PROCEEDINGS OF THE

Indiana Academy of Science

1903

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OF THE

Indiana Academy of Science

1903.

EDITOR, - - WILLIAM J. KARSLAKE.

ASSOCIATE EDITORS:

AMOS BUTLER,
W. S. BLATCHLEY,
C. H. EIGENMANN,
P. N. EVANS,
DONALDSON BODINE,
THOMAS GRAY,
JOHN S. WRIGHT.

INDIANAPOLIS, IND.
1904.

INDIANAPOLIS:
WM. B. BURFORD, PRINTER.
1904.

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

[Approved March 11, 1895.]

Preamble.

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

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

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

Publication of the Reports of the Indiana Academy of Science.

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

Editing Reports.

SEC. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such services, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports, shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less than 1,500 nor more than 3,000 copies of each

Number of printed Reports.

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.

Game Birds

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

Penalty.

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.

Permits.

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 to Science

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

Bond.

Bond forfeited.

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.

Two years.

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

Birds of prey.

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

Acts repealed.

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

Emergency.

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

OFFICERS—1903-1904.

PRESIDENT,
CARL L. MEES.

VICE-PRESIDENT,
GLENN CULBERTSON.

SECRETARY,
JOHN S. WRIGHT.

ASSISTANT SECRETARY,
J. H. RANSOM.

PRESS SECRETARY,
G. A. ABBOTT.

TREASURER,
WILLIAM A. McBETH.

EXECUTIVE COMMITTEE.

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

CURATORS.

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

COMMITTEES, 1903-1904.

PROGRAM.

G. W. Benton, John S. Wright, Katherine Golden.

MEMBERSHIP.

Stanley Coulter, G. A. Abbott, A. L. Foley.

NOMINATIONS.

Donaldson Bodine, Robert Hessler, W. J. Moenkhaus.

AUDITING.

Mel. T. Cook, Wm. J. Karslake.

STATE LIBRARY.

Stanley Coulter, A. J. Bigney, O. L. Kelso.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

M. B. Thomas, D. M. Mottier, C. C. Deam.

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, Glenn Culbertson.

EDITOR.

W. J. Karslake, Butler College, Indianapolis.

Address all communications to the Editor to 5780 Oak Ave., Indianapolis.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, Stanley Coulter, Charles R. Dryer, M. B. Thomas, Mel. T. Cook.

RELATIONS OF THE ACADEMY TO THE STATE.

C. A. Waldo, William Watson Woollen, R. W. McBride.

GRANTING PERMITS FOR COLLECTING BIRDS AND FISHES.

A. W. Butler, D. W. Dennis, W. J. Moenkhaus.

DISTRIBUTION OF THE PROCEEDINGS.

Thomas Gray, Donaldson Bodine, L. J. Rettger, H. L. Bruner, John S. Wright, W. J. Karslake.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885–6.	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886–7.	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887–8.	J. P. D. John	Amos W. Butler			O. P. Jenkins.
1888–9.	John C. Branner	Amos W. Butler			O. P. Jenkins.
1889–90.	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890–1.	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891–2.	J. L. Campbell	Amos W. Butler			C. A. Waldo.
1892–3.	J. C. Arthur	Amos W. Butler	Stanley Coulter / W. W. Norman		C. A. Waldo.
1893–4	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894–5.	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895–6.	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896–7.	Thomas Gray	John S. Wright	A. J. Bigney		W. P. Shannon.
1897–8.	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.
1898–9.	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899–1900.	D. W. Dennis	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900–1901.	M. B. Thomas	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901–1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine	Geo. W. Benton	J. T. Scovell.
1902–1903.	W. S. Blatchley	John S. Wright	Donaldson Bodine	G. A. Abbott	W. A. McBeth.
1903–1904.	C. L. Mees	John S. Wright	J. H. Ransom	G. A. Abbott	W. A. McBeth.

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 thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

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

ARTICLE III.

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

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

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

BY-LAWS.

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

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

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

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

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

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

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

MEMBERS.

FELLOWS.

R. J. Aley	*1898	Bloomington.
J. C. Arthur	1893	Lafayette.
George W. Benton	1896	Indianapolis.
A. J. Bigney	1897	Moore's Hill.
A. W. Bitting	1897	West Lafayette.
Donaldson Bodine.	1899	Crawfordsville.
W. S. Blatchley.	1893	Indianapolis.
H. L. Bruner.	1899	Irvington.
Severance Burrage	1898	Lafayette.
A. W. Butler	1893	Indianapolis.
J. L. Campbell	1893	Crawfordsville.
Mel. T. Cook	1902	Newcastle.
John M. Coulter	1893	Chicago, Ill.
Stanley Coulter	1893	Lafayette.
Glenn Culbertson	1899	Hanover.
D. W. Dennis	1895	Richmond.
C. R. Dryer	1897	Terre Haute.
C. H. Eigenmann	1893	Bloomington.
Percy Norton Evans	1901	West Lafayette.
A. L. Foley	1897	Bloomington.
Katherine E. Golden	1895	Lafayette.
M. J. Golden	1899	Lafayette.
W. F. M. Goss	1893	Lafayette.
Thomas Gray	1893	Terre Haute.
A. S. Hathaway	1895	Terre Haute.
W. K. Hatt	1902	Lafayette.
Robert Hessler	1899	Logansport.
H. A. Huston	1893	Lafayette.
Arthur Kendrick	1898	Terre Haute.
Robert E. Lyons	1896	Bloomington.
V. F. Marsters	1893	Bloomington.
C. L. Mees	1894	Terre Haute.
W. J. Moenkhaus	1901	Bloomington.

*Date of election.

Joseph Moore	*1896	Richmond.
D. M. Mottier	1893	Bloomington.
J. P. Naylor	1903	Greencastle.
W. A. Noyes	1893	Terre Haute.
J. H. Ransom	1902	Lafayette.
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	Swarthmore, Pa.
M. B. Thomas	1893	Crawfordsville.
C. A. Waldo	1893	Lafayette.
F. M. Webster	1894	Champaign, Ill.
H. W. Wiley	1895	Washington, D. C.
John S. Wright	1894	Indianapolis.

NON-RESIDENT MEMBERS.

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

*Date of election.

ACTIVE MEMBERS.

George Abbott	Indianapolis.
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George C. Ashman	Frankfort.
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Edward Hugh Bangs	Indianapolis.
Walter D. Baker	Indianapolis.
Arthur M. Banta	Franklin.
J. W. Beede	Bloomington.
William N. Blanchard	Greencastle.
Edwin M. Blake	Lafayette.
Lee F. Bennett	Valparaiso.
Charles S. Bond	Richmond.
Fred. J. Breeze	Pittsburg.
E. M. Bruce	Weston, Oregon.
Herman S. Chamberlain	Indianapolis.
E. J. Chansler	Bicknell.
Otto O. Clayton	Geneva.
Howard W. Clark	Chicago, Ill.
George Clements	Springfield, Ill.
Charles Clickener	Silverwood, R. D. No. 1.
U. O. Cox	Mankato, Minn.
William Clifford Cox	Columbus.
J. A. Cragwall	Crawfordsville.
Albert B. Crow	Charleston, Ill.
M. E. Crowell	Franklin.
Edward Roscoe Cumings	Bloomington.
Alida M. Cunningham	Alexandria.
Lorenzo E. Daniels	Indianapolis.
H. J. Davidson	Baltimore, Md.
Charles C. Deam	Bluffton.
Martha Doan	Westfield.
J. P. Dolan	Syracuse.
Herman B. Dorner	Lafayette.
Hans Duden	Indianapolis.
E. G. Eberhardt	Indianapolis.
Frank R. Eldred	Indianapolis.

M. N. Elrod	Columbus.
Samuel G. Evans	Evansville.
Carlton G. Ferris	Big Rapids, Mich.
E. M. Fisher	Urmeyville.
Wilbur A. Fisk	Richmond.
W. B. Fletcher	Indianapolis.
Austin Funk	New Albany.
John D. Gabel	Montpelier.
Charles W. Garrett	Logansport.
Robert G. Gillum	Terre Haute.
Vernon Gould	Rochester.
Walter L. Hahn	Bascom.
Victor Hendricks	Indianapolis.
Mary A. Hickman	Greencastle.
John E. Higdon	Indianapolis.
Frank R. Higgins	Terre Haute.
S. Bella Hilands	Madison.
John J. Hildebrandt	Logansport.
J. D. Hoffman	Lafayette.
Allen D. Hole	Richmond.
Lucius M. Hubbard	South Bend.
John N. Hurty	Indianapolis.
C. F. Jackson	Greencastle.
Alex. Johnson	Ft. Wayne.
Edwin S. Johonnott, Jr	Terre Haute.
Ernest E. Jones	Kokomo.
Chancey Juday	Boulder, Colo.
O. L. Kelso	Terre Haute.
Norton A. Kent	Crawfordsville.
Charles T. Knipp	Bloomington.
Henry H. Lane	Lebanon.
William E. Lawrence	Richmond.
V. H. Lockwood	Indianapolis.
William A. McBeth	Terre Haute.
Robert Wesley McBride	Indianapolis.
Rousseau McClellan	Indianapolis.
Richard C. McClaskey	Terre Haute.
Lynn B. McMullen	Indianapolis.

Edward G. Mahin .... West Lafayette.
James E. Manchester .... Vincennes.
Clark Mick .... Indianapolis.
W. G. Middleton .... Richmond.
John A. Miller .... Bloomington.
H. T. Montgomery .... South Bend.
Walter P. Morgan .... Terre Haute.
Fred Mutchler .... Terre Haute.
Charles E. Newlin .... Irvington.
John Newlin .... West Lafayette.
John F. Newsom .... Stanford University, Cal.
R. W. Noble .... Chicago, Ill.
D. A. Owen .... Franklin.
Rollo J. Peirce .... Logansport.
Ralph B. Polk .... Greenwood.
James A. Price .... Ft. Wayne.
Frank A. Preston .... Indianapolis.
A. H. Purdue .... Fayetteville, Ark.
Ryland Ratliff .... Bloomington.
Albert B. Reagan .... Rose Bud Agency, S. D.
Allen J. Reynolds .... Peru.
Giles E. Ripley .... Decorah, Iowa.
George L. Roberts .... Greensburg.
D. A. Rothrock .... Bloomington.
John F. Schnaible .... Lafayette.
E. A. Schultze .... Ft. Wayne.
John W. Shepherd .... Terre Haute.
Claude Siebenthal .... Indianapolis.
J. R. Slonaker .... Madison, Wis.
C. Piper Smith .... Alexandria.
Retta E. Spears .... Elkhart.
J. M. Stoddard .... Indianapolis.
Charles F. Stegmaier .... Greensburg.
William Stewart .... Burlington, Vt.
William B. Streeter .... Indianapolis.
Frank B. Taylor .... Ft. Wayne.
J. F. Thompson .... Richmond.
C. H. Underwood .... Indianapolis.

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.
Frank B. Wade	Indianapolis.
Daniel T. Weir	Indianapolis.
B. C. Waldemaier	West Lafayette.
Jacob Westlund	Lafayette.
Fred C. Whitcomb	Delphi.
William M. Whitten	South Bend.
Neil H. Williams	Indianapolis.
William Watson Woollen	Indianapolis.
J. F. Woolsey	Indianapolis.
Lucy Youse	Indianapolis.

Fellows	48
Non-resident members	20
Active members	127
Total	195

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.
Zoölogische-Botanische Gesellschaft in Wien (Vienna), Austro-Hungary.
Dr. J. von Csato, Nagy Enyed, Austro-Hungary.
Botanic Garden, K. K. Universitat, Wien (Vienna), Austro-Hungary.

Malacological Society of Belgium, Brussels, Belgium.
Royal Academy of Science, Letters and Fine Arts, Brussels, Belgium.
Royal Linnean Society, Brussels, Belgium.
Societé Belge de Geologie, de Paleontologié et Hydrologie, Brussels, Belgium.
Societé Royale de Botanique, Brussels, Belgium.
Societé Geologique de Belgique, Liège, Belgium.
Royal Botanical Gardens, Brussels, Belgium.

Bristol Naturalists' Society, Bristol, England.
Geological Society of London, London, England.
Dr. E. M. Holmes, British Pharm. Soc'y, Bloomsbury Sq., London, W. C., England.
Jenner Institute of Preventive Medicine, London, England.
The Librarian, Linnean Society, Burlington House, Piccadilly, London W., England.
Liverpool Geological Society, Liverpool, England.
Manchester Literary and Philosophical Society, Manchester, England.
"Nature," London, England.
Royal Botanical Society, London, England.
Royal Kew Gardens, London, England.
Royal Geological Society of Cornwall, Penzance, England.
Royal Microscopical Society, London, England.
Zoölogical Society, London, England.
Lieut.-Col. John Biddulph, 43 Charing Cross, London, England.
Dr. G. A. Boulenger, British Mus. (Nat. Hist.), London, England.
F. DuCane Godman, 10 Chandos St., Cavendish Sq., London, England.
Mr. Howard Saunders, 7 Radnor Place, Hyde Park, London W., England.
Phillip L. Sclater, 3 Hanover Sq., London W., England.
Dr. Richard Bowdler 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.
Société Entomologique de France, Paris, France.
L'Institut Grand Ducal de Luxembourg, Luxembourg, Lux., France.
Soc. de Horticulture et de Botan. de Marseille, Marseilles, France.
La Soc. Linneenne de Normandie, Caen, France.
Société Linneenne de Bordeaux, Bordeaux, France.
Soc. des Naturelles, etc., Nantes, France.
Zoölogical Society of France, Paris, France.
Baron Louis d'Hamonville, Meurthe et Moselle, France.
Pasteur Institute, Lille, France.
Museum d'Histoire Naturelle, Paris, France.

Bontanischer Verein der Provinz Brandenburg, Berlin, Germany.
Deutsche Geologische Gesellschaft, Berlin, Germany.
Entomologischer Verein in Berlin, Berlin, Germany.
Journal für Ornithologie, Berlin, Germany.
Prof. Dr. Jean Cabanis, Alte Jacob Strasse, 103 A., Berlin, Germany.
Augsburger Naturhistorischer Verein, Augsburg, Germany.
Count Hans von Berlspen, Münden, Germany.
Braunschweiger Verein für Naturwissenschaft, Braunschweig, Germany.
Bremer Naturwissenschaftlicher Verein, Bremen, Germany.
Ornithologischer Verein München, Thierschstrasse, 37½, München, Germany.
Royal Botanical Gardens, Berlin W., Germany.
Kaiserliche Leopoldische-Carolinische Deutsche Akademie der Naturforscher, Halle a Saale, Wilhemstrasse 37, Germany.
Königlich-Sächsische Gesellschaft der Wissenschaften, Mathematisch-Physische Classe, Leipzig, Saxony, Germany.
Naturhistorische Gesellschaft zu Hanover, Hanover, Prussia, Germany.
Naturwissenschaftlicher Verein in Hamburg, Hamburg, Germany.
Verein für Erdkunde, Leipzig, Germany.
Verein für Naturkunde, Wiesbaden, Prussia.

Belfast Natural History and Philosophical Society, Belfast, Ireland.
Royal Dublin Society, Dublin.
Royal Botanic Gardens, Glasnevin, County Dublin, Ireland.

Societa Entomologica Italiana. Florence. Italy.
Prof. H. H. Giglioli, Museum Vertebrate Zoölogy. Florence. Italy.
Dr. Alberto Perugia. Museo Civico di Storia Naturale. Genoa, Italy.
Societa Italiana de Scienze Naturali. Milan, Italy.
Societa Africana d'Italia. Naples, Italy.
Dell' Academia Pontifico de Nuovi Lincei, Rome. Italy.
Minister of Agriculture. Industry and Commerce. Rome. Italy.
Rassegna della Scienze Geologiche in Italia. Rome. Italy.
R. Comitato Geologico d'Italia. Rome, Italy.
R. Comitato Geologico d'Italia. Rome. Italy.
Prof. Count Tomasso Salvadori. Zoölog. Museum. Turin. Italy.

Royal Norwegian Society of Sciences, Throndhjem. Norway.
Dr. Robert Collett. Kongl. Frederiks Univ. Christiana. Norway.

Academia Real des Sciencias de Lisboa (Lisbon), Portugal.
Comité Geologique de Russie. St. Petersburg. Russia.
Imperial Academy of Sciences, St. Petersburg. Russia.
Imperial Society of Naturalists, Moscow. Russia.
Jardin Imperial de Botanique. St. Petersburg. Russia.
The Botanical Society of Edinburgh. Edinburgh. Scotland.
John J. Dalgleish. Brankston Grange. Bogside Sta., Sterling. Scotland.
Edinburgh Geological Society. Edinburgh, Scotland.
Geological Society of Glasgow. Scotland.
John A. Harvie-Brown. Duniplace House. Larbert. Stirlingshire, Scotland.
Natural History Society. Glasgow. Scotland.
Philosophical Society of Glasgow. Glasgow. Scotland.
Royal Society of Edinburgh. Edinburgh. Scotland.
Royal Physical Society. Edinburgh. Scotland.
Royal Botanic Garden. Edinburgh. Scotland.

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

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

Naturforschende Gesellschaft, Basel, Switzerland.

Naturforschende Gesellschaft in Berne, Berne, Switzerland.

La Societé Bontanique Suisse, Geneva, Switzerland.

Societé Helvetique de Sciences Naturelles, Geneva, Switzerland.

Societé de Physique et d'Historie Naturelle de Geneva, Geneva, Switzerland.

Concilium Bibliographicum, Zürich-Oberstrasse, Switzerland.

Naturforschende Gesellschaft, Zürich, Switzerland.

Schweizerische Botanische Gesellschaft, Zürich, Switzerland.

Prof. Herbert H. Field, Zürich, Switzerland.

AUSTRALIA.

Linnean Society of New South Wales, Sidney, New South Wales.

Royal Society of New South Wales, Sidney, New South Wales.

Prof. Liveridge, F. R. S., Sidney, New South Wales.

Hon. Minister of Mines, Sidney, New South Wales.

Mr. E. P. Ramsey, Sidney, New South Wales.

Royal Society of Queensland, Brisbane, Queensland.

Royal Society of South Australia, Adelaide, South Australia.

Victoria Pub. Library, Museum and Nat. Gallery, Melbourne, Victoria.

Prof. W. L. Buller, Wellington, New Zealand.

NORTH AMERICA.

Natural Hist. Society of British Columbia, Victoria, British Columbia.

Canadian Record of Science, Montreal, Canada.

McGill University, Montreal, Canada.

Natural Society, Montreal, Canada.

Natural History Society, St. Johns, New Brunswick.

Nova Scotia Institute of Science, Halifax, N. S.

Manitoba Historical and Scientific Society, Winnipeg, Manitoba.

Dr. T. McIlwraith, Cairnbrae, Hamilton, Ontaria.

The Royal Society of Canada, Ottawa, Ontario.

Natural History Society, Toronto, Ontario.

Hamilton Association Library, Hamilton, Ontario.

Canadian Entomologist, Ottawa, Ontario.

Department of Marine and Fisheries, Ottawa, Ontario.

Ontario Agricultural College, Guelph, Ontario.

Canadian Institute, Toronto.
Ottawa Field Naturalists' Club, Ottawa, Ontario.
University of Toronto, Toronto.
Geological Survey of Canada, Ottawa, Ontario.
La Naturaliste Canadian, Chicontini, Quebec.

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

WEST INDIES.

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

SOUTH AMERICA.

Argentina Historia Natural Florentine Ameghine, Buenos Ayres, Argentine Republic.
Musée de la Plata, Argentine Republic.
Nacional Academia des Ciencias, Cordoba, Argentine Republic.
Sociedad Cientifica Argentine, 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

NINETEENTH ANNUAL MEETING

OF THE

INDIANA ACADEMY OF SCIENCE,

STATE HOUSE, INDIANAPOLIS,

December 28 and 29, 1903.

OFFICERS AND EX-OFFICIO EXECUTIVE COMMITTEE.

W. S. BLATCHLEY, President. C. L. MEES, Vice-President. JOHN S. WRIGHT, Secretary.
DONALDSON BODINE, Assistant Secretary. G. A. ABBOTT, Press Secretary.
W. A. MCBETH, Treasurer.

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

With one exception, the sessions of the Academy will be held in the State House, in the rooms of the State Board of Agriculture and Horticulture; the President's address will be given in the auditorium of the Shortridge High School.

Headquarters will be at the English Hotel. A rate of $2.00 and up per day, American plan, 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 secured 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, whose sessions begin on December 29, and thus secure a one-and-one-third round-trip fare.

PROGRAM COMMITTEE.

MEL. T. COOK, Greencastle, Indiana. GLENN CULBERTSON, Hanover, Indiana.

GENERAL PROGRAM.

MONDAY, DECEMBER 28.

Meeting of Executive Committee at Hotel Headquarters.................. 10:30 a. m.
General Session followed by Sectional Meetings.............................. 2 p. m. to 5 p. m.
President's Address, Shortridge High School.................................. 8 p. m.
If advisable, the President's Address may be followed by a short session.

TUESDAY, DECEMBER 29.

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

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

WILLIS S. BLATCHLEY,

At 8 o'clock Monday evening, at Shortridge High School.

Subject: "The Indiana of Nature; Its Evolution."

The following papers will be read in the order in which they appear on the program, except that certain papers will be presented "*pari passu*" in sectional meetings. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another whose time is approximately the same. Where no time 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. "Colds" and Cold, 10m. .... Robert Hessler
2. A Prehistoric Fortification near Madison, Indiana, 5m. .... Glenn Culbertson
3. The Apache Stick Game, 10m. .... Albert B. Reagan
4. Some Paintings from one of the Estufas in the Indian Village of Jemez, New Mexico, 10m. .... Albert B. Reagan

*5. Notes on the Caves of Cuba .... J. W. Beede

6. What Bacteriology has done for Sanitary Science, 10m. .... Severance Burrage
7. Conditions affecting the distribution of Birds in Indiana, 20m. .... Amos W. Butler

PHYSICS, CHEMISTRY AND GEOLOGY.

8. A new problem in Hydrodynamics with Extraneous Forces Acting, 10m. .... E. L. Hancock
9. On the use of Nickel in the core of the Marconi Magnet Director, 10m. .... Arthur L. Foley

*10. Effect of Ultraviolet Light on the action of the Coherer, 10m. .... Arthur L. Foley

*11. The Life of Radium, 5m. .... Arthur L. Foley

12. The Edison effect in a "Hylo" Lamp, 10m. ...... Arthur L. Foley
13. On the use of MnO_2 in the generation of O from $KClO_3$, 5m. .... R. R. Ramsey, Arthur L. Foley

*14. A Method of Determining the Absolute Dilation of Mercury, 5m. .... Arthur L. Foley.

*Paper not presented.

15. Geology of the Fort Apache Region, Arizona, (by title)..........
....Albert B. Reagan
16. Geology of Monroe County, Indiana, North of the Latitude of Bloomington ....Albert B. Reagan
17. What is the Age of the Aubery Limestone of the Rocky Mountains? ....Albert B. Reagan
*18. Some Fossils from the Lower Aubery and Upper Red Wall in the Vicinity of Fort Apache, Arizona..............Albert B. Reagan
19. The Fossils of the Red Wall Compared with Those of the Kansas Coal Measures, 10m..........................Albert B. Reagan
20. Double Salts in Solution, 10m........................P. N. Evans
21. Ionic Friction, 10m...............................P. N. Evans
22. A Topographic Result of the Alluvial Cone, 10m......A. H. Purdue
23. A Note on the Radio-Activity of Strontium-Salicylate, 10m......
....J. F. Woolsey
24. Progress in Locomotive Testing, 10m................W. F. M. Goss

BOTANY AND ZOOLOGY.

25. A Note on the Breeding Habits of the Common or White Sucker, 3m..Glenn Culbertson
26. Additions to the Flora of Indiana, 8m.................H. B. Dorner
27. Additions to the List of Gall-Producing Insects Common to Indiana, 5m..Mel. T. Cook
28. Botanical Notes, 10m ....M. N. Elrod
29. Bird Notes from the Indiana State Forestry Reservation........
....Chas. Piper Smith
30. Notes Upon Some Little Known Members of the Indiana Flora, 10m ....Chas. Piper Smith
31. The Development of the Spermatozoid of Chara, 10m..D. M. Mottier
32. Further Studies on Anomalous Dicotyledonous Plants, 10m......
....D. M. Mottier
33. A Crow Roost near Richmond, Indiana, 5m...................
.............................D. W. Dennis and W. E. Lawrence
34. A New Adjustable Stand for Physiological Apparatus and Modifications in other Physiological Devices, 10m................
.............................J. F. Woolsey and John S. Wright
35. An Abnormality in the Nut of Hicoria ovata, 5m....John S. Wright

*Paper not presented.

*36. Contribution to the Flora of Indiana, No. VIII, 10m. .Stanley Coulter
*37. On the Germination of Certain Native Weeds, 10m. .Stanley Coulter
38. Revised list of Indiana Plant Rusts, 10m..............J. C. Arthur
*39. Cuban Notes, 10m.............................C. H. Eigenmann
40. Ecological Notes on the Mussels Winona Lake, 10m. . .T. J. Headlee
41. Ecological Notes on the Birds occurring within a radius of 5 miles of the Indiana University Campus (with photographs by G. C. Littell), 10m........................Waldo L. McAtee
*42. List of Mammals, Reptiles and Batrachians of Monroe County, Indiana, 10m..............................Waldo L. McAtee
43. Birds Nests of an Old Apple Orchard near Indiana University Campus, 10m................................Gertrude Hitze
44. Nerve end organ in the Pancreas, 5m..................E. O. Little
45. Discoidal Pith in our Woody Plants, 5m..........F. W. Foxworthy
46. New Science Laboratory, Moores Hill College, 5m......A. J. Bigney
47. The Sun or Gunelpiya Medicine Disk.............Albert B. Reagan

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THE NINETEENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The nineteenth annual meeting of the Indiana Academy of Science was held in Indianapolis, Monday and Tuesday, December 28 and 29, 1903.

Monday 10:45 a. m., the Executive Committee met in session at hotel headquarters.

At 2 o'clock p. m. President Willis S. Blatchley called the Academy to order in general session in the room of the State Board of Agriculture, State House. The transaction of routine and miscellaneous business occupied the first part of the session. Following this, papers of general interest were read and discussed. After the disposition of these, special technical subjects occupied the time until adjournment at 5 p. m

The address of the retiring President, Willis S. Blatchley, was delivered in the auditorium of the Shortridge High School at 8 p. m., before the members of the Academy and a number of invited guests, subject—"The Indiana of Nature; its Evolution."

*Paper not presented.

Tuesday 29, 9 a. m., the Academy met in general session before which the remaining papers of the program were read and discussed. Following the disposition of the papers unfinished business was considered.

Adjournment.

THE FIELD MEETING OF 1903.

The field meeting of 1903 was held in Madison and Hanover, Thursday and Friday, May 21 and 22. Thursday evening a well attended public session was held in the auditorium of the Madison High School; the program consisted of musical numbers and addresses. President W. S. Blatchley spoke on the mineral fuels of the State and Dr. Stanley Coulter on forestry work in Indiana. After the adjournment of the public session a short business meeting was held in the Madison Hotel.

At 8:30 a. m., Friday the 22d, the members left hotel headquarters for the field, proceeding by carriages over the Hanover road to the mouth of the gorge which leads to Clifty Falls. The remainder of the trip to the Falls was made on foot over territory of great interest to naturalists, especially to geologists and botanists. Clifty Falls was reached about noon. Luncheon was served here, after which a cross-country drive was made to Hanover College. The remainder of the afternoon was spent in viewing the college buildings and equipment, and in enjoying the magnificent scenery of the vicinity. At 6 o'clock dinner the visiting members of the Academy were guests in the homes of the members of the Hanover College faculty.

At 8 o'clock a public meting was held in the college chapel, addresses were made by Drs. Stanley Coulter, J. C. Arthur, M. T. Cook, N. A. Kent and A. F. Foerste. After this session an enjoyable reception was tendered the Academy at the home of President Fisher. The return to Madison was made that night, after which a very brief business meeting was held in the hotel headquarters. Adjournment, 12 o'clock, midnight, Friday, May 22.

The spring meeting of 1903 will be remembered as one of the most successful and enjoyable in the history of the Academy. The weather was delightful and the locality interesting from every standpoint. The Academy gratefully acknowledges its obligations to the Madison Commercial Club and to the members of the Hanover College faculty, especially to Professor Culbertson, for their generosity and thoughtful courtesies which anticipated every want of the excursionists.

PRESIDENT'S ADDRESS.

The Indiana of Nature: Its Evolution.

By W. S. Blatchley.

Afar out in the limitless realms of space a planet moves—propelled onward by an unseen, uncontrollable force around its parent orb, a sun. For millions, perhaps billions, of years, as man counts time, that planet has moved in the same pathway, meanwhile undergoing most wonderful changes in bulk and form. At first a vast, irregular mass of burning, gaseous matter, thrown off from that sun about which it still revolves, the planet gradually cooled, condensed, and assumed a spheroidal form. Its gaseous elements rearranged themselves to form new compounds, at first liquid, then solid, until in time it came to be a solid globe, or at least one with a solid but uneven crust. The processes of cooling and contraction still continued. The ocean of vapor which formed a large portion of the atmosphere about the planet condensed and fell and formed an ocean of water which filled the depressions in its crust. Above the rim of this ocean there showed in places large areas of land—bare igneous rock, absolutely devoid of life—as, for millions of years, the temperature of both rock and ocean remained too high for living things.

When the mean temperature of its oceanic waters by continued and oft repeated evaporation, cooling and condensation, was reduced to about 150° (degrees) F., there occurred the grandest event in the history of that planet. *In some unknown, unknowable manner, Life came to be.* Within the waters of its ocean there was brought about a combination of matter—a living thing—which could take from the water and from the air above certain elements, and by their aid increase in size and reproduce its kind. The first lowly parasites upon the face or surface of the planet were thus aquatic plants—algæ, fungi and kindred forms. In the course of ages there evolved from them other and higher plants which could live on land; for the decay and erosion of the igneous rocks, added to the remains of the aquatic plants thrown upon the beaches of the ocean, produced a soil from which the higher land plants could derive a part of their nourishment. As the centuries and the æons rolled by, the plants—true parasites that they were—found their way to every part of the planet's surface. Onto the tops of the loftiest mountains, into the abysses of the deepest oceans, they made their way; their province being the conversion of inorganic matter—earth, air, water—into a form of food suitable to the needs of a higher type of parasite which meanwhile was coming into existence upon the planet's surface. For, as the temperature of the ocean gradually decreased, the Era of Animal Life was ushered in.

The first animals on the planet were also lowly aquatic forms—scarcely differing from the first plants, but possessing a freedom of motion which enabled them to procure a better supply of air and water. Then, evolving into higher and more varied forms as they became adapted to new environments, they spread far and wide through ocean's depths and over plain and mountain, until the whole surface of the planet was peopled, too, by them. But, ever and always, from the time the first animal came to be upon that planet, until the last one finally disappears into the darkness of everlasting night, the *growth* of animal life will depend upon *living food* prepared by the plant—the *motion* of animal life upon *energy* stored within the cells of the plant.

That sun, which in the beginning first cast off the matter of which the planet is formed, still controls it—still rules over it and its destinies with an iron will. Both plant and animal parasite must forever bow before its power. Of the vast floods of energy which stream forth from that sun's disk, in the form of heat and light, an insignificant fraction falls upon the surface of its satellite. Of the minute portion that the planet thus arrests, an equally insignificant part is caught up by its plants and used directly in their growth. Yet the entire productive force of the living portion of that planet turns on this insignificant fraction of an insignificant fraction.

The vegetable cell is thus a storer of power—a reservoir of force. It mediates between the sun—the sole fountain of energy—and the animal life on the planet. The animal can not use an iota of power that some time, either directly or indirectly, has not been stored in the plant cell. Thus, of the two great groups of parasites upon the surface of the planet, the plant must, perforce, have preceded the animal.

For thousands of centuries each type of animal and plant parasite upon that planet was content if it could secure food enough to reach maturity and then a mate to reproduce its kind. All the energies put forth—all the variations in organ and form—all the adaptations to modified environment—were but means toward the better accomplishment of these two ends. Sometimes a type would reach a culmination or highest point, beyond which it could not advance. Then a degeneration would occur along side lines, or, in many instances, even total extinction of the race or group. Finally, after the planet was hoary with age, a race of animal parasites evolved from the lower forms, whose variations were ever concentrated toward the head or cephalic region. During untold ages their brains slowly but surely increased in size until, in time, they became possessed of the power of reason and of abstract thought. In that age the "prince of parasites" was born. From then on he began to rule not only the other animal and plant parasites about him, but to discover and control the powerful forces of nature, heretofore wholly latent. As he grew in brain power, he grew in greed, in egoism. He came to think that the planet, on which he was but a parasite, was created for him alone; that all other plants and animals were put there for his especial benefit, though many of them out-dated him by millions of years. He began to modify the surface of the planet in all ways possible—to change, as it were, its every aspect to conform to his ideas. He imagined, vain creature that he was, that he could improve upon the works of Nature. In time he divided up the entire land surface of the planet by using sometimes imaginary lines and again natural boundaries. Acres and sections, townships and counties, states and republics, kingdoms and empires were the terms he used to denote his subdivisions, and over all lands, and even seas, he proclaimed himself chief ruler. For that planet is the earth. That "prince of parasites" is Man.

To 36,350 square miles of the earth's surface, lying between the imaginary lines 37° 41′ and 41° 46′ north latitude, and between 84° 44′ and 88° 6′ west longitude, man, in time, gave the name "Indiana." How came this area to be where it is? Of what kind of matter is its surface composed? What was its condition at the time of the advent of the white race? These are questions which should be of interest to every resident of the Hoosier State.

The oldest known rocks on the American continent are those of Archaean Time laid down during the Azoic or lifeless æon of the earth. They are known as the Laurentian System of Rocks and consist mainly of coarse granites, thick-bedded gneisses and syenites, serpentines, schists and beds of modified sandstones, limestones and clays. They were formed from the debris of other rocks still older than themselves; these in their turn having been derived ages ago from those original igneous or primary rocks whose molten sands rose first above the boiling floods and cooled and crusted into a chaotic continent. For Archaean Time comprised those millions of years which elapsed while the crust of the earth was cooling down to a point where life was possible.

The Laurentian rocks are thus devoid of fossils or contain only the remains of the simplest aquatic forms. In North America they comprise the surface of a vast, V-shaped area of 2,000,000 or more square miles which lies, filled with wild lakes, pine clad, rugged, almost impassable, spread in savage sleep from Labrador to the Arctic Ocean. This area embodies the general form of the North American continent and was the nucleus of all the land which was afterward added to it. From these old Laurentian rocks came the debris and sediment which was laid down in the bed of a shallow ocean to form the first rocks comprising the surface of what is now "Indiana."

