, not being quite positive that it occurs. I have seen, however, along the road between Mount Carmel and Olney several trees which, at the time of inspection, I unhesitatingly decided to be *Q. Phellos*, but not having seen it since, while Dr. Schneck has not recorded it, I place the interrogation mark before it."[1] Since the publication of the Catalogue Dr. Schneck writes me that "a very narrow-leaved form of *Q. imbricaria* has probably been mistaken for *Q. Phellos.*" If this be true, there exists no definite record of the occurrence of *Q. Phellos* in Indiana. Collectors in the southwestern counties should examine carefully as to the correctness of this view.

Celtis pumila (Muhl.) Pursh.

"Rocky banks of Blue River" (J. Schneck, M. D.). This shrub-like Hackberry, undoubtedly occurs in our area. It is included by Britton and Brown (Vol. 1, p. 526) under *C. occidentalis* L., which is described as a "shrub or a tree." Sargent also includes under *C. occidentalis*, of which he says: "A polymorphous species; the low shrub form of hillsides and sand dunes is the *C. pumila* of Pursh." The reasons for not maintaining *pumila* in at least varietal rank are not clearly apparent. The form, however, is in the Catalogue, by inclusion in *C. occidentalis*.

Some Mid-Summer Plants of South-Eastern Tennessee.

By Stanley Coulter.

The center from which the collections here reported were made was Mt. Nebo in the Chilhowee Mountains. It is about ten miles to the east of Maryville, which gives the nearest railway communication. From the summit of the mountain the eye reaches westward over a beautiful plain. to the Cumberland Mountains, while twenty miles to the east there arise the peaks of the Great Smoky Mountains. The region lying between the Chilhowee and Great Smoky Mountains is practically virgin, only relatively small areas having been taken for agricultural purposes. The

[1]Ridgway, Robert.—Notes on the Native Trees of the Lower Wabash and White River Valleys, in Illinois and Indiana. *Proc. U. S. Natl. Mus.*, 1882, p. 83.

time of the visit was the month of August, and while the object of the trip was not botanical, a few plants were collected and preserved as well as was possible under the conditions.

At the base of the Chilhowees runs Little River, its banks thickly clothed with timber, the most prominent form both as to size and number being the sycamore. More interesting was the fact that the mistletoe, which with us is found chiefly upon the elm, the honey locust and the oak, had there its favorite resting place upon the sycamore. Upon the western slopes of the Chilhowees, the chestnut was the characteristic forest tree, reaching very often a trunk diameter of from five to seven feet. In the coves and upon the western slopes of the Great Smokies, pines made up the forests, and we drove through miles of these forests which had as yet been free from the lumberman's axe. Near the summits of the Great Smokies the trees were for the most part stunted beeches, not more than fifteen to twenty feet high or with a trunk diameter exceeding eight inches. Among the pines there grew in abundance a bright yellow orchid which I was unable to collect, but took to be either *Habenaria cristata* or *lacera*. Upon the summit of Thunder Head in the wet places the Indian pipe grew in great masses, covering acres with its graceful, snow-white blossoms. In the lower levels and encroaching everywhere upon the cultivated areas the most attractive plant was the passion flower (*Passiflora incarnata*), known locally as maypop. It was one of the most annoying weeds of the region. The masses of rhodondendrons and azaleas, though past the glory of their bloom, added another feature, strange to northern eyes. These plants practically covered the lower stretches of the mountain, and when in full bloom must have made a most brilliant landscape. No attempt was made to secure a complete collection of the plants of the region, only those being collected which promised to "preserve easily," or were of interest for some special reason.

Thanks are due to Mr. H. B. Dorner, a graduate student in botany at Purdue University, for a critical study of the collection.

Juniperus Virginiana L. Red Cedar.

Common over Chilhowee and Great Smoky Mountains.

Panicum capillare L. Witch Grass. Tumble weed.

Abundant and annoying in cultivated areas.

Commelina nudiflora L. Creeping Day-flower. (C. communis L.)

In moist places at base of mountains.

Stenanthium gramineum (Ker) Morong. (S. angustifolium Gray.)
Found chiefly well up the mountain sides.

Aletris farinosa L. Star grass. Colic-root.
In situations similar to the preceding.

Pogonia trianthophora (Sw.) B. S. P. Nodning Pogonia. (P. pendula Lindl.)
From base of mountain up to 2,500 feet.

Gyrostachys gracilis (Bigel.) Kuntze. Slender Ladies' Tresses. (Spiranthes gracilis Bigel.)
Usually well up the side of the mountain.

Tipularia unifolia (Muhl.) B. S. P. Crane-fly Orchis. (T. discolor Nutt.)
Not unfrequent on western slope of Mt. Nebo.

Carpinus Caroliniana Walt. Water Beech. Blue Beech. (C. Americana Michx.)
Along streams throughout mountains.

Polygonum Persicaria L. Lady's Thumb.
On Pine Top, Blount County, Tenn.

Silene stellata (L.) Ait. Starry Campion.
Abundant in woods throughout the mountains.

Anychia Canadensis (L.) B. S. P. Slender Forked Chickweed.

Clematis Virginiana L. Virgin's Bower.
Abundant along Little River, near Mt. Nebo.

Cassia nictitans L. Wild Sensitive Plant.
Extremely abundant. In places covering acres to the practical exclusion of other plants.

Cassia Tora L. Low Senna. (C. obtusifolia L.)
On banks of Little River, near Mt. Nebo.

Cassia Marylandica L. American Senna.
Found only about the Mountain House on Mt. Nebo, at an altitude of about 2,500 feet.

Stylosanthes biflora (L.) B. S. P. Pencil Flower. (S. elatior Sw.)

Meibomia nudiflora (L.) Kuntze. (Desmodium nudiflorum D. C.)

Lespedeza repens (L.) Bart. Creeping Bush-clover. (L. repens T. and G.)

Lespedeza frutescens (L.) Britton. (L. violacea sessiliflora Chapm.)

Lespedeza hirta (L.) Ell. Hairy Bush Clover. (L. hirta L.)

Lespedeza striata (Thunb) H. and A. Japan Clover.

Bradburya Virginiana (L.) Kuntze. Spurred Butterfly Pea. (Centrosema Virginiana Benth.)
Very abundant in the drier soils.

Rhynchosia erecta (Walt) D. C. (R. tomentosa erecta T. and G.)

Oxalis filipes Small. Slender Yellow Wood-sorrel.

On Mt. Nebo, on western slope, August, 1892.

Oxalis stricta L. Upright Yellow Wood-sorrel.

Abundant in moist soils along banks of Little River.

Polygala Curtissii A. Gray.

Polygala alba Nutt. White Milk-wort.

Very abundant in open places on Mt. Nebo.

Phyllanthus Carolinensis Walt.

Acalypha gracilens Gray. Three-seeded Mercury.

Abundant in thickets.

Euphorbia nutans Lag. Upright Spotted Spurge. (E. hypericifolia Gray.)

Euphorbia corollata L. Flowering Spurge.

Common throughout mountains.

Impatiens biflora Walt. Spotted Touch-me-not. (I. fulva Nutt.)

Near Little River, Blount County, Tenn.

Rhamnus Caroliniana Walt. Carolina Buckthorn.

Along banks of Little River, Blount County, Tenn.

Sida spinosa L.

Common throughout mountains and about cultivated fields.

Ascyrum hypericoides L. St. Andrew's Cross. (A. Crux-Andreæ L.)

Hypericum adpressum Bart. Creeping St. John's-wort.

Hypericum virgatum Lam. (H. angulosum Michx.)

Hypericum mutilum L. Dwarf St. John's-wort.

Sarothra gentianoides L. Orange-grass. Pine-weed. (Hypericum Sarothra Michx.)

Ludwigia alternifolia L. Rattle-box.

Angelica villosa (Walt) B. S. P. (Archangelica hirsuta T. and G.)

Cornus florida L. Flowering Dogwood.

On Pine-top mountain at 2,700 feet altitude.

Rhododendron maximum L. Great Laurel. Rose Bay.

Common in Great Smoky and Chilhowee mountains, along streams, forming dense thickets or "*slicks*" near the base.

Xolisma ligustrina (L.) Britton. (Andromeda ligustrina Muhl.)

Oxydendrum arboreum (L.) D. C. Sour-wood. Sorrel-tree.

Vaccinium virgatum Ait. Southern Black Huckleberry.

Mohrodendron Carolinum (L.) Britton. Silver-bell Tree. (Halesia tetraptera L.)

Ipomœa pandurata (L.) Meyer. Wild Potato Vine.

Abundant on Mt. Nebo.

Ipomœa pandurata hastata Chapm (?).

More abundant than the type especially in the lowlands bordering upon Little river.

Cuscuta arvensis Beyrich. Field Dodder.

On Pennyroyal, at foot of Mt. Nebo.

Hedeoma pulegioides (L.) Pers. Pennyroyal.

Solanum Carolinense L. Horse-nettle.

Banks of Little River, and in adjoining cultivated fields. Locally known as "Tread-softs."

Dasystoma laevigata Raf. (Gerardia quercifolia integrifolia, Benth.)

Ruellia ciliosa Pursh. (Dipteracanthus ciliosus Nees.)

Houstonia cœrulea L. Bluets. Innocence. (Oldenlandia cœrulea Gray.)

Houstonia purpurea L. (Oldenlandia purpurea Gray.)

Diodia teres Walt. Rough Button-weed.

Lobelia amœna glandulifera A. Gray. Southern Lobelia.

Abundant on Mt. Nebo.

Lobelia inflata L. Indian Tobacco.

Very common throughout the mountains.

Lacinaria squarrosa (L.) Hill. Blazing Star. Colic-root. (Liatris squarrosa Willd.)

On each side of Pine Top, Chilhowee mountains.

Graphalium obtusifolium L. Sweet Balsam. (*G. polycephalum* Michx.)

Near base of Mt. Nebo.

Silphium terebinthinaceum Jacq. Prairie Dock. (S. compositum Michx.)?

On Pine Top, Chilhowee Mountains in considerable abundance.

Achillea millefolium L. Yarrow.

Abundant throughout the mountains.

The nomenclature of the article is that of Britton and Brown's Illustrated Flora of the Northern States and Canada, the names in parenthesis being those used by Chapman in his Flora of the Southern United States, edition of 1872.

While Dr. Gattinger has done excellent work in the collation of the flora of Tennessee, there remains in the southeastern counties, especially in the deeper coves, large areas that as yet are practically botanically unknown. The remoteness of these regions from ordinary lines of travel, and the unprogressive character of the inhabitants, have joined to keep this area in a nearly virginal state. No collecting tour could be more profitable botanically than one through the coves and mountain ravines between the Great Smoky and Chilhowee Mountains.

A Study of the Constituents of Corn Smut.*

By William Stuart.

In connection with some studies upon corn smut, which were published in the twelfth annual report of the Indiana Experiment Station,[1] the question as to whether corn smut actually contained some principle injurious to farm animals was given some attention. This portion of the work, which was performed by the writer under the supervision of Dr. Arthur, was not completed in time for publication with the other studies mentioned. This work consisted in making extracts of the corn smut, and determining, by means of standard alkaloidal reagents, whether it contained an alkaloid or not. It also included a study of the physiological action of the extract upon horses, when administered to them either hypodermically or per orum. For the latter portion of the work the writer is greatly indebted to Dr. R. A. Craig, of the Veterinary Department, who administered the doses and observed its effects.

In the preparation of the extract valuable assistance was received from Mr. J. W. Sturmer, of the Purdue School of Pharmacy.

TESTS FOR ALKALOIDAL SALTS.

The methods employed in testing for alkaloidal salts were to make an alcoholic extract of the smut spores and such detritus as would pass through a fine sieve. A hundred grams of the smut spores were weighed out and, after thoroughly moistening them in an open dish with a $33\frac{1}{3}$ per cent. solution of alcohol, they were again passed through a sieve to break up all lumps, then transferred to a percolator previously fitted up for the purpose. Sufficient alcohol, of the same strength as that previously mentioned, was added to cover the spores. Maceration of the spores was continued for twenty-four hours before any of the liquid was allowed to pass over into the receiving flask, the latter being so adjusted as to prevent it. At the end of this period the receiving flask was lowered so as to permit of about two drops passing over into the flask per minute. The percolation was continued until the percolate was colorless, sufficient

* Abstract of an article published in the Thirteenth Ann. Rep. of the Ind. Exp. Sta., pp. 26–32, Jan., 1901.

(1) Arthur and Stuart, Twelfth Ann. Report Ind. Exp. Sta., p. 84–135, Jan., 1900.

alcohol being added from time to time to keep the surface of the spores covered with the liquid. The first 50 cc. of the percolate was set aside and the balance collected and evaporated down to 50 cc. on a steam bath. This was added to the first amount saved making 100 cc. of the extract. Each cc. of the extract representing one gram of the spores.

In testing the extract for alkaloids a certain amount of it was taken and evaporated to dryness on a steam bath. The residue was treated with a five per cent. solution of sulphuric acid, and filtered. The filtrate was then subjected to tests with the following reagents:

1. Potassium mercuric iodide (Mayer's solution).
2. Phosphotungstic acid.
3. Iodine in potassium iodide solution.
4. Picric acid.

A small portion of the filtrate was poured out into each of four watch-glass crystals and then a drop or two of the reagents added. The reactions obtained by this method were as follows:

Reagent 1. A slight milky turbidity was produced.
Reagent 2. A decided milky turbidity was obtained.
Reagent 3. No visible reaction.
Reagent 4. No visible reaction.

A number of tests with the same and with fresh lots of extract prepared in the same manner gave similar results.

TESTS FOR TOTAL ALKALOIDS.

In testing for total alkaloids a modified "Prollius Fluid"[2] was used. Two methods were employed. The first was to treat two grams of the smut for four hours with 50 cc. of "Prollius Fluid" in a well stoppered conical flask. The contents of the flask were vigorously shaken at intervals during that period. After macerating four hours the supernatant solution was drawn off and filtered. The filtrate was evaporated to dryness on a steam bath and the residue treated with a five per cent. solution of sulphuric acid. The acid solution was filtered and the filtrate tested as mentioned for the alcoholic extract. The reactions obtained were in each instance similar to those given for alkaloidal salts.

The second method employed consisting in macerating ten grams of the smut spores in 100 cc. of "Prollius Fluid" for twenty-four hours. The

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[2] Modified Prollius Fluid: Ether, 250 c. c.; Chloroform, 100 c. c.; Alcohol, 25 c. c.; 28% Ammonia, 10 c. c.

flask containing the spores being agitated at frequent intervals during that period. The supernatant liquid was drawn off and filtered, and 50 cc. of it transferred to a separatory funnel and subjected to the "shaking out" process as outlined in Sturmer and Vanderkleed's "Course in Quantitative Analysis: 61-64, 1898, under 'Process 1.—General for Total Alkaloid.'" The results obtained from this method by the reagents were quite similar, although more marked, to those of the preceding ones.

Reagent 1. A slight turbidity was obtained which, on standing for some time, deposited a dark brownish substance on the bottom of the glass.

Reagent 2. A marked cloudiness was obtained which, on standing for some time deposited a whitish crystalline precipitate on the bottom of the glass.

Reagent 3. No visible reaction or any deposit after standing.

Reagent 4. No visible reaction, but on standing a slight deposit was noticed on the glass.

TESTS FOR ALKALOIDS IN COMMERCIAL EXTRACTS OF ERGOT AND CORN SMUT.

The uniformity of the results obtained from the reagents employed, the first two giving positive and the last two negative reactions in each instance, led to an examination of the commercial extracts of both ergot and corn smut.

Ergot of rye test.—The commercial fluid extract of ergot was obtained from a leading wholesale druggist in the city, whose supply was obtained from the well-known firm of Park Davis & Co., of Detroit, Michigan. The fluid extract was evaporated to dryness over a steam bath, the residue treated with dilute sulphuric acid and filtered. Tests of the filtrate were made, and the reactions obtained were as follows:

Reagent 1. A yellowish brown, curdy-like precipitate was obtained.

Reagent 2. A cloudy white precipitate was obtained which on standing changed to a purplish brown, curdy-like substance.

Reagent 3. A reddish brown precipitate was obtained.

Reagent 4. No visible reaction obtained.

Corn smut ergot test.—The material used was obtained from the same local druggist, who in turn received his supply from the well-known firm of Merrill & Co., Cincinnati, Ohio. The fluid extract was treated in the same way as in the preceding test and the reactions obtained were somewhat similar.

Reagent 1. A precipitate was formed, but it was not so marked as in the ergot of rye.

Reagent 2. Reaction much the same as that in rye ergot.

Reagent 3. Reaction not quite so marked as in the rye ergot.

Reagent 4. No reaction was obtained.

A brief summary of the work shows that a substance was obtained in all the extracts made which gave positive reactions with the first two reagents used and negative ones with the last two.

Commercial extracts of rye ergot and of corn smut gave similar reactions to those obtained from the corn smut extract prepared in the laboratory, in the case of reagents one and two, and in addition gave marked results with reagent three.

PHYSIOLOGICAL EFFECT OF AN ALCOHOLIC EXTRACT OF CORN SMUT UPON HORSES.

The study of the physiological effect of an alcoholic extract upon horses was carried on in conjunction with that of the alkaloidal tests in the laboratory, the alcoholic extract used being prepared by the writer in the same manner as that described in the preceding pages. The experimental work upon the horses was performed by Dr. R. A. Craig, of the Veterinary Department of Purdue University.

The appended notes upon the amounts and effects of the doses administered were taken by him and have been kindly placed at my disposal.

Horse No. 1.—A gelding, poor in flesh, but healthy, was given 15 cc. of the extract subcutaneously. The dose seemed to have no effect. The next day 30 cc. were given in the same way. In twenty-five minutes he stopped eating. The pulse and breathing were quickened and the peristaltic movements of the intestines were increased. Forty-five minutes after the drug was given faeces were passed. No further effects were noted.

Horse No. 2.—A gelding in good condition was given 25 cc. subcutaneously. In twenty minutes he became restless, stopped eating, and the pulse and breathing were quickened. A moist evacuation of faeces occurred in twenty-five minutes. An hour after giving the injection its effects had passed off. Two days afterwards 45 cc. were given. The horse soon became restless, the intestinal murmurings were loud and an evacuation of faeces soon followed. When made to turn in the stall his movements were slow and unsteady. One hour after giving the injection his pulse was sixty and his respirations forty-three per minute. He refused to eat and remained dull till noon the following day. After an interval of a few days the horse was given 130 cc. per orum. In forty minutes he stopped eating, his pulse and breathing were quickened, but outside of this no other effects of the drug were noted.

A brief summary of the results show that an injection of 25 to 30 cc. of the drug caused restlessness and increased peristaltic movements of the intestines. This was followed shortly by evacuation of the contents of the rectum. At the same time the pulse and respiration were quickened. The effects of the dose passed off in an hour.

The injection of 45 cc. produced, in addition to the above symptoms, a dullness and an unsteady gait when made to move. The effects of the dose were much more lasting. The horse remained dull and refused to eat for twenty-four hours.

A 15 cc. subcutaneous injection and a 130 cc. per orum dose produced but little effect.

While the results of both the chemical and physiological tests of the corn smut are at variance with those obtained by some other investigators,[3] they are in accordance with results of a number of chemists,[4] and to some extent in their physiological action to that obtained by Dr. Mitchell,[5] whose experiments were performed upon the frog. The concordance of the results obtained from both the chemical and physiological tests would indicate the presence in minute quantity of some narcotic in corn smut. What this narcotic is, and why, when corn smut is consumed in large quantities by farm animals, it does not produce more harmful results, are questions which are yet to be determined.

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[3] Kedzie, Bull. Mich. Exp. Sta., No. 137 : 45, 1896.
Mayo, Bull. Kans. Exp. Sta., No. 58 : 69, 1896.

[4] Dulong, Journ. de Pharm. 14 : 556, 1828.
Cressler, Amer. Journ. Pharm. for 1861 : 306.
Parsons, Rep. Dept. Agric. for 1880 : 136–138, 1881.
Hahn, Amer. Journ. Pharm. 53 : 496, 1881.
Rademaker and Fischer, Med. Herald for 1887 : 775.

[5] Mitchell, Jas.—The Physiological Action of Ustilago maidis on the Nervous System, Inaug. Thesis, Univ. Pa., 1883. Therap. Gaz., Detroit, 10 : 223–227, 1886.

A Bacterial Disease of Tomatoes.*

[Abstract.]

By William Stuart.