At the close of the Azoic or Lifeless æon, during which the Laurentian rocks were formed, the Paleozoic or "Æon of Ancient Life" was ushered in. At its beginning the entire area of what is now known as Indiana was covered by a bread ocean which stretched far away to the southwest, while to the north and northeast it extended beyond the present sites of the Great Lakes. This ocean is known to geologists as the "Interior Paleozoic Sea." Into it was carried the sediment derived from the erosion and destruction of the old Laurentian rocks by water and air, which agencies then, as now, were ever at work. The Potsdam sandstone of the Cambrian era, which probably underlies the Trenton limestone of the Lower Silurian beneath the greater portion, if not all, of Indiana, was one of the first strata to be laid down in this sea. But as none of the surface of Indiana is represented by the Potsdam stone, it will be passed with this mere mention.

Following the Cambrian came the second grand sub-division of Paleozoic Time, the so-called Lower Silurian or Ordovician Age. At its beginning the sea covering Indiana and the area to the north and east was of course more shallow, as 1,000 feet or more of Potsdam sandstone had been deposited on its floor. The first great stratum of Ordovician rock to be laid down in this sea which is of interest to us was the Trenton limestone, which, during the past two decades, has become so noted in Indiana as the source of natural gas and crude petroleum.

It is a well known geological fact that most, if not all, limestones owe their origin to the presence of minute organisms in the water in which the limestone was formed. The animals from whose remains the Trenton limestone was, for the most part, derived, were probably very low forms —the polyps and bryozoans of the ancient Silurian seas. In untold numbers they existed, and the carbonate of lime, which makes up 80 per cent. of the unmodified Trenton rock, is largely the remains of their secretions and incrustations. Associated with these lower forms were myriads of higher ones—crinoids, brachiopods, trilobites, gastropods and even fishes. The presence of such swarms of animal life made necessary the existence of an abundance of plants; since the plant must ever precede the animal and gather for the latter the energy, and form for it the food—the living protoplasm—necessary to its existence. These plants were mostly marine algae or seaweeds and fucoids, though doubtless many other forms existed of which no remains have been preserved in the rocks of that age.

The Trenton limestones were evidently formed in rather clear waters, at moderate depths. Near the bottoms of these shallow seas great beds of calcareous sediment were gradually collected, and were swept to and fro by the tides and currents. Rivers from the older Cambrian rocks brought down their eroded particles and added to the thickness of the ocean floor. Within these beds of sediment both plants and animals found a grave—their bodies in vast numbers being buried beneath the slowly accumulating deposits of centuries. Once buried in such deposits, they did not decay, as do animals on land, because by the waters above and the calcareous ooze around them, they were shut off from free oxygen, which is the chief agent in decay. Gradually this ooze or fine sediment was, by the agency of the sea water, cemented and consolidated into limestone. In this manner that great layer of Trenton rock which underlies at variable depths the whole of Indiana, was formed. From it has been derived, directly or indirectly, more wealth than from any other one formation, either underlying or forming a portion of the surface of the State.

In time the waters of the ocean containing this vast stratum of Trenton limestone, with its enclosed accumulations of undecayed plants and animals, became turbid, and instead of calcareous sediment, deposited mud and clayey sediment in thick beds on top of the limestone strata. These deposits of mud and silt were afterward, by later deposits, compressed into the fine-grained, impervious Utica shale, 100 to 300 feet in thickness, which thus effectually sealed the Trenton limestones and so retained within them the oil and gas derived from their enclosed organic remains. This oil, and its more volatile portion, the natural gas, was not formed in a short time, but is the result of a slow decomposition or destructive distillation, carried on through thousands of centuries. Accumulating in vast reservoirs—the more porous portions of the Trenton limestone or mother rock—it there remained until man came with his iron drill and furnished a vent through which it could rise. Then by combustion he caused it to yield up the stored energy, conserved since the sun's rays fell on the plants of the old Silurian seas.

After the Utica shale had been laid down as a thick, impervious cover above the Trenton limestone, there followed the Hudson River epoch during which 200 to 600 feet of alternating beds of shale and limestone were deposited in the old sea bottom where now is Indiana. These form the uppermost division of the Lower Silurian age. During the myriads of years necessary to their deposition marine forms were excessively abundant and the advancement in the scale of animal life was correspondingly great. All the principal groups of marine invertebrates which came into existence during the Trenton epoch were represented, but the species were widely different. In addition to life in the sea, there came also to be life on land. Acrogenous plants—forerunners of the ferns and mosses—harbingers of the vast forests of future centuries—came into being along the moist waterways of the growing continent, while insects, the first winged creatures, began to traverse the air.

As yet no part of Indiana was above old ocean's level, but at the close of the Ordovician, after the Hudson River limestones and shales had been laid down, a great upheaval, caused by some subterranean force, brought above the sea a large island of Ordovician rock which ever since has been dry land. This upheaval was greatest over the point where Cincinnati, Ohio, is now located, and the "Cincinnati Uplift" is the name given by geologists to the island and the broad belt of shallowly submerged land which extended from its northern shore in a northwesterly direction, diagonally across the area of the future Indiana. The main portion of that island comprised the southwestern corner of what is now Ohio and a part of northeastern Kentucky. It also included a small part of what is now Indiana and formed the first and oldest portion of the surface of our State. The area whose surface rocks belong to this Hudson River formation comprises part or all of Wayne, Union, Fayette, Franklin, Dearborn, Ripley, Ohio, Switzerland and Jefferson counties.

Over this area the exposed rocks are composed of a series of bluish, thin-bedded limestones intercalated with bluish-green limey shales, while at the top are massive sandy limestone beds of a brownish color The shales are soft, easily weathered and very fossiliferous, while the bluish lime-

INDIANA at the Close of Lower Silurian Time.

stones are in places largely composed of fossils. As a part of an island, therefore, upheaved from the Ordovician seas, was the first born land of Indiana; and to that little corner all other portions of our noble State were added in their turn by the workings of nature's forces during after ages.

At the end of the Ordovician or beginning of the Upper Silurian age, the Interior Paleozoic Sea had greatly diminished in area. A broad belt of land had been added to the southern border of the old Laurentian crest, especially over what is now Wisconsin and a portion of northern Illinois; while, extending from what is now Labrador down to Georgia, was another broad belt, following the general trend of the present Alleghany mountains. By the raising of several large islands above its surface at the time of the Cincinnati Uplift, aided by the broad belt of shallowly submerged land already noted, the area of the Interior Sea was still further diminished and to that portion covering what is now the northeastern part of Indiana and the greater part of Ohio, West Virginia, New York and Pennsylvania, the name of "Eastern Interior Sea" is given. This was simply a great bay or eastward extension of a greater "Central Interior Sea" which, at that period, covered most of Indiana, southern Michigan, Illinois and a large portion of the present United States west of the Mississippi River. The most northeastern limits of the Eastern Interior Sea were the present sites of Albany and Troy, New York. The rock-making material which was deposited on the floor of both it and the Central Interior Sea was derived in part from the land along their borders, but mainly from the limey secretions of the life within their waters. The dry land draining into them was small in area and hence there were only small streams for the supply of sediments. Yet, in the course of countless years, sufficient material was deposited to form the thick layer of Niagara limestone which now forms the surface rock over much of northern and eastern Indiana.

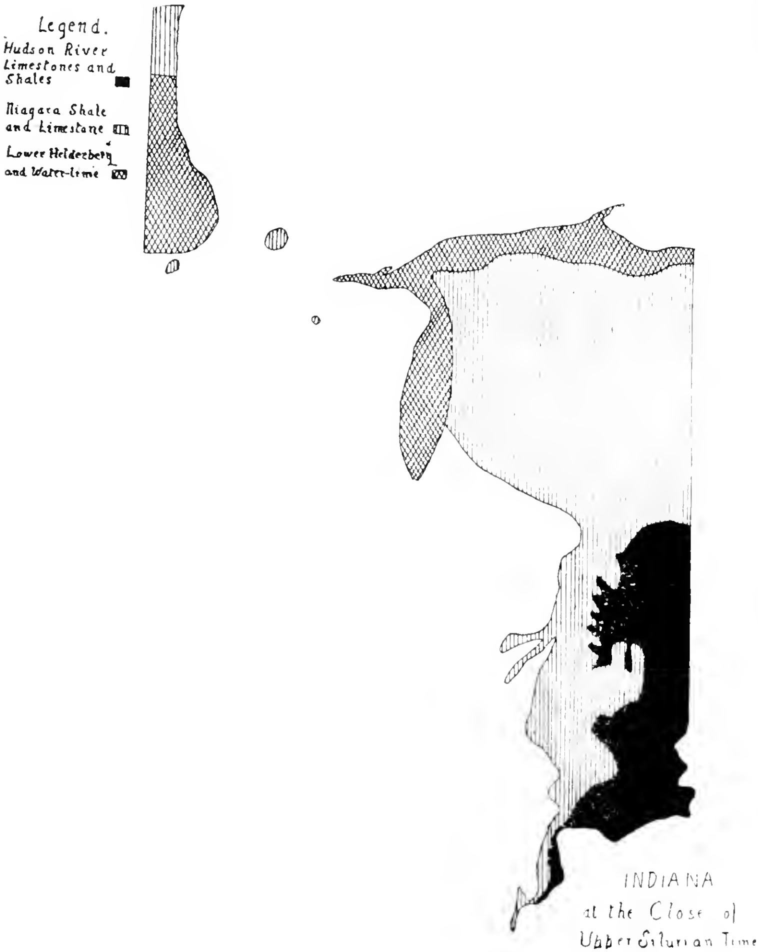
The epochs of the Upper Silurian age, as represented in Indiana, are three in number, viz., the Clinton, the Niagara and the Water Lime, or Lower Helderberg. Each is represented by its characteristic rocks, bearing the peculiar fossils of its time. The Clinton epoch is represented in the State by a close-grained, salmon-colored limestone, varying in thickness from a few inches only to about seven feet. It outcrops in a very narrow strip along the western edge of the area of the Hudson River limestone, already mentioned as the oldest rock in Indiana, and overlies that formation beneath the surface of at least the eastern third of the State. It has no economic importance and serves only as a line of demarcation separating the older Silurian rocks from those great beds of Niagara limestone which were afterward laid down in the Upper Silurian seas.

At the beginning of the Niagara epoch the waters of the Central and Eastern Interior Seas were laden with sediment and beds of bluish-green shales, known as the Niagara shales, and varying in thickness from two to forty feet, were first laid down. Owing to gradual changes in the level of the sea bottom, and a consequent shifting of its tides and currents a clearer, deeper water then resulted, within whose depths there existed life of great variety. Corals and bryozoans were especially represented, and from their remains and those of other marine forms were gradually constructed those beds of gray and buff Niagara limestone, varying in thickness from 180 feet along the Ohio River to 440 feet in the northern and northwestern portions of the State.

Near the close of the Niagara epoch a gradual uprising of a portion of the Eastern and Central Interior Seas took place. From their bottoms there emerged a long peninsula-like strip of land, whose general trend was northwest and southeast. In the former direction it was imperfectly attached to those portions of Wisconsin and Illinois which had come into existence during the Ordovician era. At its lower extremity it merged with that old island of the Cincinnati Uplift which had formed the first land of our present State. The surface rocks of the northwestern corner of Indiana, a narrow and probably interrupted strip extending diagonally across the State, a wide area in the central third and a narrower southern prolongation along the western border of the pre-existing Hudson River group, were thus, for the first time, brought above the level of the sea.

It appears that the force which caused this upraising of the Niagara sea floor was more pronounced at certain points than at others, and so caused a number of dome-like ridges or crests resembling true upheavals in the Niagara beds. These domes are present in an area extending from the Illinois line in Newton County, through the Upper Wabash Valley nearly to the Ohio line, being especially prominent near Wabash, Delphi, Monon, Kentland and other points in the region mentioned. In them the Niagara strata, elsewhere nearly horizontal, are strongly tilted and show other evidence of a true upheaval. These domes were at first probably small islands whose crests remained permanently above the surrounding sea. They thus formed, for a long period, a more or less broken or interrupted connection between the larger area of the Niagara to the southeast and that area in northwestern Indiana which was from now on a part of the continent proper.

The Water Lime and Lower Helderberg are two closely related limestones of the Upper Silurian age which, in Indiana, so merge as to be difficult to distinguish. They represent an epoch between that of the Niagara limestone and the lowest or oldest rocks of the Devonian era.



Their texture and composition shows them to have been laid down in very shallow seas close into the shores of the recently upraised Niagara limestone. The Water Lime is an impure magnesian hydraulic rock, ranging in thickness in Indiana from 20 to 90 feet. It outcrops near Kokomo where have been found numerous fine examples of its most characteristic fossils—gigantic crustaceans, two feet or more in length, closely related to the king crabs of the present seas. Over the extensive mud flats of the closing period of Upper Silurian time they were the undoubted rulers, while in the nearby waters sported descendents of those mail-clad fishes which first appeared in the Trenton period of the Lower Silurian era.

The Lower Helderberg represents the final epoch of Upper Silurian time. In Indiana its rocks form a buff to gray cherty limestone, 25 to 250 feet in thickness and often irregular and uneven in its bedding. It directly overlies the Niagara limestone where the Water Lime is absent. Outcrops occur at Logansport and other points to the northwest, and drill holes sunk for oil and gas show that it probably forms a portion of the surface rock beneath the deep drift-covered area of the northern third of the State.

The advance in life during the Upper Silurian era was not proportionally as great as that of the preceding age. The earliest of Arachnids, the scorpions, came to be, their first remains being in the Water Lime, showing that they were neighbors of the giant Eurypterid crustaceans. Cockroaches and progenitors of dragonflies were also present, but remains of other terrestrial forms are few or lacking. Among marine invertebrates, Cephalopods reached the acme of their development, the gigantic Orthoceratites of this group, whose remains are so common in the Niagara limestones of Wabash and adjoining counties, being worthy of especial mention.

We have seen that by the beginning of the Devonian Age or Era, which succeeded that of the Upper Silurian, the waters of that great bay known as the Eastern Interior Sea, had become farther separated from those of the Central Interior Sea by the uprising of the Niagara limestone area of eastern Indiana and western Ohio, and also by the deposition along the margin of this formation of the sediment comprising the Water Lime and Lower Helderberg limestones. A probable connection still existed between the waters of these two basins across the broken or interrupted strip connecting the main body of Niagara limestone in eastern Indiana with the main land area of the same formation in northwestern Indiana and northern Illinois.

The Devonian rocks of Indiana may be roughly classed as representing two great epochs, the Corniferous and the Genesee, the former being represented by beds of more or less pure limestone, ranging up to 55 feet in thickness; the latter by beds of black or brownish bituminous shales, which reach a known maximum thickness of 195 feet. The waters in which the materials of the Corniferous limestone were deposited were clear and comparatively pure, and in them sponges, corals, crinoids, trilobites and lower animal forms existed in great profusion. From the lime secreted by these marine forms the upper and purer beds of the Corniferous rock are mainly composed. The great abundance of coral life during the period is grandly shown at the Falls of the Ohio, opposite Louisville, Kentucky, where the Corniferous beds have a notable outcrop. Here "the corals are crowded together in great numbers, some standing as they grew, others lying in fragments, as they were broken and heaped up by the waves; branching forms of large and small size being mingled with massive kinds of hemispherical and other shapes. Some of the cup corals are six or seven inches across at the top, indicating a coral animal seven or eight inches in diameter. Hemispherical compound corals occur, five or six feet in diameter. The various coral-polyps of the era had, beyond doubt, bright and varied coloring like those of the existing tropics; and the reefs formed therefore a brilliant and almost interminable flower garden."

Near the close of the Corniferous epoch deposits of silt, mud and sand began to becloud the clear waters and put an end to the life of many marine forms. The upper beds of rock then laid down, known as the Hamilton, contain in places quite a percentage of magnesia and clay, and embody those vast deposits of hydraulic limestone which, in southern Indiana, have been so extensively used in making natural rock cement.

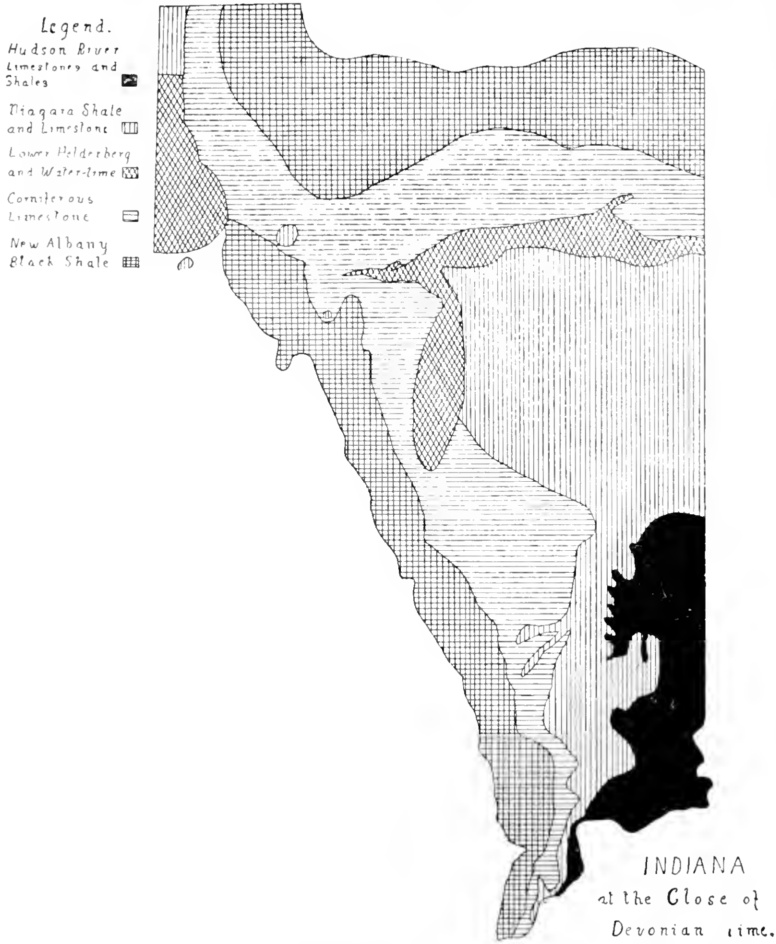
The Corniferous rock, when raised above the surface and added to the pre-existing land of the State, formed along the western margin of the latter an irregular strip 5 to 40 miles in width, extending from the present bed of the Ohio River at Jeffersonville northward to the present sites of Logansport and Monticello. North of the Wabash it has been found to be the surface rock in a number of the deep bores sunk for oil, but on account of the thick mantle of overlying drift, its exact limits are unknown. It is probable, however, that at the close of the Corniferous epoch a strip 20 miles or more in average width and extending nearly across the State was, in this region, raised above the floor of the old Devonian sea, to become a part of the permanent land of the future State.

During the latter part of the Devonian Era those lowly acrogenous plants known as Rhizocarps flourished in vast numbers in the fresh waters and brackish marshes of the time, and their spores by countless millions of tons were carried out as sediment into the surrounding seas. Mingling with the mud and silt and sand, brought down by erosion from the rapidly increasing land surface, they formed those vast mud flats which have since, by age and pressure, been consolidated into the thick beds of brown and black, finely-laminated shales which form the rocks of the Genesee epoch in Indiana. At New Albany the outcrops of this shale are 104 feet in thickness and especially prominent, so that the local name, "New Albany black shale," has been given it by geologists of the State. Along the western edge of the Corniferous limestone this shale forms a continuous strip, 3 to 35 miles in width, reaching from the present sne of New Albany north and northwesterly to Delphi and Rensselaer. Over much of this strip it is covered by a thick mantle of drift, but everywhere within the area wells or the eroding streams have proven it to be the surface rock. The black shale has also, by deep bores, been found to be the rock immediately underlying the drift over much of the area embraced within the two northern tiers of counties in the State.

The Genesee shale is rich in bitumens, derived from the spores of the ancient Rhizocarps, which also gave it color. When kindled, it will burn until they are consumed, and it is therefore, by the uninitiated, often mistaken for coal. These bitumens are, by natural processes, sometimes separated from the shale and in the form of gas or petroleum are collected in reservoirs in it or in the underlying Corniferous limestone.

During the thousands of centuries of the Devonian Period, a great advancement took place in the flora and fauna of the times, especially in the vegetation of the land and the development of the higher aquatic vertebrates. Among the acrogens growing on land, ground pines, tree ferns and equiseta or horse-tails came into existence and flourished in vast numbers. Their remains are often found in the Corniferous limestone, into the sediment of which they were drifted and preserved. The first Phanerogams, conifers of the yew and cycad families, were also evolved, their leaves and branches being found in the upper or Hamilton beds of the Corniferous epoch. As the land plants increased in number and variety, insect life became more varied and numerous.

Mayflies abounded and the first musicians of the earth appeared in the form of Orthopterans which, by means of their shrilling organs, enlivened the solitudes of the strange old Devonian forests with their love calls and wooing notes. Among fishes, the Ganoids and Selachians,



of which our gar-pikes, sturgeons and sharks are degenerate descendants, reached the acme of their development; while gigantic species of Dipnoans or lung-fishes, now only represented by the dog-fish or "John A. Grindle," abounded in the bays and bayous about the ancient Genesee flats.

At the beginning of the Lower or Sub-Carboniferous Era, which followed the Devonian in regular sequence, we find more than half of Indiana above the level of the sea. By the deposition and subsequent raising of the rocks of the Corniferous and Genesee epochs, the gap between the large area of Niagara limestone in the eastern part of the State and the mainland to the northwestward had been filled and that portion of the future Indiana became for the first time a part of the slowly growing North American continent. The rocks which were afterward added on its western side were deposited on the sloping floor of the Central Interior sea which stretched far away to the southwest, and they consequently have a notable dip in that direction.

The lowermost stratum of the Sub-Carboniferous rocks in Indiana is a thin but very persistent bed of greenish limestone, known as the Rockford Goniatite limestone. It is but about two feet in thickness at its most notable outcrops, and hence forms but a very narrow area of the surface rocks of the State. It serves well, however, as a line of demarcation separating the Upper Devonian shales from the thick beds of Knobstone which represent one of the early and important epochs of Lower Carboniferous time.

These Knobstone rocks consist at the base of a series of soft, bluish shales, which gradually become more arenaceous or sandy, until toward their western horizon they merge into massive beds of impure grayish sandstone. The formation ranges in known thickness from 440 to 650 feet. The name "Knobstone" was first given it by that eminent geologist, David Dale Owen, because its siliceous strata weather into those peculiar conical "knobs" or hills which are so prominent a feature of the topography in the southern unglaciated portion of its area. By the deposition and upraising of the Knobstone a strip of territory, 3 to 38 miles in width, extending from the Ohio River southwest of New Albany north and northwesterly to a point a few miles south of the present site of Rensselaer, Jasper County, was added to the existing land of the future State. Deep bores have also shown the Knobstone to immediately underlie the drift in a strip of varying width along the extreme northern border of the State. By its deposition and subsequent upraising over this area, all of the northeastern portion of the State became for the first time dry land, and the waters of the Eastern Interior Sea were forever banished from the future Indiana.

Over much of the northern part of its main area in Indiana, the Knobstone is at present more or less covered by glacial debris, its strata being exposed only in the stream valleys. The shales of the basal or eastern third of its unglaciated portion are excellently adapted to the making of vitrified wares, as paving brick, sewer pipe, etc., as well as for the clay ingredient of Portland cement; though as yet their possibilities of service for these products have been largely ignored.

Following the Knobstone epoch came that of the Lower Carboniferous limestones. Four distinct horizons of these limestones are recognized in Indiana, viz., the Harrodsburgh, Bedford, Mitchell and Huron, in the order named; each representing a distinct period of deposition in the slowly retreating Central Interior Sea. Their total thickness is nearly 600 feet, and together they form the surface rocks over an area 40 miles wide on the Ohio River, but which gradually narrows northward until it disappears beneath the drift in the vicinity of Crawfordsville, Montgomery County.

Of the four horizons that of the Bedford is by far the most noted, since from it is obtained that famous Bedford or Indiana oölitic limestone which is now widely recognized as the finest building stone on the continent of America. It is mainly composed of the globular shells of microscopic foraminifera or Rhizopods—minute one-celled animal organisms—which must have swarmed in untold myriads in the sea waters of the time. The shells or cell walls of these animals were composed of a very pure carbonate of lime, and when they died and sank on the old sea bottom these shells were cemented together by the same material. Under the lens they resemble a mass of fish eggs soldered together, hence the name "oölitic," meaning "like an egg." The Bedford stone is noted among architects for its strength and durability, and for the ease with which it may be sawed or carved into any desired form. For many years it has ranked as one of the principal natural resources of the State.

The "Mitchell limestone" overlying the oölitic is composed of a series of close-grained limestones, shales and cherts. Its outcrop—5 to 30 miles in width—is a fairly level plateau which is pitted with a great number of sink holes, many of which form the openings into underground caverns and the beds of subterranean streams. The thick beds of Mitchell limestone, taken in connection with the underlying Bedford and Harrodsburgh limestones, afford a series of rocks which are more or less jointed, and therefore easily eroded by underground waters. As a result, large caves, some of them possessing great vaulted rooms,

deep pits, high waterfalls and streams of water large enough to allow the ready passage of a boat, are found throughout this area. All of these caves are due to the action of water—that greatest of nature's solvents and abraders—its work of a day, a year, a century, upon the solid limestone not appreciable to the eye—yet by slow unceasing action through the ages which have elapsed since that limestone was raised above the sea, it has carved every room and passage, constructed every pillar and stalagmite existing beneath the surface of southern Indiana.

The Huron limestone or Huron group of rocks represents in Indiana the latest epoch of the Lower Carboniferous Era. It is composed of three beds of limestone with two intervening beds of sandstone, their combined thickness being about 150 feet. The sandstones carry in places concretions of iron ore and thin beds of coal, the latter being the forerunners or harbingers of those vast veins of stored energy which, in southern Indiana, represent the Carboniferous and final era of Paleozoic time.

The Carboniferous Era is noted as one of gentle oscillations in the surface of those shallow seas bordering the land, these "causing successive more or less wide emergencies and submergencies, the former favoring the growth of boundless forests and jungles, the latter burying the vegetable debris and other terrestrial accumulations beneath fresh water or marine deposits."

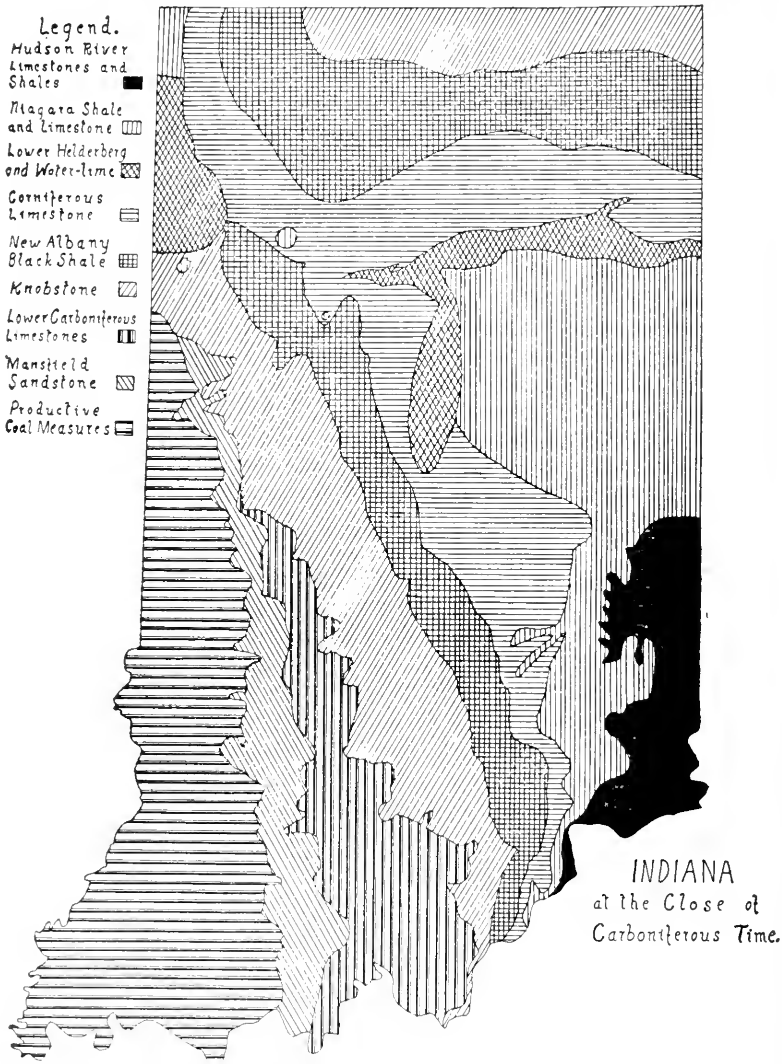
During the era, that cryptogamous land vegetation which had sprung into existence in the Devonian Era, advanced with wonderful strides. The temperature was mild; the atmosphere moist and heavy laden with carbon dioxide. As a result the vast lowland marshes were overgrown with great trees of Sigillaria, Lepidodendron and Calamites; while at their base grew dense thickets of fern underbrush, inhabited only by insects and amphibians. For the first examples of the latter evolved during this period from some mud-loving, fish-like creature. No flowering plant had as yet unfolded its petals. No bird had, as yet, winged its way through the buoyant air. No mammal was, as yet, a denizen of earth or sea. Those dim watery woodlands were flowerless, fruitless, songless, voiceless, unless the occasional shrill of a cricket or grasshopper could be called a song. Yet in the cells of the semi-aquatic plants and trees of those old forests there was stored that heat which was destined in after ages to be freed by man and used in doing the work of the world.

The rocks laid down during this era were alternating beds of sandstone, shale, clay and limestone with occasional beds of compressed vegetation which, during after centuries, has been changed into coal.

The basal formation of the Carboniferous Era in Indiana, as generally elsewhere, is a bed of coarse-grained sandstone, known as the Mansfield sandstone or "Millstone Grit." It has a total thickness of 150 feet and forms the surface rock over a strip 2 to 22 miles in width, extending from the northern part of Warren County in an east of south direction to the Ohio River, a distance of 175 miles. In Martin and Orange counties it occurs with an even, sharp grit, furnishing a most excellent material for whetstones and grindstones.

Above this sandstone are the Productive and Barren Coal Measures, which comprise 7,500 square miles of the land surface of the State. At the time of their deposition or formation the area which they cover, as well as a large part of Illinois, was a great basin or depression, but little above the level of the sea, and surrounded on every side except the southwestern by the higher lands of the older formations. By successive alternations of upheaval and subsidence—carried on through thousands of years—this depression was at times an area of the southwestern sea, again a fresh water lake, and then, for a period, a vast swamp or marsh. When raised high enough to form a marsh, the luxuriant vegetation, above mentioned, sprang up from the ooze and mud at its bottom, flourished for centuries, the newer growths springing from between the fallen masses of the older, as in the peat bogs of today, and so formed a mighty mass of carbonaceous material. By subsidence, the level of the marsh was, in time, lowered until it became a lake into which rivers from the surrounding highlands flowed, bearing with them millions of tons of clayey sediment and disintegrated quartz, the remains of the older decayed rocks. This sediment was spread out over the mass of submerged vegetation, compressing it into the hard, mineral coal; the clayey sediment itself being in time compressed into vast beds of shale, and the particles of quartz into sandstone. In some places a more prolonged subsidence took place, sinking the floor of the lake below the level of the sea, and allowing the waters of the latter with their accompanying forms of marine life to flow in. In time beds of limestone were then formed over those of the shale or sandstone, but none of these cover an extensive area or are of great thickness.

After each subsidence, with its resulting beds of coal, shale and sandstone or limestone, had taken place, an upheaval followed. The floor of sea or lake was again raised so near the surface that the semi-aquatic vegetation for a new coal seam could spring up and, in time, the processes above detailed were again undergone. Such, in brief, was the origin and



formation of those five great veins of coal which form today the chief mineral wealth of our State, and of those vast beds of overlying shale which, in recent years, have come to be used for so many varied products.

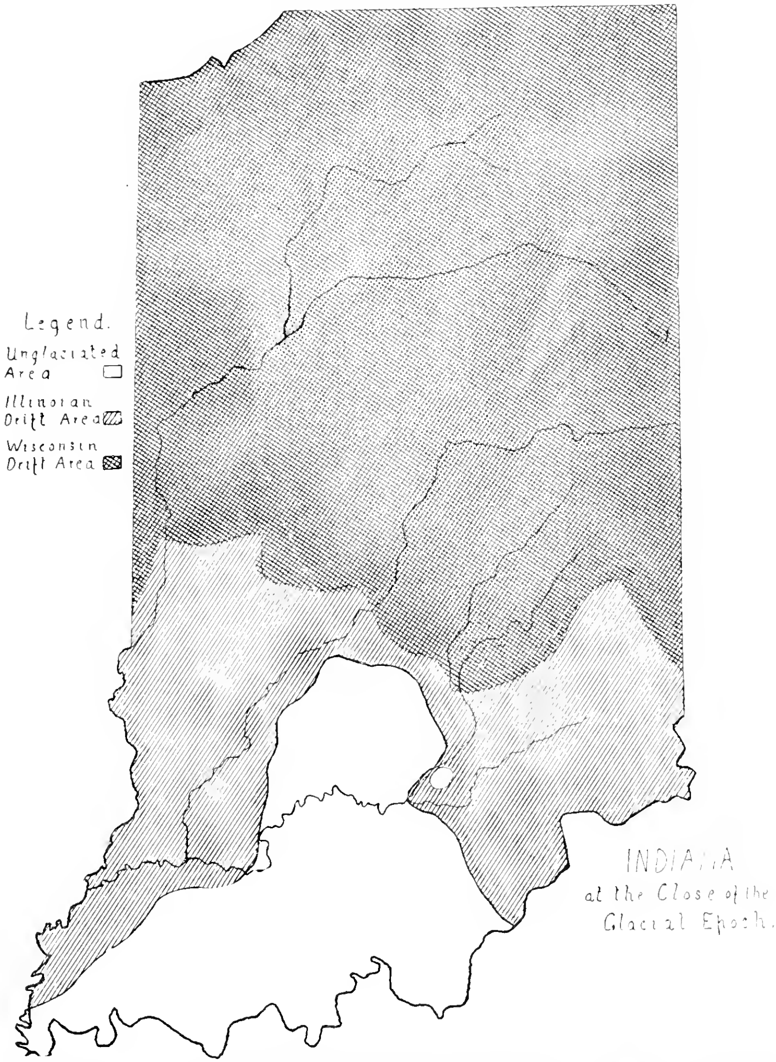
We have now traced the growth of the area comprising Indiana through Paleozoic time. We have seen how that area gradually appeared above old ocean's rim. But it was not yet the "Indiana of Nature"—the finished product of the ages ready for the advent of man. Centuries untold had yet to come and go before it was complete—centuries during which changes of momentous importance were to come to pass. For, as yet, no palm, no angiosperm or flowering plant with seeds, no osseous or common fish, no reptile, no bird, no mammal had come to be upon the surface of the earth. All these were evolved from pre-existing forms during the age or era immediately succeeding the Carboniferous or final period of Paleozoic time. This age is known as that of the Mesozoic or Middle Time, represented by the Triassic, Jurassic and Cretaceous eras. For our purpose there may be combined with these eras the Tertiary of Cenozoic or recent time. During the myriads of years ascribed to these eras, while vast changes were taking place in other parts of the American Continent, the surface of Indiana probably remained above sea level. On it there grew the plants and over it there doubtless roamed, in their turn, the animals of each successive era, but as its surface was above the sea, they left no fossil bone or footprint to tell us of their presence.

All this time, however, the silent processes of nature were unceasing in their labor, and wrought great changes in the surface of the future State. Decay and erosion were in action then as they are today. Sunshine and rain, wind and frost, trickling rills and strong streams were ever at work, softening and sculpturing and wearing down the exposed rocks, forming clays and sand and gravel and bearing them away to lower levels. At the close of the Tertiary Era, the entire surface of what is now Indiana resembled that of today in the driftless area of its southern part, being cut up by erosion into a complex network of valleys, ridges and isolated hills. In certain portions of the northern half great streams, of which there are now no surface indications, had worn their channels a half mile in width, 200 feet or more down into the solid Niagara limestone. The Ohio River valley, a trench from one to six miles wide and 400 feet deep, was mainly eroded during this period, as was also the greater portion of the Wabash Valley, from Huntington to its mouth. Everywhere over the surface was a thin soil, formed from decaying rocks and vegetation, poorer, perhaps, than much of that which at present covers the surface of the driftless area, where the underlying limestones and shales have been the parent rock. In this soil grew the cedar and the sassafras, the willow and the maple, the oak and the beech, while over its surface spread many of the coarser grasses, sedges and mosses of the present day.

During these long periods of erosion and decay, mild climatic conditions had prevailed. But near the close of the Tertiary a change in these conditions came gradually to pass—a change which was most sweeping and far-reaching in its final results. For some, as yet unknown, reason, the mean annual temperature of the northern hemisphere became much lower. The climate of the regions to the east and south of Hudson's Bay became similar to that of Greenland of today, or even colder. The snow, ever falling, never melting, accumulated during hundreds of centuries in one vast field of enormous thickness. Near the bottom of this mass a plastic, porous sort of ice was gradually formed from the snow by the pressure from above. This ice mass or glacier took upon itself a slow, almost imperceptible motion to the south or southwestward, until it covered three-fourths or more of what is now Indiana. As it moved slowly southward great masses of partly-decayed rock and clay from hillsides and jutting cliffs rolled down upon it and were carried on and on until, by the melting of their icy steed, they were dropped hundreds of miles from the parent ledge. Large irregular masses of rock from the region in which the glacier was formed were either frozen into its nether portion or rolled along beneath it, and as the ice sheet moved they served as great stone drags, grinding down and smoothing off the hills and ridges and filling up the valleys, until the irregular, uneven surface of the old preglacial rocks was planed and polished.

From the striæ formed by these imprisoned boulders and from other evidence which it is difficult to otherwise explain, it is now believed that there were several distinct epochs in the glacial period. The great ice sheet, which was at first formed, several times advanced and as often—by an increase of the temperature of the region which it entered—melted and receded; its retreat or recession being each time as gradual as its advance had been. Like a great army which has attempted the invasion of a country and has been compelled to withdraw, it would again assemble its forces and start in a slightly different direction. But, perchance, before it had reached the limit of its former invasion a force of circumstances would render a retreat necessary. Its advancing margin was thus not in a straight line, but in lobes, or long, gradual curves.

When the first ice sheet reached its greatest advance into the region now comprising Indiana, the ice "was at least 500 or 600 feet deep over



the present site of Terre Haute and nearly as deep over that of Indianapolis, and it thickened gradually northward. If an observer could have stood on one of the hills in Brown county at that time, he would have seen to the east of him the great wall of the ice front extending south toward Kentucky, while toward the west it would have been seen in the distance stretching away toward the southwest. For hundreds of miles to the east and west, and for 2,000 miles or more to the north, the glaring, white desert of snow-covered ice, like that seen in the interior of Greenland by Nansen and Peary, would have appeared, stretching away out of sight, with not a thing under the sun to relieve its cold monotony."

By the incursions of the various ice sheets all the so-called "drift soils" of northern and central Indiana were accumulated where they lie. Derived, as they were, in part, from the various primary and igneous rocks in the far north, ground fine and thoroughly mixed as they were by the onward moving force of a mighty glacier, they are unusually rich in all the necessary constituents of plant food. Principally to them does Indiana owe her present high rank as an agricultural state. All the level and more fertile counties lie within this drift covered area, and its southern limit marks, practically, the boundary of the great corn and wheat producing portion of the State. But few of the present inhabitants of Indiana realize how much they owe to this glacial invasion of our domain in the misty past. It not only determined the character of the soil, the contour of the country and the minor lines of drainage, but in manifold other ways had to do with the pleasure, the health and the prosperity of the present population.

When the final ice sheet gradually receded from the area now comprising Indiana, the surface of the glaciated portion was left covered with a sheet of drift or till composed mainly of clay, gravel and boulders, and varying in thickness from one to 400 feet or more. Over the greater portion of this area the surface of the drift was comparatively level, but in the northern fourth of the State it was in numerous places heaped up in extensive ridges and hills, due to irregular dumping along the margins and between the lobes of the melting ice sheets. In the hollows or low places between those ridges and hills the waters of the melting ice accumulated and formed those hundreds of fresh water lakes which are today the most beautiful and expressive features of the landscape in the region wherein they abound. At first all of those yet in existence were much larger than now, while for every one remaining a score have become extinct.

A new vegetation soon sprang up over the land left desolate and barren by the retreating ice. The climate gradually became much warmer than it is today. The great expanse of water in lakes and rivers, aided by the increase in temperature, gave rise to excessive moisture. Fostered by the rich soil and the mild, moist atmosphere, a vast forest of deciduous trees spread over the larger portion of our State. Through this forest and about the margins of the lakes and marshes there wandered for centuries the mammoth and the mastodon, the giant bison and the elk, the tapir and the peccary, the mighty sloth and that king of rodents, *Castoroides ohioensis*. Preying upon these and smaller mammals were the great American lion, and tigers and wolves of mammoth size. The bones and teeth of all of these species of extinct animals have been found buried beneath the surfaces of former bogs and marshes in various portions of the State. It is not improbable that with them was also that higher mammal—man—in all the nakedness of his primitive existence.

But over this phase in the evolution of the future Indiana there came again a change, for nature knows no such thing as rest. The great rivers which had borne south and southwestwardly the floods and debris of the melting glaciers gradually diminished in size and filled but a small portion of their former valleys. Extensive shallow lakes in the northwestern part of our present area gave way to marshes and these, in time, to wet prairies, possessing a rich black soil derived largely from the decay of aquatic vegetation. The climate gradually grew less moist, more cool. The mammoth, the mastodon and contemporaneous mammals disappeared, and in their stead came countless thousands of buffalo and deer. With them came, too, that son of Nature—that descendant of the naked barbarians of centuries before—the noble Red Man. From out of that dark night which hangs forever over all we know or shall know of early America he came—a waif flung by the surge of time to these later ages of our own.

With the advent of the Red Man the "Indiana of Nature" was complete, was perfect. It possessed that primeval savage beauty of a world unmarred by man. Lakes, streams, forests, prairies, stored fuel, noble game—all were here. For centuries the Indian lived in peace within its bounds. The forest yielded him bear and deer—the prairies, buffalo and wild fowl. On the higher ridges, overlooking the larger streams and lakes, he had his principal village sites. Over their placid waters he paddled his birch bark canoe. From their depths he secured with spear and hook fishes sufficient to supply his needs; while the skins of muskrat, otter and beaver which he trapped about their marshy margins furnished him protection against the cold. Through the forest glades, when returning from the chase, his cries of triumph were echoed. Here, in a land of plenty, his wants were few and easily satisfied; his ambitions lowly, his hopes eternal.

But to this, as to all things peaceful, there was an end. From across the seas came that "prince of parasites," the white man—self-styled heir to all the ages—so-called conqueror and civilizer—but in reality the greatest devastator that Nature has ever known. First as a discoverer came he. Then as a trapper and trader among the Indians; last as a settler of the future State. His first permanent hamlets or settlements were, like those of the Indians, located on the larger streams. From these he penetrated farther and farther the forest, building his cabins wherever a spring purled forth from a hillside to furnish water. In less than two centuries—a mere second as compared with those measureless eternities before he came—the white man has changed beyond recognition the "Indiana of Nature." Only its outlines remain as they were.

From its bounds he has driven forever the buffalo, bear, panther, elk, deer, wild turkey, ivory-billed woodpecker, paroquet and wild pigeon, together with the noble Red Man, the one-time contemporary and lord of them all. From its surface he has cleared that dense forest of tall trees—of which no domain could boast a better—leaving in its stead a mere remnant of what would have been termed underbrush a century ago. Following the felling of the forests came, as a direct result, the drying up of springs and the dwindling to mere rivulets of former creeks and streams. To gain control over a few more acres of mother earth, he has dredged deep ditches and so lessened greatly the size or brought about the total extinction of 90 per cent. of those crystal lakes which once gave variety and beauty to the northern fourth of the State.

He has caused the picturesque trails and woodland paths of the Indian to disappear, and in their stead we find, at intervals of a mile or two, those broad unshaded roadways, many of which are floods of dust in summer and seas of mud in winter. As a complement to these he has, in nearly every county, leveled hills, filled up valleys, bridged streams, and stretched long bands of steel spiked to wooden ties. Drawn by the harnessed forces of Nature, he rushes over these at almost lightning speed; while along them he sends, with many a roar and rumble, those necessities and luxuries of his artificial life.

Not content with his destruction of the natural beauty of the surface of the State, he has delved deep into its depths, in search of those riches of stored power, there hidden since the sun gave up its heat and light to the plant cells of the old Silurian seas and Carboniferous marshes. With his iron drill he sunk, in eighteen years, ten thousand vents to the Trenton rock. Through these there poured natural gas valued, even at the extremely low price at which it was sold, at $77,618,189. So greedy was he, so ignorant of the real value of this gaseous fuel and the manner of its formation, so reckless in its consumption, that at the end of less than a score of years there remains only the dregs of the plenty that has been.

As with natural gas, so with its mother liquid, crude petroleum. Since 1891, 16,975 bores have been sunk within the limits of the State, for it alone. Through these 55,172,755 barrels of oil, valued at $42,757,834, have reached the surface. But few years will elapse before the stored supply of it, too, will have vanished. A priceless gift of nature—hundreds of millions of years in forming--it will be sacrificed to the greed of the white man in less than the life of a generation of his kind.

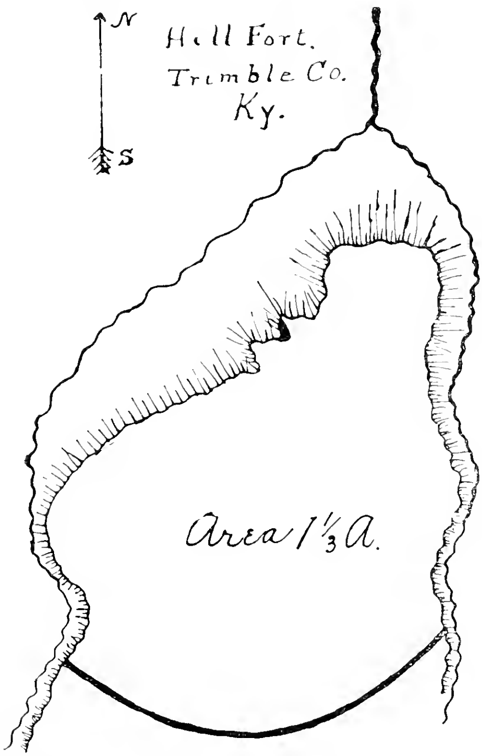
More valuable than either gas or oil, closer to the surface and, therefore, more easily secured, are those vast veins of coal which underlie the southwestern area of our State. For sixty years man has sunk his shafts and pitholes to their levels, and tunneled miles along their courses, until the output has risen above nine million tons per annum. Less than two centuries will see the end of this stored fuel, and Indiana will then have been raped of all those riches which, in the ages past, were formed beneath her surface.

But why continue? Examples manifold could yet be given of the changes wrought by man since first he gave the name Indiana to the area in which we dwell—changes which one and all have but marred the face of nature and left everywhere the signs of his greed, his egoism. Only the great blue ethereal dome—the sun which shines and rules over all—the moon, cold and lifeless—the stars, gleaming from their heights in the realms of space—the clouds which oftentimes hide even these from view—seem as they were when the Indiana of Nature was first perfected.

A Prehistoric Fortification Near Madison, Indiana.

By Glenn Culbertson.

On the farm of Mrs. James Snyder in Trimble county, Ky., and at the head of Broadway Hollow, so-called because it is directly across the Ohio river from Broadway in Madison, Ind., is located a prehistoric fortification. To a few people in the immediate vicintiy this fortification is



known as the Indian fort, but to my knowledge it has never been described, although it is one of the most interesting remains of prehistoric people in all that region.

The hills in the vicinity of Madison are approximately four hundred feet above low water level of the Ohio river. They are capped by the resistant Niagara and Clinton limestones, underlaid by the soft Hudson shales. Hence bluffs and precipitous slopes are not at all infrequent. The fortification, mentioned, is situated about a half mile back from the bluffs and steep slopes facing the Ohio, and between the two principal tributaries of the stream which occupies Broadway Hollow. These streams have eroded deep but narrow valleys which in the upper portions are enclosed in part by perpendicular cliffs.

The fortification, as may be seen from the map, is roughly triangular in shape and is bounded by cliffs some 75 feet high near the apex at the north end. These cliffs become lower gradually as the south side of the fortification is approached. At the southwest angle the height is still some thirty feet, while at the southeast angle the height of the cliff is at present not more than eight or ten feet.

The neck of land beeween the two streams at the south was fortified by means of a stone and earth wall, with a ditch or moat on the outside. The remains of the wall, except on the steeper slopes near the ends, form a mass of earth and stones some ten feet wide at base and three or four feet high. The ditch outside is still six or eight feet wide and has a maximum depth of two or three feet below the original surface. The wall was about one hundred and twenty yards long and strongly curved outwards. The area of the fortification proper is about one and one-third acres, and as the site of the fort has never been cleared of its forest growth, it is still covered with thick underbrush and small trees.

The fortification is admirably located for the purpose of defense. On two sides of the triangle it would be almost impossible for an enemy to enter the fort even if undefended, except, perhaps, at the southeast angle, where in all probability a supplementary wall was built. The stone and earth wall across the neck may have been, and probably was, surmounted by a stockade, as was done in case of many of the prehistoric fortifications in Ohio. There are, at present, however, no evidences of a stockade visible.

Of the different kinds of prehistoric fortifications now known and recognized, viz., signal and observatory stations, stockade forts, hill forts and stone forts, this one should probably be classified as a hill fort, and was intended as a place of retreat on the approach of an enemy. The tribe or clan using the fort probably cultivated the fertile bottom lands near, and fled to the fort as occasion demanded. This fortification may have been used as an observatory and signal station, also, but was not one of a series known to extend along either side of the Ohio River, since from this point it is impossible to see or be seen from the Ohio at any distance either up or down. The site is an admirable one, however, for signaling across to the headwaters of Indian Kentucky creek, in Indiana, along which are found many evidences of prehistoric inhabitants. There are no visible ash or charcoal remains in the vicinity of the fort, so the signal theory remains unproven.

A Note on the Breeding Habits of the Common or White Sucker.

By Glenn Culbertson.

While fishing on Big Creek in Jefferson County, Ind., last April the writer had an opportunity to observe at short range the spawning habits of the common White Sucker (Catostomus teres). It is the habit of this fish to spawn in the swiftly flowing water of ripples rather than in the still water of pools, and if I am not mistaken during the night rather than the day.

In the case under observation there was a school of suckers, some twenty or twenty-five in number, and ranging in size from nine or ten inches to thirteen or fourteen inches in length. The location was a short reach of swift water some three or four inches in depth, between two large pools. The ripple was close to a steep bank and was overhung by the branches of trees, making the place rather dark even at noon. The fish with few exceptions were constantly swimming about, now in the deeper water and, again for a short time in the shallow water of the ripples. A few were lying quietly on the bottom in the swift water.

My attention on observing the school for a few minutes was soon attracted to a large female, thirteen or fourteen inches in length and two males about ten or eleven inches long. Whenever this particular female swam from the pool above down into the swift water, the two males, which always swam approximately side by side, and some five or six inches apart, would endeavor to pass one on either side of the female. In the one case where the actual spawning occurred, the two males reached positions close to and on either side of the female and with the anterior portions of their heads some two inches farther back than that of the female, the heads of all being upstream. While thus stationary in this position the males struck the female each with head and then tail, alternately, and with great rapidity. This motion was continued some four or five seconds. At the same time, the swift water of the ripple below the spawning fish became of a milky white color, due to the spermatic fluid of the males. On taking the same female a few minutes later the spawn was found to be abundant and to pass very readily from the body. On taking two or three of the males the usually smooth portion of the heads was found to be covered with numerous tubercles from one to two millimeters long. The tail fins of the males were also found with rows of similar tubercles along the rays. No tubercles were found on the female.

The spawn could have done nothing else than to have floated off into the still water of the pool below, where some may have found lodgment among the water plants.

Whether polyandry, or perhaps more exactly diandry, if the term may be so used, is always the habit of the female sucker I am unable to say, but in this case it certainly was.

Notes on the Caves of Cuba.

By J. W. Beede.
(By title.)

Effect of Ultraviolet Light on the Action of the Coherer.

By Arthur L. Foley.
(By title.)

The Life of Radium.

By Arthur L. Foley.
(By title.)

"Colds" and Cold.

By Robert Hessler.

It is often said that on account of variable weather conditions, that is, sudden and violent atmospheric changes, the climate of Indiana is an unhealthy one and that this is the reason why "colds" are so common among us. Now is this true, especially the deduction?

Most of us, I believe, will admit that changes in temperature are rather sudden at times and that the daily weather conditions are quite variable, but that our climate—that is, the sum total of all weather conditions for long periods of time—is one conducive to the production of "colds," per se, may be denied by some.

Now when I speak of a "cold" I am assuming that everybody knows what that means. A cold—why, yes, of course. Everybody knows what a cold is.

As a matter of fact many think they know—which is something entirely different. We all know the dictionary definition: "Cold.—An indisposition commonly ascribed to exposure to cold; especially, a catarrhal inflammation of the mucous membrane of the nose, pharynx, larynx, trachea, bronchi, or bronchal tubes." (Century.)

Physicians use the term very freely in conversation or consultation with their patients. There is good reason for this. When the patient comes to the physician he not only wants a medicine or a prescription but he also wants to know about his disease or affection; he will want to know the name at least, and very likely also the cause. We all want an explanation of what is wrong when we are sick, and the simpler the explanation the better. If the physician wants to be exact and gives the explanation in technical terms that have a definite meaning, then he must explain the terms themselves, all of which takes a lot of time—and so the busy practitioner has recourse to a number of terms and phrases which have long been in use and with which the laity are familiar. When, therefore, the anxious patient asks for the common name of his disease or for its cause, and the knowing physician answers assuringly and perhaps authoritatively the magic word "cold," all is serene. Such words as cold, rheumatism, malaria and the like are timesavers. Such terms are often used both in the sense of cause and effect.

Well, I don't see where I got my cold or caught my cold, the patient will say. Well, I don't either, the physician may reply, while he writes the prescription or puts up the bottle of medicine. In the meantime the patient will mentally go over the events of the past few days until he finds where, as he thinks, he has exposed himself to cold, perhaps to a draught or went out bareheaded; and then he is able to account for his illness or for his "cold." This is all very simple.

Now, as a matter of fact the term cold as ordinarily understood as an ailment, or even as a cause for an ailment, has practically gone out of use among physicians themselves, and the word is seldom seen in the best medical literature of today.

But let us return to the popular use of the term. Colds in the human body have a most varied form of manifestation. A cold in the head is perhaps the most common. We often hear of colds settling in certain parts of the body or of traveling about from one organ to another. A cold which begins in the nose may travel down into the lungs or down the alimentary tract. Affections with different names may follow, such as catarrh, or tonsilitis, bronchitis or pneumonia, or congestion of the stomach or liver or kidneys; we also hear of colds in the eyes and ears.

Now a "cold" in the sense of a bodily ailment is by many of us intimately connected with cold in the physical sense, that is, the absence of heat or a lessened amount of heat in the atmosphere. An ingenious explanation that I once heard was this: A sudden alternation of heat and cold acts on the mucous membrane as it does on glass—it causes it to crack, and then disease results. This would be a simple explanation why Indiana, with its great and sudden variations in temperature, is unhealthy.

Now, this sounds plausible, and yet we are told by arctic explorers that they are singularly free from colds—and acute respiratory affections generally—while in the far north, notwithstanding that they go from their warm huts or cabins out into the intense arctic cold, where the contrast is much greater than any changes in Indiana. It would seem that if a cracking of mucous membranes takes place at all it would certainly take place there, and disease result.

It is a common observation that colds are most prevalent among us during the cold season, and so we naturally associate cold with "colds," yet explorers tell us that "colds" are practically unknown in the far north—there must need be some other explanation.

Our domestic animals with an anatomy and physiology closely resembling our own are not subject, at least to any extent, to diseases of the respiratory tract or to colds.

If our State is unhealthy, I believe we must look elsewhere than to the climate to account for the prevalence of respiratory diseases, and especially colds. The old pioneers and the farmers at the present time living in thinly-settled districts do not complain of the climate; they have been and are healthy.

The use of natural gas and overheated rooms is a fruitful cause of colds, we are told. Fires burn day and night and dry out the atmosphere, and this causes the respiratory mucous membranes to become dry and inflamed. This sounds reasonable, but, we may ask, why do not the inhabitants of dry, arid plains or deserts—with an exceedingly hot and dry atmosphere, exceeding that of our rooms—why do they not suffer from inflammations and colds? The Bedouins are said to have such delicate or sensitive mucous membranes that they can not bear the odor of a city; however, at times of windstorms they get nose and throat full of sand and dust and yet they are none the worse the day after.

Physicists tell us that the amount of moisture the air is capable of holding depends on its temperature; the higher the temperature the more moisture it can hold. A very cold air may be a very dry air which may take up considerable moisture on coming in contact with the respiratory membranes—yet it is known that in an otherwise pure atmosphere no harm results. On the other hand, a hot, dry desert atmosphere may take up considerable moisture from these membranes, and this is readily supplied as long as the body contains sufficient fluid or where there is no excessive thirst. We see practically the same conditions in an iron foundry or rolling mill. In this excessively hot atmosphere the respiratory membranes of the men may suffer very little because they give off the fluid so freely supplied the body as drink. Membranes keep themselves moist in a dry atmosphere just as the skin keeps itself moist. As a matter of fact, the amount of moisture or the dryness of the air has nothing to do with the production of colds—other things being equal.

A variation of this hot-air and dry-room theory is that it is necessary to come in contact with the outer raw air before inflammation results; that this first brings on a congestion and this in turn is followed by the inflammation or the cold. We may also be told that improper clothing plays an important part; that we either bundle up too much or that we do not dress warmly enough. Some persons account for their colds by the underwear used, both as regards material and texture.

Now, it is well known that individuals who in town are subject to colds will be free from them on going to the wild woods. The experience of hunters far away from civilization is of interest in this connection; they will undergo all sorts of hardships and exposures, get wet and cold, leave their little cabin with its red hot stove and step out into the cold winter air and back again, and yet they do not take cold.

Taking it all in all, it would seem that we will have to look elsewhere than to exposure to physical cold for the production of the affection we know as a "cold." It is not to be denied that we do take colds after an exposure, as we all know from experience, but there must be some other factor involved. Indeed, long ago that patient scientist and philosopher, Benjamin Franklin, arrived at this conclusion. In his autobiography are recorded a number of observations that he made on colds, and he came to the conclusion that simple exposure to cold was not a sufficient cause. What this something, this unknown factor, is he did not know—in fact we are just beginning to find out. I am almost inclined to believe that if Ben Franklin had been a physician or had had the education of a physician we would have known long ago.

Now, we have been using the term "a cold" without any real definition of its meeting; we assumed that everybody knows what a cold is, but as a matter of fact there is a whole list of words used by the laity in a loose way which all stand for the same thing. A cough or a running nose, headache, sore throat, catarrhal affections, tonsilitis, stiff neck, pleurisy, rheumatism, neuralgia, lumbago, gout, fever, malaria, inflammation or soreness of the kidneys and so forth, are either synonyms for a cold or are said to be due to cold or that a cold has settled in some particular part of the body.

For instance, the significance or meaning of the term malaria as ordinarily used may at first sight seem obscure, but it is very frequently used in those cases of "cold" where there is considerable fever and perhaps some chills. As a matter of fact, real malarial fever is a comparatively rare disease and is practically absent during the winter months. It can be definitely diagnosed by an examination of the blood, and cases usually require active medication, that is, the use of some antiperiodic like quinine, before recovery takes place. Self-diagnosed cases of "malaria," that is "colds," usually get well in a short time, and without the use of large doses of quinine.

Popular medical terms are used in a very loose way and physicians using them among each other are constantly compelled to define them or explain just what is meant—and we all know of the proverbial doctors' quarrel.

Now, if a physician speaking before a medical society or in writing for a first-class medical journal used the term "a cold" and had to give a definition he likely would find it a difficult task. Perhaps on examining the underlying facts we may arrive at some definite conclusions and perhaps be able to make a definition. It would likely be something after this fashion: A cold is the reaction of the body toward some irritant or infective matter, the amount of reaction depending on the amount of this matter and its localization in the body; the reaction may be general or local; it differs from the specific fevers by its history.

During a cold some irritant substance is in the body. This irritant may differ in different forms of cold. The inhalation of certain gases or chemicals or vegetable substances may be followed by a transient cold. Some forms are regarded as due to the inhalation of pollen, as rose cold and hay fever; other forms occur in diseases like measles, scarlet fever and the like. A common cold differs from these special forms by its history.

As to causes: "Getting chilled" or "overheated," or "getting the feet wet" are not real causes of common colds—they are regarded as simply exciting causes or of opening up the avenues for the real cause. They stand in about the same relation as the plowing of the field does to the sowing of the seed—you can plow and harrow and prepare the ground as much as you please, but no crop will follow unless you seed the prepared ground. A "cold" will not follow an exposure to cold in the physical sense unless the seeds are present—and this is why arctic explorers are free from colds. Moreover, we know from experience that we can catch a cold in the hot summer days as well as in the winter time.

This brings up the question: Where do we get the seed of a cold? As elsewhere, we get the seed from a previous crop. We get our colds from persons who have colds especially that aggravating form of cold known as catarrh.

How is it transmitted? may next be asked. Through the agency of the dust we inhale, is the answer.

A short time ago we spoke of infective matter: this infective matter is the seed, placed in the dust by persons who have colds.

Now, this is all theory, some will exclaim. Let us admit it is a theory. Now, a theory is of value if it explains phenomena and in proportion as it explains it becomes a true theory: moreover, a working theory has value in enabling us to predict.

Let me cite a few instances or examples and see how this infective dust theory, if you choose to call it so, works out.

Men who in towns are constantly afflicted with colds and catarrhs, with pains and aches in the joints, and with headaches, are often singularly free from these complaints while in the country for an extended period. It is true that mode of life has something to do with this: the exercise, the plain food, etc., all contribute to their well-being, but one factor stands out above all others—the pure atmosphere with the absence of infective dust.

It has long been noticed by those susceptible to colds that a cold often follows a ride on the railway, and it is usually ascribed to some draught—to some open window or door. In reality it is due to the highly contaminated air of the car—the aisles at times resemble in filthiness the habitation of some domestic animal.

Since interurban cars have come into use a new phase of this question of railway colds, so to speak, has developed. The open car furnishes an abundance of fresh air while the closed one in the winter season may not differ greatly from the steam road cars in regard to the polluted atmosphere. Susceptible persons have often been puzzled how they catch cold on a closed car on a comparatively warm day and do not catch cold in an open car on a cold, raw day, say in the fall before the open cars are taken off. The one is all draught and the other has practically no draught. The discerning individual will readily see that the air of one is pure, while that of the other is not.

Individual susceptibility of course varies greatly. Some persons seem almost immune, or succumb only after an unusual exposure; the attack itself may be slight or severe.

Some men habitually employed in situations with infected dust seem almost immune. Railroad passenger conductors are usually the picture of health. This is easily explained: it is simply the action of the law of the survival of the fittest. The managers of our railways are careful whom they employ and still more careful whom they advance. A conductor reaches his position by successive advancements, or the man best suited to the position gets the place. A consumptive conductor or one with a red, inflamed nose or watery eyes, or subject to chronic hoarseness, is almost an anomaly on our large railways—if such a man did not resign of his own accord because of his inability to adapt himself to the conditions, it certainly would not take long until the management "fired" him.

This weeding out process plays a most important part throughout life. The most susceptible perish early; long lived individuals are found mainly in thinly settled regions. It is often said of the backwood mountaineers of some of our Southern States that they do not die; they simply wither up of old age.

It is not to be understood that everybody is susceptible to dust infections; as in all other diseases, there are always some persons who escape, or who are attacked so slightly at the time of the prevalence of an epidemic that we can scarcely consider them affected. On the other hand, some individuals complain severely after each exposure, after a railway journey, or after the prevalence of a windstorm or after attending a crowded hall with poor ventilation, in fact any place where the atmosphere is contaminated. The cold may show itself the same day or not for several weeks, as in the case of pleurisy. With many persons about who are infected, the chance of becoming infected is of course greater.

The habit of sweeping and dusting a closed room while persons are compelled to be in it is a most reprehensible one—the dust stirred into the air irritates the respiratory mucous membranes, to say the least, and the feather duster is a fruitful source of coughs and colds; it is too often brought into action to dust the seats and furniture in a room or hall just prior to the arrival of an audience.* The accumulated dust of a week or more may be suspended in the air ready for inhalation, and we think little about it, although a thick layer of dust on a chair we are about to occupy strongly attracts our attention, and yet it is infinitely worse to inhale the dust than it is to get it on our clothing. It is evident that this stirred up

*Note.—To my certain knowledge this very thing occurred in the room where the Academy met; dust which lay thickly on the chairs was stirred up with a feather duster half an hour before we met. The amount of coughing and sneezing at the time this paper was read was so noticeable that the newspapers called attention to it.

dust is redeposited on our respiratory mucous membranes and only too often with evil results.

I have had many persons under observation who are subject to this dust infection, and where the source of their cold could be readily traced, and who, moreover, suffered less after it was explained to them how they catch cold—and in proportion as they have been able to avoid the inhalation of an infected dust atmosphere they have found the climate of Indiana a healthy one.

City and town people are, of course, the worst sufferers, and a sedentary life with a body habitually overloaded with food and waste products is a contributing factor—such a life places the body at a disadvantage in warding off or in resisting disease. Colds, moreover, often allow the entrance and spread of other diseases. We can frequently trace a dangerous disease back to the time of a "cold."

The subject is a serious one. According to the recent report of the Indiana State Board of Health last year, a total of 7,607 persons found their death breathing dust-laden air. Indeed, if the whole truth were known the total number would be even greater. The number of persons who are simply affected, made sick, and who do not die from the attacks of cold and diseases traceable to colds, is an extremely large one.

The experience of arctic explorers in the far north has already been referred to. Although severely exposed to cold, they are free from colds, and now it should be added that the moment they return to civilization they suffer most acutely.

We might be tempted to ask: Are "colds" a product of civilization? It would seem so. Civilized countries, however, differ greatly in the prevalence of colds and catarrhs and a host of infections due to infected dust—a number of which have already been mentioned. The inhabitants of many European countries suffer but little; inhabitants of the United States suffer greatly, and in our State colds and catarrhs are almost universal. I believe it was Charles Dickens who remarked about the accurate aim of the American in spitting, and travelers from the old world are amazed at the condition of our sidewalks and floors of public halls and railway coaches.

How far do we have to go to find the cause for the so-called unhealthy condition of Indiana It would seem that if our State is unhealthy, man himself has made it so.

I might stop here, but I am inclined to think that some one will say that the term "infective dust" is rather vague. A pathologist or bacteriologist would demand something more definite. He will likely call our attention to the little bits of yellowish or greenish matter which we so frequently spit up and which is coughed up in large quantities by persons severely afflicted with inflammation of the respiratory tract. He will tell us that this matter is made up mainly of white cells from the blood which have been killed off in the struggle with this so-called infective matter, and he will mention a lot of big names that are Greek to 999 in every 1,000 persons.

Now, I have purposely refrained from making use of the term microbe. A wise sanitarian has said that as long as you speak of infective matter you come in for very little criticism, but the moment you mention microbes the newspapers jump on you and ridicule the idea that dust is dangerous or that it is dangerous to spit whenever and wherever we choose. The newspapers are great factors in disseminating useful knowledge, and if they will not speak ill of infected dust but will antagonize any statements based on microbes, it seems to me that we would best stop and let the bacteriologist continue the discussion.

A Method of Determining the Absolute Dilation of Mercury.

By Arthur L. Foley.

(By title.)

What Bacteriology Has Done for Sanitary Science.

By Severance Burrage.

Sanitation, the science of disease prevention, has been practiced variously and in varying degrees from time immemorial; but it was of little importance and remained in comparative obscurity and impotence until the birth of bacteriology in the latter part of the nineteenth century. The establishment of this new science by Robert Koch in 1881 marked a most important epoch in the history and practice of preventive medicine. Sanitation at once became transformed from a puny, uncertain, "hit or miss" science into one of the most important factors in modern civilization. The causes of many diseases being positively known, the possible causes of many others being inferred, the sanitarian had the most important key in his possession for the prevention of those diseases. In other words, he became much better fitted to practice his profession. Furthermore, each separate branch of sanitary science has received from the bacteriologist definite knowledge which has made it far more exact and practical, and correspondingly more efficient.

Take for example the subject of disinfection. This science in various forms has been practiced for many centuries. Ovid states with regard to it, that sulphur was used by the shepherd of his time for purifying wool from contagious diseases. At the time of Hippocrates sulphur was used as a preventive against plague. While good results were often obtained by pursuing these and other such practices, the exact reasons for the results were not understood. Today, however, the bacteriologists have shown by exhaustive and conclusive experiments that certain specific disease germs are destroyed by certain disinfectants under certain conditions. They have also shown that the spores of certain bacteria will not be killed by the same processes which destroy the vegetative forms of the same species. Thus they are able to tell us that some of the ancient practices were entirely useless, others were quite unnecessary, while still others were very efficient.

More than 400 years B. C., Hippocrates advised that all polluted water should be boiled and filtered before being used for drinking purposes. Today we know what constitutes dangerous pollution, and the bacteriologist tells us precisely what the processes of boiling and filtering do to this pollution in the water. He can very readily detect a polluted water by analysis, and aside from showing the presence of pathogenic bacteria, he can show the presence as well of those bacteria which come only from sewage. Along this same line bacteriology is indispensable to the sanitary scientist in testing the efficiency of water filters, both large and small. In the matter of sewage disposal, he has shown the effects of the soil bacteria in destroying the infectious material in filth which is spread over the surface of the ground, or upon filter beds; and again, in the putrefying action in the septic tank, he has shown an efficient purification.