During the winter of 1898-99, while engaged in an experimental study in the growing of tomatoes by the aid of chemical fertilizers, considerable annoyance was occasioned by the appearance of a disease which attacked the fruit and rendered it unmarketable.[1] Usually the fruit showed no sign

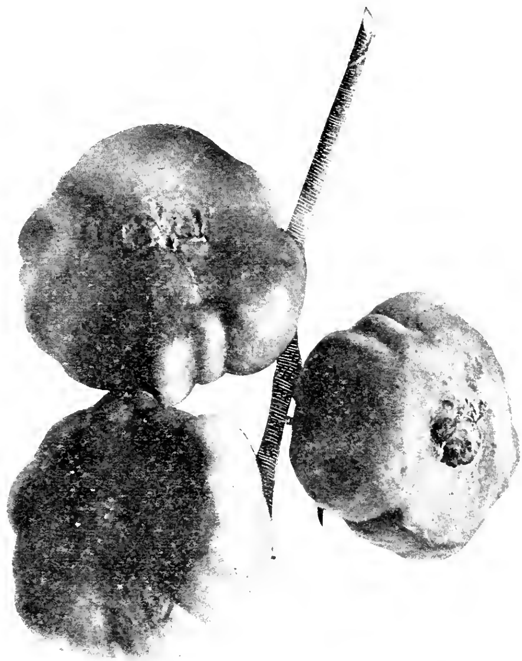


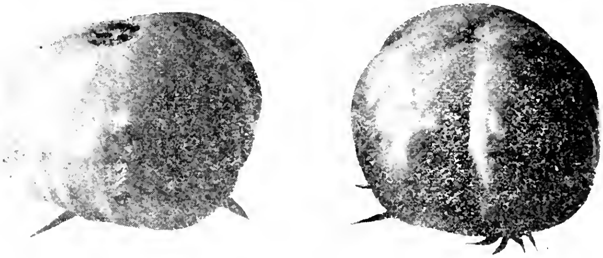
Fig. 1. Tomatoes affected with bacterial disease.

of injury until two-thirds grown, and sometimes not until fully developed. The first visible appearance of the disease in infected fruits was in a slight watery discoloration of the tissue beneath the epidermis. As the disease

[*Published in full in the Thirteenth Ann. Rep. of the Ind. Exp. Sta., pp. 33-36, Jan., 1901.]

[1]A disease similar in its character was reported by Beach, in Bulletin 125 of the New York State Agr. Exp. Sta., Geneva, pp. 305-306, July, 1897.

progressed, the affected portion assumed a darker color, followed by a gradual depression of the infected tissue, resembling in many cases that caused by the black rot Macrosporium solani (see Fig. 1), but without any fruiting hyphae growing on the surface of the epidermis. It rarely wholly destroyed the fruit, but as a rule seemed to hasten its maturity. Generally the disease attacked the apical portion of the fruit; in a few instances, however, the central or basal portions would show the characteristic watery discoloration.



a b
Fig. 2. Original condition of the fruit prior to infection.

a b
Fig. 3. Changed condition of fruit "b" due to infection.

A microscopical examination of diseased portions of the fruit gave no evidence of the presence of any parasitic fungus. The presence of a motile bacillus seemed, however, to be fairly constant in all tissue examined.

Isolation of the germ.—In the isolation of the germ two different methods were employed. In one sections of the diseased tissue were removed from the fruit with a flamed knife and transferred to bouillon tubes, from which loop plate cultures were made in agar. In the other method direct inoculation of the tubes were made from the inner portions of diseased tissue by means of a sterilized platinum wire.

The cultures obtained from both of these methods were apparently similar, both contained a minute motile bacillus, having the same appearance as that noted in the microscopical examination. The germ thus obtained was assumed at the time to be the same as that seen in the diseased fruit, but its after behavior did not in all respects bear this out.

Growth of the germ upon agar.—The growth of the germ upon slightly acid slant agar was quite characteristic; it produced a vigorous growth, with irregular outline all along the track of the needle. The color of the colonies upon agar was creamy white on the margins, becoming yellowish towards the center, and having a marked viscid surface.

Inoculation experiments.—On February 15 two tomatoes which had every appearance of being perfectly healthy were removed from plants in an adjoining room. One of these was inoculated with a pure culture of the germ, by puncturing the epidermis with a sterilized needle, and with a sterilized platinum wire transferring the germs from the tube to the interior of the fruit. The other fruit was infected by merely smearing the germs over the surface of the pistillate portion of the fruit. After inoculation both fruits were placed under a bell jar. At the end of the second day the first fruit showed signs of infection; a portion of the cells adjacent to the opening made for the introduction of the germ were fast turning a dark color. In a week the greater portion of the tomato was diseased and was giving off an offensive odor. By March 1, or fourteen days after the time of infection, it was completely decomposed, while the one on which infection material had been smeared showed no signs of disease.

On March 2 two more healthy tomatoes were removed from the vines, and after photographing them they were inoculated in the same way as those in the previous experiment. The progress of the disease in this experiment was not quite so rapid as in that of the first, some twenty days elapsing before the whole fruit was affected. Like the first the fruit into which the germs were introduced was totally destroyed, while the other remained perfectly sound. The fruits were again photographed on March 22. Fig. II represents them previous to inoculation, while in Fig. III the changed condition of the diseased fruit is shown.

In order to determine whether the same effects would be obtained by inoculating the fruit on the vine, a cluster of fruit containing four half to two-thirds grown tomatoes was selected for experimentation. Two of the tomatoes were inoculated by introducing the germs into the tissues of the fruit with a sterilized needle. In order to note the effect of the injury from needle puncture the third fruit in the cluster was punctured with a sterilized needle, while the fourth was reserved for control. All inoculations were made on the north side of the fruit in order to avoid any action of the sun upon the wounds. Three days later the tissues surrounding the infected portions of the first two fruits had begun to grow darker. From this time on the progress of the disease was quite rapid. No ill effects could be noted on the fruit punctured with the sterilized needle, both of the latter fruits remaining perfectly healthy.

In comparing the action of the disease produced in the artificially inoculated fruit with that of one naturally infected, it will be noted that with the exception of the first appearance of the disease their action was entirely different. In the natural infected fruit there was no offensive odor, the disease rarely affected the whole fruit, and never caused a sloughing of the cell tissues, as did the artificial infections. The wide difference in the action of the germ in the natural and artificially infected fruits may indicate that they were not the same, although looking so much alike, or it may be explained by supposing that in the naturally infected fruits the epidermis, not being broken, excludes all putrefactive bacteria. The putrefactive bacteria having access through the wound caused by artificial inoculation, feed upon the tissues destroyed by the inoculated germ, and thus the two acting in conjunction make the destruction of the fruit much more rapid and complete. The uniformity of the results obtained seems to favor the latter assumption.

SUMMARY.

A decay of green fruits on tomato plants grown in the greenhouse seemed from microscopical examination to be of bacterial origin.

The fruit showed patches that looked watery, became depressed, and after a time turned blackish. Usually the disease started at the apical portion of the fruit. No evidences of a fungus were present. Attempts to separate a specific germ were apparently successful.

Introducing the supposed germ into the fruit by puncturing the epidermis in every instance produced a disease.

The disease caused by the germ from the cultures did not coincide very closely with that from natural infection, and there is still doubt if the two be the same.

No preventive measures can be suggested with the limited knowledge of the disease yet available.

Device for Supporting a Pasteur Flask.

By Katherine E. Golden.

Notes on the Microscopic Structure of Woods.

By Katherine E. Golden.

Movement of Protoplasm in the Hyphæ of a Mould.

By Katherine E. Golden.

Description of Certain Bacteria Obtained from Nodules of Various Leguminous Plants.

By Severance Burrage.

(A preliminary study on the constancy of the distribution of bacterial species in definite species of leguminous plants.)

It has been quite thoroughly proven that several different species of bacteria may be found in the nodules of various leguminous plants. The following questions, however, have not, it seems to me, been definitely settled with regard to them:

Does the same species of bacteria always occur in the same species of legume?

Does the same species of bacteria always occur throughout all the nodules on the same plant of any species of legume?

Does the same species of bacteria always occur in the nodules of all the plants in a field planted with one species of legume?

Does the same species of bacteria occur constantly in the same species of legume year after year?

The following descriptions are merely the beginning of an attempt to investigate and answer these questons.

For much of the culture work, I am indebted to Mr. T. R. Perry, one of the students in Purdue University last year.

SPECIES 1.

Separated twenty times from the nodules of Trifolium pratense.

MORPHOLOGY.

Bacilli with rounded ends, occurring sometimes singly, but generally in pairs. These bacilli measured from .75 to 1 mu in width, and 2 mu in length. Examination of Zoogloea masses on agar shows a distinct capsule formation sometimes measuring 3 mu in width and 4 mu in length.

BIOLOGICAL CHARACTERS.

An aerobic, liquefying, motile, chromogenic bacillus, growing well at room temperature, but slightly better at 37½ C°.

On gelatin plates the colonies are large and white, liquefying the gelatin in a very short time.

A funnel shaped liquefaction occurs in gelatin stab cultures in about 15 days, and a distinct greenish fluorescence is given to the liquid portion, while a white precipitate sinks to the bottom of the "funnel." After all the gelatin is liquefied, a distinct green mycoderm is formed on the surface.

On the agar streak there is a thin, spreading light-green growth which imparts a distinct fluorescence to the agar. On older cultures, this growth thickens and forms a luxuriant zoogloea mass all over the agar. It is from such conditions that the capsule stage may be obtained. Upon potato a slimy, yellowish, dirty-brown growth takes place along the line of inoculation, which growth becomes darker with age.

Milk is quickly coagulated, and the whey takes on a greenish fluorescence. This milk, however, remains neutral.

In solutions containing nitrates, all nitrates are changed to nitrites in from five to seven days.

Glucose solutions are not fermented.

SPECIES 2.

Separated several times from the nodules of Vicia sativa.

MORPHOLOGY.

In crushed nodules the "bacteroid" appearance is quite common, while on the various artificial culture media these are rarely seen. Upon these media, they appear as bacilli with rounded ends, often united in pairs. They measure .8 mu in width and 1.5 mu in length.

BIOLOGICAL CHARACTERS.

This form is a faculative anaerobe, motile, non-liquefying, non-chromogenic. Grows well at the room temperature, and better at the body temperature. In gelatin stab cultures a line of very small colonies is formed along the line of puncture.

On agar plates the colonies appear in thirty-six hours, the surface colonies having a whitish appearance, while the deeper ones have a yellowish tinge.

The agar streak gives rise to a slimy, viscous, whitish growth, having no tendency to spread over the agar.

On potato, a rather restricted whitish growth takes place very slowly, and this growth is very slimy.

In solutions containing nitrates, after twenty days, a considerable portion have been reduced to nitrites, but not all, as there was positive test for nitrates as well as for nitrites.

Glucose solutions are not fermented.

Milk is not coagulated, yet is rendered strongly acid.

SPECIES 3.

Separated in several instances from nodules of Phaseolus nasus.

MORPHOLOGY.

Bacilli with rounded ends, usually united in pairs.

Measurement, 1.5 mu in width, 3 mu in length.

BIOLOGICAL CHARACTERS.

An aerobic, liquefying, motile nonchromogenic bacillus, which grows very slowly at the room temperature, but quickly at the body temperature. In gelatin stab cultures the liquefaction occurs in a straight line across the tube. The whole mass of gelatin becoming liquefied in 15 days.

On gelatin plates the colonies reach one-sixteenth of an inch in diameter, circular in outline.

On agar plates, the colonies are also about one-sixteenth of an inch in diameter, but are somewhat irregular in outline, and very finely granular.

On the agar streak, there is a luxuriant dirty-white, slimy growth, giving a very slight fluorescence.

On potato, there is at first a flesh-colored growth, later becoming a dirty white, and on the very old cultures, a brown.

Glucose solutions are not fermented.

Nitrate solutions give a fair test for nitrites after 24 days.

Milk is in no respect changed by this species.

SPECIES 4.

Found in several nodules on Trifolium hybridum.

MORPHOLOGY.

Bacilli occurring usually in pairs, rarely singly.

In the nodules, these bacilli measure 1.5 mu in width, and 4 mu in length. When taken from culture media they measure 1.75 mu in width and 5 mu in length.

BIOLOGICAL CHARACTERS.

This form is a facultative anaerobe, non-liquefying, non-chromogenic bacillus, quite actively motile. Grows better at the body temperature than at the room temperature.

In gelatine stab cultures there is a scattered growth of individual colonies along the line of inoculation, without liquefaction of the gelatin. An irregular button-like growth takes place on the surface of the gelatin. In bouillon rendered slightly acid, no growth whatever took place, while in neutral bouillon an abundant growth occurred.

On agar streak a non-spreading flesh-colored growth appears, and on potato a light lead colored growth follows the line of inoculation which becomes slimy after four days.

Glucose solutions are not fermented.

Nitrate solutions are wholly reduced to nitrites.

Milk is unchanged.

SPECIES 5.

Found in nodules on several plants of Trifolium reflexum.

MORPHOLOGY.

Bacilli usually arranged in pairs, rarely singly. They measure .5 mu in width, and 1.5 mu. in length.

BIOLOGICAL CHARACTERS.

This species is a non-liquefying, non-chromogenic, motile, facultative anaerobic bacillus, which grows very well at the room temperature, but not so well at the body temperature.

On gelatin stab cultures a few scattered colonies appear along the line of inoculation, and a button-like growth on the surface. The gelatin is not liquefied in two weeks.

On agar streak, a whitish growth follows the line of inoculation.

On potato the growth is a yellowish, lead-colored one, following the line of inoculation.

Glucose solutions are not fermented.

Nitrate solutions are completely reduced to nitrites in three days.

Milk is coagulated, but remains neutral.

Other species are now being worked upon, which have been separated from many other leguminous plants, including crimson clover, locust, small white clover, whippoorwill cow pea, black cow pea, and alfalfa.

A Few Mycological Notes for July and August, 1900, Wells and Whitley Counties.

By E. B. Williamson.

An interest in the doings which go on in fields and woods is natural to everyone, bearing, as all of us do, in our own brains, cells which still retain the impress given them as they developed and multiplied to gradually make man, by the cunning of his intellect, master of his environment. Interest is attracted most easily to those everyday, more conspicuous and beautiful objects, and those which have never been dangerous to man during the period of his later evolution. So at the present time we have popular illustrated works on birds, butterflies and flowering plants, and when the Garden shall have faded into a more correct perspective, we may expect some such popular treatises on the humble though usually beautiful, creatures which go with heads in the dust. But I leave it to the student of psychogony to discover why the fastidious human so often turns with loathing from a mushroom. It would seem that these plants, by their graceful adaptive forms and varied colors, could easily conquer the feelings which seem to frequently exist only because of the falsely suggestive name of "toadstools" commonly given to all species of the Agaricaceae. However, an interest in these larger fungi is felt by many, and one purpose of this brief note is to call attention to two recently published works which make possible at least a general knowledge of the forms to be found in the United States.

The first of these books is "Moulds, Mildews and Mushrooms," by Dr. Underwood, published by Henry Holt & Company. Keys enable the student to trace specimens to their genera, and notes on distribution, habitat, etc., conspicuous species, and a full bibliography are given. The second book is "A Thousand Fungi," by Charles McIlvaine, published by the Bowen-Merrill Company. Many fine plates from photographs and water color studies illustrate a large number of species, especially the commoner and more conspicuous forms. This work is decidedly less scientific that the first, and the many notes are usually intended especially for the mycophagist.

To the best of my knowledge those who gather fungi for food purposes in Wells County, and doubtless also in other portions of the State, confine themselves exclusively to the morel. This species is not rare in the spring. It belongs to another group than the one to which other mushrooms, as they are known, belong. Near Bluffton a species of *Geoglossum*, a genus belonging to the same order as *Morchella*, was not rare in low woods in August. It was not found in sufficient quantities to cook, but eaten raw had a nutty flavor, woody texture.

In low woods on and about rotting logs in Wells and Whitley counties during August *Clavarias* were common. *C. cristata* seemed to be the common species. Underwood says none of them are deleterious, and McIlvane recommends some of them especially for soups. In past years species of *Hydnum* have been observed commonly in the two counties mentioned above, but this year, possibly because of the little time spent in the woods compared with some former years, none were seen.

On August 17 an oak stump growing in a thick woods near Bluffton was found literally covered with *Polyporus sulfureus*. No other mass of color could have clothed the stump to render it more conspicuous in the dark woods. The fungus was young and tender, and a number of persons ate of it sliced and stewed. The flavor possibly suggested veal. I have seen this species growing more in the open on logs where it was almost completely pulverized by insect larvae.

Of the Boletaceae three genera were observed in Wells County *Fistulina*, *Boletus* and *Boletinus*. None of these were tested for their edible qualities. *Fistulina hepatica* was found only once, on August 25. *Boletinus porosus* grew in shaded woods among old leaves. The short stipe and mottle yellow-ochre and burnt umber pileus of this species render even large specimens six or seven inches in diameter inconspicuous. One species of *Boletus* was common in both Whitley and Wells counties, but was not specifically identified. Height, two inches; diameter of pileus, one and one-half inches; pileus above, chocolate brown, reddish or reddish yellow; flesh, white or very pale yellow, when broken becoming bluish, then very dark yellow; tubes yellow; stipe solid, reddish yellow, not annulated.

Pleurotus ostreatus to the mycophagist is one of the most valuable fungi in northern Indiana. About Bluffton it was found especially on the northern exposures of elm logs which still held their bark, though it has a wide range of habitat. To some its flavor is as good as any mushroom, and the quantities that can often be gathered after a rain from one log recommend it. It often becomes soggy during a rainy spell, but if it is not too much infested with larvae this does not interfere with its edibility. Fried in butter this species is as good as cooked any other way. It is attacked by more enemies than any other woods species of fungus I have noticed. At least two or three species of mollusca, two diptera, possibly a dozen coleoptera and two hymenopetera infest it. A friend reports grasshoppers feeding on it. Centipedes are often found among the gills, being there doubtless in search of insect prey.

Amanita phalloides was found once in a cleared spot in a thin woods near Shriner Lake, Whitley County. This was the only one of the few deadly mushrooms seen during the season. A species which is perhaps dangerous is *Lepiota morgani*. It reaches the maximum of size for an Agaricaceae. One specimen collected at Bluffton was ten inches high, and the pileus was eleven inches in diameter. Another specimen broken off at the ground weighed eleven ounces. I saw the species growing at only two stations and at one of these it formed an incomplete giant fairy ring as has been described. At Bluffton eight persons ate freely of this species, and none suffered any inconvenience. It is generally accepted that genuine cases of mushroom poisoning have never resulted from eating decomposing nonpoisonous species. But is it possible that the ripening of the spores might develop some minor poison? The specimens of *L. morgani* eaten at Bluffton were in every case young and the gills were not colored by the spores. Several small species of *Lepiota* were common in the woods during August, but none of these were specifically determined. One of them had the pileus usually under an inch in diameter, white, the umbone dark wood brown. As it aged the margin of the disc became a delicate and beautiful blue.

Another dangerous species is *Clitocybe illudens*. This was found twice near Shriner Lake, growing on stumps, once in an open field, the second time in the woods. None were cooked. Dr. Underwood says it is unwholesome; Mr. McIlvaine says it is poisonous to some, and its odor is certainly not attractive. It possesses fully the phosphorescent property attributed to it by authors. *Clitocybe monadelpha* was found twice near Bluffton, each cluster growing on the ground in low, thick woods. Another species was very common about logs in woods. It was gray or light brown in color, thin, woody, and wine-glass shaped. The odor if long continued was sickening. On two occasions, when I had a quantity of it in the room where I was working, it all but nauseated me, though I am not easily offended through my olfactory organ.

Collybia radicata was common in Wells County, and it and two larger species of the same genus, all growing in woodland, were frequently eaten. They have nothing in particular to recommend them. *Russula emetica* was taken in Wells County and *Russula roseipes* in Whitley County. The latter species was eaten raw. It had a nutty flavor much like *Marasmius*. A species of *Cantharellus* was found at Bluffton, August 25, but was not identified.

After rains *Marasmius oreades* appears abundantly on the lawn about my home near Bluffton. The fairy rings were seldom well marked. We could not say that the flavor of this species was superior to that of some larger mushrooms which are usually more easily collected. However, the large number of *Marasmius* which may sometimes occur within a small area make it possible to gather a quantity of caps without much labor. *Panus strigosus* was found near Bluffton, August 19. A single individual grew from a decayed spot in a living tree. It was a beautiful specimen and suggested *Pleurotus ostreatus*. *Pluteus cervinus* was common both in Wells and Whitley counties, growing on very old logs, and once in a mass of rotting sawdust, in the woods. The pileus varies greatly in coloration. The species was often eaten, but unless fried crisp it has a rather unpleasant flavor. A species of *Galera*, apparently *flava*, was not rare in the woods about Bluffton, growing in clusters on decaying logs. It was cooked and the caps retained must of their bright yellow or orange color. It might be used as "trimming" for a dish of larger species.

Agaricus campestris was taken in pastures, but I did not find it in quantities as it is often found. A single specimen taken in the woods near Bluffton seemed to be *A. silvaticus*. In the same pastures and in thin woodland, often on manure, *Psathyrella* was common. All the specimens seen seemed to belong to one species, undetermined

Belonging to another order are the puffballs, the larger species of which are among the most valuable and delicate fungi. Representatives of three genera were observed this season about Bluffton. *Geaster* was found a number of times in thin woodland. *Calvatia* was found a few times. The best way to cook it is like egg plant. In former years *Calvatia* has often been observed in great abundance, occurring at the edges of woods or in thin woodland. Specimens not less than eighteen inches in diameter have been seen, and individuals eight or ten inches in diameter were not rare. A species of *Lycoperdon*, which suggested a sea-urchin with the spines removed, was common in pastures. Its diameter seldom exceeded two inches; it seemed to ripen rapidly, and it was usually infested with larvae, so none were cooked.