It is now known through the researches of the bacteriologists that the typhoid bacillus and other pathogenic bacteria can and do resist the freezing temperatures for many weeks. Hence the freezing of water does not necessarily purify it of all of its disease-producing agencies.

It has been shown that the changes which occur in milk are wholly due to bacteria. Hence the bacteriologist has pointed out the necessity of bacteriological cleanliness in and about the dairies. Oftentimes disease germs may be found in the milk, pointing to the need of inspection of dairies and the careful supervision of our public milk supplies.

Putrefactive changes in meat and other foods, due to bacterial growths, result oftentimes in the production of ptomaines. Therefore care should be exercised in the sale of meat and other foods. Fruits and vegetables are known to harbor germs on their outer skins, and, when handled by infected persons, may result in spreading disease. Undoubtedly this is the source of many so-called sporadic cases of disease. Experiments have shown that the typhoid bacillus may remain alive in the stomach of the living oyster for several weeks. Serious epidemics of typhoid fever have been spread through the agency of oysters which were fattened in sewage polluted waters.

The masterly researches of Pasteur, Tyndall and Lister resulted in the protection of wounds from infection, and made it possible to undertake previously impossible surgical operations. They simply proved the presence of germs in the dust of the air, and showed the necessity of keeping this germ-bearing dust away from the vicinity of the operating table.

Bacteriology assists materially in the prompt diagnosis of many of the contagious diseases, such as diphtheria and tuberculosis, making early isolation and quarantine possible.

The old idea that consumption was a constitutional disease has been exploded. Dr. Koch, in 1882, declared this to be a germ disease. Experience has shown that there are as many as two million bacteria in a single expectoration. It is undoubtedly through the medium of the sputum that most of the consumption is spread, and these facts point out the necessity and importance of precautionary measures.

There have been many recent discoveries made by bacteriologists showing that certain diseases are due, not to bacteria, but to animal parasites, protozoa. There are many cases in which these animal parasites appear to be carried through the agency of insects. An example of this is the carrying of malaria germs by the mosquito. This has led the sanitarian to make important crusades against the mosquito, destroying their breeding places, and in this way checking a spread of the disease.

Experiments with the common house fly have shown that these insects carry infected material on their legs and probosces. Hence the need of disinfecting all germ-bearing material which may come within the reach of the fly. Also the destruction of their breeding places so as to reduce as far as possible the numbers of these insects.

The discovery of antitoxic serums, the direct or indirect products of bacterial action and growth, have been a great advance in bacteriology and medicine, not only for the curing of disease, but, more important, for protection against disease as well. The use of protective serums is now in its infancy, and I look forward to the time when the bacteriologist shall have discovered or manufactured, with the assistance of the bacteria, a serum or mixture of serums with which we may be inoculated, and thereby protected against all diseases, perhaps throughout life. That would indeed be a great factor in preventive medicine.

These facts show briefly the great and incalculable assistance given to sanitary science by one of the youngest of the many "ologies." That the sanitary scientists have taken advantage of this aid is evidenced by the attention which they everywhere receive, and the importance which is now attached to their dictum and doings. They can now compel legislation to enforce safeguards against disease, and it is a benighted community that does not respect these measures. These measures protect the state, municipality and the home; they affect schoolhouses, public buildings, foods, and street cleaning; in fact, there is hardly a phase of social or industrial life that is not reached by the arm of sanitary precautions. Further evidence is shown by a study of vital statistics during the past fifty years, wherein may be seen a marked reduction in the deaths from all preventable diseases. All of this has come about, and much more is yet to come, I believe, through this renaissance period in the science of sanitation, marked by the establishment of the germ theory of disease and the birth of bacteriology. From that time the bacteriologist and the sanitarian have marched hand in hand in their grand fight against disease and death.

On the Use of Nickel in the Core of the Marconi Magnetic Coherer.

By Arthur L. Foley.

The magnetic detector of electric waves, described and used by Marconi,* consisted of a "core or rod of thin iron wires on which were wound one or two layers of thin insulated copper wire. Over this winding insulating material was placed, and over this again, another longer winding of thin copper wire contained in a narrow bobbin." One terminal of the inside winding was connected to earth, the other to an elevated conductor. The ends of the outside winding were connected to a telephone. A horseshoe magnet, suitably placed, was moved by clockwork so as to cause a continuous change or successive reversals or the magnetism of the iron core. Electric oscillations of suitable period appeared to reduce the effects of magnetic hysteresis, hence the magnetism of the iron core increased or decreased suddenly with each spark of the transmitter, inducing a current in the outer winding connected to the telephone. Marconi had (June, 1902) used this apparatus for some months in the reception of wireless telegraph messages over a distance of 152 miles, and with less power employed at the transmitting station than would have been required had he used a reliable coherer instead of the magnetic detector.

Marconi noticed that "the signals in the telephone are weakest when the poles of the rotating magnet have just passed the core and are increasing their distance from it, whilst they are strongest when the magnet poles are approaching the core." To obtain more definite results on this point I arranged to use a ballistic galvanometer instead of a telephone, and to take readings for various determined positions of the magnet and core.

The core, which was 5 cm. long, consisted of twenty-six pieces of annealed piano wire, .063 cm. in diameter. Over this was wound a single layer of two hundred turns of silk insulated copper wire No. 36, giving a total diameter of core and coil of approximately .4 cm. One end of the coil was connected to a vertical wire 200 cm. long; the other end was put to earth.

*Note on a Magnetic Detector of Electric Waves, by G. Marconi, Proceedings of the Royal Society, Vol. LXX, No. 463, July 29, 1902.

The outer or secondary coil, consisting of one thousand turns of No. 30 wire, was wound on a wooden spool of such dimensions that the coil itself was 1.7 cm. long and .6 cm. in diameter (inside). The terminals of this coil were connected to a Rowland D'Arsonval galvanometer through a key arranged to short-circuit the galvanometer after each throw of the needle. This brought the needle to rest very quickly, and permitted the position of the magnet to be changed without affecting the galvanometer.

The induction coil (one inch) of the transmitter was operated by a storage cell and was adjusted to give a 2 mm. spark between two small brass spheres, one connected to a vertical wire 200 cm. long, the other to earth. The distance between the transmitter and receiver was varied from two meters to twenty meters. The results given in this paper were obtained when the distance was made five meters. No effort was made to "tune" the circuits.

The magnet was made from a bar of steel 1.6 cm. square and 3.7 cm. long, bent so as to make a horseshoe magnet about 16 cm. long with parallel legs 4.8 cm. apart. The primary and secondary coils were fastened in place on a board grooved and graduated so that the magnet could be slid back and forth in the same horizontal plane with, and in a direction at right angles to, the iron core, and placed at any desired distance from it. The graduations extended from 0 to 12 cm., zero distance corresponding to contact between the ends of the magnet and the core.

To get a reading the galvanometer was first short-circuited and the magnet placed in position. The short circuit was then broken, the transmitter operated as long as the deflection of the needle was increasing, and the throw observed.

Table 1 gives the throws of the galvanometer for the given distances between the magnet and core.

A. When the magnet is placed 10 cm. from the core and moved one space nearer each successive reading.

B. When the magnet is placed in contact with the core and is moved one space farther from it each reading.

C. When the magnet is removed some distance after each reading and the transmitter operated before the magnet is placed in position for another reading.

D. When the magnet is turned over (the field reversed) between readings.

TABLE I.

Distance.	A	B	C	D
0.0 cm	2.0 cm.	....	....	7.6 cm.
0.5 "	2.3 "	0.8 cm.	4.0 cm.	7.9 "
1.0 "	2.0 "	0 9 "	3.2 "	6 1 "
2.0 "	1.3 "	1.0 "	2.0 "	3.5 "
3.0 "	0 4 "	0 9 "	1.2 "	1 6 "
4.0 "	0.3 "	1.0 "	1.0 "	1.1 "
5.0 "	0.2 "	0 6 "	0.5 "	0.8 "
6.0 "	0.1 "	0 4 "	0 3 "	0.6 "
7.0 "	0 0 "	0.3 "	0 2 "	0.4 "
8.0 "	0 0 "	0 2 "	0 2 "	0.3 "
9 0 "	0.0 "	0.2 "	0.1 "	0.25 "
10.0 "	0.0 "	0.1 "	0.1 "	0.2 "

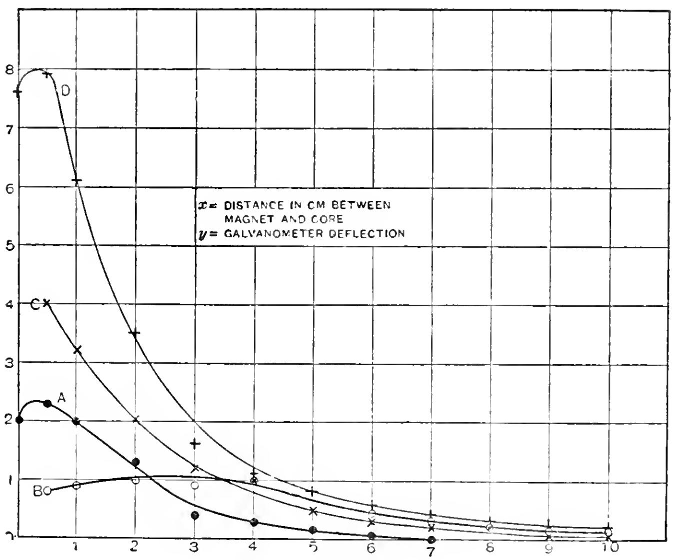


Fig. 1.

The data of Table I are plotted in Fig. 1. A comparison of curves A and B shows that the sensitiveness of the magnetic detector depends upon both the distance and direction of motion of the moving magnet. When the magnet is near the core the detector is more sensitive when the magnet is approaching, but when some distance from the core the detector is more sensitive when the magnet is receding. Both curves indicate a maximum of sensitiveness at a distance from the core, the distance being less when the magnet is approaching than when receding.

Removing the magnet and operating the transmitter tended to demagnetize the core. Then when the magnet was placed in position and the transmitter again operated, as in Curve C, there was a relatively greater change in the magnetism of the core than was obtained under the conditions of Curves A and B. Hence the deflections in column C are greater than those in A or B. It is evident that the relative change in the magnetization of the core would be greater still where the magnetic field is reversed after each reading, as in Curve D.

Since nickel is more susceptible than iron in weak magnetic fields, and less susceptible in strong fields, it occurred to the writer that a more uniform sensibility for varying distances between the moving magnet and core might be obtained by making the core of nickel.

Four cores were made, each one being 5 cm. long, approximately .4 cm. in diameter, and being wound with two hundred turns of No. 36 copper wire.

Core 1 consisted of 26 pieces of piano wire, .063 cm. in diameter.

Core 2 of 10 pieces of piano wire and 10 pieces of nickel wire, .082 cm. in diameter.

Core 3 of 2 pieces of piano wire and 13 pieces of nickel wire.

Core 4 of 14 pieces of nickel wire.

Table II gives the deflections at various distances between the magnet and each of the four cores, the magnet being moved one space at a time and having its poles reversed after each reading. The data for three of the cores is plotted in Fig. 2.

TABLE II.

Distance.	Core 1. Fe.	Core 2. Fe & Ni.	Core 3. Fe & Ni.	Core 4. Ni.
0.0 cm	7.6 cm.	10.2 cm.	7 5 cm.	6.1 cm.
0.5 "	7.9 "	9.5 "	7.5 "	9.0 "
1 0 "	6 1 "	8.0 "	7 2 "	8.9 "
2.0 "	3.5 "	4 6 "	4.0 "	4 7 "
3.0 "	1 6 "	3.0 "	2.0 "	1 35 "
4 0 "	1 1 "	1.7 "	1.0 "	0 7 "
6.0 "	0 6 "	0.5 "	0.4 "	0 35 "
8 0 "	0 3 "	0 2 "	0 2 "	0 2 "
10.0 "	0.2 "	0 1 "	0 1 "	0.1 "

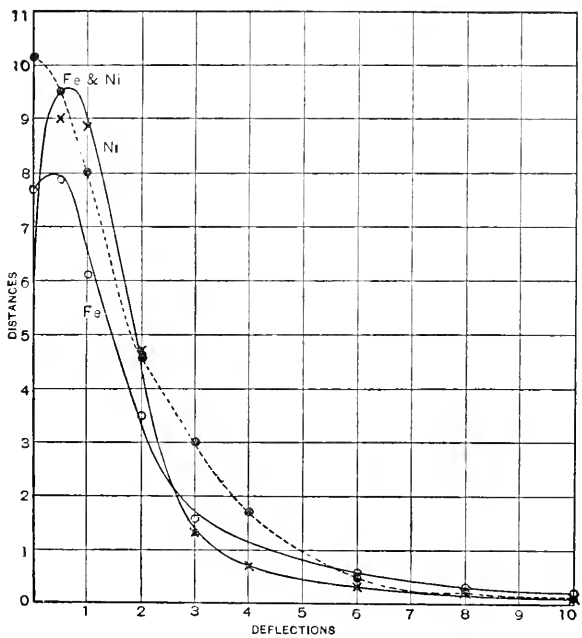


Fig. 2.

The sensitiveness of the detector with a nickel core was not very different from the sensitiveness when an iron core was used. Contrary to expectations, however, the sensitiveness with the nickel core appeared to be the greater in strong fields and with the iron core in weak fields. Both showed a maximum of sensitiveness at a short distance from the magnet, the maximum for nickel being the farther removed. The nickel core proved to be more sensitive than the iron core for distances up to 2.5 cm.

When the detector was worked with the mixed core of iron and nickel wires the deflections of the galvanometer increased as the magnet approached the core, even up to the point of contact. The curve (Fe & Ni, Fig. 2) lies above the Fe curve at all points and above the Ni curve at most points, showing that a mixed core consisting of annealed piano wire and hard-drawn nickel wire produced a more sensitive detector than was obtained by using a core of piano wire only.

The detector gave small deflections of the galvanometer when I used an antimony core; also when I used a core of iron filings contained in a thin-walled glass tube. In both cases deflections were obtained only when the magnet was near the core. A core of bismuth gave no deflection.

It is probable that the form of the curve of Figs. 1 and 2 depends upon other points than those considered in this paper, as for instance, the frequency and intensity of the oscillations sent out by the transmitter and the annealing of the steel wires used in the core.

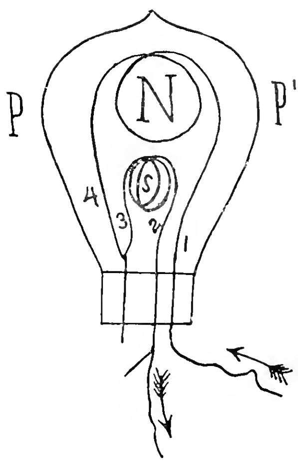
Since electric oscillations appear to "have the power of reducing the effects of magnetic hysteresis," it has occurred to the writer to test their effect upon the hysteresis loss of transformers, armatures, etc. Some experimental work on this subject has been done, but I am not yet ready to announce results.

Physics Laboratory of Indiana University, April, 1903.

THE EDISON EFFECT IN A "HYLO" LAMP.

BY ARTHUR L. FOLEY.

The figure is a diagram of a "Hylo" turn-down incandescent lamp in which N and s represent (when the current is in the direction indicated) the north and south ends respectively of the 16 c.p. filament (F) and the 1 c.p. filament (f), the former consisting of two and the latter of three turns. Whatever be the direction of the current the filament coils are of opposite polarity, the potential difference between legs 3 and 4 is small, and that between legs 1 and 4 a maximum. When f is burning F is in series with it, but the current is insufficient to render the latter luminous. When F is burning f is short-circuited, but has the same potential as leg 4 of F.



Let P and P′ be points on the globe at the ends of a diameter through the plane of the filaments, and NS and sn be points on the globe where the axes of the filaments F and f meet it. At P there is a deposit from one to two cm. wide, while the globe is perfectly clear on either side. At P′ the conditions are exactly reversed, the central region being dark with clear glass on each side. At n, also at s, there is a small circular deposit about half the area of a turn of f. This deposit is surrounded by another in the form of a ring about 1 cm. wide and 2 cm. in diameter, the ring being open next the base of the lamp. Between the central deposit and the ring the glass is clear. There is no deposit within 2 cm. of the base of the lamp, and very little on the crown.

The theory of molecular shadows and the Edison Effect, so thoroughly worked out by Fleming* and others, explains the general character of the deposit, but seems to fail to explain the definiteness of it. In general the deposit is of uniform density and quite dark, while the clear places are perfectly clear, the line of separation being as definite as if the deposit had been laid on with a brush.

The weak magnetic field of the small filament was sufficient to concentrate the deposit at the ends of its axes, leaving certain regions perfectly clear. It seems that it should be possible to keep clear any desired part of the wall of a vacuum tube.

The peculiarity of the deposit above described was noticed but a few weeks since, hence the incompleteness of this investigation. An attempt to age a number of similar lamps by running at an excessive voltage resulted in a practically uniform deposit.

Molecular Shadows in Incandescent Lamps. Philosophical Magazine, Vol. 20, 1885.
A Further Examination of the Edison Effect in Glow Lamps. Philosophical Magazine, Vol. 42, 1896.

On the Use of Manganese Dioxide in the Generation of Oxygen from Potassium Chlorate.

By R. R. Ramsey.

The statement is sometimes made in texts on chemistry that the part played by manganese dioxide in the generation of oxygen from potassium chlorate is one of conduction only, that any other oxide, or ordinary sand, which would come in intimate contact with the potassium chlorate, would do as well. Since the black oxide, although not expensive, is more expensive than sand, the use of sand would to some extent diminish the cost of oxygen when generated from potassium chlorate.

To test this point Prof. Foley and the writer, at the suggestion of the former, made the experiments as described below.

The potassium chlorate, mixed with a definite proportion of black oxide or other material, was placed in an ordinary sheet-iron generating retort which was heated with a large Bunsen burner. The oxygen was led through a lead pipe coiled inside a calorimeter. From the calorimeter it passed through an experimental gas meter reading to 10 c.c. By this means the total volume of oxygen generated and the generating rate could be determined directly, and from the rise of temperature of the contents of the calorimeter the approximate temperature of the gas could be determined. Experiments were made with manganese dioxide, powdered silica, sand, and Venetian red.* In no case except with the manganese dioxide, did the amount of gas given off compare with that computed from the chemical formula. In fact the rate of generating, when using substances other than manganese dioxide, was so slow that calorimetric determinations could not be made. The following table will give a general view of the results:

*Equal parts iron oxide and calcium sulphate.

	Substance.	$KClo_3$	Generating Time.	Volume.		t	
				Observed.	Calculated.		
1	50 gms. MnO_2	250 gms.	8 min.	73 Liters.	74.4	22°	
2	200 " "	1000 "	18.5 "	257 "	296.5	18	Gas lost.
3	186 " Silica	930 "	24 "	56 "	273	19	Exploded.
4	500 " Sand	500 "	20 "	16.7 "	147.5	21	
5	120 " MnO_2	600 "	11 "	137.5 "	177.5	21	Gas lost.
6	65 Venetian red	325 "	25 "	21.9 "	97.6	25	

The first column gives the amount and name of substance used; 2d, amount of potassium chlorate; 3d, duration of the experiment in minutes; 4th, the volume of gas liberated as shown by the gas meter; 5th, volume of gas as calculated from mass of potassium chlorate and temperature and pressure of gas in the meter; 6th, temperature of gas in meter.

In the third experiment with powdered silica heat was applied steadily for twenty-four minutes until suddenly the delivery tube connecting the retort to the calorimeter was blown off and a stream of blazing molten silica was shot a distance of fifteen feet across the room. Upon cleaning the retort it was found that the mass of chlorate and silica had been in a foaming semi-fluid condition filling the entire retort and forcing itself through the delivery tube. In the case of sand (from the shore of Lake Michigan) heat was applied for twenty minutes with a very small amount of oxygen given off. In every case with manganese dioxide the gas had been entirely driven off in a shorter time with a flame greatly reduced from the normal. In fact a considerable amount of gas bubbled through the meter owing to the rapid rate of generation. With Venetian red a very small amount of oxygen was obtained, although the temperature was raised to the point where the entire mass was fused. Subsequent experiments performed in a test tube showed the temperature of fusion to exceed 360° C., while the temperature at which oxygen is liberated from the manganese dioxide mixture as shown by Mahin [Proc. Ind. Acad. Sci., P. 170, 1902] does not exceed 180° C. Calorimetric computations and direct observation in test tubes show the temperature of the gas to be from 65° to 100° C. It would seem that there is a lowering of temperature at liberation analagous to the fall of temperature when water vapor is driven from a salt solution.

In conclusion, it seems that manganese dioxide serves for more than a distributer of heat, that it has a catalytic effect upon the potassium chlorate, permitting the oxygen to be liberated at a much lower temperature than when potassium chlorate is used alone. Powdered silica, sand, and Venetian red do not produce this effect, at least not to the same extent, at low temperatures, as black oxide of manganese.

Double Salts in Solution.

By P. N. Evans.

In a paper presented to this Academy four years ago, the author called attention to numerous apparent exceptions to the rule that an electrolyte is less soluble in a solution of another electrolyte with an ion in common with the first than in water alone. The evidence presented at that time was that many saturated solutions fail to give precipitates on addition of second electrolytes having ions in common with those already in the solutions.

Since that time some of the cases then noted have been further investigated, and it has been proved, as then suspected, that in these cases the electrolyte is more instead of less soluble in a solution of a second electrolyte with a common ion than in water alone.

The substances chosen were lead chloride and nitrate, and barium chloride and nitrate. The method of investigation was the determination of the solubility at zero centigrade of one compound in solutions of the other of varying concentrations up to saturation, one hundred cubic centimeters of the solution being used in each case for analysis.

Lead chloride was estimated by determining chlorine in the solution volumetrically, beginning with pure water and ending with a saturated solution of lead nitrate, after saturating with lead chloride. It was found that the solubility of the chloride increased with the concentration of the nitrate, the curve being a straight line within the limits of experimental error. The solubility of lead chloride in water was found to be 0.5426 grams in one hundred cubic centimeters of the solution; in saturated lead nitrate solution, 1.83 grams.

The solubility of lead nitrate in solutions of lead chloride was not determined, on account of the very limited solubility of the latter.

Barium chloride was estimated by determining chlorine in the solution. It was found in this case also that the solubility of the chloride increased with the concentration of the nitrate, the curve again being a straight line. The solubility of barium chloride in water was found to be 33.89 grams in one hundred cubic centimeters of the solution; in saturated barium nitrate solution, 37.42 grams.

Barium nitrate was estimated by determining barium in the pure water solution, barium and chlorine in the solutions containing chloride, and considering the excess of barium over chlorine to be present as nitrate. Again the curve was a straight line, showing an increasing solubility of nitrate with higher concentrations of chloride. The solubility of barium chloride (anhydrous) in water was found to be 5.11 grams in one hundred cubic centimeters of the solution; in saturated barium chloride solution, 9.38 grams.

These results all agree with the assumption that double salts are formed when these salts are mixed in solution, as lead chloride-nitrate and barium chloride-nitrate.

A single instance of this kind has been noticed by other observers, potassium nitrate and lead nitrate by LeBlanc and Noyes. In this instance it is interesting to note that the common ion is the anion, while in the new cases here presented it is the kathion.

These exceptions to the general rule are apparently not uncommon and deserve more consideration in the text-books on physical chemistry, where they are rarely mentioned at all.

In conclusion, the author desires to express his appreciation of the careful experimental work performed by Mr. R. W. Duncan, B.S., at that time a student in Purdue University.

Lafayette, Indiana, December, 1903.

Ionic Friction.

By P. N. Evans.

The velocity of a moving body is proportional to the impelling force and inversely proportional to the resistance offered by the surroundings. In the case of dissolved particles moving through a solution the resistance is of the nature of friction.

The movement of ions through solutions may be observed in the diffusion of dissolved electrolytes from positions of higher to those of lower concentrations, and also in the migrations of the ions during the electrolysis of solutions. The impelling force in the first case is the osmotic pressure; in the second, electric tension. The resistance in both cases is the friction against the other particles—mostly those of the solvent. That this resistance or friction is enormous is seen in the force necessary to overcome it—three hundred and two million kilograms will move a gram of hydrogen ions in water with a velocity of one centimeter per second.

It has been observed that the addition of a non-electrolyte to a solution of an electrolyte increases the resistance to the passage of the electric current. This might be due to either or both of two causes—the number of ions or carriers of the current might be diminished by the non-electrolyte's causing a partial deionization of the electrolyte, or the resistance of the solution to the migration of the ions—the ionic friction—might be increased. The second of these two hypotheses has been shown to be the correct one when only moderate quantities of the non-electrolyte are added, though the first also becomes appreciable with larger quantities.

The lines of reasoning and experiment leading to this conclusion have been of two kinds. First, the degree of ionization of the electrolyte in pure water and in water containing the non-electrolyte was determined in the usual way, based on the conductivity at some definite concentration compared with that at infinite dilution and found to be the same when moderate quantities of the non-electrolyte were present. Second, the increase in the resistance to the passage of the electric current and to the movement of ions by diffusion due to osmotic pressure has been found to be approximately proportional to the increase in internal friction measured by the rate of flow through a capillary, indicating friction as the immediate cause.

The purpose of the investigation here reported was to attack the problem by a method not hitherto used apparently in this connection. The freezing point method was employed, and the solutions examined were those of hydrochloric acid and sucrose. The freezing points determined were those of water, of twice-normal and twentieth-normal water solutions of hydrochloric acid, of water solutions of sucrose containing 1, 5, 10, 25 and 35 grams in 100 cubic centimeters, and of water solutions of hydrochloric acid and sucrose of corresponding concentrations. The ordinary Beckmann apparatus was used.

It was found that the lowerings of the freezing point produced by known weights of acid and sugar mixed in a given quantity of water was equal to the sum of the lowerings produced by the same weights of acid and sugar each dissolved separately in the same quantity of water. This result harmonizes with those found by the other methods mentioned above in showing no effect of the sugar on the degree of ionization of the acid, and leading to the conclusion that the increase in resistance to the current observed in corresponding solutions of hydrochloric acid on addition of sugar, was due wholly to an increase in the friction between the ions and the solutions.

The author desires to express his appreciation of the experimental work done by Mr. H. E. Bachtenkircher, B.S., at that time a student in Purdue University.

Lafayette, Indiana, December, 1903.

A New Problem in Hydrodynamics with Extraneous Forces Acting.

By Edward Lee Hancock.

The solution of most problems in hydrodynamics depends upon the proper combination of the equations of motion of the fluid interior of a given closed surface with the differential equation of the surface, or with the equations expressing the boundary conditions.

Lord Kelvin has shown that the differential equation of the surface for both compressible and incompressible fluids has the following form:

$$u.F'(x) + v.F'(y) + w.F'(z) + F'(t) = 0$$

where (t) is a variable parameter of the equation

$$F(x, y, z, t) = 0.$$

In the treatment of problems of the motion of incompressible fluids in three dimensions, where the surface under discussion is spherical or nearly so, the usual particular solutions of Laplace's equation ($\nabla^2 \phi = 0$), such as, zonal, tesseral and spherical harmonics, are adequate, since in these cases the velocity-potential satisfies Laplace's equation. The solution used in any particular case depends upon the symmetry of the boundary conditions. Where the surface differs much from the spherical form as in ellipsoids, ellipsoidal harmonics are used. Problems of this kind have been extensively investigated.

In discussing the anchor ring Mr. W. M. Hicks[1] has derived modified forms of the zonal, tesseral and spherical harmonics by means of which the potential both outside and inside the ring may be completely investigated. The same problem has been solved by Mr. F. W. Dyson[2] by using elliptic integrals.

The problem is much simplified when the motion takes place in a single plane, in which case, if the boundary consists of a straight line, two parallel straight lines, or is rectangular, the velocity-potential may be expressed as a Fourier's series or a Fourier's integral.

1. Phil. Trans. 1893.
2. Phil. Trans. 1881, Part III.

In other cases there is no direct method of procedure. The inverse process of finding what boundary conditions will give known solutions of Laplace's equation is used, with the hope of finding the desired solution. The method of images is also applicable to some cases, more especially perhaps in the case of rotational motion.

For the irrotational motion of a perfect liquid there always exists a velocity-potential which satisfies the equation

$$\nabla^2 \phi = 0.$$

The potential ϕ and the rectangular velocities u, v and w may be found from the given conditions, for all points of the interior. The potential being always least at the boundary the lines of flow and equipotential lines begin and end there. This is true whether the motion is "steady" or not and true, therefore, when the extraneous force is gravity.

Much work has been done on the motion of many of the regular solids immersed in a liquid, when acted upon by a system of impulsive forces and also by constant forces. The motions of the liquid in the neighborhood of such solids has also been discussed. Both tidal waves and waves due to local causes have been investigated and their properties discussed to some extent. The related problem of the effect of high land masses upon neighboring bodies of water has been worked out by Professor R. S. Woodward and others.

Perhaps the most familiar problem of the effect of an extraneous force upon a body of liquid, is the "Torricelli Theorem" on the efflux of a liquid from an aperture in the side or bottom of the containing vessel. There the vessel is kept filled to a constant level the motion becomes steady making $\frac{du}{dt}=0$, $\frac{dv}{dt}=0$ and $\frac{dw}{dt}=0$; and giving the well-known result $q^2 = 2\,gz$, where q is the velocity. In case the liquid rotates under the influence of gravity angular velocity is introduced, giving $\frac{dv}{dx}-\frac{du}{dy}=2w$. Showing that a velocity potential does not exist, and that such motion could not take place in a perfect liquid.

Cases of motion where no extraneous forces are acting have been completely worked out by methods of conjugate functions and the theory of images. iIn these cases the lines of flow and equipotential lines are orthogonal systems of curves, and methods of plotting such are easily devised. But when extraneous forces are acting these lines no longer belong to orthogonal systems of curves and no method has yet been devised by means of which the lines could be drawn under specified conditions.

It was hoped that some graphical method applicable to all cases might be found in connection with the present work, but thus far none has been discovered that is at all general. I have found the equipotential lines and lines of flow for a rectangular area where a constant extraneous force is acting.

Taking the liquid as incompressible since the external forces is constant the motion is steady and the velocity potential may be made to satisfy the equation

$$\frac{\delta^2\phi}{dx^2} + \frac{\delta^2\phi}{dy^2} = 0$$

$$\text{and} \frac{\delta\phi}{\delta x} = ku, \quad \frac{\delta\phi}{\delta z} = kw.$$

A constant must be added to one of these velocities to express the effect of the constant force. This is more clearly seen perhaps in the case of vertical motions due to the force of gravity. In this case the constant to be added to w is of course g and since this is a constant Laplace's equation is still satisfied. The lines of flow and equipotential lines are no longer orthogonal, but are, as we shall presently see, inclined at different angles, being tangent at some points of the interior.

If the area be taken in the sphere of attraction of the earth and near enough so that the attraction may be taken as constant we shall have

$$u = k\frac{\delta\phi}{dx}$$

$$v = k\frac{\delta\phi}{dz} + k\rho g.$$

where ϕ satisfies Laplace's equation.

Professor C. S. Slichter[1] has shown that the motions in an area A B C D, Fig. 1, filled with sand and having water flowing through it, entering along A B and flowing out along A D—the sides B C and C D being impervious—may be fully discussed by replacing the sand and water by a perfect liquid having a velocity potential, and that the velocity potential in this case would be identical with the pressure function. This being true, it is possible to find the pressure at any point in the interior as well as the component velocities at these points, just as soon as the

1. 19th Annual Report, U. S. Geological Survey, Part II.

boundary conditions are known. Accordingly in what follows the velocity potential will be replaced by the pressure function.

If the section be horizontal, the problem may be treated in the usual way, but in case the section is vertical the extraneous force, gravity, gives a system of curves which are not orthogonal.

Let D C = a and A D = b, and suppose the head of water along A B zero. The boundary conditions then to be satisfied are:

$$P = 0 \text{ when } x = 0$$
$$P = 0 \text{ when } x = a$$
$$P = h \text{ when } z = b$$
$$w = 0 \text{ when } z = 0$$

And since the area is a rectangle P, u and w are expressed as Fourier's series:

$$P = \frac{4g\rho a}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\sinh \frac{n\pi(b-z)}{2a}}{n^2 \cosh \frac{n\pi b}{2a}} \cdot \sin \frac{n\pi x}{2a}$$

This differentiated with respect to x and z for u and w gives:

$$u = \frac{4g\rho k}{\pi} \sum_{n=1}^{n=\infty} \frac{\sinh \frac{n\pi(b-z)}{2a}}{n \cosh \frac{n\pi b}{2a}} \cdot \cos \frac{n\pi x}{2a}$$

$$w = \frac{4g\rho k}{\pi} \sum_{n=1}^{n=\infty} \frac{\cosh \frac{n\pi(b-z)}{2a}}{n \cosh \frac{n\pi b}{2a}} \cdot \sin \frac{n\pi x}{2a} + g\rho k$$

In the above equations n represents each of the successive odd numbers, a and b being the sides of the rectangle may have any desired value. But for simplicity they were in the present case taken equal to ten, and for the same reason $g\rho k$ was taken equal to unity.

Making these changes the equations become:

$$P = \frac{80}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\sinh \frac{n\pi(10-z)}{20}}{n^2 \cosh \frac{n\pi}{2}} \cdot \sin \frac{n\pi x}{20}$$

$$u = \frac{4}{\pi} \sum_{n=1}^{n=\infty} \frac{\sinh \frac{n\pi(10-z)}{20}}{n \cosh \frac{n\pi}{2}} \cdot \cos \frac{n\pi x}{20}$$

$$w = \frac{4}{\pi} \sum_{n=1}^{n=\infty} \frac{\cosh \frac{n\pi(10-z)}{20}}{n \cosh \frac{n\pi}{2}} \cdot \sin \frac{n\pi x}{20} + 1$$

From these equations the values of P, u and w were found at each of the one hundred points given in the area. This was done by computing the series for x = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 when z = 1, and then when z = 2, 3, 4, 5, 6, 7, 8, 9, 10, i. e., by making one hundred computations of each series. The value of u and w being found for each point it was not difficult to determine the resultant in both magnitude and direction. This gave the flow at each of the points of the area. We find from Fig. 1 that there is actual motion throughout the whole area.

The motion, indeed, at some points is very slight, but there is no point in the entire area where there is no motion. This is important if we regard this as an immense area in homogeneous ore-bearing rock. It indicates that at every point of the area the water is continually moving and coming into contact with new rock surfaces, thus increasing its capacity for dissolving the mineral salts from the area. From the length and direction of the arrows it is seen that at the corner D the lines are crowded down closer together than at A. This shows that the constant force gravity has distorted the field, causing the lines of flow to be concentrated at the bottom, and showing that underground waters must take very long journeys before reaching their destination and so come in contact with a very great area of rock surface.

As before stated, the relations of the equipressure lines to the lines of flow differ from that found in horizontal planes. From Fig. 1 it is seen that the angle between the systems of curves varies from nearly a right angle to two right angles, that is, to tangency. In fact, there is in the area what may be called a line of tangency meeting the sides A D and D C. These lines of flow as before indicated taken at equal distances along A B crowd near each other down near D, showing the effect of gravity upon them. If we cause the constant force g to cease to act in the case under consideration, the lines of flow would be arcs of circles cutting A B and A D at equal distances from A. The effect of gravity then is to pull these arcs of circles out into cycloidal-like curves crowding near D C. As a matter of fact the curve drawn from $x = 5$, $z = 10$ is nearly a cycloid. Those in the upper left-hand corner being too low and long and those in the lower right-hand corner too short and high for cycloids.

The lines of pressure are hyperbola-like curves drawn for pressures, 1, 2, 3, 4, etc., all the curves beginning and ending in the boundary.

It is easy to see that we may take a similar area a b to the right of A B C D and leaving an open face similar to A D and an impervious bottom and water at zero pressure along the top. We should then have these two areas one on each side of B C with the liquid flowing in opposite directions. The liquid in each area flows directly down B C and so the motion will not be interrupted if B C be removed. That is, the method of images is applicable horizontally. If, however, a similar area to A B C D be taken just below C D we can not say that the method of images as usually applied holds true. We may regard A D in the upper area as an absorbing slit and A D in the lower area as a similar slit and the position C D between them as a mirror the corresponding parts of A D in the upper and lower slits are not found at equal distances above and below C D. They are found drawn down by gravity so that the method of images must be modified for vertical distributions. By integrating u with respect to z between the limits b and $\frac{9}{10} \cdot b$; $\frac{9}{10}$ b and $\frac{8}{10} \cdot b$, etc., the amount of flowage from each of the ten equal divisions of A D may be calculated. And in a similar way the amount of liquid going in at each of the ten equal divisions of A B is obtained by integrating w with respect to x between the limits a and $\frac{9}{10} \cdot a$; $\frac{9}{10} \cdot a$ and $\frac{8}{10} \cdot a$, etc. The equations for the flowage and the amount absorbed are then:

$$f = \int_c^d u \, dz = \frac{8ag\rho k}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\cosh \frac{n\pi(b-z)}{2a}}{n^2 \cosh \frac{n\pi b}{2a}} \cdot \cos \frac{n\pi x}{2a} \Big]_c^d$$

$$a = \int_c^d w \, dx = \frac{8ag\rho k}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\cosh \frac{n\pi(b-z)}{2a}}{n^2 \cosh \frac{n\pi b}{2a}} \cdot \cos \frac{n\pi x}{2a} \Big]_c^d \quad g\rho kx \Big]_c^d$$

where c varies from $\frac{9}{10} \cdot b$ or $\frac{9}{10} \cdot a$ down to zero, and d varies from a or b down to $\frac{1}{10} \cdot b$ or $\frac{1}{10} \cdot a$. Solving the ten equations for the ten different values of f and a, we get the following table:

No....	1	2	3	4	5	6	7	8	9	10
a	.958	.875	.800	.726	.664	.611	.566	.535	.512	.502
f	.042	.126	.216	.315	.424	.556	.716	.935	1.24	2.07

TABLE I.

It will be seen from the table by counting the divisions from A as 1, 2, 3, etc., that nearly half the water flows through the first three divisions and that there is a gradual decrease toward B. The relative value of f from the different divisions shows a very slight flowage from the first division with a rapid increase from each of the succeeding divisions until the two lower divisions at D carry off one-half of the amount absorbed. This shows in a very vivid way the pronounced effect of gravity or any constant external force upon a liquid. The amount going in along A B is of course equal to the amount flowing out along A D, since the equation of continuity must hold true.

It is interesting to note that the curve given by plotting the flowage from A D is very nearly a tractrix or antifriction curve. See Fig. 3. It would undoubtedly be an exact tractrix had the number of divisions of A D been taken small enough, i. e., if twenty or thirty equal divisions had been taken instead of ten.

In Fig. 3 the line O X corresponds to the distance A D in Fig. 1, and the y-coördinates of the curve are given by the values f taken from Table I.

Fig. 4 shows the distribution of absorption into the area A B C D along A B, the line A B of the figure corresponding to the line A B of the area. The y-coördinates of the curve being taken from Table I as the different values of a.

Figs. 3 and 4 then show the distribution of absorption and flowage along A B and A D.

Extending this method by taking A B one hundred and keeping A D ten, we get approximately an artesian well area. The values of f and a for this case are given below:

No....	1	2	3	4	5	6	7	8	9	10
a	5.51	1.44	.139	.044	.028	....	....	....	....	.005
f	.040	.162	.210	.348	.446	.616	.762	.981	1.32	2.53

TABLE II.

It will be seen that the amount flowing in at the first division of A B is about two-thirds the total amount flowing into the entire area, and that this supplies the flowage for the first nine divisions of A D while the tenth division of A D gives out the water from $\frac{9}{10}$ the distance A B. If the rock in the area be soluble it is easily seen that the water flowing from this lowest division of A D will be very highly charged with mineral matter, while the remaining two-thirds that flows out above will be very slightly charged. This is more especially evident when the long sweeping paths of the water are considered compared with the very short paths of the waters of the first division of A B. We have this represented graphically in Fig. 5, where the lines of flow are drawn for the case where A B = 100 and A D = 10, or a typical artesian area. If A D be a crevice in the rock it is evident that this place will be favorable for the deposition of the mineral salt dissolved in the water since the pressure is released at this point and there is apt to exist some reagent that will cause a precipitate of the ore. This reagent may exist in the crevice itself or in the opposite wall.

In Fig 6 the curve has been plotted for the flowage from A D for the case A D = 10 and A B = 100. This does not differ much from the case where A D = 10 and A B = 10, except that the convexity downward is somewhat more pronounced, making the curve less like the tractrix.

Ten equal divisions were taken along A D and the values of y taken from Table II corresponding to different values of f.

The absorption curve for the case A D = 10 and A B = 100 is given in Fig. 7. Here the scale has been somewhat changed due to the large value of A B. The distance A B was divided into one hundred equal divisions, while the same vertical scale was used for y as in the preceding cases. The values of y were taken from Table II, being the different values of a in that table.

The rapid fall of the curve at first and then more gradual fall corresponds to the values of a found in Table II and also emphasizes the relative slowness of the motion of the water in the right-hand half of the area A B C D, Fig. 5, as compared with that of the left-hand half.

The method used in the preceding cases might be extended to areas of different dimensions, but the results would not differ much from those already stated.

If A B be taken greater than one hundred, while A D remains ten, or if we have any similar relation between the two, it will be more advantageous to use the Fourier's integral instead of the Fourier's series, since for such a difference between A B and A D the area may be considered as an infinite strip.

The results obtained are especially interesting in connection with the motion of ground water, because of their bearing on the theory of ore deposits, artesian wells and drainage flumes. The fact that sand through which water is flowing, as before indicated, can be replaced by an ideal liquid having a velocity-potential which is identical with the pressure opens a new field of investigation in hydrodynamics from which many important results will be obtained.

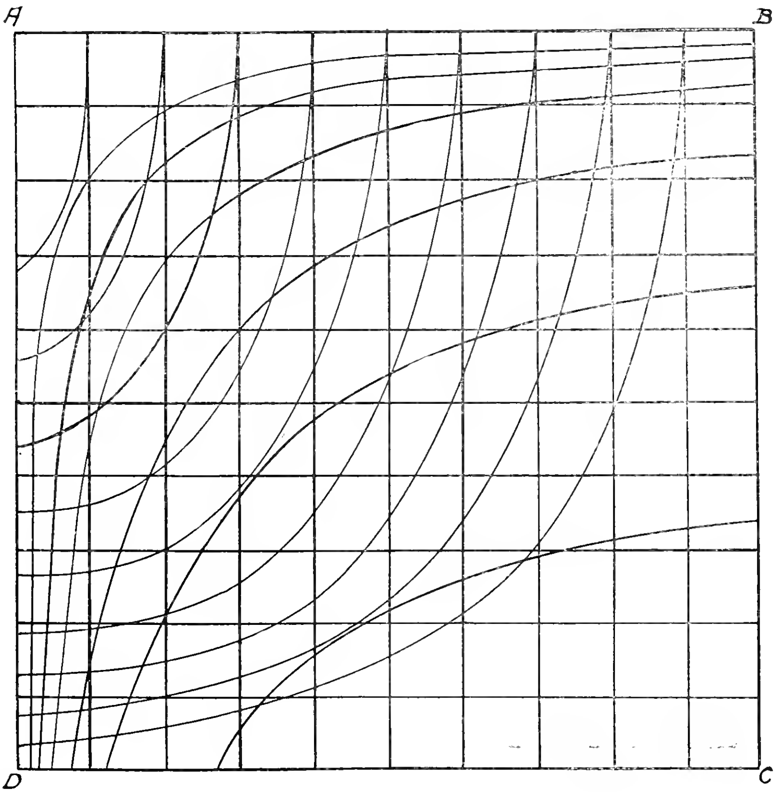


FIG.-1

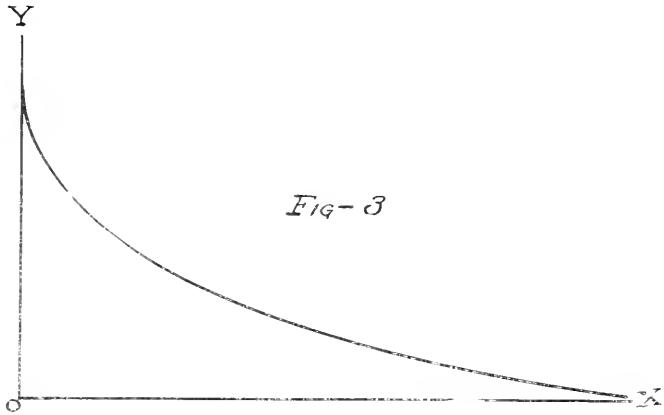


Fig-3

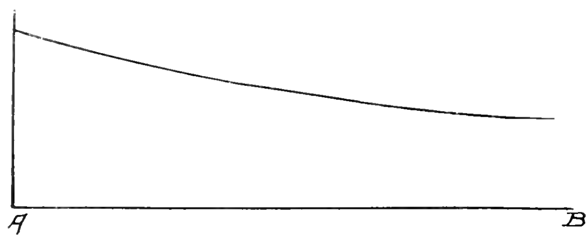


Fig.—4

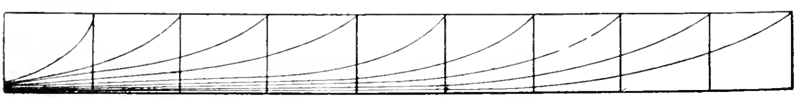


Fig.—5

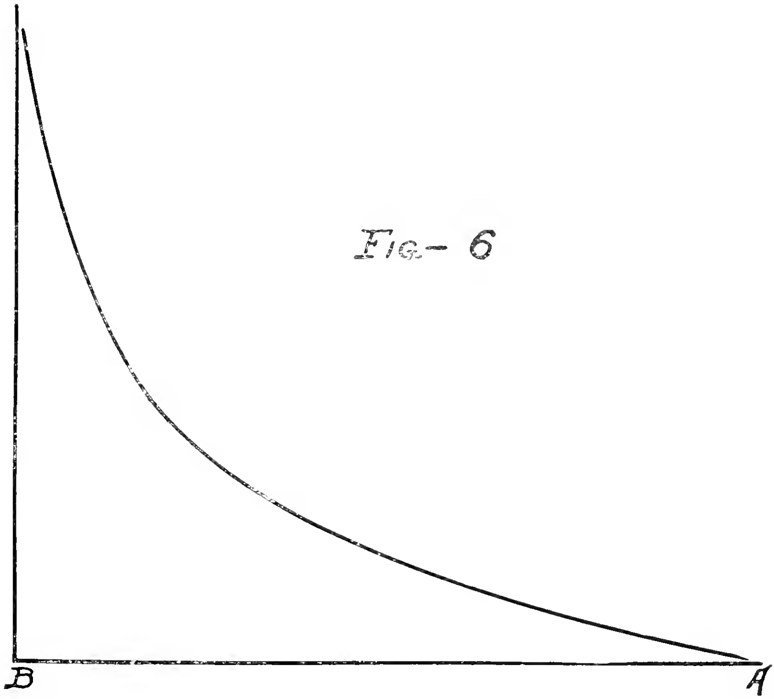


FIG.— 6

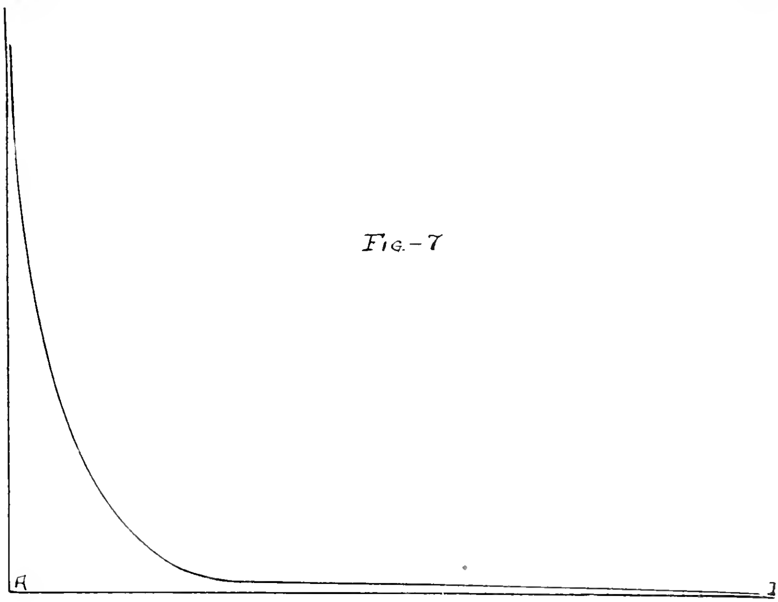


FIG.—7

A Topographic Result of the Alluvial Cone.

By A. H. Purdue.

An alluvial cone that is composed mainly of more or less finely comminuted material would not last long enough after the area covered by it ceases to be one of deposition to produce an enduring topographic feature. It would soon succumb to the agents of erosion and transportation. Even if composed of coarse material, its life might be short if the lithological character and climatic conditions were such as to bring rapid disintegration. But if the cone be composed mainly of coarse material that can withstand the weathering agencies, there is every reason to believe that it would have lasting topographic results.

In transverse section, alluvial cones are higher in the middle than on the borders next the escarpment, as shown in Fig. 1, so that the tendency

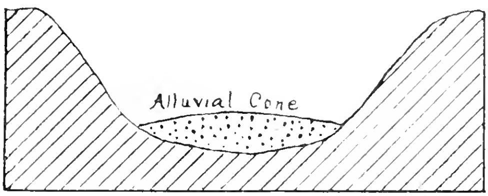


Fig. 1.

is for the streams which form them to shift either to the right or to the left, running along the base of the escarpment. If such a stream is not overloaded at this point, it becomes a cutting stream, and the profile, that

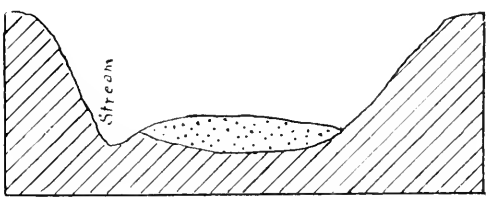


Fig. 2

shown in Fig. 2. Should the cone be formed immediately below the junction of two streams, as in Fig 3, both streams might shift, one to either

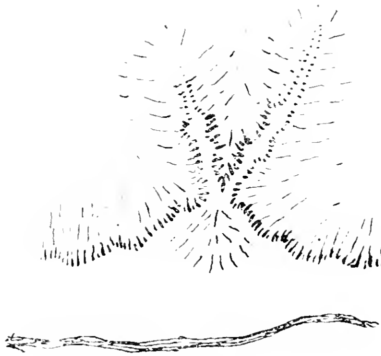


Fig. 3

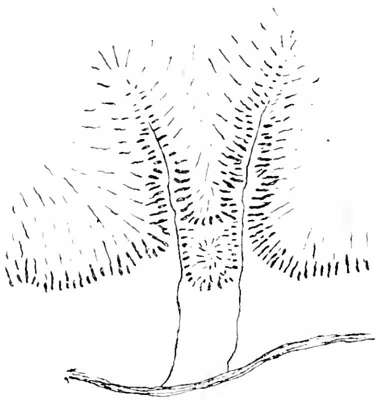


Fig. 4.

side, leaving the cone between them, as in Fig. 4, and with the profile as shown in Fig. 5. The writer has in mind a case of this kind, where the shifting has recently taken place.

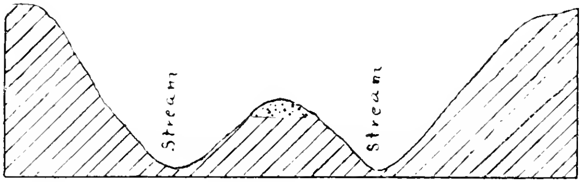


Fig. 5.

In the Boone chert region of northern Arkansas, there are many alluvial cones, composed almost entirely of fragmentary chert. This chert withstands weathering to a remarkable degree. It readily permits the rainfall to pass through it, thus preventing erosion, and forming an ideal protection for the underlying rocks.

Also, over this region, there are numerous knobs of the character shown in Fig. 6. These knobs are capped with fragmentary chert, resting upon the magnesian limestone that underlies the Boone chert. The sur-

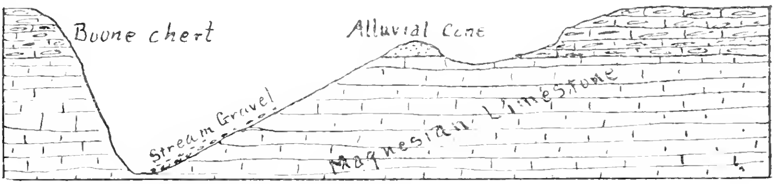


Fig. 6

rounding geography is that shown in Fig. 4. Nearly all the capping material is angular, but close search will often reveal water-worn pebbles.

The writer is of the opinion that the capping material is that of alluvial cones, and that the preservation of the rock beneath from erosion, is due to the protection afforded by the cones. Such knobs are sometimes 500 feet above the valleys beneath. The small number of water-worn pebbles is accounted for in the fact that the débris of the cones was transported but short distances, and there was not time for much rounding. Besides, the material is hard, and would wear slowly.

The material of these old cones must not be confounded with the gravel that is common in this region, and which occurs on the hill sides (see Fig. 6) often extending up to the height of 200 feet or more above the present stream level. This material, unlike that capping the knobs, is all water-worn, and was left on the inside curve of the streams as they shifted laterally.

Progress in Locomotive Testing.

By W. F. M. Goss.

It is now fourteen years since the initial steps were taken to install at Purdue University a locomotive testing plant. Plans which were then formulated were rapidly worked out, and in the fall of 1891, the completed plant was put into operation. It consists of a mounting mechanism, upon which any locomotive can be operated in much the same manner as upon the road, while retaining its fixed position in the laboratory; and of such accessory apparatus as is needful in measuring its power and in determining its efficiency. A locomotive mounted upon the testing plant can be fired as if upon the road and can be run at any speed and under any load, its action being controlled in precisely the same manner as when in actual service, while its fixed position in the laboratory allows the attachment of delicate apparatus, and permits great accuracy in the methods employed in studying its performance.

The practical value of the Purdue plant was at once recognized. It had long been understood that in testing a steam engine, the maintenance of constant conditions was of prime importance, whereas the operation of a locomotive on the road is attended by a great variety of changes in conditions which affect its action. Again, upon the road, so great are the limitations governing the attachment of apparatus that observations had necessarily been of a very elementary sort. Difficulties in testing arising from these and other causes were entirely overcome by the advent of the testing plant. By its use it became possible to apply to the locomotive the same accurate methods in observing the performance of a locomotive which had previously been elaborately developed for testing stationary engines. Mechanical engineers and superintendents of motive power visited the laboratory to witness the operation of the Purdue testing plant, from many parts of our own country, and from several foreign countries. Other plants were soon proposed. In 1896 the Chicago & Northwestern Railway Company equipped its Chicago shops for locomotive testing, and more recently, Columbia University has supplied a locomotive testing plant for its engineering laboratory. Other institutions have plants in contemplation. Meanwhile, the work of the Purdue plant has proceeded steadily from the beginning. Besides serving in the instruction of hundreds of students, it has supplied the means for conducting a number of important researches, the results of which have been duly published and important problems are now in process of solution under the patronage of the Carnegie Institution. This, while in terms too brief to be entirely complete, gives a fair picture of the present status of locomotive testing from a laboratory point of view.

Just at this time, all who are interested in locomotive design or performance have their faces turned to the Louisiana Purchase Exposition. Engineers have always looked upon a great exposition as serving in many ways to advance the practice of their profession. It has often happened that in addition to the far-reaching influence of their general exhibit, such expositions have given occasion for a considerable amount of highly scientific work. At the Centennial Exposition at Philadelphia, in 1876, a system of steam-boiler testing was developed. The Columbian Exposition at Chicago in 1893 had its engineering congress, and it is of interest to know that the Louisiana Purchase Exposition at St. Louis is to be emphasized by the working out of extensive plans for locomotive testing.

It has been announced that the Pennsylvania Railroad Company is to make a locomotive testing plant the central features of its exhibit at St. Louis, and is to conduct tests upon locomotives throughout the period of the Exposition. To this end, it is now installing in the Transportation Building at the Exposition, an elaborate and most beautifully designed testing plant. The undertaking is being directed by Mr. F. D. Casanave, acting as special agent in charge of the company's exhibit, with whom the various technical departments of the railroad are co-operating. That the work of testing locomotives may be free from all taint of selfishness, and that it may serve as large a purpose as possible, the company has invited the American Society of Mechanical Engineers and the American Railway Master Mechanics' Association to have a part in giving direction to its work. Each of these organizations, in accepting the invitation has appointed a committee of three to represent it, which committees, acting together, constitute what is now known as the Advisory Committee of the Pennsylvania Company for Locomotive Testing. The writer's connection with the work is that of a member of the Advisory Committee.

It has been planned to test twelve locomotives, a number of which will be of foreign manufacture. One is to be a de Glehn balanced compound, which has been ordered by the Pennsylvania Company and will be imported from France for use on the testing plant. German manufacturers are to send locomotives equipped with superheaters. The coming to this country for the purpose stated of these typical foreign locomotives is a matter of more than ordinary significance. The American locomotives selected for test will represent different types of modern freight and passenger engines.

It is expected that a test will be started each day between eight and nine o'clock in the morning, and will be continued for from two to four hours, depending upon the conditions of running. Any engineer, therefore, interested in locomotive testing may see a test in progress by visiting the Transportation Building during any morning of the Exposition.

It is proposed to have the results obtained from all the tests given publicity by means of bulletins, which will be issued from time to time by the Pennsylvania Company, and which will be sent to the technical press and to individuals under conditions yet to be announced. Bulletin No. 1, describing the organization and the methods has already been issued.

Additions to the Flora of Indiana.

By Herman B. Dorner.

The plants given in the list below, are some which were collected, by the writer within the past three years, and have not, as yet, been included in the State flora.

It was thought best, in presenting this list, to add such notes as might be of interest to botanical workers of the State.

The nomenclature used is that of "Britton's Manual of the Flora of the Northern United States and Canada."

1. *Panicum Columbianum* Scribn. Tippecanoe County.

Collected, in 1902, along the Wabash Railroad east of Lafayette.

2. *Panicum Lanuginosum* Ell. Tippecanoe County.

This species was collected, during the season of 1902, in three localities. It was first collected along the Wabash Railroad, east of Lafayette, and again on a wooded hillside about three miles east of the city. The third collection was made about three miles north of the city, along a shaded roadside.

Britton gives as the range of this species, "from southern New Jersey to Florida and Alabama."

3. *Panicum oligosanthes* Schult. Tippecanoe County.

This was first collected, in 1901, along the Wabash Railroad east of Lafayette. Observations in this locality, during the succeeding years, show that it is gradually spreading over more territory.

In 1902, it was again collected south of the city, along Wea Creek.

Britton gives for its range, "Virginia to Georgia and Mississippi." Its introduction into the State is probably due to the railroads.

4. *Sporobolus longifolius* (Torr.) Wood. Tippecanoe County.

This occurs in Tippecanoe County in several localities. It was first collected south of Lafayette, along the banks of Wea Creek. Later it was found on a dry, open hillside, about three miles east of the city.

It is quite abundant where found.

5. *Bromus patulus* M & K. Tippecanoe County.

Quite common on Purdue farm and on State Street, West Lafayette.

All attempts to determine this species referred it to *B. squarrosus* but the description did not seem to fit it. Specimens were then sent to Prof. Hitchcock who determined it as *B. patulus* M. & K. In regard to it he says, "It is allied to B. *squarrosus*, but has a more loose and open panicle. It is not described in the manuals, as it seems to be introduced in only a few places in this country."

A description of this species will be found in Mr. Shear's "Revision of the Genus Bromus," published as bulletin 23 of the Division of Agrostology.

The plant seems to be well established in this locality.

6. *Hordeum pusillum* Nut. Tippecanoe County.

This species was collected along the Wabash Railroad, east of Lafayette, where it seems to be well established.

It was first collected in 1900 and specimens have been taken each succeeding year.

This species was probably introduced in refuse, thrown out from cattle-cars.

7. *Tradescantia brevicaulis* Raf. Tippecanoe County.

Found very commonly, about Lafayette, on partly shaded hillsides.

8. *Asarum acuminatum* (Ashe) Bicknell. Tippecanoe County.

Very common in woods and on shaded hillside, east of Lafayette. *A. Canadense* F. with which it is confused was also found in the same locality.

9. *Allionia linearis* Pursh. Tippecanoe County.

First collected along the Wabash Railroad in 1901. Observations since then show that it has become well established and is slowly spreading.

10. *Geranium pussillum* Burm. f. Tippecanoe County.

In the summer of 1902, this was found growing among the grass on the Experiment Station grounds.

This one collection, however, without any additional observations is hardly enough to admit it to the State flora.

11. *Androsace occidentalis* Pursh. Tippecanoe County.

Found growing somewhat abundantly in lowland near Wea Creek.

This is listed on page 606, of the Catalogue of the Flowering Plants of Indiana, by Prof. Coulter, as a doubtful member of the State flora.

Specimens of all the plants listed above have been deposited in the herbarium of Indiana plants at Purdue University.

In conclusion, the writer wishes to acknowledge his indebtedness to Prof. Stanley Coulter, for much kind help in his work, and to Prof A. S. Hitchcock, of the Department of Agriculture, for help in the determination of the grasses.

Botanical Notes.

By Moses N. Elrod.

Tecoma radicans (L.) D C. The trumpet-flower presents many peculiar characters that are of great value in securing cross-fertilization, and it seems to be constructed on a plan admirably adapted to meet the needs of the humming-bird.

One among the first things in its structure to attract attention is the nearly horizontal position of the flower, its short, unexpanded lower lip, the opposite of the arrangement in many flowers dependent upon insect visitors for fertilization, and the manner in which the filaments are twisted right and left so as to bring the dehiscing anther on the same plane with their backs against the upper lip of the corolla. This grouping of the anthers is effected by the outer and longer pair of the angular, dimorphous filaments making one turn on their axes and the inner pair making a half turn. The pistil is a little longer than the stamens and terminates in a two-branched, foliaceous, spatulate stigma.

In July, 1902, I noticed that the stigma is sensitive. While searching in my pocket for a magnifying glass the lobes of a plucked flower had closed so that the stigmatic surfaces were in close contact. The use of force failed to separate them for more than a moment and when one of the thin lobes was cut away the other curled up into a loose roll. At the time, I supposed that I had made a discovery, but soon found that I had been anticipated. In Müller's "Fertilization of Flowers" it is stated that when the stigma of *Bignonia* has been "touched by an insect visitor they then close up immediately." He also quotes the experiments of his brother on a South American species, showing that successful fertilization was secured only when the pollen applied came from a plant growing "at a distance." It was to test the sensitiveness of the stigmas and the conditions under which cross-fertilization was effectual that my observations of *Tecoma radicans* were made.

The stigmatic lobes of a flower which had just come into bloom, when irritated with the point of a knife-blade or any other hard substance, closed in five seconds, and those of the faded flowers in thirty seconds. A drop of water acted as an irritant when applied soon after the stigmas had matured, but a warm rain had no effect. Fresh flowers placed in a refrigerator were not affected by the reduction of the temperature, while those exposed to cold rains seemed to have their irritability diminished. The application of pollen from the same or another flower had no effect when care was exercised not to roughly touch the stigma. Pollen was applied one evening to the tip of the lower lobe, which is the larger and longer of the two lobes, and it did not hinder their opening next morning. After closing up from the use of an irritant alone they opened again in about two hours. But if the irritation had been accompanied with the application of pollen from the same or another vine they rarely opened again, and never if the ovary was fertilized.

More than fifty experiments to determine the effects of pollenization with pollen from the same flower as the stigma treated, or from another flower growing on the same stock, gave negative results. In some cases the ovary seemed to swell and remained attached to the vine longer than those not pollenated, but they all turned black or dropped off within fifteen days.

All the stigmas treated, to determine their irritability, and the effects of pollen applied to them coming from a distance, grew on vines in the back yard of No. 823 Washington Street, Columbus, Indiana. Six strong stocks, coming from the same root, cover the fence and an old apple tree. In the autumn of 1901 they produced many matured capsules. August the 19th and 20th, 1902, eleven stigmas were pollenated from flowers collected two and one half squares distant. Six of these began to develop in fine style, but came to naught. September 9th and 10th, six stigmas were treated with pollen from a vine found growing outside the city limits, one-fourth mile west on the Nashville road. As a result, the ovary, in one instance grew to be one inch long and then withered. The others were failures and their ovaries did not appear to have grown a little bit. The season closed with nothing to show for my work and the distance theory unverified. The vine in my yard began blooming again July 1st, 1903, and the first experiment of that year was made to see how much influence the soil in which the vine grew had to do in determining the final results of cross-fertilization. July 5th, I collected flowers from a vine growing in the rich bottom land of Clifty Creek, two miles south of the city, and twenty stigmas growing in my yard were pollenated. The flowers treated, were in all stages of blooming, from those just opening to others that were fading, but none where the lobes of the stigma did not promptly close when irritated. These experiments resulted in twelve full grown capsules. July 31st and August 3d eighteen stigmas were pollenated from flowers found growing on clay soil, one mile south of the city, which resulted in three mature capsules. August the 14th and 18th, nineteen stigmas were treated with pollen from a vine growing in clay soil one-half square north of my vine, and three mature pods were the result. Ten stigmas were pollenated August 19th from a vine growing in clay soil, at the root of a large elm tree, about one square northwest of the home vine, and eight mature capsules were the result.

Summarized, the results show that sixty per cent. of the pollenations made with pollen from a vine growing in rich loam were successful; fifteen and sixteen per cent. were successful when the pollen came from clay soil, and the vines grew in the open, under conditions nearly the same as that of my back yard, and eighty per cent. as the result when the pollen came from a vine whose roots were planted in clay soil and entertwined with those of a big elm. From this it seems that the soil in which the vine grows, has some influence on the fertilizing power of its pollen. The pollen used in the 1902 experiments, which resulted in failures, came from vines growing in the open and rooted in clay soil. The idea that pollen coming from the big elm tree vine is in some way peculiarly efficacious in producing seed is confirmed by the fact that a vine within one hundred yards of it, and favorably located to encourage humming-birds to visit between the two, has borne an abundant crop of capsules for the past two years.

The only insects noticed on the trumpet-flowers were robbers, whose visits were without compensating advantages. Black ants and little sweat bees came early and stayed late; the ants to get nectar, and the bees to collect pollen. Sometimes they found an entrance between the lobes of the corolla limb before the flower was open. The bees made short work of collecting all the pollen in sight—half of it going within fifteen minutes. When the pollen was knocked down into the tube they did not seem to be in any way put out, but went on collecting until all was gone. As many as six bees were seen together in a corolla, very busy, crowding and fighting for place. Had they found any pollen on a stigma they would have taken it. During a drouth conical holes were found in the calyx, of many flowers, that reached down to the ovary, and as mud-dauber wasps, *Sphegidæ*, were seen about the holes they were charged with making them. After rain came they disappeared, and may have done the drilling to get at the nectar as food, or as a substitute for water in tempering their building material. Humble and honey-bees occasionally were seen prospecting around the flowers, but they rarely stopped for more than a moment.

It is remarkable, while the mechanism of *Tecoma* is peculiarly effective in preventing self-pollenation, that its pollen is impotent except when applied to the stigma of another plant under restricted conditions, and that the humming-bird is its only visitor of service in its fertilization.

Impatiens aurea Muhl. The pale touch-me-not is a common plant in Indiana, growing best in the damp, rich soil of the shaded river bottoms.

The mechanism of the flower is generally understood, but the part played by the scales, on the inner side of the filaments, is not so well known. The filaments are so arranged as to form a group, which is held together by the coherent scales. With reference to the mouth of the spur the posterior part of the group is closed by a single filament and the sides by two filaments, leaving the front with a larger opening between the anterior pair than elsewhere. The scale of the posterior filament is divided into two parts which are continuous with the coherent scales of the sides. The two resulting appendages are symmetrical, and are in close contact, on an antero-posterior line, so as to form a roof or hood over the end of the stigma. On the under side of the hood is a pocket into which the stigmatic end of the ovary is inserted. The end of the ovary is marked by a slight papilla near the anterior end of the dividing line of the hood. The pocket is so placed with reference to the plane of the hood that the end of the ovary does not push at right angles, but in an oblique direction. The filaments cease to grow when the flower opens, while the ovary continues to increase in length, and by this arrangement with reference to the hood it pushes against it without protruding, until the filaments are broken from their attachment to the receptacle. When the connection with the receptacle is broken the filaments curl backward with such force as to often cause the cap of withered anthers to fall to the ground. If this does not happen, the cap is easily displaced by the first insect-visitor that attempts to enter the spur.

When it is recalled that the touch-me-not flower is suspended from the end of a slender peduncle, and bobs and swings with every breeze or touch of an insect, the function of the hood in excluding self-pollenation becomes evident. Observations show that the hood is frequently covered with pollen that has sifted through the chink between the anthers, or has been carried to it by small insects. But the stigmas are not always so well protected as the foregoing might indicate. As the season advances flowers begin to appear in which the stigmatic end of the ovary is exposed. On the 16th of September a patch of *I. aurea* was visited and the ovary found protruding in a majority of those examined. That this change was due to the waning vigor of the plant seems to be shown when, at a later date, after rain and continued warm weather, only one out of twenty-five flowers was found with the stigma exposed. Examination with a microscope showed pollen adhering to the papillae of the stigma. Soon after the exposed stigmas are seen cleistogamous flowers begin to appear.