The Kankakee Salamander.

By T. H. Ball.

The Eel Question and the Development of the Conger Eel.

(Abstract.)

By C. H. Eigenmann.

The eel question, or "when, how and where does the eel reproduce," which is as old as history, was in part solved by Grassi, who in 1897 found that one of the numerous species of Leptocephali found near Messina is the larva of the eel. The eel is said to seek the deeper water, where it deposits its eggs and then dies. During the past summer the eggs of the Conger eel were taken by the U. S. Fish Commission vessel Grampus on the surface of the Gulf Stream. This is the first notice of an eel egg outside of the Mediterranean. A full account of these eggs will appear in the Bulletin of the U. S. Fish Commission.

The Mounting of the Remains of Megalonyx Jeffersoni from Henderson, Kentucky.

By C. H. Eigenmann.

During the fire of the Museum of the Indiana University in 1882 the bones of the Megalonyx belonging to the University were away to be figured. In this way this specimen was saved from the destruction that overtook most of the other specimens in the collections. The trustees have recently decided to have the specimen mounted. The bones have been mounted in their relative positions without reconstruction of the lost parts. It came originally from Henderson, Kentucky.

Contribution Toward the Life History of the Squeteague.

(Abstract.)

By C. H. Eigenmann.

The Squeteague is one of the important food fishes of Narragansett and Buzzard's Bay. During the past summer I studied the habits of the young of this fish. The details will be published in the Bulletin of the U. S. Fish Commission.

A New Oceanic Fish.

[Abstract.]

By C. H. Eigenmann.

A new species of Centrolophine fishes was taken during last summer under a medusa in the Gulf Stream off Newport, R. I. It will be described in detail in the Bulletin of the U. S. Fish Commission.

A New Species of Cave Salamander from the Caves of the Ozarks in Missouri.

[Abstract.]

By C. H. Eigenmann.

While collecting in the caves of Missouri I found a species of Spelerpes rather abundant. It was taken in Wilson's Cave, Rockhouse Cave, Fisher's Cave and also near Marble Cave. It proved to be a new species which is the fourth salamander known to inhabit the caves of North America. It is a twilight species rather than a strictly cave species, being found within a short distance from the entrance of the cave in all instances.

An Addition to the Fishes Occurring in Indiana.

By L. J. Rettger.

Some Observations of the Daily Habits of the Toad (Bufo Lentiginosus).*

By J. Rollin Slonaker.

Wishing to observe the daily habits of the toad and to see if it would hibernate if kept in a warm room during the winter months, a medium-sized female toad (Bufo lentiginosus) was secured October 8th. Not having a suitable place ready for her, she was placed temporarily in a running water aquarium. Here she could climb upon some bricks and be out of the water, but it was evidently too damp, for she showed signs of uneasiness.

On the 16th she was noticed to shed and swallow her skin. This I find is not an uncommon occurrence. October 19th she weighed 59.6 g., and was transferred to a dry earth aquarium. Here she made a hollow in the soft dirt under some leaves and seemed perfectly at home.

*These observations were made at Clark University during the year 1897-8.

It was interesting to see the way she made a hollow, or buried herself. She always used the same method, pushing the dirt to each side with her hind legs and shoving herself backward with her fore legs.

She was accurate in predicting changes in temperature, appearing very hungry, and after eating, burying herself completely before a decided fall in temperature. Before rising temperature she seemed less concerned about getting her food and would not cover herself completely, usually leaving her head out as though waiting for insects.

Plenty of grasshoppers and flies were kept in the aquarium, and she ate freely each day till November 1st, when a cold wave arrived and the room cooled off during the night. This time she buried herself completely. Neither did she again appear nor show signs of life till November 29th, when she slowly emerged. This may be spoken of as a short period of hibernation.

She was in and out almost every day after this, and on December 7th she ate three flies and 2.8 g. beefsteak. In regard to their eating, toads show the same peculiarity that frogs do, in that they will not attempt to take anything that is not in motion. In order to get the toad to eat meat I threaded a small piece on a string and twirled it before her. Her attention would first be attracted by the moving object, and after gazing at it for a few seconds she would quickly run out her tongue and take it. The whole process is almost instantaneous, and one can see but a flash of light red and hear the shutting of her mouth.

After eating this amount she refused to take any more, and buried herself, as I supposed, for another hibernation. But the next day she was out again and ate a fly. On the day following she ate 12 flies and 3 g. of meat. I continued feeding her every few days and, when hungry, she would eat frozen or stale meat and thrust her tongue at any near moving object. With the exception of cold "snaps," when she would remain covered up two or three days at a time, she showed no further signs of hibernation throughout the winter.

On February 14th she weighed 88.9 g. This shows that though there was a tendency to hibernate at first, it did not manifest itself again, for an animal loses weight during hibernation. February 20th she weighed 97 g., showing a gain of 8.5 g. in six days. This rapid increase in weight was probably due to the nutritive diet of beef and to the rapid secretion of eggs.

March 2d she remained several hours in the water, and I have no doubt that she would have deposited her eggs if she had had a mate. At this time her weight was 104.7 g. Her appetite always appeared good, and though I had only meat to give her for two months, she usually took some whenever it was offered her. She always knew when she had enough meat, in fact was never very eager to take it. But with flies she was gluttonous, became excited and eager, and always had room for one more, as shown by the following day's record.

I confined a large number of flies in the aquarium with her. When she heard and saw the flies buzzing about she became very much excited and nervous, and immediately began hopping about and catching them. When thus excited, the long toes of the hind feet always had a peculiar twitching, while the remainder of her body would be comparatively motionless. It was interesting to see how rarely she missed her aim and how rapidly she ate them. At first she averaged about four per minute. Being curious to know how many she would eat, I watched and counted. When she had eaten 40 her rate began to slacken, though she was still anxious and would approach nearer when a fly was beyond her reach. At 50 she showed less energy in the chase. When 60 had disappeared she simply waited till they came within reach of her tongue, while about every third or fourth fly swallowed she would squirm and twist as though making room for one more. When she had eaten 76 I was called away. When I returned about an hour later the remaining 15 or 20 flies had disappeared. Some of these, however, may have been eaten by two or three small frogs that were confined in the same aquarium. One would think she would not want anything more soon, but the next day she was ready for more, and averaged about 40 flies each day.

The greatest weight she reached was 111.5 g. on a diet of meat and flies. It was also interesting to note that if, when she had eaten all the meat that she wanted and had begun to back into the ground, a fly with clipped wing was put before her she would quickly take it, or, if it should run out of her reach, would eagerly give chase.

One day I placed a medium-sized garter snake in the aquarium to see the effect. The toad was out and happened to be close to the side of the aquarium. As the snake crawled slowly toward her seeking a means of escape, her sides began to swell out while she slowly turned her broad back toward the snake. This made her resemble a clod of dirt more than a toad. Evidently she knew that flight was useless and, as a place of concealment was not at hand at that late moment, her safety lay in protective coloration and in resembling a toad as little as possible.

April 20th I placed a male of the same species in the aquarium, thinking she would lay her eggs, but she would have absolutely nothing to do with him. As there seemed to be no likelihood of further development I changed them to a small park which I had prepared in a sunny part of the yard. It was mainly composed of sod, but in one corner was an area of soft earth, while in the center was a large pan of water. Here they mated at once and spent the greater part of two days hopping about, resting part of the time in the water. May 12th they buried themselves completely in the soft dirt to await the passing of a cold wave. When the cold wave had passed they emerged and the mating ceased without the deposition of eggs.

Among the things the toad was observed to eat during her captivity were ants, flies, grasshoppers, bees, wasps and many other insects which found their way within her reach. The eating of bees and wasps was followed by no ill effects except a momentary twisting or wincing. By far the greater part of her food consisted of flies and ants. These are household pests, and since the toad will average 40 or more each day it is needless to say that it is a very useful animal and one that should be protected.

The Methods and Extent of the Illinois Ichthyological Survey.

By Thomas Large.

At the present time the Natural History Survey of the Illinois State Laboratory of Natural History is working on an extensive report on the Fishes of Illinois. This is a continuation of the work begun in 1878 and carried on with many interruptions since that time by Prof. S. A. Forbes and his collaborators. It is the purpose to have every fish known to occur within the State accurately described, with complete statement of all that is known concerning food, habits and breeding, and to have the geographical distribution indicated on maps. In addition to this it is the purpose to illustrate each species with colored plates reproduced from water-color drawings of living fish. The number of species occurring is in the neighborhood of two hundred.

At present several lines of work are in progress: At the Biological Station on the Illinois River, located in the past two summers at Meredosia, aquaria were fitted in the floating laboratory and a gasoline engine and pump on the shore made to furnish clear water in which colors of living fish were studied for color descriptions and were painted by the laboratory artists. The field work for the geographical distribution has been pushed forward by means of wagon and launch expeditions and by volunteer collectors. The launch has not been used sufficiently for extended excursions to make the experience of value to others. With the wagon two men were in the field for six weeks in the fall of 1899, making collections in the Big Vermillion and Kaskaskia rivers and their tributaries. In 1900, with the advantage of the experience of the previous year, an expedition was fitted out to make collections in eastern Illinois, with Golconda on the Ohio River as the objective point, and returning to Urbana, the starting place, through the western and central portion of the State. The equipment consisted of an ordinary covered grocer's delivery wagon and two horses, a 9x9 miner's pyramid tent, woolen blankets, a blue-flame oil stove, an aluminum cooking outfit, a supply of groceries and canned meats, five large milk cans for shipping collections home, "hand-cans" for killing specimens as soon as taken, a ten-foot minnow seine hung to fish three feet, a thirty-foot minnow seine hung to fish five feet, and a forty-yard minnow seine hung to fish six feet. The Baird nets are not serviceable in the muddy streams of Illinois, as the bag collects too much mud. The party, consisting of two men who had had experience in such work, made no attempt to secure accommodations from farmers more than horse feed and water, experience of the previous year proving it to be very expensive in time and temper. Occasionally stops were made at hotels. The entire distance covered was about six hundred miles, in six weeks' time. The cost of subsistence in field, including some repairs, was about ten dollars per week.

In preserving fish the laboratory uses 10 per cent. formalin solution for killing, in which the fish is put as soon as taken from the water. In this the fish die with fins expanded. After remaining a few hours in this solution they are wrapped in cheese-cloth and transferred to a weaker solution (about 1 per cent. to 5 per cent.), for shipment. After being brought into the laboratory they are bottled in a solution consisting of 70 parts

95 per cent. alcohol, four parts glycerine, one part of formalin, and twenty parts of water. In this solution preservation is secured without the brittleness resulting from high per cent. alcohol.

The method of this institution in caring for collections may prove valuable to those interested in museum methods. Each catch is kept separate and given an accessions number referring to all data concerning it, which is entered in an accessions catalogue. The species are then separated and bottled, with tags (similar to those attached) on the outside and inside of the bottles.

Ac. No. Sp. No. Jor. & Ev. No.	**Ac. No.** **Sp. No.** **Jor. & Ev. No.**

Those on the inside are made of ledger paper and written with lead-pencil; those for the outside are written with India ink. The tags bear accessions number, a number referring to the species list of the laboratory, and a number referring to the species number in Jordan & Evermann's "Fishes of North and Middle America." All bottles containing a particular species are racked together in series according to accessions number and placed in shelves. The racks used are wooden trays of two sizes, the larger 4½x15 inches and meant to be wide enough to hold a two-quart fruit jar. The smaller are for vials and small bottles, and are 2x13 inches. This arrangement is exceedingly convenient for ready reference to any particular fish desired.

The plan of securing collections from volunteers in localities from which materials were needed for study of geographical distribution, was put in operation in April, 1900. It commends itself because of excellent results secured and the comparatively light cost. Letters inviting co-operation were sent to high school teachers and others, in localities that had not already been covered by field work. To those responding were sent two pairs of hip boots, a twenty-five foot minnow seine, a five-gallon milk can and a quantity of formalin, with directions for catching, labeling and preserving. In return for the service each collector receives a named set of the fishes from his locality. As a result of the volunteer work of the spring and summer a large triangular area lying between the Illinois and Mississippi rivers as far north as a line from Peoria to Rock Island was quite thoroughly worked, besides several other localities. Some collectors made collections representing entire counties.

Additions to the Indiana List of Dragonflies with a Few Notes.

By E. B. Williamson.

ADDITIONS.

1. *Calopteryx aequabilis* Say. Whiting, Lake County, June 9, 1900, along a ditch which drains into Calumet River, one male; and Wolf Lake, Lake County, July 21, 1900, two males. Clarence C. Bassett.

2. *Lestes eurinus* Say. Elkhart, June 8, 1900, one female. R. J. Weith.

3. *Enallagma calverti* Morse. Lake Maxinkuckee, May 27, 1900, two males, one female. Howard North.

4. *Nasiaeschna (Aeschna) pentacantha* Rambur. Banks of St. Joe River, Elkhart, June 10, 1900, two females. R. J. Weith.

5. *Aeschna multicolor* Hagen. City limits, Elkhart, September 5 and October 12, 1899, three females, one identified by Dr. Calvert. R. J. Weith.

6. *Sympetrum albifrons* Charpentier. Bluffton, Indiana, September 9, 1900. E. B. Williamson.

7. *Libellula exusta* Say. Woods near Simonton Lake, May 15 and 20, 1900. R. J. Weith.

The State list now numbers 91 species of Odonates. Four of the above additions are due to Mr. Weith, who has also added several species, known from other points in the State, to his local list. Collections are being made at Lake Maxinkuckee, Winona Lake, Evansville, and perhaps at other points, so further additions to the list may be expected, and our knowledge of seasonal and geographical range within the State is certain to be augmented. Descriptions of two of the species mentioned above are unfortunately not found in "The Dragonflies of Indiana." They are given in the notes which follow.

NOTES AND CORRECTIONS.

1. *Enallagma calverti* Morse is of the color type of *En. doubledayi* Selys. The male may be recognized by having the superior abdominal appendages much shorter than the inferiors, in profile appearing like a short cylinder with a rounded apex which is usually distinctly notched below the middle. Mr. Morse's original description of the male of this species follows: "Abd. 23–25mm., hind wing 17–19.5mm. Prothorax greenish black, the following pale (bluish): sides; a transverse line on anterior lobe; the hind margin and a cuneiform spot on each side of

posterior lobe. Thorax with a rather narrow mid-dorsal stripe (sometimes divided by a mere line of blue, most distinct anteriorly), and a very narrow humeral stripe, wider in front, especially at the suture, and a spot on second lateral suture, black. A wide ante-humeral stripe, equal to or wider than the mid-dorsal black stripe, blue. Abdomen blue, the following black: A spot on base of 1; a transverse lunule (convex side forward, doubly concave behind) near apex and a narrow marginal band on 2; an apical spot connected with marginal band on 3 and 4; apical third of 5, two-thirds of 6, five-sixths of 7, and all of 10.

"Superior appendages short, one-fourth to one-third as long as 10, blunt, with the apex directed downward and slightly notched in profile; the upper limb thick and rolled inward, the lower limb thin, rolled inward and upward, appearing like a small, rounded, inwardly projecting shelf on the lower edge of the apex of the appendage. In profile the upper apical angle is very obtusely rounded, the lower slightly notched. Inferior appendages longer, two-thirds as long as 10, rather slender, tapering, slightly curved upward, directed upward and backward, the lower margin convex throughout." Nevada, Wyoming and other western States, and Massachusetts. This is an interesting addition to the list of *Enallagmas* known to occur in Indiana, bringing the number to thirteen, and leaving two regional species, *doubledayi* and *aspersum*, yet to be discovered.

2. *Ischnura kellicotti* Williamson sometimes has the blue ante-humeral stripe of the thorax interrupted as it is normally in *Nehallennia posita* and rarely in *Ischnura verticalis* and *Enallagma germinatum*. Individuals were taken which had the stripe continuous on one side and interrupted on the other. The species was very abundant at Shriner, Round and Cedar Lakes, July and August, 1900, found only about the white water-lily beds. Orange females were numerous.

3. Dr. Calvert has recently called attention to the fact that *Gomphus externus* as identified by Kellicott and as described in "The Dragonflies of Indiana," is in reality *Gomphus crassus*. What is said of *Gomphus externus* on pages 289 and 290 of "The Dragonflies of Indiana," excepting geographical range, belongs to *Gomphus crassus*. *Gomphus crassus* is known from Kentucky, Ohio, Indiana and Illinois. *Gomphus externus* has been taken in Illinois and westward in Nebraska, New Mexico and Texas. It must be dropped from the Indiana list, though it may be found in the State in the future. It may be separated from *fraternus* and *crassus* by the following points: In *externus* the two lateral thoracic stripes are complete, not shortened or interrupted. *Externus* has the dorsum of 9 and 10 with a yellow band as usual in *crassus*. The appendages of the male of *externus*, as figured in the "Monographie des Gomphines," plate XXI, fig. 2, as seen in profile, somewhat resemble fig. 20, plate VI, "Dragonflies of Indiana," excepting

that they are more acute and the lower edge is less angular. The vulvar lamina in *externus*, as in *fraternus*, is not constricted at the middle as it is in *crassus*. In *externus* the lamina is bifid for almost half its length; in *fraternus* it is bifid for scarcely more than a fourth of its length. *Fraternus* and *externus* are about the same in size.

On page 285, "Dragonflies of Indiana," the references should be to plate VI, and not plate VII, as there printed. Line 17 from the bottom, same page, for *Abdomen about 40 in length.* EXTERNUS, read *Abdomen about 38 in length.* FRATERNUS.

4. In "Occasional Memoirs of the Chicago Entomological Society," Vol. I, No. 1, March, 1900, pp. 17 and 18, Mr. James Tough has described and figured the appendages of the male of a very interesting species of *Gomphus* under the name of *Gomphus cornutus*. The author's description is quoted.

"Length, ♂, 55–57mm.; abdomen, 40–42mm.; hind wing, 32–33mm.

"Yellowish green, with black and brown markings. Face and occiput yellowish green, eyes posteriorly black above, yellowish below, occiput distinctly convex, notched in center and fringed with black hairs, vertex and antennae black. Prothorax black, with a geminate spot in center and a patch on each side, yellowish. Thorax yellowish green, except a narrow band, indistinct or absent anteriorly, on each side of mid-dorsal carina, also except humeral and antihumeral bands, and margins of first and second lateral sutures, all of which are brown. Legs black, front femora yellowish green below. Wings hyaline with viens black, pterostigma yellowish, and costa yellowish green. Abdomen of uniform thickness, black, a dorsal stripe or spot on segments 1–8, small and basal on 8, and a small quadrangular spot on 10, yellowish; dorsum of 9 entirely black.

"Superior appendages dull yellowish; seen from above, internal branches produced inward and backward until they meet, acute and spinose at tip; external branches short, rather broad, and tipped with a blunt spine. Inferior appendage, seen from above, slightly longer than superiors, spreading, the distance from tip to tip of outer extremities being more than twice the width of the tenth abdominal segment at base. From side view the internal branches of superiors are seen to bear a conical tooth about midway between base and apex; the inferior curving upward gradually and each branch bearing a curved spine at tip.

"Described from two male specimens, taken at Glen Ellyn, Du Page County, Illinois, one June 14, 1897, the other May 30, 1898."

Mr. Tough writes me that he thinks he has since taken the female of this species. The occiput is high, rounded, and in front is a triangular pyramid, its base bounded by the line between the vertex and occiput, and by lines drawn from the extremities of this line to the middle point of the posterior edge of the occiput. This species will very probably be found to inhabit Indiana.

5. *Gomphus pallidus* Rambur. St. Joe River, June 8, 1900, one female. R. J. Weith.

6. *Gomphus spicatus* Hagen. Elkhart, May 20, 1900. R. J. Weith. In plate VI, "Dragonflies of Indiana," figs. 18 and 19 will *not* serve to distinguish the males of *Gomphus spicatus* and *G. descriptus*. Seen from above the superior appendages of *spicatus* have a distinct median external tooth; *descriptus* has the appendages angulated beyond the middle, but there is no tooth.

7. *Gomphus sp.* Page 294, "Dragonflies of Indiana," is a new species soon to be described by Mr. Hine.

8. With a knowledge of the nymph of *Tachopteryx thoreyi* another arrangement of the genera of the Gomphinae than that employed in the "Dragonflies of Indiana" becomes desirable. The arrangement of genera of the Gomphinae as worked out by Selys in his "Synopsis des Gomphines" and culminating with his final "Note sur la classification" in the fourth addition to the Synopsis, may be employed here for the genera taken in Indiana. The genera would then stand in this order: *Ophiogomphus*, *Dromogomphus*, *Gomphus*, *Progomphus*, *Hagenius*, *Tachopteryx*, *Cordulegaster*.

9. The genus *Nasiaeschna* has recently been established by Selys (Természetrajzi füzetek, XXIII, 1900, p. 93) for the species *Aeschna pentacantha* Rambur. In the key to genera in "The Dragonflies of Indiana" *pentacantha* will run out to the genus *Epiaeschna*. The genus *Nasiaeschna* is distinguished from *Epiaeschna* by the supplementary sector between the subnodal and median sectors being separated from the subnodal by one row of cells (two rows in *Epiaeschna*), by having the face excavated, by the absence of a dorsal spine on abdominal segment 10 in the male, and by the superior appendages of the male being shorter and less dilated.

10. *Aeschna multicolor* Hagen. Calvert (Odonata of Baja California, p. 509) has the following paragraph relating to the range of this species. "*Distribution.* Mexico (Cordova, Baja California), California, Texas, Dakota, Colorado, Yellowstone, British Columbia (Victoria)." In Bull. Geol. Surv. Terr. 1875, p. 591, Hagen says of it, "A decidedly western species." To find it in Indiana is a surprise. The following description is found in the Syn. Neur. N. A., 1861, p. 121. "Fuscous, spotted with blue, head blue (♂) or luteous (♀), front with a T spot, each side terminated with yellow, and a band before the eyes, black; thorax fuscous, dorsum each side with a stripe (interrupted or absent in the female), sides, each side with two oblique ones blue (♂) or yellow (♀); feet black, femora

rufous above, the apex black, anterior femora beneath, luteous; abdomen moderate, slender, cylindrical, narrow behind the inflated base; fuscous, spotted with blue (♂) or yellow (♀), segments 3–10 with two large, apical spots, segments 3–8 with two triangular spots upon the middle, and a basal, divided spot each side, segment 2 with a medial interrupted fascia, and a broad apical one, blue or yellow; superior appendages of the male black, long, foliaceous, narrow, the base narrower, inwardly carinated, straight, curved inwardly before the apex, an elevated triangular lamina above, and a longer tooth placed more inferiorly; the apical tip acute, curved downwards; the inferior appendage, pale fuscous, one-half shorter, elongately triangular; appendages of the female moderate, fuscous, foliaceous, broader; wings hyaline, those of the female towards the apex, subflavescent, pterostigma short, fuscous, or luteous (♀); membranule fuscous, the base white; 16–17 antecubitals; 8–9 postcubitals. Length 65–67 mm. Alar expanse 90–100 mm. Pterostigma 3–3½ mm." Calvert (Odonata of Baja California, p. 503) describes the superior appendage as having the apex distinctly forked when viewed in profile. "Front wings with discoidal triangle 4–6-celled, internal triangle 2-celled, rarely free, 3–4 other median cross-veins, 1–2 supratriangulars, first and sixth or seventh antecubitals thicker. Hind wings with discoidal triangle 4–5-celled, internal triangle 2-celled, 2–3 other median cross-veins, 1–2 supratriangulars, first and fifth or sixth antecubitals thicker. Male: anal triangle 3-celled; 10 with a small, median, basal, dorsal tooth and a smaller one on each side. Abdomen ♂ 47–51, ♀ 49. Hind wing ♂ 43–47, ♀ 45–47." (Calvert, Odonata of Baja California, p. 508).

11. *Didymops transversa* Say. Simonton Lake, May 15 and 20, 1900; and St. Joe River, Elkhart, May 29, 1900. R. J. Weith.

12. *Epicordulia princeps* Hagen. St. Joe River, Elkhart, July 7, 1900. R. J. Weith.

13. Males of *Sympetrum rubicundulum* and *Sympetrum obtrusum* exhibit but little difference in coloration. *Rubicundulum* has the face light brown, yellowish, darker above; *obtrusum* has the face white. The general body color of females of the two species is distinctive. *Obtrusum* and *rubicundulum* seem specifically distinct for the following reasons: both sexes offer differences in color and structure; they occur together, often in the same isolated swamp; and there seem to be no intermediate forms. On September 9, 1900, *obtrusum*, *rubicundulum* and *albifrons* were associated together in a small swamp surrounded by woodland in Wells County, near Bluffton. At a glance both sexes of *albifrons* may be recognized by the face, white below, shading above into a clear china blue, the frontal vesicle being of the same color.

14. The genus *Diplacodes* is distinguished from related genera: by the triangle of the fore wings long and narrow, free (usually) and followed by two rows of post-triangular cells (three or four rows in related genera); and by the last antenodal not continuous. *Diplacodes minusculum* could *not* be traced out by the key to genera, "Dragonflies of Indiana," p. 250. The hind lobe of the prothorax in this species is narrower than the middle lobe, sides straight, but with the hind margin emarginate, giving it a bilobed character. The supratriangular space is free and there are eight antecubitals in the front wings. In the arrangement of the genera in the "Dragonflies of Indiana" *Diplacodes* may be placed between *Pachydiplax* and *Nannothemis.* Old males of *Diplacodes minusculum*, like old males of *Nannothemis bella*, are entirely pruinose.

Eskers and Esker Lakes.

By Charles R. Dryer.

(Published in full in Journal of Geology, Vol. IX, p. 123.)

(Abstract.)

(1) The sand, gravel and till ridges around High Lake, Noble County, Indiana, with their associated lakes and kettleholes, are described and their structure and origin discussed. The till ridge is thought to be a frontal moraine, the others to be the result of subglacial drainage and the sliding or dumping of drift material into crevasses. These forms are so connected in space and related in structure as to render genetic classification difficult. The system as a whole constitutes an esker-kame-moraine.

(2) The esker system of Turkey Creek, Noble County, Indiana, is described. These sand ridges traverse the valley floor and nearly inclose the basin of Gordy's Lake. High and Gordy's lakes seem to constitute a distinct species for which the name *esker lakes* is proposed.

The paper is accompanied by two maps.

Spy Run and Poinsett Lake Bottoms*.

By J. A. Price and Albert Shaaf.

Spy Run and Poinsett Lake are located near Fort Wayne, Indiana, and to understand their history a knowledge of the region about Fort Wayne is necessary. This region is situated in that portion of the State which was formerly covered by the Erie ice-lobe. At different periods in its recession the end of the Erie ice-lobe was stationary, for a long time depositing large terminal moraines. Four of such moraines were thus formed, upon one of which, the first Erie moriane, Fort Wayne is located.

The territory in question lies on the first Erie moraine, a full description of which may be found in the Sixteenth, Seventeenth and Eighteenth Annual Reports of the State Geologist, and in Charles Dryer's "Studies of Indiana Geography." This moraine, a massive, well defined ridge with a hommocky surface, enters the State at the southeast corner of Adams County and follows the Wabash River to the northwest corner of Wells County, running parallel to the present shore line of Lake Erie; it then turns to the north and northeast and enters the southwest corner of Allen County. Increasing in width, it continues in a northeasterly direction and leaves the State at the northeast corner of Dekalb County.

As the ice continued to recede a large lake was formed northeast of the present site of Fort Wayne. The surplus waters of this glacial lake were drained into the head waters of the Wabash through the Erie-Wabash channel. Glacial Maumee Lake, as it was called, probably existed for many years, but as its eastern bank was a massive wall of ice it was doomed to destruction. As the ice melted the lake was slowly drained until it was entirely destroyed, and as the waters of the lake ebbed away its outlet dwindled and was finally silted up. St. Joseph and St. Mary's rivers, which had emptied at the point where the Erie-Wabash channel left the lake, now turned back and formed the Maumee, a slow, sluggish, meandering stream which wound itself across the old lake bottom.

The territory covered by the accompanying map lies about one and a half miles northwest of Fort Wayne, and north of the Wabash-Erie

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* Credit is due Robert Feustel for his work on the accompanying map.

channel and west of the St. Joseph River. The Lake Shore and Michigan Southern Railroad passes along its eastern and the Grand Rapids and Indiana road along its western edge. It is crossed by two wagon roads, the Lima and the Goshen. Both basins are oblong, Spy Run Lake basin being about four-sevenths of a mile long and two-sevenths of a mile broad, Poinsett Lake basin being about one mile long and one-half of a mile broad.

The topography in general is smooth and level, with gentle swells here and there, characteristic of lake bottoms. The region is drained by Spy Run Creek and its tributary, the Poinsett. Numerous artificial channels are led into these streams which make the drainage more perfect. Where these channels do not occur, swamps are found as indicated on the accompanying map.

The origin of Poinsett and Spy Run lakes dates from interglacial times. These two lakes belonged to a large class of lakes which once diversified the surface of parts of the glaciated portion of the State, but which now have become extinct: irregular basins with rich soil and level bottoms remain to tell the story of their former existence. A number of these lakes were formed by glacial dams and may be divided into two classes: those produced by the irregular deposits of moranic material and those caused by the ice itself during the period of its continuance. It is quite probable that both of these causes united to form the two lakes under consideration. As the Erie ice-lobe withdrew to the northeast irregular deposits of glacial debris were left in its wake, forming knolls and basins; these basins were in the course of time filled by subsequent rains. The streams entering these basins may have been dammed by the ice front, when it occupied the position indicated by the lines *a b* on the accompanying map. The basins are enclosed at most places by rather steep banks, varying in height from ten to thirty or more feet. Between the basins and north of the stream the bank is low and gentle, running back for some two or three hundred yards. Indications of a shore line may be seen about half-way up this gentle slope, indicating a union of the two lakes.

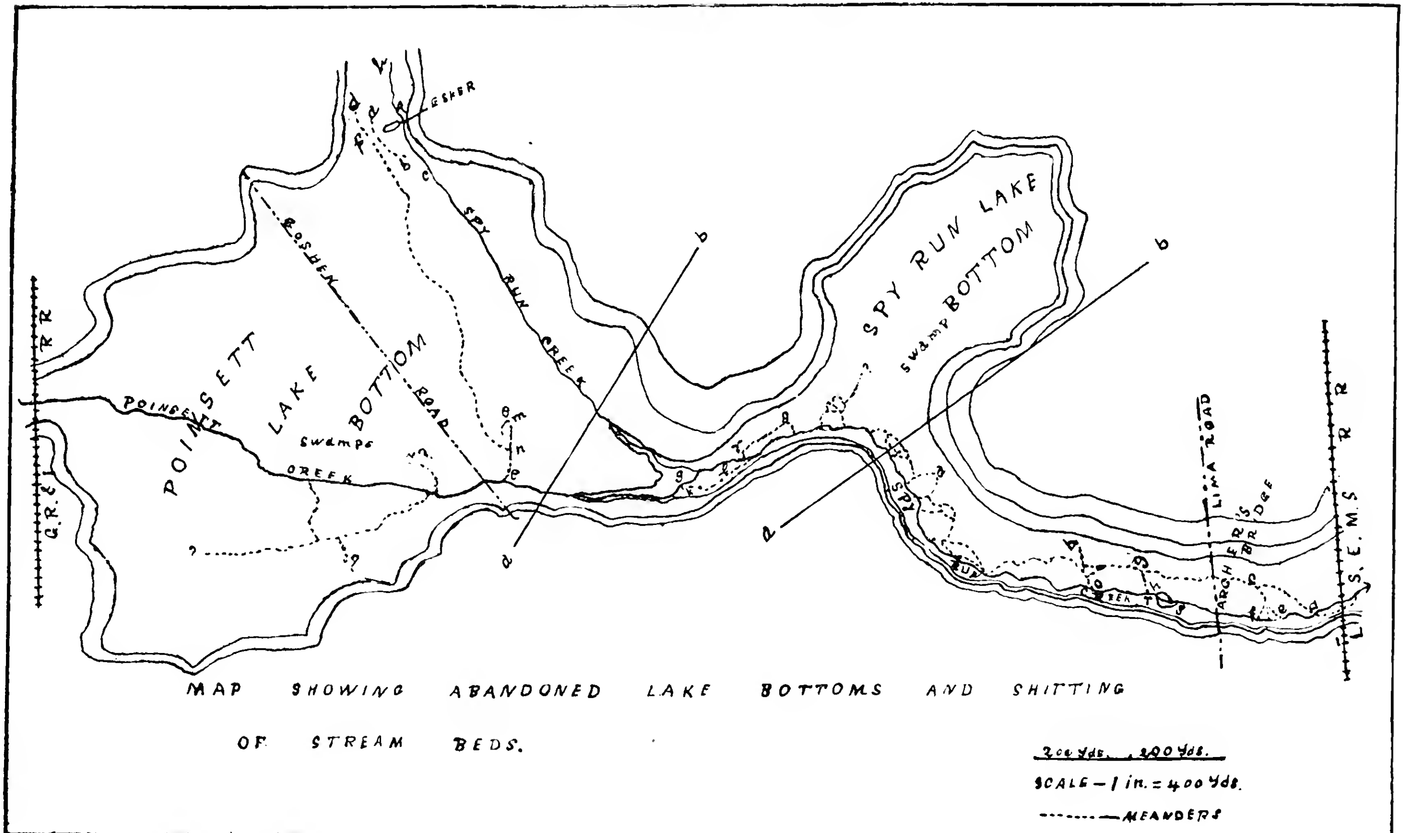
The length of time during which these lakes existed may be inferred from the depth of the silt which accumulated over their bottoms. The accumulation of this silt has made favorable the growing of crops. Man has taken advantage of these conditions and where it is not too swampy is cultivating the soil. This is only one instance where the former existence of glacial lakes has made favorable the conditions for man's occupancy. Maumee Lake basin, mentioned above, has a very rich soil, and yields some of the finest crops grown in the vicinity. Beyond the boundaries of our own State, and south of the line marking the farthest extension of the ice during the ice age, and south of lines marking periods of rest in its recession are many such basins; rivers were dammed, new lakes formed, and old ones enlarged, until to-day thousands of square miles of rich farming lands are found in the United States which would not otherwise have been here. The great wheat growing region and fine pasture lands of North Dakota are thus explained. "Such was the heritage which the great glacier of the ice age left as its parting gift, thus assuring the permanent prosperity of large and widespread regions of North America."

Abandoned Meanders of Spy Run Creek.

By J. A. Price and Albert Shaaf.

Spy Run Creek rises in the north central part of Washington Township, Allen County, and empties into the St. Mary's River, near Fort Wayne. It is a small, insignificant stream, but has, however, some noteworthy features, foremost of which is the marked shifting of its bed in and below Spy Run lake basin.

The head waters of this creek probably existed before the final retreat of the Erie ice lobe from the site of the first Erie moraine. The creek was dammed by the ice front, thus helping to form Spy Run Lake. The waters of the lake followed the ice in its gradual retreat and in this manner the lower extension of the creek was formed. At this time this part of the stream was probably much larger than at present. Its increased volume was due to the supply of water received from the lakes. It is impossible to say how long the stream was occupied in draining these lakes. At present, however, the stream has a well developed flood plain varying in width from two to three hundred yards. As a rule there are two or three annual overflows, during which time the waters cover a part or all of the flood plain. The depth of the water varies from six to eighteen or more inches. The strength of the current over the flooded area may be inferred from the fact that several years ago a rail fence



MAP SHOWING ABANDONED LAKE BOTTOMS AND SHITTING OF STREAM BEDS.

crossing the bottoms was carried away. As the waters disappear from the flood plain very little sediment is left behind, owing to the fact that at this time the lower parts of the old lake bottoms are covered with water which serves as a filter. If this were not the case the old meanders that are now found on the flood plain would doubtlessly be filled up.

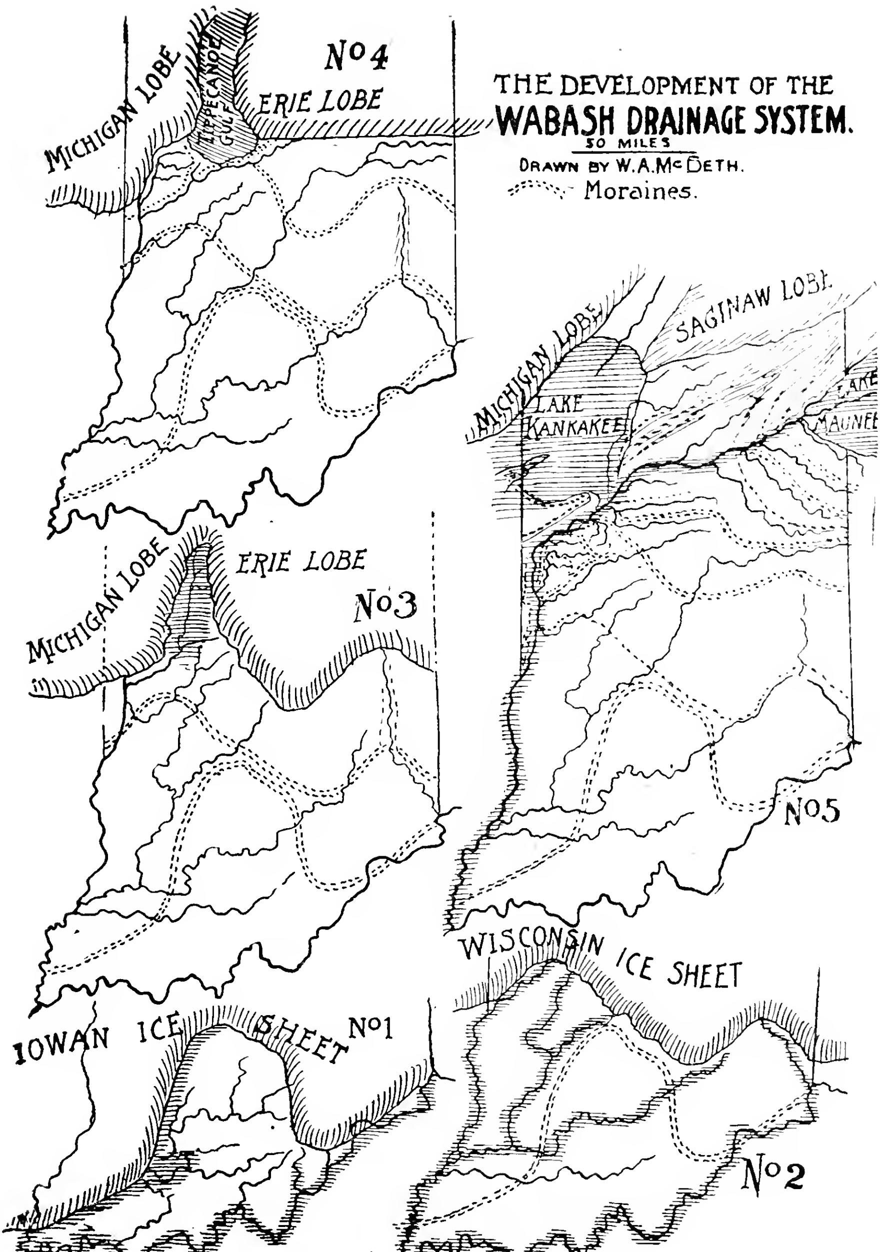
An inspection of the accompanying map will reveal the complexity of these meanders. In Poinsett Lake bottom the complexity is less than in and below Spy Run Lake bottom. There is one long abandoned channel (*fe*) crossing the bottoms from north to south parallel to the present channel of the stream, and entering Poinsett Creek below Poinsett bridge. The north half of this channel is well defined, having a width of three to six feet and a depth of one to three feet. Its bottom and banks are covered with a heavy growth of underbrush. Its northern end gradually decreases and finally disappears: this may be due to the fact that this part of the basin has been longer under cultivation. One hundred and fifty yards south of the north end of channel *fe*, and twenty-five yards east, lies a portion of an old meander marked *ab*. This channel is probably younger than that part of *fe* indicated by *de*. The stream left the old channel at *d* and occupied *abcg*, a part of which, *cg*, is still occupied; channel *cg* has probably been straightened by man. North of *c* the present channel is artificial, cutting diagonally through the east end of an esker at *p*. This portion as far north as was examined seems to be very young. The channel through the esker is narrow, with steep sides about ten or twelve feet high. This esker is eight or ten feet high and about one hundred and twenty-five yards long; it was connected with the uplands at *p*. Channel *fe* connects with a short, crooked channel, marked *mn*, in the southeastern part of the basin. This channel marks the lowest part of the southeastern portion of the lake bottom and was probably the last part covered by the lake waters. This last fact is indicated by the crookedness and blind ending of the channel. Between points *e* and *g* there are two or three small meanders along Poinsett Creek not marked on the map. Two abandoned meanders are found between the lakes; one, *kl*, belongs to Poinsett Creek, and the others, *rs*, to Spy Run Creek. The former is very recent, the stream having been turned from its course by the artificial channel *kg*. Below point *l*, at the sharp turn in the creek, the bank on the east and convex side is steep and nearly perpendicular; on the opposite side a flood plain is developing. In the southwest part of Spy Run Lake bottom occurs a complex system of old channels which indicate the part of the lake last drained. This is further shown by the more or less swampy condition of this part. Below the lake bottom the system of meanders is so complex that it is impossible to trace out, with any degree of certainty, the different stages which occurred in the shifting of the stream bed. Along the north side of the flood plain there is an old channel which seems to be the oldest in the system. Near the south side, where the stream is now located, the channels are less obscured, indicating that the creek has shifted its position from north to south and suggesting that probably the complex system of meanders is due to this migration. A number of cross channels connect the old channel on the north with the present one. In developing this system of meanders the stream may have followed channel *abc*, leaving it at *c* and entering its present channel, first at *d* and then at *e* and *f*. It then probably left the old channel at *g* and crossed to its present one by the cross channel *gh*, and at *b* by channel *bo*. Above this point the complexity increases, the meanders are smaller, with a greater number of cross channels. Four very young meanders lie south of the stream, one of which, *rs*, is at times occupied by part of the stream, forming a small island.