Just over, or anterior to the protuberance, made on the hood by the end of the ovary, is an erect, membranous appendage, composed of two pieces about one line long. Its function is not obvious, but it may serve as an increased protection to the stigma against self-pollenation. So far as seen it is peculiar to *Impatiens aurea*.

Impatiens biflora, Walt. After two years of observation, I am led to believe that the spotted touch-me-not produces its crop of cliestogamous flowers in the spring only, before the conspicuous flowers begin to appear. This fact has led some writers, who looked for them in autumn, to state that this species does not produce concealed flowers. Last spring hundreds of them were examined and concealed flowers found in the axils of the leaves of all the plants over six inches high. The glaucous stem of the *I. aurea* distinguishes the young plant of that species before it blooms, but to make sure of the species, they were again visited after conspicuous flowers had become abundant. The first conspicuous flowers had the stigmas exposed through a hole in the hood. But this exposure of the stigma was confined to the spring flowers. The first normal flower seen in my yard came into bloom June the 9th, and produced a seed-bearing capsule. The distance at which this plant grew, from any others then in bloom of the same species, probably excludes the possibility of cross-fertilization. Those blooming a few days later had holes in the hood.

The touch-me-not is cross-fertilized through the agency of bees. Rarely a humming-bird poises over a flower, but does not seem to find anything to detain it long. Its bill is too long and slender to make it a good instrument for carrying pollen. Humble-bees become numerous about the flowers late in the season, and by their size and clumsy movements, not only detach the anther cap, but frequently manage to bring themselves to the ground imprisoned in a withering corolla. Other smaller bees, in search of honey, enter the spur without touching the anthers.

Claytonia Virginica L. The movements of the stamens and stigmas of this plant are curious and somewhat puzzling. When the petals first open the pistil is longer than the proterandrous stamens, but of the same length after the branches of the stigma are recurved. In some flowers the stamens remain clustered around the style and closed stigma for a time after the petals have opened, and while in this position, the under part of an insect-visitor readily becomes dusted with pollen. Later the stamens are bent backward until the anthers rest on the face of the horizontal pistils. When this outward movement of the stamens takes place the lobes of the stigma are also bent outward and in position for cross-fertilization. Quite often it happens that it can scarcely be said that the stamens are proterandrous, all the movements before described occurring at the time the anthers become dehiscent. When this takes place the insect-visitor has little chance of collecting pollen, but it leaves the stigma in an ideal position for cross-fertilization. Flowers can be found in all of these stages at the same time; and the honey-bee in making its rounds soon becomes dusted with pollen, without having to depend on the recurved stamens for a supply.

Unlike many flowers that are in part or wholly dependent on insects for fertilization, the spring beauty lasts but one day. It comes into bloom early in the season and its day is past before insects become numerous, hence, as might be expected, there is a provision which assures self-pollenation. The petals that open in the morning begin to close in the afternoon, and by night are gathered into an imbricated roll. If the day has been cold and the lobes of the stigma have not become fully recurved, so as to bring their papillae on a level with the anthers, the process of recurvation is completed before they are caught by the closing petals. Examination shows that after closing the anthers with pollen still adhering are in close contact with the stigma. Pollen was found at night on the papillae of the old flowers that was not there before insects ceased to fly that afternoon. No insect other than the honey-bee was seen about them, and, as its visits were rather rare, the numerous and well filled capsules must have been the result of self-pollenation.

Hydrophyllum appendiculum Michx. is proterandrous. When the flower first comes into bloom the pistil is about one-half the length of the mature stamens. The dehiscing anthers are gray with pollen, which disappears within six hours. By the time the pollen is gone the pistil has grown to the same length as the stamens, the two lobes of the stigma are recurved and ready for cross-pollenation. Bees are the pollen carriers, which they get from the anthers of flowers that bloom at irregular hours throughout the day. A plant in my yard began to bloom early in May and was still producing a few flowers August 8th. During dry weather in July, the flowers were less than one-half the normal size, the tube very much shortened, and in others the corolla changed from campanulate to rotate.

Polemonium reptans L. The stamens are not as long as the pistil. Dehiscence begins when the corolla is about half open, and before the lobes of the stigma are recurved. Later the stamens are bent outward and the pistils left to occupy the center field. Honey-bees enter the half-blown flowers and come out well dusted with pollen, which they carry to the older flowers. Invariably, when a bee comes to a plant, it pays its respects first to the half-blown flower, and may not visit the older ones at all. It seems to know that they have been exhausted of nectar. As it enters the slenderly supported flower it clasps all the organs at once, and its movements are about as graceful as those of the humble-bee.

The pistil of *Lysimachia quadrifolia* L. and of *L. terrestris* (L.) B. S. P. when the flowers first open are sharply curved to one side by a bend near the middle of the style. After the anthers have shed their pollen the pistil is erected and the stigma in position for cross-fertilization by the insect-visitor. That this may be accomplished, the blooms last for several days.

The stigmatic lobes of *Sabbatia angularis* (L.) *Pursh.* are as long or longer than the supporting style and the whole pistil only about one half the length of the stamens when the flower first opens. To make it doubly sure that self-pollenation shall not occur, the lobes are closely twisted together until the coiled anthers have unrolled and shed their pollen. In the meantime the pistil has increased in length and the lobes curved back at right angles to the style. The lobes are stigmatic along the inner side, and remained twisted after they are recurved, so that an insect passing over or under them with pollen on its back or under parts, would be likely to effect fertilization. Many of the flowers are in bloom at the same time, are quite handsome, fragrant, and stay in bloom a week or more. It is curious that finding the plant in a certain locality one season is no sign that it can be found there next year.

Taraxacum Taraxacum (L.) Kerst. While watching the effects of temperature on the dandelion in June a number were found which were not producing pollen, the heads were perfect in every way, but had no pollen on the styles or branches of the stigmas when the bees were excluded.

The connate anther-tubes, which were of the normal form in all stages of development, were examined under the microscope and not a grain of pollen found in them. The sterile heads were of a uniform pale yellow and lacked the golden tinted center of the fertile heads found growing near by. Bees indifferently passed from one kind to the other. Seed was formed on the sterile heads, but there were more aborted achenes than usual.

The dandelion is very sensitive to change of temperature, while the absence of sunshine has very little effect. Early in the season the same heads may be exposed as often as three days in succession, and the involucre not be opened for more than two or three hours at any one time. As the temperature increases they stay exposed from early morning until shut up by the falling temperature of the afternoon, and may not open again next day.

Ruellia strepens L. produces a large crop of cleistogamous flowers during late summer and autumn. The flowers are clustered in the axils and hidden by the long segments of the calyx. The change from conspicuous to concealed flowers involves more than a change from gamopetalous to apetalous. The stamens are reduced in length to that of the ovary with a small pollen-producing surface at the tip, which is in close proximity to the sessile stigma. The resulting capsules are numerous and well filled with seed.

Falcata comosa (L.) Kuntze sends forth long, slender, stoloniferous runners in early summer that produce apetalous flowers before the conspicuous blooms appear. Not only is the form of the flower quite different from that of those coming later, but the early, ovoid, single-seeded, fleshy pod is very unlike the three-seeded, bean-like pod of the later flowers. The mature single-seeded pods are found on or near the ground after the conspicuous flowers have come into bloom.

If *Oxalis stricta* L. produces cleistogamous flowers on recurved scapes, at the base of the plant I have not seen them, but have found flowers in

July in which the calyx remained closed over the dwarfed corolla. The only change in structure noted was that the five shorter stamens bore aborted anthers, and that the pollen-bearing anthers were in contact with the stigma. Contrary to what some writers state the stamens of *O. Stricta* are often dimorphic. The self-pollenation of the normal flower is accomplished by the corolla closing after exposure, and pressing the anthers against the stigma.

One of the most interesting changes in structure from a conspicuous to a cleistogamous flower is seen in the violet. The showy flowers are so constructed that the honey-bee is the only insect that I know to be of service in its fertilization, and only a part of the anthers are called into use by it. To reach the spur in which the nectar is stored, the bee, after it settles, has to reverse its position, and force its tongue between the two appendages on the lower stamens. In doing this it comes in contact with the stigma and at the same time is dusted with pollen from the appendaged stamens. The anthers of the other three stamens do not aid in supplying the bee with pollen, and seem to be of very little if any use to the plant. In the concealed flowers, they are aborted. The pistil, of the cleistogamous flowers of *Viola Striata* Ait., is declined, so as to bring the stigma against the end of the ovary, and in contact with the two connivent anthers. Two appendages grow from the fertile stamens, just below the anthers, that are expanded so as to cover the anthers and the whole of the pistil.

V. striata continues to produce showy flowers longer than many other species, and as a consequence its concealed flowers come in summer.

Viola pubescens Ait. develops a few yellow flowers in early spring. It continues to grow until August, and as it grows, concealed flowers are developed in the axils of the leaves.

The abruptness of the change from a showy to a cleistogamous flower was beautifully shown on a plant of *Impatiens biflora* that produced a well-developed, conspicuous flower on one branch of a peduncle and a concealed flower on the other branch.

The fact that the stigma of *Tecoma radicans* returns to its former position in two hours after it has been changed in response to an irritant, unless the irritation has been accomplished by pollen of a certain quality, shows that the process of fertilization begins within two hours after the right kind of pollen has been applied, and that the stigma is endowed with remarkable selective power. The whole process suggests the shadowy beginning that has culminated in the will, and recalls Professor Minot's definition of consciousness, "the function of consciousness is to dislocate in time the reactions from sensations." In *Tecoma* the reaction is not dislocated from the sensation, for there can not be such a thing as sensation in a plant, but there is a curious tendency in that direction.

The calyx of *Scutellaria cordifolia* Muhl. splits back to the base at maturity, and the helmet-like upper lip falls away. Before the upper lip falls the ripe nutlets lie loose in the bowls of the persistent lower lip. A gust of wind strong enough to set the dry leafless stems to swaying will detach the upper lip and send the seeds flying with the wind.

The following plants, which are not included in Professor Coulter's "Flowering Plants and Ferns of Indiana," are known to occur in Bartholomew County. *Quercus Schneckii* Britton is common in the western part of the county, and frequently wherever red and black oaks grow. *Quercus Alexanderi* Britton formerly was abundant on the Knobstone hills of Bartholomew and Brown counties and the north part of Jackson County. Locally it is known as chestnut oak or tan-bark oak. Some years ago the bark was an important source of revenue to the inhabitants of Brown County. Along the line of the Baltimore & Ohio Southwestern Railroad, where it grows in dense forests, it is being shipped for use as telephone poles.

Perilla frutescens (L.) Britton grows on the south side of Columbus, Hope & Greensburg Railroad one-fourth mile east of Lambert's Switch. It is abundant in that locality.

Tradescantia bracteata Small occurs sparingly, and *T. reflexa* Raf., commonly, on the sandhills of Bartholomew and Brown counties. *T. bracteata* blooms in April, and does not last later than May. The oaks above named have been reported as occurring in the State by Professor Coulter, the others are believed to be new to the Indiana list.

Bird Notes From the Indiana State Forestry Reservation.

By Chas. Piper Smith.

During the summer of 1903 I was fortunate in being located, for some five weeks, upon the State Forestry Reservation, in the "Knob" region of southern Indiana. Although engaged in making a survey of the plant life of the Reservation, my ears were ever attentive to the bird voices about me, and a list of the various species heard or seen was preserved. Sixty-one species were noted within Reservation limits, as recorded below. No especial care was taken to study the relations of the birds to the trees and their other natural surroundings; but a few general remarks may be based upon a review of the bare list.

It will be noticed that the birds enumerated include forms characteristic of both woodland and open, though the number of woodland species far exceeds the number of kinds loving the field, sky or orchard. The absence of running water, during the summer and fall months, makes impossible the conditions necessary to attract water and swamp-loving forms; hence the scarcity of such in the list. Of the two thousand acres composing the Reservation, possibly eighteen hundred are wooded. Thus it is apparent why the woodland birds exceed in number of species; and it is likewise true that many of these woodland forms lead in regard to number of individuals. Some four hundred feet difference in elevation exists between the lowlands and the tops of the higher knobs, the deep ravines between the knobs forming tempting bird haunts.

Although not intending to give time to my favorite study, the birds and all that concerns them, I was ready to give heed to Mr. Butler's suggestion to look for the Pine Warbler, *Dendroica vigorsii*, and evidence of its nesting there. As far as known to us, this bird has not been definitely reported as a breeder within our State, although there are several localities which have conditions apparently meeting the demands of this pine-loving little warbler. What evidence I was able to glean is contained in the following testimony, but it is, of course, not equal to the best evidence, namely, the collection of a nest with the eggs and the parents.

I first saw the Reservation on the twentieth of July and I began my list that day. Two days later, while upon the Hollister knob, an unfamiliar bird song diverted my attention from stuffing plants and leaves into my "botany-can," and, forgetting my botanical work for a few moments, I turned aside to seek the singer. The song ceased upon my intrusion, but after a short search, I spied a family of four small dull-colored warblers which seemed not anxious to make my acquaintance. As I had no means of getting one of these into my hand, I was about to pass the group by as too uncertain of identification for recording, when a male Pine Warbler, as easily recognized, joined them and showed himself to be no stranger amongst them. Then resemblances in plumage were noted which removed all doubt on my part as to the identity of the others. Three of the family, in appearance and voice, strongly suggested young of the year, and, before I left them, or rather they left me, I had the pleasure and satisfaction of seeing the supposed female side up to and feed one of the three of juvenile appearance.

Later this song was heard on various occasions, and, on July 21st and August 18th, I had most satisfactory observation of Pine Warblers, both of adult males and their duller-colored followers; but no further evidence was secured as to the breeding of this species there. All my Pine Warbler observations were upon the knob-tops, close to the pine areas. I am anxious to visit the Reservation during some May or June when, I am confident, I could collect more conclusive evidence of the breeding of the Pine Warbler within our State.

As to the other Reservation birds I will limit myself to the mere listing of them, the species recognized being:

1. *Colinus virginianus* (Linn.). Bob-white.
2. *Zenaidura macroura* (Linn.). Mourning Dove.
3. *Cathartes aura* (Linn.). Turkey Vulture.
4. *Falco sparverius* Linn. American Sparrow Hawk.
5. *Megascops asio* (Linn.). Screech Owl.
6. *Coccyzus americanus* (Linn.). Yellow-billed Cuckoo.
7. *Dryobates villosus* (Linn.). Hairy Woodpecker.
8. *Dryobates pubescens medianus* (Swains.). Downy Woodpecker.
9. *Melanerpes erythrocephalus* (Linn.). Red-headed Woodpecker.
10. *Colaptes auratus luteus* Bangs. Northern Flicker.
11. *Antrostomus vociferus* (Wils.). Whip-poor-will.
12. *Chordeiles virginianus* (Gmel.). Nighthawk.

13. *Chætura pelagica* (Linn.). Chimney Swift.
14. *Trochilus colubris* Linn. Ruby-throated Hummingbird.
15. *Tyrannus tyrannus* (Linn.). Kingbird.
16. *Myiarchus crinitus* (Linn.). Crested Flycatcher.
17. *Sayornis phœbe* (Lath.). Phœbe.
18. *Contopus virens* (Linn.). Wood Pewee.
19. *Empidonax virescens* (Vieill.). Green-crested Flycatcher.
20. *Cyanocitta cristata* (Linn.). Blue Jay.
21. *Corvus americanus* Aud. American Crow.
22. *Molothrus ater* (Bodd.) Cowbird.
23. *Sturnella magna* (Linn.). Meadowlark.
24. *Icterus galbula* (Linn.). Baltimore Oriole.
25. *Astragalinus tristis* (Linn.). American Goldfinch.
26. *Poocætes gramineus* (Gmel.). Vesper Sparrow.
27. *Coturniculus savannarum passerinus* (Wils.). Grasshopper Sparrow.
28. *Chondestes grammacus* (Say). Lark Sparrow.
29. *Spizella socialis* (Wils.). Chipping Sparrow.
30. *Spizella pusilla* (Wils.). Field Sparrow.
31. *Peucæa æstivalis bachmanii* (Aud.). Bachman Sparrow.
32. *Pipilo erythrophthalmus* (Linn.). Towhee.
33. *Cardinalis cardinalis* (Linn.). Cardinal.
34. *Cyanospiza cyanea* (Linn.). Indigo Bunting.
35. *Piranga erythromelas* Vieill. Scarlet Tanager.
36. *Piranga rubra* (Linn.). Rose Tanager.
37. *Progne subis* (Linn.). Purple Martin.
38. *Hirundo erythrogaster* Bodd. Barn Swallow.
39. *Ampelis cedrorum* (Vieill.). Cedar Waxwing.
40. *Lanius ludovicianus* Linn. Loggerhead Shrike.
41. *Vireo olivaceus* (Linn.). Red-eyed Vireo.
42. *Vireo gilvus* (Vieill.). Warbling Vireo.
43. *Mniotilta varia* (Linn.). Black and White Warbler.
44. *Helminthophila pinus* (Linn.). Blue-winged Warbler.
45. *Dendroica vigorsii* (Aud.). Pine Warbler.
46. *Seiurus aurocapillus* (Linn.). Oven-bird.
47. *Geothlypis formosa* (Wils.). Kentucky Warbler.
48. *Geothlypis trichas* (Linn.). Maryland Yellow-throat.
49. *Icteria virens* (Linn.). Yellow-breasted Chat.
50. *Wilsonia mitrata* (Gmel.). Hooded Warbler.

51. *Galeoscoptes carolinensis* (Linn.). Catbird.
52. *Toxostoma rufum* (Linn.). Thrasher.
53. *Thryothorus ludovicianus* (Lath.). Carolina Wren.
54. *Thryomanes bewickii* (Aud.). Bewick Wren.
55. *Sitta carolinensis* Lath. White-breasted Nuthatch.
56. *Bæolophus bicolor* (Linn.). Tufted Titmouse.
57. *Parus carolinensis* Aud. Carolina Chickadee.
58. *Polioptila cærulea* (Linn.). Blue-gray Gnatcatcher.
59. *Hylocichla mustelina* (Gmel.). Wood Thrush.
60. *Merula migratoria* (Linn.). American Robin.
61. *Sialia sialis* (Linn.). Bluebird.

Notes Upon Some Little-Known Members of the Indiana Flora.

By Chas. Piper Smith.

As a member of the senior class in botany at Purdue, during the last spring, I began a season of active field work in botany, which circumstances led me to continue through the summer and autumn.

Five weeks during July and August were spent upon the State Forestry Reservation, in Clark County, the major portion of the season, however, after leaving Lafayette in June being spent about Indianapolis.

Britton and Brown's "Illustrated Flora of the Northern States and Canada" was used as the basis of study, the more recent Britton's Manual not being at hand for comparison.

Dr. Coulter's catalogue of the State flora was always referred to as each plant was handled, and it is in reference to this list that I make the following notes.

Most of the plants here considered have been checked over for me by Mr. Bartlett, of the Shortridge High School, and most of the specimens upon which determinations have been based have been laid before Dr. Stanley Coulter and left in his charge.

Carex Baileyi Britton. Bailey's Sedge.

Common about Indianapolis. Taken by Mr. Bartlett and myself along streams and in wet places. Also taken by me upon the Forestry Reservation, where it was first recognized. Not recorded by Dr. Coulter.

Carex Hitchcockiana Dewey. Hitchcock's Sedge.

Taken by me in Tippecanoe County. Noted but once.

Carex Careyana Torr. Carey's Sedge.

Found once in Marion County.

Carex stipata Muhl. Awl-fruited Sedge.

Taken in Tippecanoe County.

Carex vulpinoidea Michx. Fox Sedge.

Taken in Hamilton County.

Carex sterilis Willd. Little Prickly Sedge.

Taken in Tippecanoe County.

Carex Muskingumensis Schwein. Muskingum Sedge.

Taken in Hamilton County, associated with the next.

Carex scoparia Schk. Pointed Broom Sedge.

Carex cristatella Britton. Crested Sedge.

Common in Hamilton and Marion counties. Heretofore unrecorded.

Juncus marginatus aristulatus (Michx.) Coville.

This form of the Grass-leaved Rush was found upon the Reservation. Not reported in the State catalogue.

Quercus Prinus L. Rock Chestnut Oak.

This species is the chestnut oak of the Forestry Reservation. As Dr. Coulter withdraws the record for Tippecanoe County, this form is not definitely recorded from the State, though I am sure that others have recognized it. I have studied the specimens of *Q. Alexandrii* near Lafayette, as also various specimens of *Alexandrii* and *acuminata* about Indianapolis, and I am sure that the Reservation chestnut oaks should be referred to this species.

Sisymbrium altissimum L. Tall Sisymbrium.

Taken by Mr. Benj. W. Douglass and myself along the "Monon," north of the State Fair Grounds, Indianapolis. One fine, large specimen was the only one found.

Agrimonia pumila Muhl. Small-fruited Agrimony.

Taken upon the Reservation. Not very common. Found with *A. mollis*, which was quite common.

Vicia angustifolia Roth. Smaller Common Vetch.

Taken by Mr. Harley, H. Bartlett and myself along the "Monon," north of the State Fair Grounds, Indianapolis.

Hypericum maculatum Walt. Spotted St. John's-wort.

Reported from only one county (Steuben), but frequent in Marion County, and abundant upon the Reservation. *H. perforatum* was also taken in Marion County, and was used for comparative study.

Sarothra gentianoides L. Pine-weed.

Presumably one of the rarest plants of the State. A small patch of plants was found upon the Reservation.

Lechea racemulosa Michx. Oblong-fruited Pin-weed.

Lechea tenuifolia Michx. Narrow-leaved Pin-weed.

These two pin-weeds are common in certain dry, barren areas on the Reservation, and are always associated where found. *L. racemulosa* has not been recorded from the State.

Angelica villosa (Walt.) B. S. P. Pubescent Angelica.

A common plant on the Reservation. An addition to the State flora.

Scutellaria campestris Britton. Prairie Skullcap.

Noted as common on one barren knob-side upon the Reservation. First record for the State. *S. parvula* was also taken, in moist soil in the lowlands. The hairy form seems to be well defined.

Stachys ambigua (A. Gray) Britton. Dense-flowered Hedge Nettle.

Taken upon the Reservation. First record for the State.

Salvia lanceolata Willd. Lance-leaved Sage.

Found sparingly at a dumping ground along Fall Creek, at Central Avenue, Indianapolis. Identification verified by Prof. W. S. Blatchley. Second Indiana station of this western plant.

Ilysanthes attenuata (Muhl) Small. Short-stalked False Pimpernel.

This easily recognized form was taken upon the Reservation. First record for the State.

The Development of the Spermatozoid of Chara.

By D. M. Mottier.

(Abstract.)

The spermatozoid of *Chara fragilis* is a spirally-coiled body consisting of a nucleus and a specially differentiated part of the cytoplasm, the blepharoplast, existing in the form of a thread, or band, bearing two long cilia. The nucleus occupies the middle part of the spermatozoid. The anterior end of the blepharoplast is thinner than the posterior and tapers slightly toward the extremity. The two cilia are borne some distance back of the anterior extremity. The posterior end is broader and thicker and terminates bluntly. In cross section the blepharoplast is crescentic, being convex on the outside and concave within. With the exception of a strip of granular substance along the concave side of the posterior end, it is of a homogeneous structure. The entire spermatozoid makes two and one-half or three spiral turns.

The blepharoplast arises as a delicate thread-like differentiation of the cytoplasm at the surface of the cell, extending some distance along the cell from the nucleus and on opposite sides of the latter. It seems to be a modification of the plasma membrane. No centrosome-like body, or "Plasmahöcker," was observed from which the blepharoplast might develop as described by Belajeff, Strasburger and others.

The nucleus is transformed from an elliptical or oval body, with a hollow chromatin spirem, to a dense, homogeneous, sausage-shaped structure making one spiral turn or more.

The cilia were always found attached some distance back of the anterior extremity of the blepharoplast. Their origin was not traced to a centrosome-like body, but they seemed to grow directly from the thread-like blepharoplast.

Contribution to the Flora of Indiana.

By Stanley Coulter.

(By title.)

Further Studies on Anomalous Dicotyledonous Plants.

By D. M. Mottier.

(Abstract.)

The studies referred to deal with the development of the embryo with special reference to the origin of the cotyledons in *Actea alba*, *Stylophorum diphyllum* and *Sanguinaria canadensis*. In the origin of the cotyledons all three species show, in varying degrees, the distinguishing characteristics of typical anomalous dicots. In each the embryo becomes pear-shaped before any indication of the cotyledonar primordium is apparent. The primordium of the cotyledons now appears as an almost complete, circular, ridge-like outgrowth from the margin of the broadly truncated end of the embryo. With the further growth of this ridge a bifurcation soon appears at a point exactly opposite the primary cleft of the primordium, so that the two young cotyledons, which may or may not be of the same size, seem to represent two separate and opposite lobes of the distal end of the embryo with one of the clefts a little deeper than the other. In some cases (Stylophorum) the two cotyledons seem to arise as separate and independent outgrowths, but a little later their common base grows faster on one side than on the other, and in this manner the two clefts or bifurcations become unequal in depth.

It is important to note, however, that in embryos of different individuals of the same species the anomalous character is much more strongly marked than in others.

On the Germination of Certain Native Weeds.

By Stanley Coulter.

(By title.)

Revised List of Indiana Plant Rusts.

By J. C. Arthur.

Five years ago a list of the plant rusts of Indiana was prepared, and printed in the Proceedings for 1898, to show not only how many and what species occur within the State, but the application of the revised nomenclature, to which great attention has been directed within the last decade. At that time the writer had made little study of the basis for the generic names, but accepted largely the conclusions announced by Kuntze in his *Revisio generum plantarum*. Since the presentation of the list, two other papers have been brought before the Academy by the writer, discussing the status of the genus names *Puccinia* and *Gymnosporangium*, the only considerable points in controversy touched by the Indiana list.

In order to embody the latest conclusions and reaffirm those remaining unchanged, as well as to correct a few errors and add the species brought to light since that list was issued, the writer presents herewith a revised list of the Indiana plant rusts. It is given in the latest nomenclature to familiarize the members of the Academy with this phase of scientific movement. It is not a nomenclature that can be generally used at present, for the reason that no standard works of reference are yet available employing the accepted names. But it does not materially detract from the usefulness of a local list, like the present one, and yet gives the reader a chance to see the direction in which the new movement is leading.

The present list, like the preceding one, does not include the unattached aecidia and uredo. Some thirteen of these that have been mentioned from time to time in the Proceedings of the Academy have been traced to their teleutosporic connections since the last revised list was published, and are here included as autonomous species. Besides these, eleven species of rusts have been added to the State flora, having never been reported in any form before. The hosts reported in this list for the first time are recorded by month, county and collector. The specimens, on which these data are based, are in the herbarium at Purdue University. The references after the other hosts are to the page and year of the Proceedings of the Academy, where additional information can be found. The nomenclature for hosts is that of Britton and Brown's "Illustrated Flora of the Northern States and Canada."

The present list contains 185 species of plant rusts under sixteen genera, being an increase of more than 33 per cent. over the previous list of 1898, which contained 80 species under ten genera.

COLEOSPORIACEÆ.

1. COLEOSPORIUM SONCHI-ARVENSIS (*Pers.*) *Wint.*
   On Hieracium scabrum Michx. Vigo Co., 5, 1893 (Underwood).
2. COLEOSPORIUM IPOMŒÆ (*Schw.*) *Bur.*
   On Ipomœa pandurata (L.) Mey. 1896:171, 218.
3. COLEOSPORIUM SOLIDAGINIS (*Schw.*) *Thuem.*
   On Aster azureus Lindl. 1893:50.
   On Aster cordifolius L. 1893:51.
   On Aster Novæ Angliæ L. 1893:51.
   On Aster paniculatus Lam. 1893:51.
   On Aster puniceus L. 1893:51.
   On Aster sagittifolius Willd. 1893:51.
   On Aster salicifolius Lam. 1893:51.
   On Aster Shortii Hook. 1893:51.
   On Aster Tradescanti L. 1893:51.
   On Solidago arguta Ait. 1893:51.
   On Solidago cæsia L. 1893:51.
   On Solidago Canadensis L. 1893:51.
   On Solidago flexicaulis L. (*S. latifolia* L.) 1893:51.
   On Solidago patula Muhl. 1893:51.
   On Solidago rugosa Mill. 1893:51.
   On Solidago serotina Ait. 1893:51.
4. COLEOSPORIUM VERNONIÆ *B. & C.*
   On Vernonia fasciculata Michx. 1893:51.
   On Vernonia Noveboracensis (L.) Willd. 1893:51.

MELAMPSORACEÆ.

5. CHRYSOMYXA ALBIDA *Kühn.* (*Coleosporium Rubi E. & H.*)
   On Rubus cuneifolius Pursh. 1893:50.
   On Rubus villosus Ait. 1893:50.

6. Pucciniastrum Agrimoniæ (*DC.*) *Diet.* (*Cæoma Agrimoniæ* Schw.)
On Agrimonia hirsuta (Muhl.) Bick. (*A. Eupatoria* Am. Auct.) 1893:50. 1896:218.
On Agrimonia parviflora Sol. 1893:50.

7. Thecopsora Hydrangeæ (*B. & C.*) *Magn.* (*Uredo Hydrangeæ* B. & C.)
On Hydrangea arborescens L. 1893:56. 1896:218.

8. Hyalopsora Polypodii (*Pers.*) *Magn.* (*Uredo Polypodii* DC.)
On Cystopus fragilis (L.) Bernh. 1893:56.

9. Melampsora Medusæ *Thuem.*
On Populus balsamifera L. 1893:51.
On Populus deltoides Marsh. (*P. monilifera* Ait.) 1893:51. 1896:218.
On Populus grandidentata Michx. 1893:51.
On Populus tremuloides Michx. 1893:51. 1898:188.

10. Melampsora farinosa (*Pers.*) *Schroet.*
On Salix amygdaloides Anders. Steuben Co , 8, 1903 (*Kellerman*).
On Salix cordata Muhl. 1893:51.
On Salix discolor Muhl. 1893:51. 1896:218.
On Salix fluviatilis Nutt. (*S. longifolia* Muhl.) 1893:52.
On Salix interior Rowl. Steuben Co., 8, 1903 (*Kellerman*).
On Salix nigra Marsh. 1893:51.

11. Melampsoridium betulinum (*Pers.*) *Kleb.*
On Betula lutea Michx. Steuben Co., 8, 1903 (*Kellerman*).

PUCCINIACEÆ.

12. Aregma disciflora (*Tode*) *Arth.* (*Phragmidium subcorticium* Wint.)
On Rosa Carolina L. 1893:52.
On Rosa humilis Marsh. (*R. lucida* Am. Auct.) 1893:52.
On Rosa setigera Michx. 1893:52.

13. Aregma Fragariæ (*DC.*) *Arth.*
On Potentilla Canadensis L. 1893:52. 1896:218.

14. Aregma speciosa *Fr.* (*Phragmidium speciosum* Cke.)
On Rosa Carolina L. 1896:219.
On Rosa humilis Marsh. 1898:179.

15. Triphragmium Ulmariæ (*Schum.*) *Lk.*
On Ulmaria rubra Hill. Tippecanoe Co., 6, 1899 (*Arthur*).

16. Gymnoconia interstitialis (*Schl.*) *Lagh.* (*Puccinia Peckiana* Howe and *Æcidium nitens* Schw.)
    On Rubus occidentalis L. 1893:54.
    On Rubus villosus Ait. 1893:54. 1896:220. 1898:188.

17. Cæomurus acuminatus (*Arth.*) *Kuntze.*
    On Spartina cynosuroides Willd. Jasper Co., 5, 1903 (*Arthur*); Steuben Co., 8, 1903 (*Kellerman*).

18. Cæomurus Caladii (*Schw.*) *Kuntze.* (*Uromyces Caladii* Farl.)
    On Arisaema triphyllum (L.) Torr. 1893:56. 1896:222. 1898:189.
    On Arisaema Dracontium (L.) Schott. 1893:56. 1896:222.

19. Cæomurus caryophyllinus (*Schr.*) *Kuntze.*
    On Dianthus Caryophyllus L. 1893:56.

20. Cæomurus Euphorbiæ (*Schw.*) *Kuntze.*
    On Euphorbia dentata Michx. 1893:57. 1896:222.
    On Euphorbia nutans Lag. (*E. hypericifolia* Gr.) 1893:57. 1896:222.
    On Euphorbia humistrata Engelm. Tippecanoe Co., 6, 1902 (*Arthur*).

21. Cæomurus Solidagini-Caricis (*Arth.*) *nom. nov.*
    On Carex lanuginosa Michx. Jasper Co., 3, 1903 (*Arthur*).
    On Carex varia Muhl. Jasper Co., 3, 1903 (*Arthur*).

22. Cæomurus graminicolus (*Burr.*) *Kuntze.*
    On Panicum virgatum L. 1893:57.

23. Cæomurus Howei (*Pk.*) *Kuntze.*
    On Asclepias incarnata L. 1893:57. 1896:222.
    On Asclepias purpurascens L. 1893:57.
    On Asclepias Syriaca L. (*A. Cornuti* Dec.) 1893:57. 1896:222. 1898:187.

24. Cæomurus Hedysari-paniculati (*Schw.*) *Arth.*
    On Meibomia Canadensis (L.) Kuntze (*Desmodium C.*). 1896:222.
    On Meibomia canescens (L.) Kuntze (*Desmodium c.*). 1893:57.
    On Meibomia Dillenii (Darl.) Kuntze (*Desmodium D.*). 1893:57. 1896:222.
    On Meibomia laevigata (Nutt.) Kuntze (*Desmodium l.*). 1893:57.
    On Meibomia paniculata (L.) Kuntze (*Desmodium p.*). 1893:57.
    On Meibomia viridiflora (L.) Kuntze (*Desmodium v.*). 1893:57.

25. Cæomurus Hyperici-frondosi (*Schw.*) *Arth.*
On Hypericum Canadense L. 1893:57.
On Hypericum mutilum L. 1893:57.
On Triadenum Virginicum (L.) Raf. (*Elodea campanulata* Marsh.) 1893:57.

26. Cæomurus Junci (*Schw.*) *Kuntze.*
On Juncus tenuis Willd. 1896:222. 1898:187.

27. Cæomurus Lespedezæ-procumbentis (*Schw.*) *Arth.*
On Lespedeza frutescens (L.) Brit. (*L. reticulata* Pers.) 1893:57.
On Lespedeza procumbens Michx. 1893:57.
On Lespedeza repens (L.) Bart. 1896:222.
On Lespedeza capitata Michx. Jasper Co., 3, 1903 (*Arthur*).
On Lespedeza hirta (L.) Ell. Marshall Co., 10, 1893 (*Underwood*).