The Development of the Wabash Drainage System and the Recession of the Ice Sheet in Indiana.

By W. A. McBeth.

The development of the Wabash drainage system has now been worked out to such an extent as to show that it is not only a subject of interest in itself, but also has an important bearing on the question of the movement and recession of the North American ice sheet. The whole of the axial stream, except a few miles near its mouth and perhaps 30,000 of the 33,000 square miles comprised in its basin, were buried beneath the ice one or more times, and there is scarcely a tributary which does not show plainly the effects of the influence of the ice sheet in determining its course and its drainage area.

Along the line of the lower Wabash, the earlier ice approached within twelve or fifteen miles of the Ohio River, and almost to the limit of ice


THE DEVELOPMENT OF THE
WABASH DRAINAGE SYSTEM.
50 MILES
DRAWN BY W. A. McBETH.
Moraines.
No 4
MICHIGAN LOBE
TIPPECANOE GULF
ERIE LOBE
No 3
MICHIGAN LOBE
ERIE LOBE
SAGINAW LOBE
MICHIGAN LOBE
LAKE KANKAKEE
LAKE MAUMEE
No 5
WISCONSIN ICE SHEET
No 2
IOWAN ICE SHEET
No 1

movement the evidence of obstruction and readjustment appears. Near the southern limit of the drift the Patoka River is an example of a stream made up of several sections. Three northwestward flowing streams were obstructed in their lower courses by the ice, and compelled to seek westward outlets across divides along the ice border. The lower course of White River was also obstructed and the part within the unglaciated area ponded up in its deep valley through the Knobstone. In the main stream and in many of its tributaries temporary lakes were formed which overflowed over the ice or along the ice border.

West White River is conspicuously a border drainage line as far up as northern Monroe County, as shown in its course through Owen, Greene and Daviess counties.

The position of the Shelbyville moraine indicates that Raccoon Creek was in existence through half its length before the Wabash was uncovered north of Vigo County. Further recession northward brought Sugar Creek into existence. This stream is very distinctly of border drainage type, as shown by the prominent moraine along its north bank from its mouth to southwestern Clinton County. After further recession of the ice sheet Coal Creek took its way north of a region of morainic uplands, until it came against a strong north and south moraine which deflected its north branch in a great bend, remarkably like that of the Wabash. The part of this stream above its great bend is comparatively meandering and its valley, which is very shallow, is in marked contrast with the deep, broad valley below the bend. South Shawnee Creek runs west parallel with North Coal Creek and bends to the north within a mile of where this creek bends to the south. A broad, marshy valley connects the two bends, indicating that South Shawnee Creek formerly turned south. These creeks have their sources at the crest of the kame moraine, which runs northwest from Darlington, Montgomery County, toward Independence, Warren County, and are guided by moraines trending east and west. To the east of the Darlington-Independence divide, the streams flow northeast in a direction opposite to that of the Wabash. They are turned northwest into that stream by a moraine running southeast from a point about five miles south of Lafayette to the southeast corner of Tippecanoe County. The three forks of Wild Cat Creek coming from the east turn north along the western side of a moraine, which lies along the western edge of a till plain rapidly rising to the east. This moraine, in my opinion, is the strong outer moraine of the Erie lobe and marks the westward limit of Erie ice as a separate lobe. The Wild Cat creeks, above their northward bend, are bordered along their northern bluffs by weak, but distinct, moraines.

Returning to the Wabash, at the great bend we find it following the south side of a strong moraine from the mouth of Tippecanoe River to the point of its southward deflection. The drainage on the south side of the stream through this section was all to the south and west previous to the recession of the ice to the north side of the river. Above the mouth of the Tippecanoe the Wabash becomes probably a distinctly terminal drainage stream of the Erie lobe, and its tributaries have come into existence in pairs on opposite sides of the main stream as the ice withdrew toward its source. The head waters of the southern tributaries have in several instances been pirated by the stream to the south and west of them, as in the case of the deflection by the Mississinewa of a tributary of West White River north of Muncie, and the capture of the Salamonie by the Wabash above Ceylon. The development of these upper tributaries and the former connection of the St. Mary's and St. Joseph rivers and the glacial Maumee Lake with the Wabash by way of the broad valley of Little River extending from Ft. Wayne to Huntington have become familiar facts through the investigations made by Dr. C. R. Dryer and published in the Sixteenth, Seventeenth and Eighteenth Reports of the State Geologist of Indiana. The Tippecanoe River, after the manner of the upper tributaries of the Wabash, may be paired with the Wild Cat Creek. Below the great bend of the Tippecanoe, in Starke County, it drains the western edge of the Erie drift; above that bend it receives its water supply from the Saginaw drift. From its mouth to New Buffalo, ten miles north of Monticello, it has a deep valley (100 feet at Monticello) and varying from one-half of a mile to a mile in width. Above this deep portion, the character of its valley changes rather abruptly to a very narrow and superficial channel, not much too large to carry its flood waters. This shallow valley is remarkably meandering, much of the general course being originally guided by sand ridges. The lower portion of the Tippecanoe was evidently the former outlet of a lake of considerable extent, which covered the country north of Monticello. The earliest lake area may have extended southward to the immediate vicinity of the mouth of the river, where the strong moraine running along the north bluffs of the Wabash changes abruptly near the Tippecanoe battleground to a chain of low gravel mounds, which continue across Pretty Prairie, a gravelly terrace plain, a distance of three miles to the mouth of the Tippecanoe River. The crest of this moraine at the Soldiers' Home, four miles north of Lafayette, is higher than the surface of the plain at Monticello or Winamac, and the gap has the appearance of having been once the passageway for a large stream from the north. The part of the Tippecanoe from New Buffalo to the great bend is the newest part of the stream. It established its meandering course among the sand ridges along the eastern side of the lake bed and connected the part above the bend, which formerly flowed into the lake, with the part which was the lake outlet, giving an interesting example of a spliced stream.

The description of the development of the drainage of the Wabash system has been traced to the above extent in order to group its main facts together and bring them to bear on the question of the manner of recession of the ice sheet from its basin and some of those basins adjoining it.

Several writers on problems connected with the drift area seem to assume that the ice sheet could not have receded in any other way than from west to east. The Kankakee Lake, the western Indiana bowlder belts and various other problems are perplexing problems on this assumption. While in a general way the view is doubtless true that the recession was in this direction, the solution of several interesting points connected with Indiana drainage becomes simple by the acceptance of good evidence that in western Indiana the recession was from east to west.

The Michigan, Huron and Erie depressions were doubtless lines of southward and southwestward movement which became filled with ice and overflowed before the country between was invaded. Gradually the ice accumulated and covered the crests of the divides, becoming a confluent area with smooth, regular slopes on the surface, but conforming generally on the under side to the relief of the rock surface below. Valleys and low tracts of the preglacial surface would become lines of more rapid flow and the ice would move farther forward along these lines than elsewhere. The arrangement of the moraines in Illinois, Indiana and Ohio shows the influence of this lobate movement to the limits of the drift of any period.

The curving to the north of the glacial boundary in Indiana is easily explained by the stranding of the ice along the north and south belt of resistant rocks, including the Knobstone in that part of the State, while the lower regions to the east permitted the advance of the ice to the Ohio River, and on the west the ice crept south almost to the mouth of the Wabash in Indiana and nearly to the mouth of the Ohio in Illinois. The last general invasion sent ice much further south in Illinois than in western Indiana.

The recession of the ice was in general the inverse of its advance. It melted away on the divides, became differentiated again into lobes, which gradually withdrew up the depressions along their lowest lines. The evidence is abundant to show that the last ice sheet disappeared along a line running east of the Wabash River from Terre Haute through Crawfordsville to Lafayette before the region traversed by the present river below Lafayette was uncovered. Probably this interlobate melting continued northward along the line of the lower Tippecanoe and upper Kankakee into Michigan.

The evidence that the last ice in western Indiana occupied the region south and east of the great bend of the Wabash after it had receded from the country farther east is embraced in the condition and arrangement of numerous moraines, many overflow channels, and temporary lake beds with their traversing stream lines of different ages.

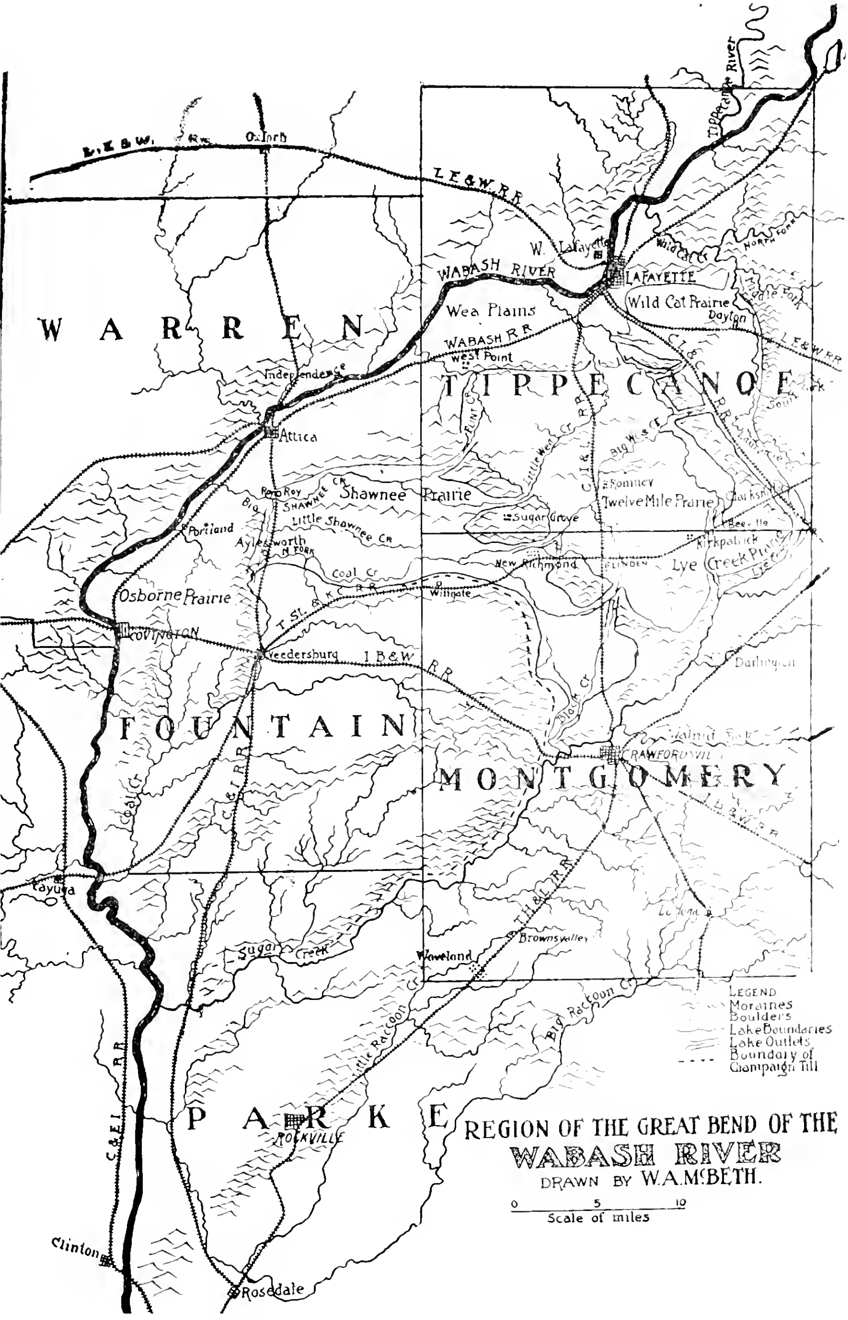
The moraines along Raccoon Creek, Sugar Creek, the southward flowing part of Coal Creek and the east and west ridges extending across Fountain County, together with a high, sharp, and in some places very narrow moraine running east from the town of West Point, Tippecanoe County, to a point five or six miles southeast of Lafayette, do not seem to have been overridden or much disturbed since they were laid down. They were deposited by ice from west and north of the present river line and according to their shape and trend, evidently by the Lake Michigan lobe. The heavy moraine north of the Wabash and west of the mouth of the Tippecanoe has not been overridden. It is a moraine of the Michigan lobe called, by Mr. Frank Leverett, the "Bloomington moraine," and extends twenty-five or thirty miles farther northeast than he has mapped it.* Moraines trending northwest and southeast in southern Tippecanoe County seem to be outposts of minor advances of the ice from the Erie lobe around the southern edge of the Michigan lobe. These ridges run across the line of division between the lobes and have numerous gaps through them.

*See map pp. bet. 24-25, in his late U. S. G. S. Monograph XXXVIII on the Illinois Lobe.

These gaps and old channels are numerous and conspicuous in northern Montgomery and southern Tippecanoe counties particularly. Lye, Potato and Black creeks, flowing south into Sugar Creek, have their present sources at gaps in the divide to the north, where they approach in some cases within a few feet of the sources of streams flowing northeast and north into the Wabash.

A map and discussion of this region was presented to this body at its last winter meeting, and the points reviewed are referred to in connection with the present question of recession. The Independence-Darlington moraine has at least six overflow channels across it, from which the water formerly flowed south between this ridge and the eastern edge of what Mr. Leverett calls the "Champaign Till Sheet" in his report mentioned above. This till sheet approaches in the vicinity of New Richmond, Montgomery County, within a mile of the Independence-Darlington ridge, the space between showing long stretches of very fertile level prairies, doubtless the beds of former lakes. North Coal Creek now flows west along the northern bordei of this portion of the Champaign till sheet, to the great bend where it flowed against the eastern edge of the Michigan lobe and was turned south within six miles of the present line of the Wabash and compelled to make its way twenty-five miles to the south before joining it. South Shawnee Creek turned south then and joined Coal Creek at the bend through the marshy sag now connecting their abrupt elbows.

A comparison of the altitudes of these gaps with the altitudes of stations along the Cloverleaf Railway (T., St. L. & K. C.) shows very well the westward slope of the country along the divide between the streams flowing north into the Wabash and those flowing south into Sugar Creek. In the order of their occurrence from east to west the stations and their altitudes are: Clark's Hill, 818 feet; Beeville, 792 feet; Kirkpatrick, 787 feet; Linden, 783 feet; New Richmond, 776 feet; Wingate, 776 feet; and Aylesworth, at the bend of Coal Creek, on the C. & E. I. R. R., 644 feet. Aylesworth is 150 feet lower than Beeville and 130 feet lower than New Richmond. The water then must have been held in by a barrier approximating 150 feet in height to account for the overflow channels south along the eastern edge of the Champaign sheet. The altitude of the overflow channels toward the south would give the lake lying north and east of the divide a depth increasing with the northeastern slope to more than 100 feet at Dayton in eastern Tippecanoe County, whose altitude is 673 feet, as compared with 787 feet at Kirk-



REGION OF THE GREAT BEND OF THE WABASH RIVER
DRAWN BY W. A. McBETH.

patrick or 776 feet at New Richmond. The recession of the ice from the present line of the Wabash removed the back wall from this arrangement of features and the gradual cutting down of the valley of the Wabash eventually drained the larger and several succeeding smaller lakes and permitted the establishment of the present drainage of southeastern Tippecanoe County.

It may now be said that an extension of the same process further north and the disappearance of the ice along the line of the Tippecanoe to its great bend, and along the upper Kankakee, while the ice still occupied the country to the west, would make quite simple the problem of Lake Kankakee and other temporary glacial lakes.

The arrangement of moraines along the north bank of the three forks of Wild Cat Creek together with the pirating of the heads of several southern tributaries of the Wabash indicates a comparatively rapid northward recession of the southern edge of the Erie lobe.

The region embraced in the Wabash basin still doubtless presents in almost every county interesting problems for the intelligent investigator who may care to look for them, and the facts and opinions here set forth are intended as suggestions to be verified or rejected by others or myself, after further investigation.

Note: In No. 3 and No. 4 of maps illustrating the development of the Wabash drainage system I have indicated the probable line of interlobate melting. I have suggested the name Tippecanoe Gulf for this reentrant area.

A Theory to Explain the Western Indiana Bowlder Belts.

By W. A. McBeth.

The proximity of the bowlder belt southeast of Independence, Warren County, to the moraine which parallels it a little distance to the west, is a marked relationship. The bowlders lie on and along the foot of the eastward slope of the moraine. Where the slopes are gentle the belt widens out, and on the abrupt slopes the width decreases and the bowlders are more numerous. There are also patches of them on the ridges and knolls that lie to the east at levels lower than the main divide. Bowlders are not infrequent anywhere in the whole of western Indiana, but are considerably more numerous in the belt than elsewhere. They are also more numerous about the eastern ends of the sags or low valleys through the Independence-Darlington moraine. They are very numerous in the valley of the Wabash at Independence where the belt crosses the river. Here in the lowest part of the valley, and on the terrace north of the river, they lie so thick over the surface that a man might cross a field stepping from one to another. The belt is not continuous, but there are gaps both south and north of Independence.

A number of theories to explain these bowlder belts has been proposed. The theory which was in some way suggested to Mr. T. C. Chamberlin, that they are beach lines, was dismissed by him with scant notice. His objections to the theory were that the slopes are all to the southwest and that there could be no ponding of great extent in front of the ice sheet. The general slope indeed is to the west, but the slopes on which the bowlder belts lie are eastward slopes. Further, the belts lie at the western side of areas that have been for considerable periods of time covered with water.

The belt southeast of Independence is conspicuously related to the western border of such a lake area. The belt northwest of the Wabash follows quite closely the western curve of the border of the south arm of Lake Kankakee, as mapped by Mr. Leverett.*

This belt is not necessarily or probably a continuation of the belt south of the Wabash River. Nor are the bowlders lying across the valley at Independence certainly to be correlated with the belts to the north and south. All the bowlders were probably deposited by floating ice. at the western shallow edges of the lakes, where bergs and floe ice would strand and drop their loads. They were deposited in the river valley at Independence while the river was at that point the outlet of an extensive lake held in the deep preglacial valley extending upstream to the mouth of the Tippecanoe River and of unknown width and extent. This lake has since been filled by gravel deposits, but bergs stranding about the outlet may have deposited the bowlders at the top of the terrace, and they have since dropped to lower levels as the valley was cut deeper. Reasons for believing that the ice sheet disappeared from the region to the east of the present southward flowing course of the Wabash and along the Tippecanoe River are stated in the article on "The Development

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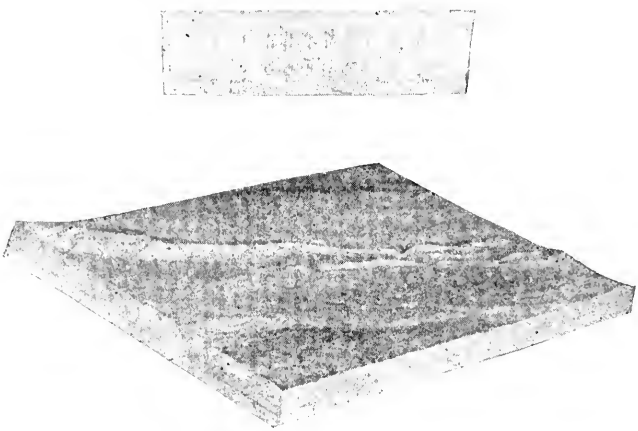
* In his Monograph on the Illinois Lobe, pages between 24 and 25.

of the Wabash Drainage System," in this volume. The westward wall of ice along this Tippecanoe Gulf helps to explain the laking which was due to the obstruction of drainage toward the west.

Commenting on the theory proposed, Dr. C. R. Dryer mentioned that the Iroquois Beach in New York is thickly strewn with bowlders in much the same way as the Indiana belts mentioned.

Aids in Teaching Physical Geography.

By V. F. Marsters.



Harper's Ferry Sheet.

The past decade has witnessed a growing interest in and a corresponding advancement along rational lines in geography, now justly regarded as a technical science. One of the pertinent reasons for this is that the seeker after knowledge, long before the college is reached, is becoming cognizant of the fact that the mere accumulation of geographical facts does not constitute geographical knowledge in the scientific sense. To know *where* the Blue Ridge is, is simply memorizing a *fact;* to know *what* it is, and, still further, to find out for one's self something about the sequential history of this topographic feature, constitutes *real geographic knowledge.* The former calls for observation and the sole exercise of memory; the latter demands that we not only accumulate facts, but that we seek a rational explanation of the facts observed. And just so far as we can see the relationships of the factors concerned in a geographical problem, and the role each has played in producing the observed results, to that degree have we gained real and useful scientific knowledge.

It was with this fundamental principle in mind that I have set about to prepare some geographical helps to attain this end. Any piece of apparatus such as a geological model, or map which properly expresses an evident relation between the geology or rock structure and the topography provides good material from which may be gained genuine geographical knowledge. Such material, however, is often in poor form and shape for laboratory use, and more often quite useless for lecture purposes, the scale being too small, or facts not well expressed. The material I describe below is intended primarily for use in lecture work. It consists of a lantern slide of a model representing a type of land form, and showing at once the relief of the land as well as the rock structure in two cross sections. With the picture of a model which brings out clearly the relations of structure to topography, and all the larger features of adjustment of drainage to structure, the lecturer can actually show up the facts as well as the arguments leading to his interpretation of the actual history of the land form discussed. Such details as could not be shown on ordinary maps may be clearly depicted by this method of illustration.

The data used in the construction of the illustrated model were gathered from the Geological Atlas sheets published by the United States Geological Survey. The area selected is that covered by the Harpers Ferry sheet. From the data therein contained, a model was constructed on the scale of one inch to the mile, vertical scale one inch to sixteen hundred feet.

The method used in the construction of the base may be aptly termed the contour method. The course of procedure was as follows: The topographic sheet was first enlarged to the desired scale. In the case of Harpers Ferry it was enlarged from two miles to the inch to one mile to the inch. The culture in addition to the topography was also transferred to the enlarged sheet and the whole traced on tracing cloth. The next step was to determine the vertical scale which would give the most expressive and yet close approach to the natural appearance of the topography when combined with a given horizontal scale. In the illustration selected it was found that sixteen hundred feet to the vertical inch gave the most effective result. Inasmuch, then, as the contour interval used on the topographic sheet was one hundred feet, and we wished to adopt in the construction of the model the scale mentioned above, it follows that sixteen sheets of strawboard, one-sixteenth of an inch in thickness, placed one upon another, would provide the vertical scale desired. This determined, each contour, beginning with the lowest, was then traced on separate sheets of strawboard, carefully cut out, piled in their proper succession and location, and tacked to a well seasoned wooden base or platform. The model at this stage presented a terrace-like appearance. This objectionable feature so often seen on geographical models, was easily obliterated by covering the entire surface with a sheet of clay, taking care of course to preserve as much of the details of relief as was shown on the original map. A plaster negative was next made from the original and from it a final positive was prepared. After thorough drying, the surface was painted a dead white. The partings or the contacts between adjacent formations as indicated on the geologic sheets referred to above, were carefully plotted and drawn on the white surface, in well defined black lines, sufficiently broad to be clearly photographed on a scale small enough to be transferred to a lantern slide. Before taking this step, however, another addition was made to the model. Two cross sections expressing the structural geology, one from east to west and the other from north to south, the former located on the south end and the latter along the east side of the model, were prepared. The outline of the topography along the respective sections was also traced on each section and cut out. These sections were then fastened to the end and side of the model in their proper vertical position, so that the relief, partings and structure were correctly correlated. The model was then photographed in a tilted position so that both sections could be clearly seen and the relief at the same time well expressed by obtaining moderately strong light and shade. It is especially important that the lines of contact be clearly brought out, as they determine the limits of the formations to be subsequently colored. A slide was next made from the negative and sent with a copy of the Harpers Ferry Atlas sheet to a photographic artist, with instructions to color the slide, adopting of course, so far as might be feasible, the same scheme of colors as appear on the geologic sheets.

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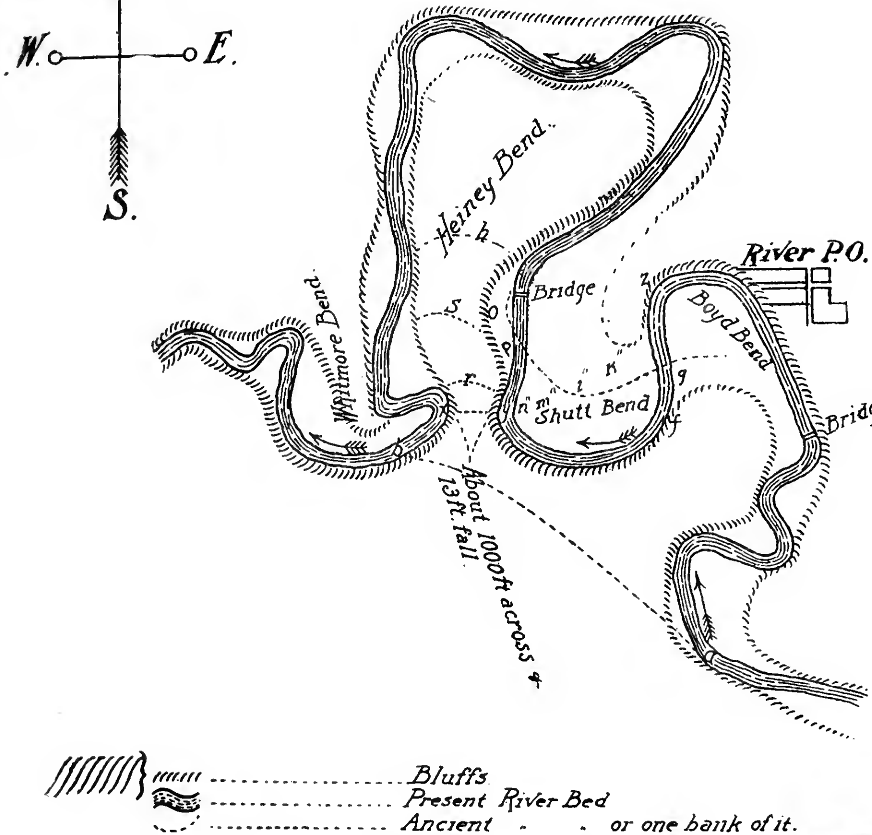
Fig A.



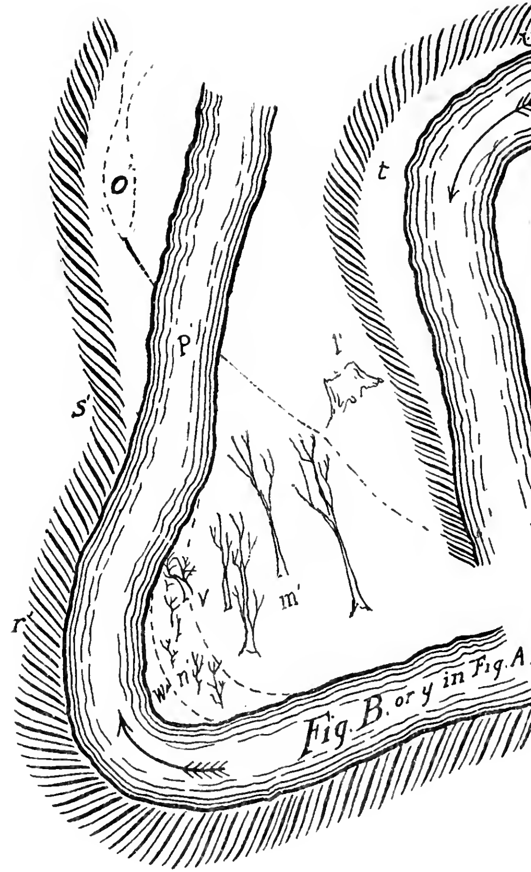


Fig. A represents about 15 miles of the course of the SALAMONIE RIVER in the southern part of Huntington county, Indiana.

From X' & Y'. in Fig. D. is contracted to about 1/3 what the Scale Would Make it.

Fig. D.

In fig D. the Scale is 1/8 in to 10 ft & in Figs. B & C. it is approximately the Same.

Use.—In conclusion it should be said that a trial of the first slide made it evident that the use of such illustrations would materially increase the facilities for teaching geography and increase the educational value of the work accomplished. Such material may not only help the lecturer to avoid technical description of features usually not illustrated at all, when simplicity of treatment is demanded, but with this aid he is enabled to show his class or audience a mass of facts upon which he bases his interpretation of the phenomena discusssed. By this means, the lecturer may even treat somewhat technical and involved problems so that they may be made easy to comprehend, and, most important of all, whatever geographical knowledge be absorbed, is properly attained through the exercise of observation, comparison and deduction. For just so far as the student subjects himself to such mental discipline, in the same degree does he acquire a scientific knowledge and the power of analysis that is lasting and of true educational value.

The picture attached below is a copy from the negative from which the lantern slide was prepared.*

River Bends and Bluffs.

By Wm. M. Heiney.

Bends and bluffs of rivers are interdependent. While under the universal river law of taking the course of least resistance, the embryonic bluff must first exist, the matured bluff is the product of the river's course. But, early the relation begins shifting, and the bend becomes the consequence of the bluff. Again, however, the bend batters down the bluff, so that the relations first attained are repeated.

The above propositions are verified by tracing the historical relation of the bluffs and bends in a very crooked section of about fifteen miles of the Salamonie River, found in the southern part of Huntington County, Indiana.

Fig. A represents the stream in its present course, with the bluffs and their connecting ridges, which define the territory over which the stream

*I will be glad to correspond with any person who desires to obtain copies of these slides for school or college collections. Others are being prepared.

has been shifting its course during the past few centuries. The dotted lines indicate the location of ridges, which when carefully traced are found to mark one or the other of the banks of the more ancient stream.

I will return to this after detailing some of the operations of the agencies which I have observed during the past quarter of a century.

At z, Fig. A (enlarged section, Fig. C), is a small tableland (t), which twenty to twenty-five years ago was broader and extended upstream five to seven rods further than it now does. In half a century more, at the present rate of erosion, the part of the tableland still remaining will all have disappeared, and what is now a well defined ridge will have become a bluff. Both the ridge and the tableland are covered with forest trees, while the bluff for a mile up the stream, and from the point of contact (u) of river and ridge, is barren, indicating constant and rapid weathering, and consequently a gradual northward movement of the stream bed. I shall return to this again after giving fuller observations of similar changes at the bend y, Fig. A.

This bend is best studied in Fig. B. More than twenty years ago I was familiar with the bar, n′, lying under but upstream from the sycamore tree, v, which still stands. Then the bar, n′ (see n, Fig. D), was the only one, and formed the river bank. It was of pure, washed sand and had no vegetation whatever growing upon it. It now has willow and sycamore trees five or six inches in diameter. Now, also, there is another bar (w′ in Fig. B and w in Fig. D), which is the one bordering the river, of pure, washed sand and without vegetation.

These facts stimulated further investigation and furnished the key to deeper secrets. I examined the topography farther east and found a considerable elevation about forty feet wide (m′ in Fig. B and m in Fig. D), and succeeded by a lowland; then, again, another rise, l (l′), extending eastward for two hundred and fifty feet, and in turn succeeded by a sink, better marked than any of the others (see k in Fig. D and k′, Fig. A). Both these bear evidence of being former bars, and their relative ages are evidenced by the trees, which I have tried to indicate in my drawings, by trees and stump. Those trees which have grown upon m (m′) are not larger than fifteen inches in diameter, while those upon l (l′) were large forest trees, many three and four feet in diameter. This last is all cleared of its timber now and is a well cultivated field. In Fig. A, n″, m″, l″, and k′ do not represent the correct relative distances, only relative position.

From f to y, Fig. A, is a barren bluff and gives evidence of the river bed's gradual southward movement, but at y (enlarged section of which is found in Fig. B) the westward movement of both bed and bluff is quite marked. Within the time of my own observation, I am certain that from twelve to fifteen feet of the bluff, which is some fifty feet in height, has disappeared. A year ago a mass of earth (see g in Fig. D) 6x8x30 feet dropped down five feet at the north end, but still clings to the surface at the south end. It is rapidly yielding to the elements, and two years hence no trace of it will remain. As this bluff moves westward the one at x is moving eastward at about the same rate of speed. Thus in the course of two thousand years will occur a phenomenon rarely found on this stream, i. e., a waterfall or rapid—a fall of thirteen feet in one thousand, and possibly a canyon, also.

Yet there will still remain enough bend to renew the northward movement of the channel and in time the highland of the "Heiney Bend" will disappear—the stream will bend far to the north—the bottom lands will lie south of the stream, with the adjoining bluff of the river on its north bank. The newly formed bottom lands will lie much lower than those of the "Sheet Bend" at present.

Now let us leave the present and future of the stream and go back to its past. Following the old bed as indicated by its right bank (the dotted line, pq, in Fig. A, and p′, Fig. B), and taken in relation with some sink holes (o in Fig. A and o′ in Fig. B), along the foot of the ridge, it is evident that the old bed crossed its present bed at p and q, and that the "Shutt Bend," which is extending itself southward, was once much smaller than now. This bend has been greatly eroded. It is considerably lower than its neighbor on the west, the south part of the "Heiney Bend," and as a consequence does not bear the remains of as ancient river beds as the latter. In Fig. B, I have endeavored to show the low places in the surface by shortening the lines which indicate the bluffs and ridges; thus r′ and s′ correspond with the dotted lines r and s in Fig. A, and doubtless locate the successive channels of the river before it settled down between the ridges and bluffs which bound its present immediate basin, or what the farmers term the "first bottom," more generally recognized as the "lower terrace." From the present topography it is certain that after the river left its channel, r, and before it took its present general course between the ridges, it crossed at s, and again at h. A far more ancient channel than any of these, however, is found from a to b. This rises on much higher ground at a and though not so well marked as the more recent channel its lower course, as it nears b, has become well emphasized by recent drainage of the adjacent country.

The stream will probably forage its way to all the bounding ridges and denude them—render them bluffs—before cutting its new channel, xy, when it will again leave them to weather themselves into symmetrical shapes, dress in forest verdure and present history as well as future possibilities, which speculation in this age is unable to suggest.

Notes on the Ordovician Rocks of Southern Indiana.

By Edgar R. Cumings.

The present paper dealing with the stratigraphy of the Ordovician of Indiana is preliminary to a more complete report on this interesting series of rocks, which the writer has in preparation. In the latter paper an extended discussion of the faunas of these rocks will be possible. At present the study of the large collections obtained is not sufficiently advanced to admit of any such presentation. It is therefore proposed to give here practically nothing but the notes taken in the field, with such supplementary remarks as may seem necessary.

The work of the Indiana University Geological Survey during the field season of 1900 covered the counties of Dearborn, Switzerland, Ohio and Jefferson. The following sections were measured and from most of them extensive collections were made:

Section in Kentucky opposite the mouth of the Miami River (5.9A):*

	Ft.	*In.*
51—Covered to top of hill	112	..
50—Fragments of Strophomenoid shells	..	7
49—Shale	1	..
48—Limestone. Fragments of Brachiopods	..	6
47—Shale	1	..
46—Hard limestone with *Rafinesquina*	..	5
45—Shale	2	4
44—Limestone. *Rafinesquina* abundant	..	5
43—Covered, probably shale	17	6

*This section in Kentucky is given because it is the farthest east of any section showing exposures of rock to river level.

	Ft.	In.
42—Shale	2	6
41—Limestone	5	2
40—Shale with thin layers of sandstone	8	6
39—Limestone with Bryozoa and *Rafinesquina*	..	3
38—Mostly shale	10	8
37—Crystalline limestone. *Rafinesquina* and *Dalmanella*	9	..
36—Shale	2	3
35—Thin layers of bryozoal limestone	1	..
34—Shale	6	9
33—Bryozoal limestone	..	6
32—Shale	7	..
31—Limestone, shale at top. *Dalmanella* (aa)	..	7
30—Covered	42	..
29—Compact highly crystalline limestone; few fossils	..	3
28—Shale	2	9
27—Highly crystalline limestone containing fragments of *Asaphus*	..	7
26—Shale	..	5
25—Compact limestone containing *Dalmanella*	..	5
24—Covered, probably some limestone	16	..
23—Brachiopod limestone (?)	..	4
22—Covered	8	4
21—Limestone. *Rafinesquina* and Trilobites	..	3
20—Shale	6	4
19—Covered (probably shale)	16	..
18—Limestone (in place?)	..	6
17—Shale	10	8
16—Limestone. Bryozoa, *plectambonites*	..	3
15—Shale	1	..
14—Limestone. *Balmanella*, *Plectambonites*	..	2
13—Shale	..	7
12—Sandstone	..	3
11—Shale	2	9
10—Limestone with *Dalmanella*	..	3
9—Shale, possibly some sandy layers	5	..
8—Hard compact limestone, very few fossils	..	5
7—Shale	6	..
6—Layer of crystalline, crinoidal limestone	..	..
5—Partly covered, mostly shale	33	..
4—Sandy layer with *Trinucleus concentricus*	..	1
3—Shale	5	4
2—Limestone containing *Dalmanella* (aa*)	2	3
1—Shale to level of Ohio river	6	2
Total section	361	..

* a, abundant; aa, very abundant; c, common; r, rare.

In the high hill just south of Aurora the rocks are exposed as follows (§ 1.35 A):

	Ft.	*In.*
45—A few layers at the top contain *Rafinesquina*, the remainder covered	60	..
44—Limestone with *Platystrophia*, *Hebertella*, *Rafinesquina*, *Monticulipora*, etc	16	..
43—Highly fossiliferous limestone. *Platystrophia*, *Hebertella*, etc	1	6
42—Shale with occasional layers of limestone	4	4
41—Limestone with *Zygospira* and Gastropoda	3	4
40—Limestone. Rafinesquina (aa)	1	6
39—Shale	..	8
38—Same as 32	..	4
37—Covered	1	8
36—Coarsely crystalline highly fossiliferous limestone	..	2
35—Covered	6	10
34—Same as 32	..	3
33—Shale	1	8
32—Coarse-grained fossiliferous limestone, with yellow argillaceous material in streaks	..	8
31—Shale	..	6
30—Limestone. *Zygospira* and *Hebertella*	..	6
29—Shale and shaly limestone	1	3
28—Very fine grained compact limestone, no fossils	..	3
28—Shale	1	..
26—Limestone intercalated with shale	1	6
25—Shale	..	9
24—Sandstone	..	3
23—Covered	2	6
22—Coarse-grained, blue limestone, mottled with brown. Large thick-shelled *Rafinesquinas*	..	8
21—Shale	..	8
20—Hard blue crystalline	..	8
19—Covered	1	4
18—Limestone (in place?)	..	10
17—Covered, probably limestone	10	8
16—Steel-blue finely crastalline limestone with *Rafinesquina*	..	5
15—Shale	..	8
14—Shaly sandstone	..	3
13—Coarse crystalline limestone	..	8
12—Shale	.	6
11—Compact limestone, gray mottled with yellow	..	6
10—Shale	..	9
9—Compact fine-grained drab limestone. Few fossils	..	9
8—Shale	1	..

	Ft.	In.
7—Compact, hard, coarsely crystalline limestone containing *Rafinesquina*	..	7
6—Shale	..	10
5—Blue crystalline limestone. *Rafinesquina*	..	4
4—Shale	.	6
3—Crystalline limestone with *Rafinesquina*, *Platystrophia*, *Monticulipora*, etc	..	6
2—Talus with immense number of fossils	85	..
1—Covered to the level of the river. *Dalmanella* abundant in the loose pieces near the bottom	180	..
Total section	393	..

On the north side of Laughery Creek, opposite Hartford, the following section was measured: (§ 1.36 A.)

	Ft.	In.
34—To top of the hill, loose pieces of limestone containing *Platystrophia* and *Hebertella*	60	..
33—Thin bedded limestone	..	5
32—Covered	2	8
31—Same as 29	..	3
30—Shale	..	4
29—Limestone with argillaceous streaks	..	5
28—Covered	2	8
27—Hard compact limestone	..	4
26—Covered	..	8
25—Coarse-grained crystalline argillaceous limestone	..	4
24—Covered	..	6
23—Limestone containing Gastropoda and *Rafinesquina*	..	6
22—Covered	5	..
21—Same as 18	..	3
20—Covered	1	..
19—Same as 18	..	4
18—Limestone coarsely crystalline, light colored	..	3
17—Sandstone	..	3
16—Same as 14	..	2
15—Same as 14	..	4
14—Drab crystalline limestone	..	3
13—Covered	..	6
12—Same as 10	..	5
11—Covered	6	..
10—Thin-bedded crystalline limestone	6	5
9—Covered	1	4
8—Coarse crystalline limestone	..	6
7—Covered	..	6

	Ft.	In.
6—Coarse crystalline limestone	..	10
5—Covered	10	8
4—Same as 2	..	3
3—Covered	..	2
2—Very hard compact limestone. *Rafinesquina*	..	9
1—Covered to level of road	150	..
Total section	255	..

In the bluff on the north side of Laughery Creek, a little over a mile west of Milton, the following section was measured: (¶ 1.36 B.)