28. Cæomurus Orobi (*Pers.*) *nom. nov.*
On Vicia Americana Muhl. 1896:222.

29. Cæomurus perigynius (*Halst.*) *Kuntze.*
On Carex virescens Muhl. 1893:57.

30. Cæomurus Phaseoli (*Pers.*) *Arth.*
On Strophostyles helvola (L) Brit. (*Phaseolus diversifolius* Pers.) 1893:56. 1896:172, 222.
On Vigna Sinensis (L.) Endl. Tippecanoe Co., 10, 1903 (*Arthur*).

31. Cæomurus plumbarius (*Pk.*) *Kuntze.* (*Uredo gaurina* (Pk.) DeT.)
On Gaura biennis L. 1896:222.

32. Cæomurus Polygoni (*Pers.*) *Kuntze.*
On Polygonum aviculare L. 1893:57. 1896:223.
On Polygonum erectum L. 1893:58.

33. Cæomurus Rudbeckiæ (*Arth. & Holw.*) *Kuntze.*
On Rudbeckia laciniata L. 1894:152. 1898:187.

34. Cæomurus Trifolii (*Hedw.*) *Gray.*
On Trifolium hybridum L. 1893:58.
On Trifolium medium L. 1893:58.
On Trifolium pratense L. 1893:58. 1896:223. 1898:187, 189.
On Trifolium repens L. 1893:58.

35. Cæomurus Rhyncosporæ (*E. & G.*) *Kuntze.*
On Rhyncospora alba Vahl. Tippecanoe Co., 10, 1894 (*King*).

36. Dicæoma albiperidium (*Arth.*) *nom. nov.*
On Carex pubescens Muhl. Tippecanoe Co., 4, 1901 (*Arthur*).

37. DICÆOMA Aletridis (*B. & C.*) *Kuntze.*
On Aletris farinosa L. Lake Co., 7, 1884 (*Hill*).

38. DICÆOMA AMBIGUA (*A. & S.*) *Kuntze.*
On Galium Aparine L. 1896:172.

39. DICÆOMA ANDROPOGONIS (*Schw.*) *Kuntze.* (*Puccinia Andropogi* Schw.)
On Andropogon furcatus Muhl. 1896:219.
On Andropogon scoparius Michx. 1896:219.
On Pentstemon hirsutus (L.) Willd. 1896:217.

40. DICÆOMA ANEMONES-VIRGINIANÆ (*Schw.*) *Arth.* (*Puccinia solida* Schw.)
On Anemone cylindrica Gr. 1896:219.
On Anemone Virginiana L. Tippecanoe Co., 6, 1903 (*Arthur*); Steuben Co., 8, 1903 (*Kellerman*).

41. DICÆOMA ANGUSTATUM (*Pk.*) *Kuntze.*
On Eriophorum polystachyon L. Noble Co., 8, 1884 (*Van Gorder*).
On Eriophorum Virginicum L. Noble Co., 8, 1884 (*Van Gorder*).
On Scirpus atrovirens Muhl. 1893:52. 1896:219.
On Scirpus cyperinus (L.) Kunth. 1893:52.
On Lycopus Americanus Muhl. (*L. sinuatus* Ell.) 1898:189.

42. DICÆOMA APOCRYPTUM (*E. & Tr.*) *Kuntze.*
On Hystrix Hystrix (L.) Millsp. 1893:52.

43. DICÆOMA ARGENTATUM (*Schultz*) *Kuntze.*
On Impatiens biflora Walt. (*I. fulva* Nutt.) 1893:52. 1896:220.

44. DICÆOMA ASPARAGI (*DC.*) *Kuntze.*
On Asparagus officinalis L. Lake Co., 10, 1899 (*Breyfogle*); Fountain Co., 9, 1900 (*Beatty*); Tippecanoe Co., 3, 1901 (*Arthur*); Steuben Co., 8, 1903 (*Kellerman*).

45. DICÆOMA ASPERIFOLII (*Pers.*) *Kuntze.* (*Puccinia Rubigo-vera* (DC.) Wint.)
On Avena sativa L. 1893:55.
On Secale cereale L. 1896:221.

46. DICÆOMA ASTERIS (*Duby*) *Kuntze.*
On Aster cordifolius L. 1893:52.
On Aster lateriflorus (L.) Brit. (*A. diffusus* Ait.) 1896:219.
On Aster paniculatus Lam. 1893:52.

47. DICÆOMA CANALICULATA (*Schw.*) *Kuntze.* (*Puccinia nigrovelata* E. & T. and *P. indusiata* D. & H.)
On Cyperus strigosus L. 1893:53, 54. 1894:154, 157. 1896:219, 220.

48. DICÆOMA CARICIS-ASTERIS (*Arth.*) *nom. nov.*
On Aster cordifolius L. 1893:49.
On Aster Drummondii Lindl. Tippecanoe Co., 5, 1901 (*Arthur*).
On Aster paniculatus Lam. Tippecanoe Co., 5, 1901 (*Arthur*).
On Aster sagittifolius Willd. 1893:49.
On Carex cephalophora Muhl. Tippecanoe Co., 6, 1902 (*Arthur*).
On Carex fœnia Willd. Tippecanoe Co., 4, 1901 (*Arthur*).

49. DICÆOMA CARICIS-ERIGERONTIS (*Arth.*) *nom. nov.*
On Erigeron annuus L. 1894:151.
On Erigeron ramosus (Walt.) B. S. P. Jasper Co., 6, 1903 (*Arthur*).
On Leptilon Canadense (L.) Britt. Jasper Co., 6, 1903 (*Arthur*).
On Carex festucacea Willd. Tippecanoe Co., 4, 1901 (*Arthur*).
On Carex straminea Willd. 1893:52.

50. DICÆOMA CARICIS-SOLIDAGINIS (*Arth.*) *nom. nov.*
On Solidago cæsia L. 1893:49.
On Solidago Canadensis L. 1893:49.
On Solidago flexicaulis L. (*S. latifolia* L.) 1893:49.
On Solidago patula Muhl. Tippecanoe Co., 6, 1902 (*Arthur*).
On Carex Jamesii Schw. Tippecanoe Co., 4, 1902 (*Arthur*).
On Carex tetanica Schk. Tippecanoe Co., 6, 1899 (*Arthur*).

51. DICÆOMA CHRYSANTHEMI (*Roze*) *nom. nov.*
On Chrysanthemum Indicum L. Tippecanoe Co., 10, 1899 (*Dorner*).

52. DICÆOMA CIRCÆÆ (*Pers.*) *Kuntze.*
On Circæa Lutetiana L. 1893:53. 1896:219.

53. DICÆOMA CONVOLVULI (*Pers.*) *Kuntze.*
On Convolvulus sepium L. 1893:53. 1896:219.

54. DICÆOMA DAYI (*Clint.*) *Kuntze.*
On Steironema ciliatum (L.) Raf. 1893:53.

55. DICÆOMA DULICHII (*Syd.*) *nom. nov.*
On Dulichium arundinacea (L.) Brit. 1893:52.

56. DICÆOMA EATONIÆ (*Arth.*) *nom. nov.*

On Eatonia Pennsylvanica (DC.) Gray. Tippecanoe Co., 5, 1903 (*Arthur*).

On Ranunculus abortivus L. 1893:50.

57. DICÆOMA ELEOCHARIDIS (*Arth.*) *Kuntze.*

On Eleocharis palustris (L.) R. & S. 1893:53. 1896:219.

58. DICÆOMA ELLISIANUM (*Thuem.*) *Kuntze.*

On Andropogon scoparius Michx. Tippecanoe Co., 11, 1898 (Stuart).

59. DICÆOMA EMACULATUM (*Schw.*) *Kuntze.*

On Panicum capillare L. 1893:53. 1896:220.

60. DICÆOMA EPIPHYLLUM (*L.*) *Kuntze.* (*Puccinia Poarum* Niels.)

On Poa pratensis L. 1893:57. 1898:189.

61. DICÆOMA FUSCUM (*Pers.*) *Kuntze.*

On Anemone quinquefolia L. (*A. nemorosa* Mx.) 1894:151.

62. DICÆOMA HELIANTHI (*Schw.*) *Kuntze.*

On Helianthus annuus L. 1893:55.

On Helianthus divaricatus L. 1893:55.

On Helianthus giganteus L. Steuben Co., 8, 1903 (*Kellerman*).

On Helianthus grosse-serratus Mart. 1893:55. 1896:221.

On Helianthus mollis Lam. Jasper Co., 3, 1903 (*Arthur*).

On Helianthus strumosus L. 1893:55.

On Helianthus tracheliifolius Mill. 1893:55.

63. DICÆOMA HELIOPSIDIS (*Schw.*) *Kuntze.*

On Heliopsis scabra Dunal. 1893:54.

64. DICÆOMA MUHLENBERGIÆ (*A. & H.*) *nom. nov.*

65. DICÆOMA WINDSORIÆ (*Schw.*) *Kuntze.*

On Sieglingia seslerioides (Mx.) Scrib. (*Triodia cuprea* Jacq.) 1894:154. 1896:221.

On Ptelea trifoliata L. 1893:50. 1896:217.

On Muhlenbergia diffusa Schreb. 1893:53, 55.

On Muhlenbergia sylvatica Torr. 1896:221.

66. DICÆOMA IMPATIENTIS (*Schw.*) *nom. nov.*

On Elymus Virginicus L. 1893:55. 1896:221.

On Impatiens biflora Walt. (*I. fulva* Nutt.) 1893:50.

On Impatiens aurea Muhl. 1896:217.

67. Dicæoma kuhniæ (*Schw.*) *Kuntze.*
On Kuhnia eupatorioides L. 1893:54. 1896:220.

68. Dicæoma lateripes (*B. & R.*) *Kuntze.*
On Ruellia strepens L. 1893:54. 1896:218.

69. Dicæoma Lobeliæ (*Ger.*) *nom. nov.*
On Lobelia syphilitica L. 1893:54. 1896:220.

70. Dicæoma ludibundum (*E. & E.*) *Kuntze.*
On Carex sparganioides Muhl. 1896:220.

71. Dicæoma Majanthæ (*Schum.*) *nom. nov.*
On Phalaris arundinacea L. Tippecanoe Co., 10, 1889 (*Stuart*).

72. Dicæoma Melicæ (*Syd.*) *nom. nov.*
On Melica diffusa Pursh. Tippecanoe Co., 10, 1899 (*Stuart*).

73. Dicæoma Menthæ (*Pers.*) *Gray.*
On Blephilia hirsuta (Pursh.) Torr. 1893:54. 1896:220.
On Cunila origanoides (L.) Brit. 1893:54.
On Mentha Canadensis L. 1893:54.
On Monarda fistulosa L. 1893:54. 1896:220.
On Koellia pilosa (Nutt.) Brit. 1893:54.
On Koellia Virginiana (L.) MacM. 1893:54. 1896:220.

74. Dicæoma obtectum (*Pk.*) *Kuntze.*
On Scirpus lacustris L. 1894:151.

75. Dicæoma Pammelii (*Trel.*) *nom. nov.* (*Puccinia Panici* Diet. and *Æcidium Pammelii* Trel.)
On Panicum virgatum L. 1901:283.
On Euphorbia corollata L. 1893:49. 1901:284.

76 Dicæoma Peckii (*De T.*) *nom. nov.*
On Carex cephalophora Muhl. Tippecanoe Co., 6, 1902 (*Arthur*).
On Carex stipata Muhl. Tippecanoe Co., 6, 1902 (*Arthur*).
On Carex trichocarpa Muhl. Tippecanoe Co., 11, 1901 (*Arthur*).
On Onagra biennis (L.) Scop. 1893:50. 1896:217.

77. Dicæoma Physostegiæ (*P. & C.*) *Kuntze.*
On Physostegia Virginiana (L.) Benth. 1894:151. 1896:220.

78. DICAEOMA POCULIFORME (*Jacq.*) *Kuntze.* (*Puccinia graminis* Pers. and *Aecidium Berberidis* Pers.)

On Agrostis alba L. Steuben Co., 8, 1903 (*Kellerman*).

On Avena sativa L. 1893:53. 1896:220.

On Berberis vulgaris L. 1893:49.

On Cinna arundinacea L. Tippecanoe Co., 4, 1901 (*Arthur*).

On Dactylis glomerata L. 1896:220, 223.

On Hordeum jubatum L. 1896:220, 224.

On Poa compressa L. 1893:53.

On Poa pratensis L. 1893:53.

On Triticum vulgare L. 1893:54. 1898:188.

79. DICAEOMA PODOPHYLLI (*Schw.*) *Kuntze.*

On Podophyllum peltatum L. 1893:54. 1896:221. 1898:189.

80. DICAEOMA POLYGONI-AMPHIBII (*Pers.*) *Arth.*

On Geranium maculatum L. 1893:49. 1896:217. 1898:188.

On Polygonum emersum (Mx.) Brit. (*P. Muhlenbergii* Wats.) 1893:55.

On Polygonum hydropiperoides Michx. 1898:184. 1898:189.

On Polygonum lapathifolium L. 1898:184.

On Polygonum Pennsylvanicum L. 1898:184.

On Polygonum punctatum Ell. (*P. acre* H. B. K.) 1893:55, 57.

81. DICAEOMA POLYGONI-CONVOLVULI (*Hedw.*) *Arth.*

On Polygonum Convolvulus L. 1898:184.

On Polygonum scandens L. 1896:223.

On Polygonum Hartwrightii Gray. Steuben Co., 8, 1903 (*Kellerman*).

82. DICAEOMA PRENANTHIS. (*Pers.*) *Kuntze.*

On Nabalus albus (L.) Hook. 1893:55. 1896:221.

83. DICAEOMA PUNCTATUM (*Str.*) *nom. nov.*

On Galium asprellum Michx. 1893:53.

On Galium concinnum T. & G. 1893:53.

On Galium triflorum Michx. 1893:53.

84. DICAEOMA PUSTULATUM (*Curt.*) *nom. nov.*

On Andropogon furcatus Muhl. Jasper Co., 6, 1903 (*Arthur*).

On Andropogon scoparius Michx. Jasper Co., 3, 1903 (*Arthur*).

On Comandra umbellata (L.) Nutt. 1893:50.

85. DICÆOMA RANUNCULI (*Seym.*) *Kuntze.*
On Ranunculus septentrionalis Poir. 1893:55.

86. DICÆOMA RHAMNI (*Gmel.*) *Kuntze.* (*Puccinia coronata* Cda. and *Æcidium Rhamni* Gmel.)
On Avena sativa L. 1896:219. 1898:189.
On Calamagrostis Canadensis (Mx.) Beauv. 1893:53.
On Rhamnus lanceolata Pursh. 1898:184.

87. DICÆOMA SAMBUCI (*Schw.*) *nom. nov.* (*Puccinia Bolleyana* Sacc.)
On Carex lurida Wahl. 1893:52.
On Carex Frankii Kunth. 1893:55. 1898:187.
On Carex trichocarpa Muhl. 1893:52. 1896:219.
On Sambucus Canadensis L. 1893:50.

88. DICÆOMA SANICULÆ (*Grev.*) *Kuntze.*
On Sanicula Canadensis L. 1893:55.

89. DICÆOMA SILPHII (*Schw.*) *Kuntze.*
On Silphium sp. 1893:55.
On Silphium integrifolium Michx. Tippecanoe Co., 8, 1901 (*Dorner*).

90. DICÆOMA SORGHI (*Schw.*) *Kuntze.*
On Zea Mays L. 1893:54. 1898:188.

91. DICÆOMA TARAXACI (*Plowr.*) *Kuntze.*
On Taraxacum Taraxacum (L.) Karst. 1893:53. 1896:219. 1898:188.

92. DICÆOMA TENUE (*Burr.*) *Kuntze.*
On Eupatorium ageratoides L. 1893:55. 1896:221.

93. DICÆOMA THALICTRI (*Chev.*) *Kuntze.*
On Thalictrum dioicum L. 1893:55.

94. DICÆOMA URTICÆ (*Schum.*) *Kuntze.* (*Puccinia Caricis* Reb. and *Æcidium Urticæ* Schum.)
On Carex riparia Curt. Steuben Co., 8, 1903 (*Kellerman*).
On Carex stricta Lam. Tippecanoe Co., 4, 1901 (*Arthur*); Steuben Co., 8, 1903 (*Kellerman*).
On Urtica gracilis Ait. 1898:185.

95. DICÆOMA VERBENICOLA (*E. & K.*) *nom. nov.* (*Puccinia Vilfæ* A. & H.)
On Sporobolus longifolius (Torr.) Wood. 1896:221.
On Verbena stricta Vent. 1896:218.

96. DICÆOMA VERNONIÆ (*Schw.*) *Kuntze.*
On Vernonia fasciculata Michx. 1893:55.

97. DICÆOMA VEXANS (*Farl.*) *Kuntze.*
On Bouteloua curtipendula (Michx.) Torr. 1901:283

98. DICÆOMA VIOLÆ (*Schum.*) *Kuntze.*
On Viola obliqua Hill (*V. cucullata* Ait.). 1893:56.
On Viola striata Ait. 1893:56.
On Viola pubescens Ait. Decatur Co., 5, 1889 (*Arthur*); Tippecanoe Co., 4, 1898 (*Arthur*).

99. DICÆOMA VULPINOIDIS (*D. & H.*) *Kuntze.*
On Carex vulpinoidea Michx. 1893:56. 1896:221.

100. DICÆOMA XANTHII (*Schw.*) *Kuntze.*
On Ambrosia trifida L. 1893:56. 1896:222.
On Xanthium Canadense Mill. 1893:56. 1896:222.
On Xanthium strumarium L. 1893:56.

101. GYMNOSPORANGIUM GLOBOSUM *Farl.* (*Rœstelia lacerata* Fr.)
On Crataegus coccinia L. 1893:56.
On Crataegus Crus-Galli L. 1894:153.
On Crataegus mollis (T. & G.) Scheele. (*C. subvillosa* T. & G.) 1898:186. 1898:188.
On Crataegus punctata Jacq. 1893:56.
On Juniperus Virginiana L. 1893:51.

102. GYMNOSPORANGIUM JUNIPERI-VIRGINIANÆ *Schw.* (*Rœstelia pyrata* Thax.)
On Malus coronaria (L.) Mill. (*Pyrus coronaria* L.) 1893:56. 1896:218.
On Malus Malus (L.) Brit. (*Pyrus Malus* L.) 1898:186. 1901:255.
On Pyrus communis L. 1893:56.
On Juniperus Virginiana L. 1893:51. 1896:218. 1901:255.

103. JACKYA CNICI (*Mart.*) *nom. nov.* (*Puccinia Cirsii-lanceolati* Schroet.)
On Carduus lanceolatus L. 1893:53.

104. PILEOLARIA BREVIPES *B. & Br.*
On Rhus radicans L. (*R. Toxicodendron* Am. Auct.) 1893:58 1896:223.

105. UROPYXIS AMORPHÆ (*Curt.*) *Schroet.*
On Amorpha canescens Pursh. 1893:58.

Additions to the List of Gall-Producing Insecta Common to Indiana.

By Mel T. Cook.

One year ago the writer presented a list of gall-producing insects, with a list of host plants, for the State of Indiana. This list is no doubt very incomplete, since the writer has collected specimens in Illinois and Ohio which have not been reported from Indiana. Furthermore, this collection of galls which I have received from other parts of the United States and Canada lead me to believe that galls have a very wide distribution; it is probable that the galls are distributed over as wide an area as the host species and, in some cases, are as widely distributed as the host genera. However, the insects may in some cases be restricted to smaller areas, due to other environments. Our knowledge of American galls is at present so limited that it is impossible to draw any definite conclusion on this subject.

Within the past year I have collected a large number of galls in Illinois, Indiana, and Ohio, but, of course, many of these duplicate those reported in the list of one year ago. I have also received collections from various parts of the United States and Canada, and wish especially to thank Mr. F. L. Sims, of Laporte, Indiana, Mr. C. C. Deam, of Bluffton, Indiana, and Prof. W. A. Kellerman, of Columbus, Ohio, for interesting collections of Indiana galls.

The additional list which I now present gives an increase of two genera and eleven species of insecta.

Hemiptera:

41. Pemphigus populis-caulis, Riley, on Populus deltoides Marsh.
42. Pemphigus populis-transversus, Riley, on Populus deltoides Marsh.

Diptera:

43. Sciara ocellaris, O. S., on Acer saccharium L.
44. Cecidomyia holotricha, O. S., on Hicoria alba L. (Britton.)
45. Cecidomyia tubicola, O. S., on Hicoria alba L. (Britton.)

Hymenoptera:

46. Amphibolips sculpta Bass. on Quercus rubra L.

47. Andricus femoratus Ashm. on Quercus rubra L.

48. Andricus lana Fitch. on Quercus rubra L.

49. Diastrophus nebulosus O. S. on Rubus villosus Ait.

50. Diastrophus cuscutæformis O. S. on Rubus nigrobaccus Bailey.

51. Rhodites dichlocerus Harris. on Rosa sp ——.

Nos. 41 and 42 were collected in Wells County, Indiana, by C. C. Deam; Nos. 46 and 47 were collected near Laporte, Indiana, by F. L. Sims; No. 50 was collected in Steuben County, Indiana, by Prof. W. A. Kellerman, of the Ohio State University. All others were collected by me near Greencastle, Indiana.

No. 12, Trypeta solidaginis of the last report should have been placed under the order Diptera.

I should very much appreciate collections of galls from various parts of Indiana.

Nerve-End Organs in the Pancreas.

By E. O. Little.

The following is an abstract of work done to determine the number, position, and distribution of the Pacinian corpuscles in the pancreas of the cat. Mr. F. C. Jackson sectioned the material and counted the corpuscles.

	Cubic Centimeters of Pancreas.	Number of Pacinian Corpuscles in Pancreas	Number of Pacinian Corpuscles per c. c.
Pancreas, No. I. .	10 5	72	6.85
" No. II. .	12	43	3.58
" No. III	5 5	25	4.54
" No. IV	5	22	4 4
" No. V	7	85	12 14

Average number of corpuscles in pancreas 49.4, average number of corpuscles in per cubic centimeter of pancreas 6.17.

Ninety-five per cent. of the corpuscles are near the surface of the gland and may be stripped off with the mesentary; 5% are deep in the gland tissue. Of the 95% found near the surface, 28% were near dorsal, 72% near the ventral surface. Only occasionally was a corpuscle found in contact with the intestine.

A Crow Roost Near Richmond, Indiana.

By D. W. Dennis and Wm. E. Lawrence.

What is said in this paper about crows and their roosting is based upon observations taken by Professor Dennis and myself of one particular roost found about three miles south of Richmond, Indiana.

Through the latter part of January, 1903, crows were noticed flying in a direction about south by east in the evening and returning from the same direction in the morning. The evening flight was from 3 to 5:30; the crows were in flocks of from two or three or in a constant stream. The principal line of flight was about one-half mile west of Richmond. By actual count crows passed at the rate of one hundred or more in a minute for more than two hours. They were often so numerous it was impossible to count them. Judging from this there must have been at least 15,000 crows which roosted at this place. By 7 o'clock in the morning nearly every crow had returned from the roost on its way to cornfields, etc., in search of food.

Not far west of Richmond, in a small woodland, they stopped to rest or for some other reason. I have seen crows here by the thousand. It was here at this resting station that very evident exemplification was noted of their fear of man and their signaling to others following. I entered the woods and climbed a tree in order to watch better their maneuverings; however, they were not so kind and not one flew over the tree in which I was stationed. Repeatedly they flew at top speed in a line directly overhead but always, on discovering my presence, made a quick turn, uttered a peculiar call and passed around. This call evidently was a signal for those following to fly in like manner, because for the next few minutes the line passed to one side. Then some crow, not noting the signal, would appear coming directly towards me; but he never failed to make the sudden turn, utter the call and fly around.

This is more clearly brought out by "Driving the line." It was only necessary to walk in a railroad cut under a line of flying crows and it would bend around at a greater distance, the crows at the bend all the while signaling to those behind. In this manner on one occasion Professor Dennis drove them one-half mile to the west after which they passed on the east. On his return he in like manner drove them an equal distance to the east.

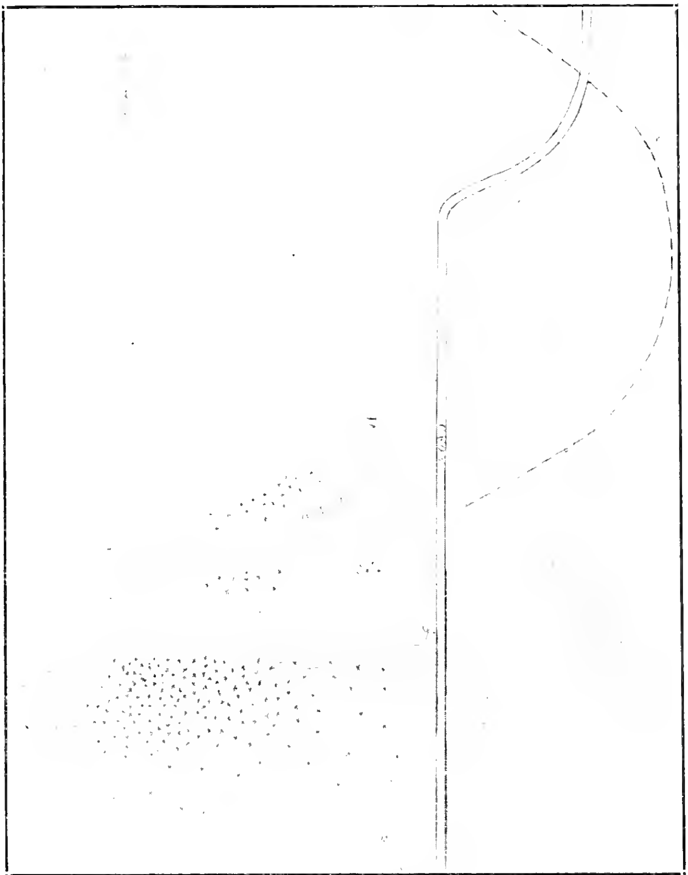
For some reason the crows never went directly to the roost. Whether it was done purposely to conceal the real roost can not be stated. However, they deceived us in this manner and caused us much trouble to find the roost. Three visits were made to the vicinity, two at night and one in the day time. The first visit, February 21st, they were found in a wood and an adjoining cornfield along a small stream of water. As we approached they preceded us. Approaching as quietly as possible, we stopped by a large tree and remained quiet, thinking we might be in the midst of the roost. Gradually all left; meanwhile scouts had been sent to watch us. They would fly directly overhead and then return to give information to the others. The roost was yet to be found. We went to the top of a neighboring hill and saw in the darkness several hundred feet beyond thousands of crows on the snow-covered ground. We could not approach without disturbing them. We did not remain till they went to the trees.

The next time was February 23d, from 6 to 6:30 p. m. We now found all the crows in the trees, most of them across the river from the place where we first saw them, in a large wood, the others in the sycamores along the river quite a distance from the main roost. They must have been doing picket duty, because they uttered no cries, while the others were constantly cawing; also when we purposely disturbed them some of them left silently to join the others.

The last visit, March 2d, was in the day time; the ground was carefully gone over; the boundaries were easily determined by the droppings, examination of which gave good evidence that they were eating a great deal of corn.

The main roost was located on the north side of a hill, 120 feet high, thickly wooded with beech, elm, and ash, and near the foot of this hill. Reference to the map will show that the roost was located in a gorge shut in by hills 90 feet high on the east, 50 feet high on the north and west, and, as before mentioned, 120 feet high on the south. A public road runs north and south to the east of the roost, and, as would be expected, the ground gave evidence of more crows roosting some distance from the road.

This particular hill was only used during the coldest weather; at other times the crows moved about from place to place for their roost. The hill



MAP OF VALLEY OF CROW ROOST.

∴∵ Indicates roosting crows.
------ Indicates path of crows entering the valley.
Contour lines 10 ft. apart.

and the elevation of the surrounding land (as shown in the map) certainly furnished protection against the cold.

The crows began to arrive about 4 p. m., alighting in the neighboring trees and along the river bank, drinking water and picking pebbles. The main line seemed to arrive from the northeast and from no other direction. But, to our surprise, on our way home after leaving the valley, it was discovered that the crows from the northwest were flying southeast on a tangent with the valley and alighting in the trees and fields to the east; then turning at almost right angles they flew over the hill down into the valley where the roost was. Was this purposely done for protection?

In conclusion the main things to be noted are the bending of the line when men are seen; the signaling of danger to the oncoming line; that the crows never approached the roost directly and that they only roosted on the hillside during the coldest weather.

Some New Forms of Physiological Apparatus.

By J. F. Woolsey.

All branches of scientific work require special apparatus to fulfill their particular needs. The apparatus here shown was devised to meet certain requirements for adjustable apparatus, for use with the kymograph, in recording physiological experiments. It is apparently desirable in this work to have as many adjustments to the apparatus as possible, the solidity of the apparatus being unimpaired.

ADJUSTABLE STAND.

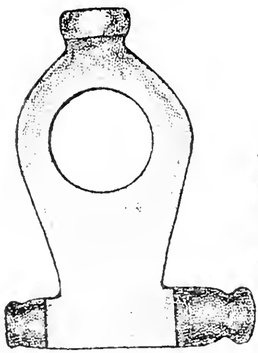
This stand consists of a base 5½"x8"x1"; a standard 18" high and 1" in diameter, to which is attached, by means of arms, the swinging rod upon which is supported, by means of universal clamps, the various forms of apparatus used in making the records upon the smoked drum of the kymograph. The entire stand weighs 15 pounds.

The swinging portion of the apparatus deserves special notice. Figure 2 of the mechanical parts serves as the top arm, and the upper plate of the lower arm. It is 3½" long and 1⅝" wide at the broadest part. Figure 1 is the lower plate of the lower arm, and is proportional in size to the upper plate. Figures 3 and 4 show the entire mechanism. In Figure 3, (a) is the coarse adjustment, and by releasing the set-screw the swinging rod (d) can be revolved about the standard (e); the desired pressure of the stylus against the drum of the kymograph is obtained by the manipulation of the more finely-threaded screw (b). In Figure 4, (b) represents the fine adjusting screw, and (f) the strong coiled spring, which operates the swinging rod attached to (g), as shown in Figure 3. The swinging rod is 14" long.

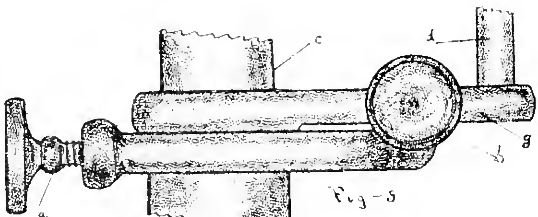
The University of Pennsylvania uses adjustable stands, devised and made by themselves, but the entire movement of the swinging rod is obtained from the bottom, and the mechanism is entirely different from the above. Credit is due Mr. R. P. Hobbs for his assistance in devising the mechanical parts.

FROG TABLES.

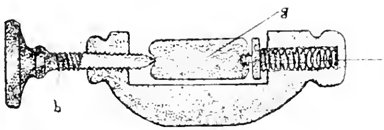
These tables are modifications of those used in the University of Pennsylvania, and meet certain requirements better. They consist, Figure 6, of a brass plate 4½"x8", to which is glued a single piece of cork ½" thick, and the adjustable arm or support. The adjustable part consists of a brass block (c) which slides upon the square rod (e), the set-screw (b), and has a horizontal play of 4½". The set-screw (a) allows of a further circular movement of the plate, and the square supporting arm is held to the stand by a universal clamp.



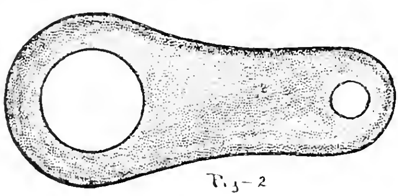
Fig—1



Fig—5



Fig—4



Fig—2

Mechanical Parts of Adjustable Stand.

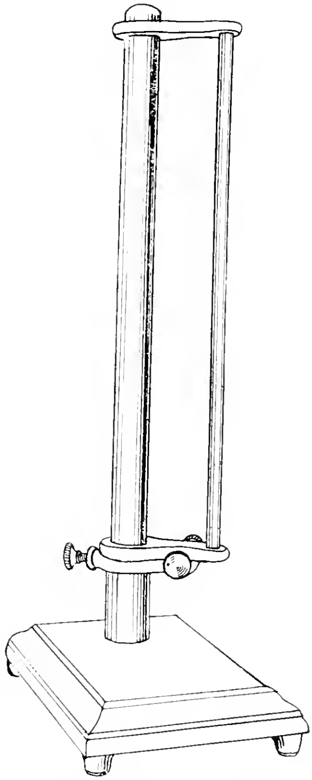


Fig. 5. Adjustable Stand.

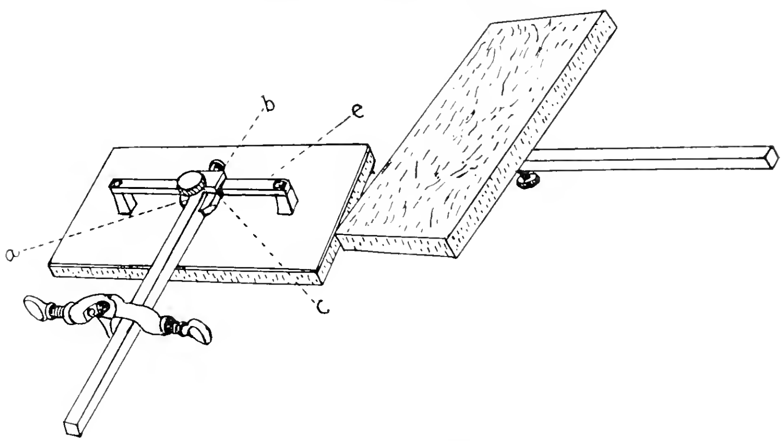


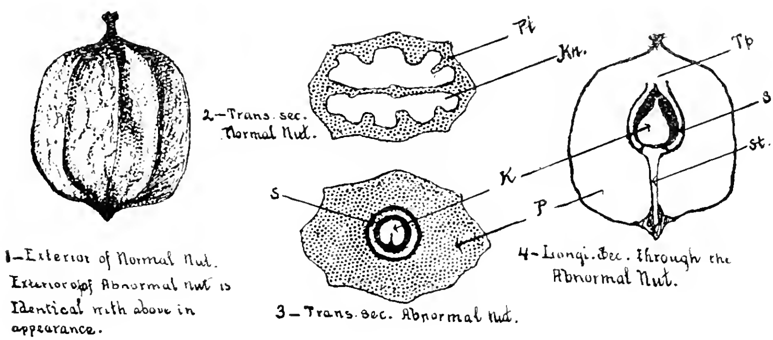
Fig. 6. Frog Tables.

An Abnormality in the Nut of Hicoria Ovata (Mill) Britton.

By John S. Wright.