	Ft.	In.
18—To top of hill. *Platystrophia. Hebertella*, etc., in loose pieces	38	6
17—Limestone with *Platystrophia laticosta*	..	3
16—Covered	19	..
15—Same as 11	..	8
14—Covered	9	6
13—Same as 11	..	3
12—Covered	5	6
11—Coarse crystalline limestone, gray mottled with yellow	..	3
10—Covered	2	..
9—Thin-bedded limestone with *Rafinesquina*, crinoids, etc	1	2
8—Covered	4	2
7—Very coarse gray crystalline limestone. *Rafinesquina* (fragments) very abundant	.	4
6—Covered	43	..
5—Limestone with Bryozoa	..	6
4—Covered	48	..
3—Crystalline limestone with *Dalmanella*	.	6
2—Covered to road	43	4
1—Covered to creek level	20	..
Total section	237	..

In the north bluff of Laughrey Creek, one mile south of the mouth of Hayes branch, is the following section: (¶ 1.36 C.)

	Ft.	In.
45—Covered to top of hill	40	..
44—Same as 43	10	..
43—Limestone with *Platystrophia* and *Hebertella*	1	..
42—Covered	5	6
41—Coarse crystalline limestone streaked with yellow. *Rafinesquina*	..	8
40—Partly covered. Limestone with *Rafinesquina*	12	6
39—Drab to bluish compact limestone, no fossils	..	8
38—Coarse gray crystalline limestone	1	4

	Ft.	In.
37—Covered	10	..
36—Coarse limestone streaked with yellow. Contains Bryozoa	1	6
35—Covered	4	..
34—Very hard compact limestone. Lower layer contains Brachiopoda and Bryozoa	..	3
33—Limestone containing large numbers of *Rafinesquina*	1	3
32—Covered	5	..
31—Coarse limestone. *Rafinesquina*	..	6
30—Covered	1	9
29—Limestone with layer of sandstone at the top	..	8
28—Covered	2	4
27—Limestone with Bryozoa and crinoids	..	7
26—Covered	1	4
25—Coarse blue limestone streaked with sandstone	1	..
24—Covered	1	8
23—Blue coarse-grained limestone with Brachiopoda and Bryozoa	..	4
22—Covered	..	6
21—Coarse-grained blue compact limestone	..	3
20—Covered	20	9
19—Coarse lumpy argillaceous limestone. Bryozoa	..	7
18—Covered	..	6
17—Very coarse, ferruginous, Bryozoal limestone	1	2
16—Covered	5	4
15—Yellow-mottled limestone. Bryozoa	..	5
14—Covered	5	..
13—Blue coarse limestone. Fragment of *Rafinesquina* very abundant	.	5
12—Covered	1	2
11—Fine grained limestone. Bryozoa	..	6
10—Covered	3	4
9—Gray limestone with large white crystals of calcite. Many fragments of fossils	..	9
8—Covered	16	.
7—Coarse, crystalline, drab, unfossiliferous limestone	..	3
6—Covered	1	6
5—Thin limestones. Bryozoa very abundant	..	1
4—Coarse gray crystalline limestone. *Dalmanella* (aa)	..	5
3—Covered	22	..
2—Blue-mottled crystalline limestone	..	5
1—Covered	50	..
Total section	235	

Level of the creek.

Just south of the Weisburg station, in the bank of the creek to the west of the railroad, the upper layers of the Ordovician are exposed. From this exposure a large and very satisfactory collection of fossils was obtained. A section at this point is as follows (§ 1.34 A):

	Ft.	*In.*
15—A number of feet of barren limestones		
14—Blue compact fine-grained limestone. No fossils	1	..
13—Covered	5	..
12—Compact limestone. *Rhynchotrema capax*	..	6
11—Thin-bedded limestone	1	..
10—Very compact, fine-grained limestone	..	8
9—Calcareous shale with *Strophomena*	..	7
8—Limestone. Fragments of *Asaphus*	..	4
7—Shale	..	9
6—Limestone with *Hebertella*	..	3
5—Limestone same as 4	..	8
4—Blue limestone with *Rafinesquina* edgewise (aa)	..	3
3—*Rafinesquina* flatwise (a)	..	3
2—Shale	..	2
1—Coarse compact limestone, no fossils	..	10
Total section	12	

Level of creek below railroad culvert.

Continuing on down the creek from this point, the following layers are passed over (§ 1.34 B):

	Ft.	*In.*
4—Limestone	..	8
3—Irregular lumpy shale	2	6
2—Limestone and shale with *Rafinesquina* and *Hebertella*	1	4
1—Very coarse-grained limestone. *Rhynchotrema* (aa)	2	3

Down stream from this point no measurements were made, owing to the effect of rainy weather upon the barometer, but the characteristic fossils of the successive layers were noted. These are as follows from the last mentioned layer downward (§ 1.34 C):

16—*Plectambonites sericea* (aa).
15—*Strophomena rugosa* (aa).
14—Barren shale.
13—*Strophomena*.
12—*Streptelasma* (aa).
11—*Hebertella* (aa).
10—*Streptelasma*.
9—*Leptæna rhomboidalis* (aa).

8—*Dinorthis subquadrata* (a).
7—*Hebertella occidentalis* (a).
6—*Rafinesquina*, *Streptelasma*, *Platystrophia*, *Leptæna*.
5—*Rafinesquina*, *Monticulipora*.
4—*Dalmanella* (shaly limestone).
3—*Rafinesquina*.
2—*Asaphus*, *calymene*. *Rafinesquina*.
1—*Rafinesquina*.

Rafinesquina remains the dominant fossil for some distance farther down the creek, where its place is taken by the several varieties of *platys'rophia biforata*.

No good sections of the Ordovician are to be found in the vicinity of Rising Sun. Numerous exposures of the various members may, however, be seen at a number of points. These exposures show that the lower members are, as in the other localities already studied, characterized by the great abundance of *Dalmanella* and *Plectambonites*. These fossils are succeeded in the beds next above by a number of species of *Trepostomata*, which in places completely fill the rocks.

Above the Bryozoa beds *Rafinesquina alternata* becomes abundant, though of course occurring in limited numbers at almost every level. Next follows the zone of *Platystrophia biforata* and its varieties. This is in turn succeeded in the tops of the hills by a zone in which a varietal form of *Rafinesquina alternata* is abundant, to the exclusion in places of almost every other fossil. The higher zones are not present in the vicinity of Rising Sun.

Vevay, in Switzerland county, is one of the best localities in the State for the collection of Ordovician fossils, and especially of the various forms of Platystrophia. Two detailed sections were measured at this place. These are designated A and B. Section A begins at the head of Main Cross street and extends up the little gully just east of the Orphan Asylum.

This section (A) is as follows (¶ 1, 38 A.):

	Ft.	*In.*
87—Covered to the top of the hill	80	..
86—Limestone with *Platystrophia* and *Hebertella*	6	..
85—Yellowish argillaceous sandstone	..	4
84—Thin-bedded limestone containing *Platystrophia* and *Hebertella*	12	..
83—*Platystrophia biforata*	..	6
82—Yellow sandstone	..	4
81—Covered	3	3
80—Argillaceous arenaceous limestone	..	4
79—Some covered, mostly thin layers with *Rafinesquina*	14	..
78—Limestone with *Rafinesquina* and Bryozoa	..	5
77—Covered	3	8
76—Compact limestone with *Rafinesquina*	..	4

	Ft.	in.
75—Covered	..	6
74—Same as 72	3	8
73—Covered	1	3
72—Coarse-grained limestone *Zygospira Bryozoa*	..	4
71—Covered	3	..
70—Fine-grained limestone. *Zygospira*	..	3
69—Shale	..	6
68—Coarse limestone *Rafinesquina* (aa)	..	5
67—Covered	1	8
66—Thick, coarse, light gray limestone. Fragments of *Rafinesquina* (aa). *Zygospira* (c)	1	..
65—Thin-bedded light colored limestone. Bryozoa	8	..
64—Covered	6	..
63—Bryozoal limestone	..	6
62—Covered	..	8
61—Limestone. *Dalmanella* (aa)	1	2
60—Covered	8	8
59—Dark drab limestone. *Dalmanella*	..	4
58—Covered	2	..
57—Compact limestone with *Dalmanella* (aa)	..	7
56—Covered, probably limestone	25	..
55—Coarse limestone with large white crystals of calcite	..	6
54—Shale	..	6
53—Limestone, fragments of *Rafinesquina* (aa)	..	3
52—Shale	..	10
51—Limestone flecked with large flakes of calcite	..	3
50—Shale	2	8
49—Coarse-grained limestone. *Dalmanella* (aa)	..	6
48—Shale	1	..
47—Limestone with *Dalmanella* and Bryozoa	..	3
46—Yellow weathering shale	2	..
45—Thin layers of limestone with *Dalmanella*	5	..
44—Shale	2	3
43—Layers of calcareous sandstone	..	6
42—Shale	3	..
41—Limestone	..	2
40—Shale	3	8
39—Crinoidal limestone	..	8
38—Shale	5	..
37—Bryozoal limestone in thin layers	2	6
36—Shale and thin limestone	2	6
35—Bryozoal limestone	5	..
34—Shale	2	..
33—Massive hard limestone. Fragments of *Dalmanella* and Bryozoa	..	10

	Ft.	In.
32—Thin limestone and shale. *Dalmanella*	2	4
31—Limestone. Very perfect specimens of *Dalmanella* (aa)	..	4
30—Shale	1	8
29—Limestone. *Rafinesquina* (aa)	..	7
28—Shale	..	8
27—Sandstone	..	4
26—Shale with thin layers of limestone	6	3
25—Dark crystalline limestone. Few fossils	..	4
24—Shale	5	4
23—Limestone. Crinoids. Bryozoa. Trilobites. *Dalmanella*	..	7
22—Shale	2	6
21—Limestone. Fragments of Trilobites and *Dalmanella*	..	3
20—Shale	..	7
19—Thin layers of limestone with intercalated shale	1	..
18—Shale	7	..
17—Limestone. Fragments of *Dalmanella*, *Rafinesquina* and Bryozoa	..	3
16—Shale	2	6
15—Same as 13	..	6
14—Shale	..	5
13—Compact Bryozoal limestone	..	3 to 5
12—Shale, with occasional layers of limestone containing stems of Bryozoa	6	4
11—Limestone spotted with argillaceous material and containing large Bryozoa	..	3
10—Shale with occasional thin lenticles of limestone	2	3
9—Thin layers of fine-grained compact limestone containing *Dalmanella* and Bryozoa	1	..
8—Shale	1	..
7—Limestone with argillaceous material in spots. Contains *Dalmanella*	..	5
6—Shale	4	..
5—Same as 3	..	10
4—Shale	4	6
3—Dark blue crytalline limestone. *Plectambonites* and *Dalmanella* (aa)	..	6
2—Blue clay shale	6	..
1—Covered to river level	101	..
Total section	389	..

Along the road (not the pike) running over the hill back of Vevay most of the rocks of section A are exposed together with *all* of the rocks represented by No. 87 (covered) of that section. The latter are very important, inasmuch as they include the greater part of the platystrophia beds, here ideally exposed for the collection of fossils. In fact several hundred specimens of this species were obtained, most of them in an excellent state of preservation. An exact record was kept of the layer from which each specimen came, thereby rendering the material of the utmost value for the study of variation.

This section (B) is as follows (§ 1.38 B):

	Ft.	*In.*
60—Heavy compact limestone. Few fossils	27	..
59—Shaly limestone with *Platistrophia lynx*. *Hebertella*, *Monticulipora*, etc., *P. laticosta* toward the top	49	..
58—Shaly limestone. *Hebertella* (aa) some *Platystrophia* and *Rafinesquina*	10	8
57—Shaly limestone. *Rafinesquina* and *Hebertella*	2	..
56—Thin argillaceous limestone	16	..
55—Limestone. Base of *Platystrophia* zone	..	3
54—Limestone	..	3
53—Limestone. *Rafinesquina*	2	10
52—Limestone with *Zygospira*	..	5
51—Limestone with *Rafinesquina*	6	4
50 Very coarsely crystalline gray white-spotted limestone	..	6
49—Sandstone	..	1
48—Crinoidal limestone with fragments of *Raf.* (aa)	..	4
47—Covered	7	..
46—Mostly limestone with *Rafinesquina*	5	4
45—Fine grained limestone with *Rafinesquina*	..	2
44—Covered	2	4
43—Limestone with Bryozoa (aa)	..	3
42—Limestone with *Rafinesquina*	..	5
41—Covered	1	10
40—*Rafinesquina*. Bryozoa	..	8
39—Covered	17	..
38—Thin layer of light colored limestone with *Rafinesquina* (shells weathering red)	1	3
37—Covered	2	4
36—Same as 35	1	..
35—Limestone with *Dalmanella* (aa). Bryozoa (aa) *Rafinesquina* (fragments)	4	..
34—Limestone. Soft, gray. *Dalmanella* (aaa)	1	6
33—Covered: some exposed shale and limestone	12	..
32—Thin limestones	1	8
31—Coarsely crystalline light gray limestone containing *Dalmanella* and Bryozoa	..	8
30—Covered	5	6
29—Compact limestone. *Dalmanella* and Bryozoa	1	..
28—Shale	..	4
27—Limestone	..	4
26—Shale	7	..

	Ft.	In.
25—Limestone. *Dalmanella* (aa) Bryozoa. Fragments of *Rafinesquina*	1	3
24—Shale with thin layers of Bryozoal limestone	4	..
23—Bryozoal limestone with some shale..........................	4	4
22—Shale	2	2
21—Limestone with Bryozoa and *Zygospira*	..	5
20—Shale	1	2
19—Bryozoal limestone	..	4
18—Shale	..	10
17—Thin layers of Bryozoal limestone..........................	1	9
16—Shale	1	6
15—Two four-inch layers of Bryozoal limestone	..	8
14—Blue shale..	5	4
13—Bryozoal limestone	..	6
12—Mostly compact Bryozoal limestone...............	5	..
11—Coarse crystalline Bryozoal limestone........................	..	10
10—Covered, probably shale	5	6
9—Limestone and shale. *Dalmanella*	2	6
8—Layers of limestone with *Dalmanella* Bryozoa, etc..............	1	..
7—Covered, probably shale	2	2
6—Compact limestone with *Dalmanella*. Lower part consisting of sandstone	..	8
5—Covered	5	6
4—Limestone with *Rafinesquina* (aa)	..	6 to 8
3—Shale	5	6
2—*Dalmanella* layer	..	..
1—Covered to river level.......................................	140	..
Total section...	385	..

The *Platystrophia* beds are to be seen about Mt. Sterling and in the banks of the east branch of Indian Creek. They reach the bed of the creek two miles northwest of the former place. In the bed of the creek just west of Mt. Sterling the zone of *Dalmanella* is exposed and extends up the creek for a mile and a half. Here it is succeeded by the *Rafinesquina* zone and then by the *Platystrophia* zone, as stated. One mile northwest of Bennington along the road the zone of *Rhynchotrema capax* is exposed, and between the latter place and the *Platystrophia* zone are abundant exposures of the upper zone of *Rafinesquina*. Large collections were obtained from all of these zones and await description in another paper.

The Ordovician and Silurian rocks of Madison, Jefferson County, Indiana, have for many years been the subject of more or less detailed study by geologists and paleontologists. The sections of the Madison hill in the railroad cut as given by Owen and Borden[1] are certainly far from being accurate. The writer

[1] Geol. surv. Ind., 1874, E. T. Cox; pp. 164-166.

obtained from Mr. W. B. Blake, engineer of the P., C., C. & St. L. Railway, accurrate data in regard to the per cent. of grade, length and depth of the cuts, and distance between same, for the steep Madison hill grade of the road above mentioned. The elevation of the terrace upon which Madison stands is approximately 60 ft. above river level, and the elevation of North Madison above Madison is 427 ft. The old reservoir at the south end of the big cut is given in Borden's report (loc. cit.) as 210½ ft. above low water of the Ohio River. The data given me by Mr. Blake are as follows: Grade, five and eighty-nine one-hundredths per cent. (5.89%); distance of south end of south cut from low water mark on north side of Ohio River, 2,700 ft.; distance through south cut, 800 ft.; distance from north end of south cut to south end of north cut, 1,100 ft.; distance through north cut, 1,100 ft ; besides this there are north of the north cut about 1,500 ft. of cut in places 40 ft. deep. The maximum depth of the south cut is 60 ft. and of the north cut 100 ft. The section which follows was measured independently of these figures and departed very little from them. One or two corrections have been made, however, in accordance with the above data. Section of the cut at Madison (½ 1.12 A.):

	Ft.	*In.*
71—Massive whitish limestone	10	.
70—One layer of bluish-white limestone	5	..
69—Thin-bedded limestone like No. 70	5	..
68—Blue shale	2	6
67—White arenaceous limestone	3	10
66—Shaly sandstone and shale	8	3
65—Massive white arenaceous limestone (Niagara)	2	6
64—From a few inches to nearly a foot of pinkish or yellowish to salmon colored crystalline limestone (Clinton?)	1	..
63—Massive white arenaceous limestone	4	2
62—Thick-bedded argillaceous arenaceous limestone	9	8
61—Same as 62, but banded on weathered surface with pink, gray, and buff	12	10
60—One massive conspicuous arenaceous layer	3	6
59—Thin-bedded, argillaceous, arenaceous, weathering brownish, with some calcareous layers containing Bryozoa	7	..
58—Nothing to four inches of coarse limestone with Ordovician fossils	..	4
57—Sandstone with lenticles of limestone containing Bryozoa	3	..
56—Argillaceous layer. *Faristella stellata*	2	..
55—Shale	6	..
54—*Faristella stellata*	1	2
53—Thin layers of limestone alternating with argillaceous and sandy layers. Bryozoa (aa). *Rafinesquina. Hebertella*	5	3
52—Massive soft sandstone	7	8

	Ft.	In.
51—Blue fossiliferous limestone shale and arenaceous layers	6	..
50—Fine shale with layers of limestone, *Rhynchotrema*, *Hebertella*, *Monticulipora*, *Calymene*, *Rafinesquina*	10	..
49—Same as 50. *Strophomena*, *Streptelasma*, *Plectambonites*, *Dalmanella*, *Platystrophia laticosta*, *Ambonychia*	8	..
48—Probably shale and thin layers of limestone; covered by talus	22	..
47—Heavy layers of limestone seen in the *west* side of the south cut, at the top.		
46—Heavy layers of limestone seen in the *east* side of the south cut, at the top. The lowest layers in the big cut (north cut) are 24 feet above the top of No. 45 if the foot of the big cut be taken as 210 feet above the river. Part of the layers of No. 46 would therefore be repeated in 45. Allowance is made for this fact. Nos. 46 and 47 together	24	..
45—Shale. The top of No. 45 is at the culvert just north of the south cut	10	..
44—Several layers of limestone with *Cyclonema*, *Rafinesquina*, *Calymene*, etc	1	2
43—Shaly limestone. *Cyclonema*	2	8
42—Limestone. *Ambonychia*, *Cyclonema*, *Rafinesquina*, *Monticulipora*, Crinoids	2	..
41—Limestone and shale. *Ambonychia*	5	..
40—Compact close-grained limestone. *Rafinesquina*	..	3
39—Limestone and shale. *Zygospira*, *Ambonychia*	2	4
38—Limestone. *Rafinesquina* edgewise (aaa)	..	4
37—Argillaceous compact limestone. *Rafinesquina*	6	9
36—Limestone. Bryozoa	..	6
35—Shaly limestone	5	8
34—Limestone	..	8
33—Shaly limestone	2	8
32—Limestone. *Rafinesquina*, *Calymene*, *Hebertella* (?), Gastropoda, Bryozoa	..	8
31—Shale, with occasional 2-inch to 3-inch layers of limestone	10	8
30—Limestone. *Rafinesquina* edgewise (aaa)	..	3
29—Shaly limestone. *Rafinesquina* (aa), *Modiolopsis* (aa), *Zygospira* (aa)	6	9
28—Similar to 26	..	4
27—Shaly limestone	1	4
26—Blue fine-grained limestone. *Zygospira* (aaa)	..	3
25—Shaly limestone. *Rafinesquina*, etc	13	..
24—Very compact fine-grained limestone; no fossils	..	6
23—Shale and limestone, with excellently preserved specimens of *Rafinesquina* (aa)	4	2

	Ft.	In.
22—Limestone, with top of layer composed of immense numbers of *Zygospira modesta*	..	3
21—Rather coarse shale	2	..
20—Lumpy, shaly limestone. *Asaphus, Rafinesquina*	3	..
19—Coarse to fine-grained barren limestone	..	8
18—Lumpy, shaly limestone. *Rafinesquina* (aa), Trilobites (a), *Zygospira*, Streptelasma, Bryozoa	12	..
17—Limestone, with *Rafinesquina, Zygospira* (aa), Bryozoa, *Orthoceras*.	5	10
16—Shale, with thin layers of limestone	1	..
15—Very compact, fine-grained blue barren limestone	..	6
14—Shale	..	8
13—Compact limestone. *Calymene, Zygoapira*, etc	..	5
12—Limestone. *Calymene* (aa), Bryozoa, *Rafinesquina, Orthoceras*	1	3
11—Shale, with thin layers of limestone	3	8
10—Thin argillaceous limestone with *Calymene* and Bryozoa (a)	1	..
9—Massive blue limestone. *Rafinesquina*, Trilobites, Bryozoa	..	7
8—Limestone. *Rafinesquina, Zygospira*, Bryozoa	2	9
7—Thin argillaceous yellow-spotted limestone. *Platystrophia, Hebertella. Rafinesquina*, Bryozoa	1	..
6—Limestone. *Hebertella* (aa), *Rafinesquina nasuta, Platysstrophia lynx*.	1	2
5—Bryozoal limestone	..	4
4—Covered, probably shale	1	..
3—Limestone with Trilobites, *Zygospira*, etc	..	2
2—Coarse crystalline limestone. *Hebertella*	..	6
1—Covered to river level	62	..
Total section	357	

Number 7 of this section represents the top of the Platystrophia zone. At Vevay the top of the same zone is 358 feet above river level, and at Lawrenceburg about 390 feet. The Madison section affords an excellent opportunity to study the upper Rafinesquina zone. It is in the upper zone that this fossil is so constantly associated with *Zygospira modesta* and a number of species of Lamellibranchs. In the lower zone it has no such constant associates.

Section along Clifty creek (¾ 1.12 B):

	Ft.	In.
22—Limestone. *Rafinesquina*, Lamellibranchiata, Gastropoda, Crinoids	..	6
21—Limestone and coarse lumpy shale	7	4
20—Shale and limestone. Top, a heavy layer of limestone with conspicuous wave-like markings	21	4
19—Partly covered, but represented by heavy layers of limestone in the bank above 18	11	..
18—Limestone and shale	14	4
17—Limestone. *Rafinesquina* (aaa). *Hebertella*	5	.

	Ft.	In.
16—Shale, shaly limestone, some thick layers of limestone. *Rafinesquina*, Bryozoa, Trilobites, *Zygospira* (aaa) in some layers......	40	..
15—Heavy layer of limestone..	..	6
14—Shale and shaly limestone. Trilobites (a)......................	9	6
13—Limestone. *Rafinesquina*, *Asaphus*, *Calymene*, *Platystrophia*........	8	6
12—Mostly shale	4	10
11—Argillaceous compact layer. Trilobites, Gastropods............	..	6
10—Shaly limestone..	2	9
9—Limestone and shale. *Platystrophia*. *Hebertella*.................	3	..
8—Limestone. *P. lynx* and *laticosta*. *Hebertella*....................	3	6
7—Covered	10	..
6—Limestone, more shaly than 5. *Hebertella* (form with dorsal fold), *P. lynx* and *laticosta*..	3	..
5—Same as 4 but *P. laticosta* more abundant	3	10
4—Thin shaly limestone. *Hebertella*	1	2
3—Thin shaly limestone. *Hebertella*, *P. laticosta*, *Monticulipora* (aa).	1	..
2—Thin shaly limestone. *P. lynx* (aa), *laticosta* (a), *Hebertella occidentalis* (c) Trilobites, *Monticulipora*	1	..
1—Covered to river level..	45	..
Total section..	198	

This section shows some 30 feet more of the Platystrophia beds than the Madison section; otherwise it is the same in the main as the basal part of that section.

P. lynx is here abundant in the lower layers and *laticosta* in the upper layers.

From the detailed sections now described of the Ordovician rocks of Indiana it will at once be seen that there are certain well-defined faunal zones which may be traced without fail over the whole area. It has long been known that the zone characterized by the presence in abundance of *Platystrophia*, forms a well-marked and persistent stratum; but apparently the other zones, if recognized at all, have been minimized in importance. Any one of them is however as persistent and as easily traced as the Platystrophia zone.

These zones are in ascending order as follows (the thickness is given in parentheses):

1—Dalmanella multisecta (200–240 feet).
2—Rafinesquina alternata (50–70 feet).
3—Platystrophia (60–80 feet).
4—Rafinesquina alternata var. fracta (100 feet ±).
5—Dalmanella Meeki (20 feet ±).
6—Streptelasma.
7—Strophomena (10 feet ±).
8—Rhynchotrema capax (10 feet ±).

Some Developmental Stages of Orthothetes Minutus N. Sp.

By Edgar R. Cumings.

The specimens discussed in this paper are from the abandoned quarry known as the Cleveland Stone Company's quarry, located one mile north of Harrodsburg, Monroe County, Indiana. This quarry is in the so-called Bedford limestone, and the specimens come from the top of the quarry—and also from near the summit of the formation. They are, so far as I can ascertain without having seen the original specimens of Hall,* specifically the same as Spergen hill forms referred by the latter gentleman to the Orthis (Terebratulites) umbraculum of Schlotheim.†

Description of the shell:

Shell semiovate to subquadrate in old individuals; hinge line usually less than the greatest width of the shell, especially in young individuals; cardinal extremities forming an obtuse, or sometimes a right angle with the lateral margins. Surface finely plicated; plications increasing toward the margin by interstitial addition. Crests of the plications crenulated by equally spaced fine concentric lines.

Ventral valve concave with a pronounced tendency to irregular growth about the beak. In mature individuals the beak becomes strongly retrorse and is greatly elevated, equaling in height one-half the length of the shell. Area well defined, flat, showing in well preserved specimens a low ridge on each side of the prominent deltidium and parallel with its margins. The younger specimens seem to show a perforation at the apex of the deltidium.

Dorsal valve regularly convex, greatest elevation about one-third of the way from the beak to the front margin, though there is considerable variation in this respect in shells of different age. Usually some flattening at the cardinal extremities. Area very narrow or usually scarcely at all conspicuous.

Interior of the ventral valve showing rather prominent teeth, which diverge widely. Cardinal process in the dorsal valve elevated, projecting

*Acting under the impression that some of the original specimens of Hall were in the Albany Museum, the writer sent a number of specimens of the form under consideration to Dr. John M. Clarke to compare with Hall's specimens. While owing to the fact that Hall's specimens are not at Albany, Dr. Clarke could not make the comparison, nevertheless he gives it as his opinion that the two are *probably* identical.

†Petrefk. 1, 256; Schnurr, Brachiop. der *Eifel* 216; Bronn Lethaea Geog. I, 361. See Hall, Trans. Alb. Inst. 4, p. 12.

somewhat beyond the hinge line; notch shallow, the grooves on the posterior faces of the apopnyses very faint.

Ratio of breadth to length in an average adult specimen about as 11 to 8.

This species can not be referred to the *O. (Terebratulites) umbraculum* of Schlotheim, from which it differs in the less length of the hinge line, fewer number of plications, greater proportionate height of the area, which in the present species tends to become strongly retrorse in mature individuals, and the subquadrate rather than semicircular outline of the shells. The figures of Schlotheim's species also show it to possess a strongly quadrilobate cardinal process, while in the present form the notch in the process is very shallow and the grooves very faint.

The species to some extent resembles *O. lens*, from which it differs in the form of the cardinal process and in the greater proportionate length of the latter.

Development.—In the search for specimens of this rather rare species (about 50 specimens were found among several thousand of the common Spergen hill forms) a number of very young stages was obtained. While even the adult individuals share in the general stunting so characteristic of the entire Spergen hill fauna, no complete specimen in the writer's collection having a length of more than 5mm.* nevertheless these larger individuals present the usual features of maturity.

The smallest individual observed has a breadth of .9mm and a length of .6mm. In this specimen the ventral valve is roughly conical, though slightly more convex toward the beak, which projects over the hinge line and is very prominent. The surface shows 18 plications as against 40 in the largest individual observed, while the posterior third of the shell is without surface ornamentation except a few obscure concentric markings. The area is high and the deltidium less sharply marked off from it than in the older specimens. The dorsal valve has its greatest convexity at the center and is also smooth for a considerable distance from the beak. It shows no sign of an area.

Individuals of the length of 2mm have the area perpendicular to the plane of separation of the valves, and the ventral valve showing a slight concavity toward the front. The number of plications also has increased

*Since the above was written, the author has found at Stinesville, Monroe County, Indiana, specimens of this species over one inch in breadth, but agreeing in all essential features with the adult specimens described here.

to 22 or 23, and the region of greatest convexity in the dorsal valve has approached, somewhat, the beak. The youngest individual is conspicuously shorter on the hinge line than farther forward. In fact it in every respect approaches the generalized type of Brachiopod shell, as Beecher & Clarke have shown to be the case in the species of the Waldron fauna.*

The Cold-Blooded Vertebrates of Winona Lake and Vicinity.†

By Earl E. Ramsey.

Winona Lake is located in sections 15, 16, 17, 21 and 22 of Township 32 north, Range 6 east, in Kosciusko County, Indiana. The main body of the lake is about one mile southeast of Warsaw. It is one of the series of lakes belonging to the Mississippi drainage system and is drained into the Tippecanoe River. It lies about six miles south of the watershed between the St. Lawrence and the Mississippi basins.

The lake is irregular in outline and has an area of 0.98 square miles. The greatest length is from north to south and is somewhat more than one mile. The average width is about five-eighths of a mile. The greatest depth is 81 feet.

The lake, like all the small lakes of northern Indiana, is of glacial origin. The catchment basin is large as compared with the size of the lake itself. Unusually heavy rains change the lake level as much as two to two and one-half feet. The tributary streams are three in number. The largest is Cherry Creek, which flows into the lake on the southeast. For the most part it flows through woodland. Two other streams, the larger of which is Clear Creek, enter the lake at its extreme southern part. The output of Clear Creek is nearly as much as that of Cherry Creek. Numerous springs on the Winona Assembly grounds drain into the lake. Lands lying to the north are drained into Pike Lake and Center Lake, both of which lie about one mile northwest of Winona Lake.

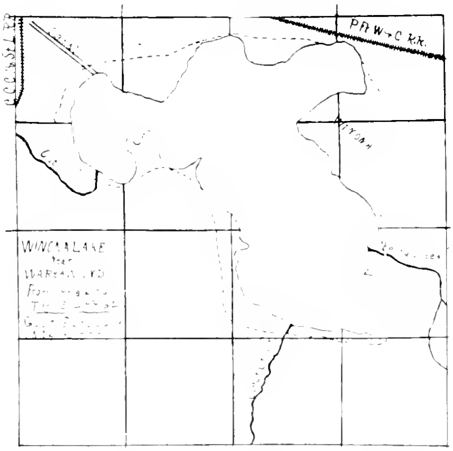
The outlet is situated at the southern part of a small bay connecting with the main lake on the northwest. It empties into Tippecanoe River at a point about one mile northwest of Warsaw.

The shore line, for the most part, is low. On the north, a small stretch of cultivated land rises rapidly to a ten-foot elevation line. The Winona Assembly grounds on the east have the greatest elevation. This

*Memoirs of the N. Y. State Museum, Vol. I, No. 1.

†Contributions from the Zoölogical Laboratory of the Indiana University, C. H. Eigenmann, Director, No. 39.

elevation is from ten to fifty rods back from the lake. The other parts of the ground lie below a ten-foot line. The south shore is uniformly low and swampy. On the west, an abrupt raise is found at Yarnelle's Landing. To the north of the landing, the shore is low, and the elevation gradual. Natural woodland is found at Yarnelle's, at the outlets of both Clear Creek and Cherry Creek and on the Assembly grounds.



The shores are about equally divided between sand and turf formation. A peninsula extending into the lake from the Winona grounds is of turf. On the south a great part of the shore, as well as the shore of the bay on the west of the main lake, is of such a formation. Other parts are sandy. In a general way, that part of the land which has lately been reclaimed from the lake has a coast line formed of decayed plant life—turf.

By reference to the map of Eagle Lake (now Winona Lake) prepared by the U. S. Survey in 1834, it will be seen that the lake was considerably larger at that time than now. The difference in the lake has been brought about, first by dredging the outlet channel and lowering the level of the lake; second, by the encroachment of plant life upon the lake proper, and the luxuriant plant life on the land partially dried by lowering the lake level. As noted farther on, the plant life of the lake is abundant. The dense banks of Scirpus, Nuphar, etc., tend to collect material that may float into them, and they also contribute their own growth to the formation of new lake bottom. A third agency which has acted in some parts of the lake—notably the southern part—is that of the ice. With the lowerin of the lake level, stretches of lake bottom were left barely covered by water and were in most cases separated from the land by deeper water. As the ice formed, it pushed the ground higher on these shallow places. The ice cracks in excessively cold weather, the cracks fill with water and freeze again. This crowds the ice and the substratum of earth still farther shoreward. Very much of the south shore of the lake shows such a formation. The ice-beach near the outlet of Clear Creek is at least thirty inches above lake level and separates a dense swamp from the lake. In this swamp thus isolated from the main lake, the semi-aquatic plants readily establish themselves and thus finally reclaim the swamp land.

The plant life in the lake is abundant. A bank of Scirpus practically encircles the lake. Nuphar, Nymphaea, Typha, Potamogeton, Ceratophyllum and Chara are also abundant. The outlet is now entirely "overgrown" by Nuphar, Nymphaea, Typha and Scirpus arranged in water zones.

The average temperature of the water from July 6 to August 23, 1899, at a depth of two feet, was 80°; the air temperature for the same time was 81.5°. The deep water of the lake marked 41° and was, of course, subject to no diurnal changes, nor even to any considerable seasonal variation. The prevailing winds during the summer months are west to southwest.

THE FISHES.

The number of species of fishes thus far secured is forty-one. Considering the great variety of physical conditions, the number of species is small. But the number of individuals in each species is much more disappointing. The scarcity of the larger food fishes is due to the great amount of fishing in the lake. But the scarcity of the smaller fishes, the Cyprinidae, many species of the Darters, Labidesthes, etc., is not accounted for in this way.

To show the relative numbers of a very common form which serves as food for the larger species, I may take the Labidesthes sicculus. As many as a gallon of this form may be secured in either Turkey Lake or Tippecanoe Lake at a single haul of the seine. Not more than three or four dozen were secured in Winona Lake during the entire summer. This fact in itself will partially account for the scarcity of the larger food fishes. The same relative proportions are true of many other forms. The following list gives the species and locality from which they were secured. The column marked (N)* gives some notion of the relative abund-

*In some cases the number of specimens collected is marked; (+) indicates that the species is abundant; (·), not so abundant; (—), but few.

ance. Thirteen families are represented and thirty-three genera. The +'s in the other columns indicate the localities in which the various species are found.

SPECIES.	Cherry Creek.	Clear Creek.	Lake.	Outlet.	Tippecanoe R.	N.
Lampetra wilderi, Gage				+		1
Lepisosteus osseus (L)			+			1
Lepisosteus platostomus, Rafinesque			+			×
Amia calva, L			+			—
Ameiurus nebulosus (Le Sueur)			+			
Ameiurus melas (Rafinesque)				+		2
Schilbeodes gyrinus (Mitchill)				+		3
Carpiodes (Sp——)*			+	+		2
Catostomus nigricans, Le Sueur	+	+	+	+		
Catostomus commersoni (Lacépède)		+				—
Erimyzon sucetta oblongus (Mitchill)				+		
Minytrema melanops (Rafinesque)		+				1
Campostoma anomalum (Rafinesque)	+	+				+
Pimephales notatus (Rafinesque)	+		+			+
Notropis whipplei (Girard)	+		+	+		+
Notropis cornutus (Mitchill)	+			+		
Hybopsis kentuckiensis (Rafinesque)	+	+				—
Semotilus atromaculatus (Mitchill)	+	+		+		+
Abramis crysoleucus (Mitchill)			+			×
Umbra limi (Kirtland)	+					5
Lucius vermiculatus (Le Sueur)	+		+	+		×
Fundulus notatus (Rafinesque)			+			+
Fundulus dispar (Agassiz)				+		—
Labidesthes sicculus (Cope)	+		+	+		—
Pomoxis sparoides (Lacépède)			+			1
Ambloplites rupestris (Rafinesque)	+		+	+	+	+
Chænobryttus gulosus (Cuv. and Val.)	+		+	+		×
Lepomis pallidus (Mitchill)	+		+	+	+	+
Lepomis megalotis (Rafinesque)				+	+	
Eupomotis gibbosus (Linnaeus)	+		+	+		
Micropterus dolomieu Lacépède					+	5
Micropterus salmoides (Lacépède)			+	+	+	—
Percina caprodes (Rafinesque)	+		+		+	
Hadropterus aspro (Cope and Jordan)	+		+		+	3
Boleosoma nigrum (Rafinesque)		+	+	+	+	+
Diplesion blennioides Rafinesque					+	2
Etheostoma iowæ, Jordan and Meek	+			+		—
Etheostoma coeruleum, Storer	+	+		+	+	—
Microperca punctulata, Putnam				+		—
Perca flavescens (Mitchill)	+		+			
Cottus ictalops (Rafinesque)	+	+		+		+

*Two large specimens taken by fishermen were seen. The species was probably C. Velifer (Rafinesque), but no positive identification further than genus could be made

BATRACHIANS.

This group is represented by but few species.

1. *Necturus maculosus* (Rafinesque). Three or four specimens were found by workmen who were deepening the channel of Cherry Creek.
2. *Bufo lentiginosus americanus* (Le Conte).
3. *Acris gryllus gryllus* (Le Conte).
4. *Acris gryllus crepitans* (Baird).
5. *Hyla versicolor* (Le Conte). But two specimens of this interesting little animal were taken.
6. *Rana pipiens* Kalm. This is the most abundant of the frogs.
7. *Rana clamitans* Latreille. The individuals of this species are nearly as numerous as those of *R. pipiens*.
8. *Rana catesbeana* Shaw. But one or two specimens found.

SNAKES.

Eight species of snakes have been found:

1. *Storeria dekayi* (Holbrook), is rare.
2. *Clonophis kirtlandi* (Kennicott). Only two or three specimens were taken.
3. Two varieties of the garter snake, *Thamnophis sirtalis parietalis* (Say), and *Thamnophis sirtalis sirtalis* L., were taken. This snake is the most abundant of the forms found in this locality. On July 19, a female bearing thirty-one well developed embryos was killed. On August 5, one kept in a pen gave birth to young. The number of young could not be ascertained.
4. *Regina leberis* (L.). The leather snake is abundant. It is third in this locality in point of number. On August 12, 1899, a gravid female was found having ten well developed embryos. Its haunts are along creeks.
5. *Natrix sipedon* (L.). This species is plentiful. On July 23, 1900, a female containing twenty-six embryos was killed. The water snake is a swamp-loving form, and is of a sullen and vicious disposition.

6. The blue racer, Bascanion constrictor (L.) is the largest snake in this locality, and is comparatively abundant. When captured and put in a pen, it soon tames and seems to take delight in being handled. Its movements and shape are peculiarly graceful. Its food consists of frogs, garter snakes, etc. A specimen forty-two inches long swallowed a garter snake twenty-eight inches long. I have known it to lay its eggs about the middle of June, and have found the young hatching about the middle of September. Its egg-laying habit is worthy of note. One specimen selected the soft ground between two rows of potatoes and pushed her way under the ground. As she crawled along in this underground passage, the eggs, twenty-two in number, were laid in the channel which her body had made. Another laid her eggs in the hollow root of a half decayed stump. The eggs are white in color, and about one inch in length, and have a uniform diameter of one-half inch. The soft shell is so tough that it will sustain a weight of more than one hundred pounds without breaking. The young, when first hatched, are seven or eight inches in length. The first action when the little head is thrust through the shell is to stick out its tongue. The blue racer frequents the woods or high grass and weeds.

7. Lampropeltis doliatus triangulus (Boie) is found rarely.

8. Sistrurus catenatus (Rafinesque) is second in point of numbers. The garter snake is more plentiful than the prairie-rattler. During the summer of 1899 eleven specimens were caught, and nine were taken during the following summer. They are usually found in low land and run but little during the day unless disturbed. Nothing was learned concerning their food, since they persistently refused to eat when kept in confinement. A female kept in a pen gave birth to seven young on August 13. Several of the little ones were kept in a glass aquarium for a time. On August 17 they drank drops of water from a pipette and ate a few small bits of fresh meat. Three days later they began their first moult. They were about eight and one-half inches long at birth. A case was reported to me in which thirteen young were born. The adults are inoffensive and move slowly. They are easily captured by means of a noose slipped over their heads or by an insect net.

TURTLES.

The land and water forms together number eight species. Of these the soft-shelled turtle, the speckled tortoise, Blanding's tortoise and the box tortoise are rare. Even the commoner species are not very abundant. No more than two dozen eggs were found. They were of the Aromochelys odoratus (Latreille), and were laid in heaps of debris which had been washed up along the shore. The species are as follows:

1. Aspidonectes spinifer (Le Sueur).
2. Chelydra serpentina (L.).
3. Aromochelys odoratus (Latreille).
4. Graptemys geographicus (Le Sueur).
5. Chrysemys marginata (Agassiz).
6. Clemmys guttatus (Schneider).
7. Emydoidea blandingi (Holbrook).
8. Terrapene carolina (L.).

I desire to acknowledge the helpful suggestions of Dr. C. H. Eigenmann in the preparation of this brief report. Dr. S. E. Meek has also kindly aided me in preparing a partial catalogue of the fishes, and has mapped out the general plan of the paper.

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