The abnormal hickory nut figured and described here was one of a lot purchased in the market. In all outward appearances it was normal, the peculiarities were noted in cracking it. Fig. 2, a transverse section of a normal nut, shows the relative proportion of shell and seed. Fig. 3, transverse section of the abnormal fruit, shows the cavity one-celled and greatly reduced by the thickened walls (P). Figs. 3 and 4 show the interior filled with a nut somewhat like that of the hazel; (s) the walls hard and shell-like, and (K) the kernel, folded as indicated by the convolution on one side. The kernel had a bland, oily taste, faintly resembling that of the hazel nut. At the apex the tissues of the shell of this smaller nut appear to be continuous with those of the outer shell (Tp). The inner nut had a pedicel, indicated (st) in the figure. In cracking, this pedicel separated from the body of the small nut along a definite line. The shaft of this pedicel reached through the thick outer shell and readily separated from the surrounding tissues.

In view of the fact that the hickory nut is not extensively cultivated and apparently has not been observed hybridizing to any extent, or otherwise modified by breeding, the occurrence of this deviation from the type is deemed worthy of notice.



Bird Nests of an Old Apple Orchard Near Indiana University Campus.*

By Gertrude Hitze.

As part of my work in Nature Study during the Spring of 1902 I was assigned an old orchard east and north of Indiana University Campus. My work was to locate and report on all of the birds' nests of this orchard.

As a preliminary a plot was made of the orchard. The rows of trees were numbered serially from 1 to 22, and the individual trees in each row were also numbered. The orchard was thoroughly searched for nests between the latter part of April and the early part of June. The exact location of the nests is omitted in this report.

From an ethical and sentimental standpoint the work was very discouraging. Two-thirds of the nests were not completed or were destroyed in different ways. In all, 24 nests were found, and 18 of these came to grief in one way or another, as the report will show.

The report will be of interest as showing the vicissitudes of birds near a town, and the expense at which birds become and remain adapted to their environment.

TURTLE DOVE.

May 21st I found a nest loosely made of twigs, lined with hay and feathers, and containing two pure white eggs. May 23d this nest was robbed and destroyed. The old birds were flying about the orchard. On June 2d I saw no doves in the orchard.

CHIPPING SPARROW.

May 21st I found a little nest under a grapevine. It was built of dry grasses and lined with horsehair. The nest was built in a little hole in the ground. It contained one white egg with many brown

*Contributions from the Zoölogical Laboratory of Indiana University. No. 61.

spots. May 23d this nest had been robbed like so many others. The nest was not destroyed but the birds never returned.

May 23d I found a nest under another grapevine. The nest had four eggs in it. Two of the eggs were pipped. June 2d four little birds were in the nest, one of them with a lady beetle in its mouth. June 4th, birds almost feathered. They seemed not to be afraid of me as I drew near them. The mother did not go far from the nest as long as I was near. June 8th, the birds have flown. There were *six* little birds hopping about in a tree near the deserted nest.

SONG SPARROW.

May 23d, along the north fence I found a nest in a grapevine, nicely hidden among the leaves. The nest was made of twigs lined with dry grass. There was one white egg, spotted with heavy brown spots. June 2d, two eggs were in the nest. No bird was near at this time. June 4th, the nest had been robbed but not destroyed. No birds were near.

WHITE-THROATED SPARROW.

On April 30th I found a White-throated Sparrow building a nest in a brush heap. The bottom of the nest was finished and made of twigs. Every time the Sparrow carried any material to the nest a Catbird would fly down and take it away. The Catbird fought and chased the Sparrows until they left the nest unfinished.

HOUSE WREN.

May 21st, in the southeast corner of a shed I found a nest in the old woodwork. The nest was made of dry roots lined with chicken and turkey feathers. There were seven young almost feathered and nearly ready to fly. May 23d, the birds have flown.

CRESTED FLYCATCHER.

May 7th I saw two Crested Flycatchers flying around an old tree. They were building a nest, for one carried a feather, while the other flew at me whenever I came near them. I was unable to find their nest. May 9th I looked again for the nest but was unable to find it. May 21st I found the nest in a hole in the old tree. It was in a dead limb at a depth of about twelve inches from the opening. It was lined with feathers. There were five light eggs with heavy brown markings, especially at the large end. May 23d, no change in the nest. The birds were near. June 2d, five little birds were in the nest. June 9th, birds are just ready to leave the nest. June 11th, birds have flown.

BROWN THRASHERS.

I found a nest in a brush pile on April 23d. The nest was made of twigs lined with dry grass There were three eggs with brown specks, more spots at the large end. On April 30th the nest had been robbed and no birds were near.

On April 30th I found another nest in another brush heap. There were two eggs in it. The mother remained hiding in the brush. On May 5th I found the brush pile was burned and the birds gone.

On May 7th I found an unfinished nest in still another brush pile. May 9th, the nest was finished but no bird was near. May 14th, four eggs in the nest with the Brown Thrasher on the nest. She was not a bit shy, and allowed me to come quite close to her. She then hopped off the nest and from twig to twig, and out upon the ground, and then flew away. The male sat off at the other side of the orchard and sang very merrily. May 16th, the female was still upon the nest, the male was very happy as he sat up in the tree and sang. May 21st, the nest had not been destroyed. The bird was quite friendly, as she would sit and allow me to talk to her. On the 23d I found that some boys had been in the orchard. They had robbed and destroyed all the nests. This one was not spared. The birds have disappeared.

On May 7th I found the foundation of a nest in a tree, nicely hidden by leaves. It was built of large twigs and lined with a few dry grasses. The nest seemed deserted. On May 9th no birds were near and no work had been done on the nest. June 1st, the birds had been working on the nest. It had been entirely relined. June 5th, one egg, blue, flaked with brown, was in the nest. June 9th, there were three eggs in the nest. The mother bird was quite nervous when I was near the nest. No further observations were made on this nest.

CATBIRD.

On May 2d I saw two Catbirds weaving straws into a nest. May 5th, the nest was gone. Catbirds not near. I believe they are hard to please, for they begin a nest and then desert it, sometimes leaving the foundation and other times entirely destroying every trace of it.

On May 7th I found a nest made of twigs and dry grass with Catbirds near it. On May 9th this nest was partially destroyed. The birds were gone.

On May 7th I found a nest in a tree. I chased the birds off from the nest to find two greenish eggs in it. The eggs were smaller than the Robin's eggs. The old birds fought me. May 9th, no change in the nest. Birds fought even harder than the last time. May 14th, one egg was pipped. May 16th, I climbed the tree. No birds flew at me, and I soon found that, like so many other nests, this one had been robbed. The eggs were gone. No shells nor birds were near.

On May 7th I found an unfinished nest. It was nicely hidden by leaves. It was built of twigs and a few dry grasses; no birds were near. This nest was deserted, as no more work had been done and no eggs were found in it on later visits.

On May 9th I found the fifth Catbird's nest. It contained one egg. No bird was near to fight. On May 14th two eggs were in the nest, and on May 16th the eggs had been broken and the nest torn up. No birds were near.

The sixth nest was found on May 9th. It contained one egg, but no bird was near to fight. On the 14th the nest had two eggs in it, but they were broken and the nest was destroyed.

On May 14th I found a nest quite high in the tree. There was one egg in it. May 21st, the egg was gone; it looked as though it had been broken. The inside of the nest was torn out.

On May 21st I found a newly built nest. The Catbirds were in the tree and seemed very interested in the nest. On May 23d the nest was destroyed and no birds were near.

ROBIN.

On April 21st, 1902, a Robin's nest was found on the rail of a fence, about four feet from the ground. The nest was made of roots, dry twigs, dry grass, plastered together and to the fence with clay. Softer grass was used in the center. Two blue-green eggs were in the nest, their small ends toward the center of the nest. On the 23d the bird was on the nest when I made my round, but she flew off. There were four eggs in the nest, and just as soon as I left she flew back. On the 30th the nest was found to have been torn from the fence and thrown upon the ground. The eggs were broken. No birds were noticed near this place again.

On April 14th I found an unfinished nest in a tree. It was being constructed like the one above described. Birds working hard. April 17th the nest was completed, but the birds were not near. April 21st I found one blue-green egg in the nest. April 23d I found that three eggs had been laid but had been broken, and the shells were on the ground near and far. The nest was wet with the white of the egg, and the inside of the nest destroyed. I was unable to find the cause of the nest being destroyed. Nothing further was done on this nest by the birds up to the end of the observations.

On April 17th I found a nest in a tree which had been completed. The Blue Jays and the Robins were fighting, the latter being driven away. On April 23d I found a Robin on the nest sitting on one egg. April 30th I found the bird sitting on three eggs. The Robin seemed quite friendly, for she allowed me to come very near to her. Then she flew only after I made a motion as though to touch her. May 2d I found the bird sitting on four eggs. May 5th the Robin was still on the nest. She allowed me to come quite near. May 7th, two little Robins in the nest; the other two eggs were pipped. May 9th, four little birds. They seemed all mouths and eyes. The mother flew as soon as I came near the nest, but did not go more than five feet. The male followed me a long distance. This was the first time he had shown fight. On March 14th, the birds have grown very much. They would not take anything from me. Both the old birds tried to fight, and as I left the nest the male followed. May 16th the birds were nearly feathered; very shy. May 17th, all the birds have flown. In just one month from the time I found the nest all trace of the birds was gone. It was twenty-four days from the time the first egg was laid in the nest until the nest was empty.

On May 4th I found a Robin's nest up high in the tree. Made like those above described. May 7th I found four blue-green eggs in the nest with the female on the nest. On May 14th two of the eggs were pipped. The mother was very nervous. On May 16th four little birds were in the nest. On May 21st the little birds were nearly feathered, and on the 23d the birds had flown.

BLUEBIRD.

May 21st I found a nest with one blue egg in an old and partially hollow tree. It was in a cavity on the east side about ten inches from the opening. The nest was lined with fine feathers, but in pulling off the bark much of the loose, decayed stuff fell into the nest. May 23, the nest has been robbed and the lining pulled out.

List of Mammals, Reptiles and Batrachians of Monroe County.

By Waldo L. McAtee.

(By title.)

Ecological Notes on the Mussels of Winona Lake.*

By T. J. Headlee and James Simonton.

In the summer of 1903 the writers, under the direction of C. H. Eigenmann, made observations on the mussel distribution of Winona Lake with a view to determining the reason for the same. We examined the shore line from 4 inches to 4 feet by wading, from 4 to 7 with a clam rake, from 7 to 86 feet with an iron dredge.

The species found were determined by comparison with shells that had been named by Call, Simpson and Baker. The nomenclature is that used by Call in his report on Indiana Mollusca, Geological Report, 1899. They were: Unio luteolus, Unio subrostratus, Unio glans, Unio fabalis, Unio rubiginosus, Anodonta grandis, Anodonta edentula Margaritana marginata.

This is a deep kettle-hole lake. In general the beaches are composed of sand and gravel, which shade off with varying rapidity into marly sand, then into sandy marl, then into coarse white marl, and finally into the fine dark marl that covers the bottom in all the deeper parts of the lake and which is the accumulation of plankton tests. The bottom steadily grows softer as the proportion of dark marl increases. So soft does it become that a small sounding lead sinks into it of its own weight from 6 to 12 inches. In some places, especially the southwest side and in the little lake the shallow part of the beach is formed of muck which shades off into marl without the presence of any sand or gravel.

In general it may be said that the mussel zone extends from the shore line to where the bottom changes to very soft marl. This region will average from 4 inches to 9 feet of water, although in some places the mud comes to within a few feet of the water's edge, while in others the sandy and gravelly bottom runs out into 22 feet of water.

A. grandis is usually found just on the outer edge of the sand and gravel bank, while A. edentula appears most numerously a little farther out. A few specimens of both species were taken closer in shore,

*Contributions from the Zoölogical Laboratory of Indiana University, No. 62.

grandis being sometimes found on sandy bottom, edentula, however, invariably upon a soft bottom. Neither (healthy forms) was ever taken on hard sand or gravel.

U. glans has been taken upon sandy and gravelly bottoms, in from 4 feet out. U. fabalis appeared in about the same region except that it goes out on the soft bottom even farther than edentula.

U. subrostratus appears on the outer edge of the sand and gravel banks in about four feet of water and extends out as far as the light form of U. luteolus.

U. luteolus is the most variable, the most widely distributed and the most abundant species in the lake. It varies from a moderately thin, light straw-colored shell, marked by radiating greenish lines, to an extremely heavy, almost black form. The gradations of form, color, and size are shown in the plate and are very nearly perfect. The straw-colored variety is found in from 4 inches to 22 feet of water; it is, however, dominant inshore, in weed patches (Potomogeton and Ceratophyllum), and on chara-covered bottoms. The dark variety occupies the same region but is dominant upon sand and gravel bottoms in from three and one-half to twenty-two feet of water. The intergrading forms cover the same territory as the straw-colored and dark varieties but can not be said to be dominant anywhere.

U. rubiginosus occupies about the habitat dominated by the dark form of U. luteolus, except that it was not found in deeper water than ten feet.

M. marginata was found so infrequently (only six times) that the writers could tell little of its distribution. The specimens found were taken on sand and gravel, and white marl bottoms in from four to twenty-two feet.

There are a number of conditions in the environment which suggested themselves to us as possible explanations for this distribution —age, sex, light, heat, food supply and oxygen, pressure, wave action, character of the bottom, and enemies. Sex can not be important, for males and females are found together throughout the habitat; light can have but little to do with it, for mussels are absent in places in three feet of water and are abundant in others in fifteen feet, the difference in light being considerable. Further, the light over some of the immense beds in White River is no greater and perhaps even less than in twelve feet of lake water. That heat has little effect, during the summer at least, is shown by the fact that heavy beds were found in different temperatures, and by the fact that temperature variation in the mussel zone did not amount to more than two degrees; oxygen is not important, for the supply of oxygen throughout the mussel zone varies very little; pressure can have but little to do with it, for we found specimens on a sandy bottom in twenty-two feet of water, while on dark marl bottoms in ten feet none were taken in any case. Food supply can not be effective, for it is about equally abundant throughout the zone. The food consists principally of diatoms; secondarily of low algae forms, and one-celled animals.

It seems to us that there are three causes which control the distribution of mussels as it appeared in Winona Lake—wave action, character of the bottom and enemies.

The first cause applies only in water less than three feet deep. As U. luteolus and A. grandis appear in this region they are subjected to this agency. Specimens of both A. grandis and the dark form of U. luteolus have been found washed ashore after a storm, and scores of these shells appear along the shore line. Under similar conditions we have seen the light form of U. luteolus moving from the water's edge out into deeper parts; these facts point to the conclusion that the two first mentioned forms are prevented from occupying shallow water by wave action, but that the light form of U. luteolus, being very active and having a thick shell, can well occupy this region. Not only is washing ashore fatal to A. grandis, but wave action quickly action quickly wears away the shell and leaves the animal open to attack. Unio glans, fabalis, edentula, and subrostratus are very light and slow moving; U. rubiginosus is heavy and clumsy, like the dark form of luteolus; the first three, if washed ashore, would be unable to get back, and their shells would be unable to resist the wearing action of the waves, while the last mentioned form could resist wave wearing but would be unable to get back if washed ashore.

The character of the bottom applies throughout the mussel zone. The bottom in the weed patches differs from that in the deeper parts of the lake in being slightly less soft. The sandy and gravelly bottom affords firm foothold and allows the mussel to assume that position which enables it to get the best supply of food and oxygen, while the pure marl allows it to sink so far as to be smothered. Even if the animal does not sink entirely under, the overlying sediment is sufficient to smother it. That there is an overlying sediment is shown by the following experiment: We pumped water from twelve and six inches above the sandy and gravelly bottom in seven, ten, fifteen, twenty-five feet of water; the specimens revealed no sediment that would not settle on standing. Specimens were taken in thirty and thirty-six feet of water over a marl bottom and the twelve-inch samples yielded a small amount of such sediment, while the six-inch samples showed a decided amount. That matter in suspension is fatal to the mussel is shown by the fact that we found in the west side and south end of the lake what were evidently once thriving mussel beds, buried under a thin layer of coarse marl, which had been stirred up by the action of the steam dredge two years before. These mussels were found in the normal position undisturbed in any way. That the mussels were alive five years ago is shown by Dr. Moenkhaus' statement that he and his classes collected an abundance for study in those same regions at that time.

In order to test the ability of the mussel to stand these bottom conditions we made three wire clam baskets, lowered one in twenty-five feet of water, another in thirty-five feet, another in eighty-five feet. We got the following results:

August 5, a basket containing thirteen U. luteolus and one A. grandis was placed in 25 feet of water on a dark marl bottom. On the 10th two examples of U. luteolus were dead; on the 15th one U. luteolus was dead; on the 17th two U. luteolus were dead and four were missing.

August 9, a basket containing five U. luteolus of the light variety and one of the dark, and one A. edentula was lowered in 35 feet of water on a sandy gray marl bottom. On the 15th, one A. grandis and one U. rubiginosus were added. On the 20th one U. luteolus of dark variety was dead; on the 24th five U. luteolus and one U. rubiginosus were found to have the gills badly choked with sediment, while the anodontas were missing.

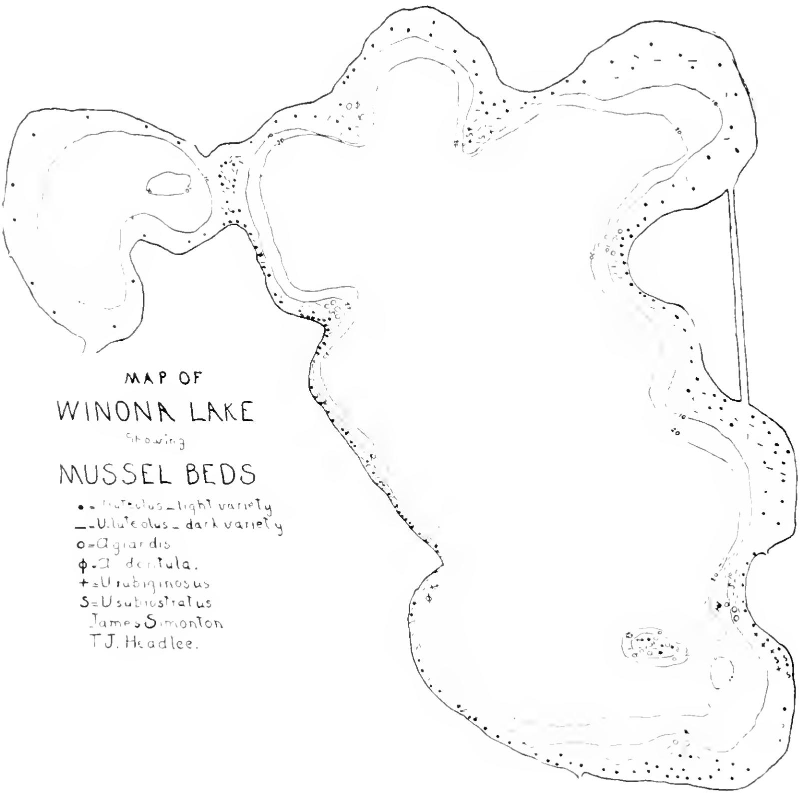
August 15, a basket containing seven U. luteolus of light and one of dark variety, two A. edentula, and one A. grandis was lowered in 85 feet on a pure dark marl bottom. On the 21st one U. luteolus of dark variety was dead; on the 24th seven U. luteolus and one A. grandis showed gills badly choked with sediment, while the two edentula were in better condition, showing very few patches of marl in gills.

To sum up: In the basket in twenty-five feet, lowered on dark marl, in nineteen days five were found dead and four missing; in the basket in thirty-five feet, lowered near Sandy Point on a sandy gray marl bottom, in fifteen days one was dead, all showed gills partly filled with sediment; in the basket in eighty-five feet, lowered on pure dark marl, in nine days two were found dead and the gills of all but A. edentula badly choked with sediment. U. fabalis, U. glans and U. subrostratus were not included in this experiment because the first two would have slipped out through the meshes and the third could not be obtained at the time. However, it seems reasonable to suppose that they would have proven not unlike the others. It seems, therefore, that those forms possessing light weight in proportion to surface exposed and close-fitting valves are best able to resist the soft marl and the overlying sediment.

A. grandis and edentula, having light and close-fitting valves, are found accordingly on the outer edge of the sandy marl bank; the edentula, being better fitted to withstand the bottom conditions, is found out in the edge of the dark marl. U. glans and fabalis, owing to lightness and close-fitting valves, occupy about the same situation, the fabalis having much the lighter shell, being found out as far or farther than the edentula. They are also found inshore, where not subjected to wave action. U. subrostratus, having medium weight valves, which are also close-fitting, is confined to the gravel and sand banks, weed patches and chara-covered beds. U. rubiginosis, having very heavy and rather loose-fitting valves, is confined to clear sand and gravel banks. The dark form of luteolus, having extremely heavy and rather loose-fitting valves, is confined to hard sand and gravel banks. The straw-colored form by its medium weight and tight-fitting valves is able to live on sand, gravel, in mud patches and on chara-covered bottoms. Owing to the fact that so few specimens of M. marginata were found we were unable to draw any conclusions as to its ecology.

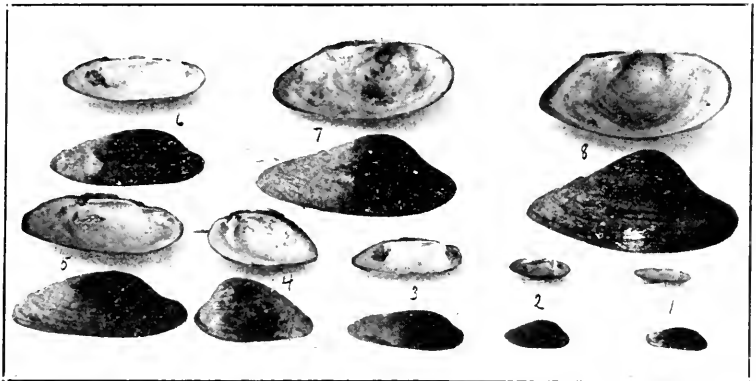
The muskrat is the principal enemy of the mussels; around his house many mussel shells are found, but no live mussels. Shells of all the species in the lake except the smaller ones are found, the Anodonta shells being in much greater evidence than is proportionate to their total number. They do not appear so on first examination, for they are broken up by the animal and worn by the waves. The conditions on the sand banks beyond reach of wave action are very favorable for Anodonta life, except for the presence of the muskrat. Anodontas are absolutely absent from water some distance from his home, where we found Unios rather abundantly. This points to the fact that the muskrat confines the Anodonta to the deeper waters at the edge of the sandy and gravelly banks.

It seems to us that the foregoing facts give basis for the following conclusions: First, that the mussel zone lies mainly upon sandy and gravelly banks, and on the outer edge of the same; second, that wave action and the muskrat determine the limit of the distribution shoreward, and that the character of the bottom is the principal factor determining the outer boundary of the zone.



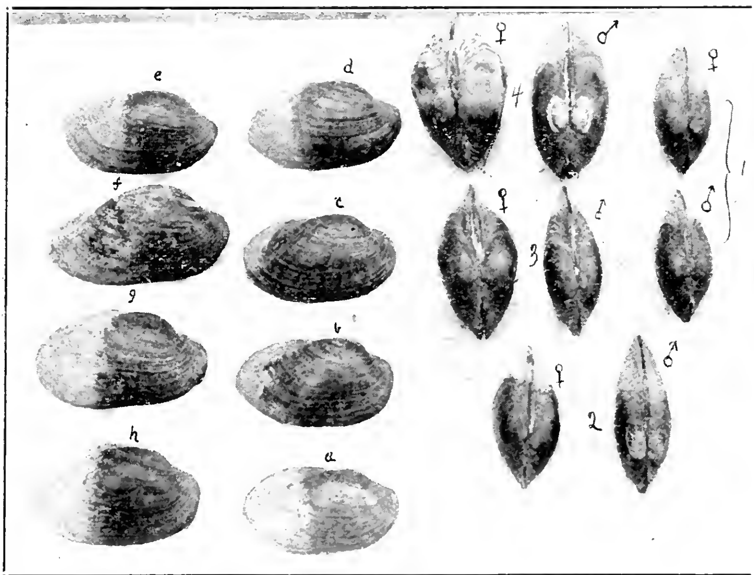
EXPLANATION OF PLATES.

PLATE I.



1—Unio fabalis; 2—Unio glans; 3—Unio subrostratus; 4—Unio rubiginosus; 5—Margaritana marginata; 6—Unio luteolus; 7—Anodonta grandis; 8—Anodonta edentulus.

PLATE II.



1, 2, 3, and 4 are pairs of U. luteolus, which exhibit gradations of form, color and size from the light straw-colored forms to the almost black variety.

a, b, c, d, e, f, g, and h exhibit the gradations of color and markings found, from white to dark varieties, without regard to sex.

Conditions Effecting the Distribution of Birds in Indiana.*

By Amos W. Butler.

GENERAL CONDITIONS.

The regular annual movements of birds, their migrations, are among the most striking of the manifestations of Nature. With the revivifying breath of spring, the absent birds return. Last fall, when the summer's work was done, they went to warmer climes. Now, they seek anew their breeding grounds. Some make their homes with us; others go farther north to rear their young. The semi-annual ebb and flow of these tides of bird-life, the breeding range and the food supply are general factors that enter into the distribution of birds everywhere. Our ancestors noted them as signs of the seasons. They exist today, though we do not see them so readily because of our changed conditions.

ZOÖLOGICAL AREAS.

Indiana is a meeting-ground of various birds. Into it range typical forms of different zoölogical regions. From the west, are prairie birds; slightly tinging the north, are northern forms; while the dominating influence of the lower part of the State is southern. Indiana lies within the eastern (Atlantic) faunal province. According to Mr. Allen, it is distinctively Carolinian (Bull. Mus. Comp. Zoöl. II, No. 3, pp. 393-395), yet the southwestern part is within the range of many birds characteristic of the Louisianian Fauna (Austroriparian Province of Prof. Cope, Bull. U. S. Nat. Mus. No. 1, 1875, pp. 67-71). Dr. Merriam would include the bulk of the State in the Upper Austral Zone, the Lower Austral Zone reaching into southwestern Indiana and the Transition Zone influencing the northern part (Bull. No. 10 Biol. Surv. U. S. Dept. Agr. 1898).

*Contributions from the Zoölogical Laboratory of Indiana University, No. 37.

DISPERSAL BY STORMS.

Following heavy storms, of wide extent, at sea, it sometimes happens that birds are blown or driven far inland. This, in part, accounts for the unusual occurrence, at times, of numbers of certain birds. One of the most notable instances of this was the wide dispersal of Brünnich's Murres (Uria lomvia) by a north-Atlantic storm, in December, 1896. They were driven as far south as South Carolina and over the eastern United States, at least to Indiana and Michigan. A number of specimens were taken in Indiana (Butler, The Auk, XIX, 1897, April, 197-200).

CHANGES IN CONDITIONS.

The birds about us are not those that were familiar to our fathers. Many kinds that were common to them have disappeared. Others that they did not know have come to take their places. In the early days of our history, dense forests stretched unbroken, save by water courses, from the Ohio River northward almost to Lake Michigan. Through these, threaded the runways of wild animals and the trails of wild men. Within the gloom of these continuous woodlands dwelt birds peculiar to such surroundings. With the clearing of our land, there disappeared from that area many forest-inhabiting birds. The range of others became restricted to the remaining timber districts. Meadows and pastures replaced the forests. Birds loving such surroundings, prairie forms, there made their homes.

The beautiful little Carolina Paroquet (Conurus carolinensis), which once ranged in countless numbers throughout the eastern United States, as far north as the Great Lakes, has not only disappeared from our limits, but also from almost every part of its range. From but a few almost inaccessible localities in the Southern States has it been recently reported, and it is now on the verge of extinction. It was last reported in Indiana from Knox County in 1859 (Hasbrouck, The Auk, VIII, Oct. 1891, pp. 369-379; Butler, Ibid, IX, Jan., 1892, pp. 49-56).

The Ivory-billed Woodpecker (Campephilus principalis), the largest representative of its family, was found in the early part of this century in suitable localities in southern Indiana, notably in Franklin and Monroe counties and in the lower Wabash Valley. Their shy, retiring ways led them to leave when men appeared bearing the evidences of civilization.

They have almost entirely disappeared from earth. A few individuals linger among the almost inaccessible regions of the Southern States (Hasbrouck. The Auk, VIII. 1891, pp. 174-176).

The Pileated Woodpecker (Ceophloeus pileatus), known to the early settlers as Logcock and Black Woodcock, was familiar to the eyes and ears of the early colonists. They were averse to sharing their haunts with the white man. Less and less their numbers grew. They disappeared from one locality after another, until now but few are left in the more sparsely settled districts of the State (Butler. Birds of Ind., 1897, p. 838).

The croak of the Raven (Corvus corax sinuatus) was a familiar sound to the early pioneers. They saw its numbers lessen from year to year, until their children, now, never see its form and do not know its voice. From one locality after another, the few remaining birds have disappeared, until at this time it is probable that none are to be found within the State. Until within the last five or six years, they have been known to nest in Martin and Dubois counties, but I can learn of none having done so since (Proc. Ind. Acad. of Sci., 1897, p. 202).

The Wild Turkey (Meleagris gallopavo), our most noble game bird, has been generally extirpated, although it is still reported from Knox, Gibson and other counties of the lower Wabash Valley. It, probably, is also to be found, in rare instances, in some of the wilder regions, elsewhere, in southern Indiana. It formerly was numerous throughout the State.

The Swallow-tailed Kite (Elanoides forficatus) is known but to few. In 1812, Alexander Wilson reported these graceful, giant, swallow-shaped birds as abundant upon the prairies of Ohio and Indiana Territories (Amer. Orn., VI, 1812. p. 70). For seventy years after that but one was reported from Indiana (Haymond. Proc. Phil. Acad. N. S., Nov., 1856. p. 287). Since then they have been seen at irregular intervals in the southern two-thirds of the State.

Wild Pigeons (Ectopistes migratorius) were formerly found in such countless numbers that no estimate could be made of their abundance. During the season of their flight, flocks of enormous size successively passed, obscuring the sun and sometimes hiding the sky. At night, they gathered in roosts in favorite localities. These roosts were often of great extent. They alighted upon the underbrush, crushing it to the ground, and so weighted the trees that limbs of large size were broken off by the burden put upon them. After the first third of the century, their numbers began noticeably to diminish; but few large flights were seen in our State after 1870. Ten years later, they had almost disappeared. Now, they are nearly extinct. A few individuals are to be found in certain localities in the rougher portions of southern Indiana (Proc. I. A. S., 1899).

In the extreme northern part of the State, prairies and swamps, lakes and woodland alternate. The marshes and lowlands of northwestern Indiana form attractive spots to many swamp birds and waterfowl. Different kinds of ducks collect there and a number of species breed in the more retired places. Formerly, they were much more numerous. There, also, the Whooping (Grus americana) and Sandhill Cranes (Grus mexicana) bred in numbers. Snipe and Plover were found abundantly. Phalaopes and Black Terns (Hydrochelidon nigra surinamensis) frequented the lakes and ponds. Gallinules, Coots and Grebes still rear their young. Rails of four species make their homes among the reeds. Marsh Wrens and both the American (Botaurus lentiginosus) and Least Bitterns (Ardetta exilis) frequent the sedges; while the stems of these plants are drawn together to form nesting places for the Red-winged (Agelaius phœniceus) and Yellow-headed Blackbirds (Xanthocephalus xanthocephalus), and their tops are woven into the globular nests of the two species of Marsh Wrens. The dryer marshes are the breeding grounds of such rare forms as Henslow's (Ammodramus henslowii) and Nelson's Sparrows (Ammodramus caudacutus nelsoni). The swampy woodland is the home of other water-loving species. Among the tops of the tallest trees are still to be found the small remnants of large colonies of Great Blue Herons (Ardea herodias) and Black-crowned Night Herons (Nycticorax nycticorax nævius). Here, too, we have recently learned that the beautiful White American Egrets (Ardea egretta) commonly made their homes, nesting in colonies or heronies. By this fact, its known breeding range is extended northward a distance about equal to the length of this State (Proc. I. A. S., 1897, pp. 198-201). Among the tree-tops, too, were to be found the nests of the Osprey (Pandion haliaetus carolinensis) and Bald Eagle (Haliæetus leucocephalus). In the larger cavities in the tree trunks, the Wood Ducks (Aix sponsa) still rear their broods, and the deserted Woodpecker holes in the old snags are occupied by White-bellied Swallows (Tachycineta bicolor) and Prothonotary Warblers (Protonotaria citrea).

All this has greatly changed. Some of these characteristic forms have almost disappeared, while the draining of the swamps and the reclaiming of the land have lessened the area favorable for the homes of others. Few, indeed, are the numbers of most of these birds in this region compared with the innumerable company that occupied it a half century or more ago.

Field Sparrows (Spizella pusilla), Vesper Sparrows (Pooecetes gramineus), Dickcissels (Spiza americana), Grasshopper Sparrows (Ammodramus savannarum passerinus) and Meadowlarks (Sturnella magna) are representatives of those that sought the fields with which man replaced the native woods. Others, such as the Bobolink (Dolichonyx oryzivorus) and Prairie Horned Lark (Otocoris alpestris praticola), also extended their range as favorable localities were found. At the time of the settling of our State, the breeding-grounds of the Bobolink within our present limits were probably about the southern end of Lake Michigan, extending southward over the prairies of the Kankakee Basin and eastward as far as the site of Rochester. Possibly some bred in the smaller prairies in the northeastern part of the State. From these points they have gradually spread southward, extending their breeding range as far south as the counties of Union, Decatur, Marion and Vigo. They are not numerous there; but under favorable conditions, a few may be found at nesting time, enlivening the scenes of rural life with their charming songs, as far south as has been indicated (Butler, Proc. I. A. S., 1896). The Prairie Horned Larks, too, from practically the same districts, have gradually been found to nest farther south until they have been reported as breeding in Franklin, Decatur, Johnson, Monroe and Knox counties. Following their extension southward, their numbers have gradually increased until now they are familiar birds in many places where they were unkmown a few years ago (Butler, Birds of Ind., 1897, pp. 874-6).

As tillable land is neglected and begins to grow up in bushes and briers, other birds press in to occupy such congenial haunts. The most notable of these, perhaps, are Bachman's Sparrow (Peucaea aestivalis bachmanii), the Lark Sparrow (Chondestes grammacus), the Cardinal or common Redbird (Cardinalis cardinalis) and the Yellow-breasted Chat (Icteria virens). All these have been observed to be extending their range, where conditions are favorable; but the extension, perhaps, is the most striking in the case of the two sparrows first mentioned.

From the south other forms are ranging into our limits. The Black Vulture (Catharista atrata) was found by Audubon in southern Indiana. From 1834 to 1879, it was not reported from the Ohio Valley. It was next noted in Indiana in 1879 (Quick. J. C. S. N. H. 1881. p. 341). It is now recognized as a resident in some numbers in the lower Wabash and Whitewater valleys, and is found in regularly increasing numbers in the southern third of the State. Bewick's Wren (Thryothorus bewickii) is slowly spreading over the same district (Trans. Ind. Hort. Soc. 189. p. 99). It soon becomes acquainted with man and takes up its abode about his home. In that region, it becomes the House Wren, replacing the larger Carolina Wren (Thryothorus ludovicianus) which has, latterly, to a great extent, left the vicinity of man's structures and inhabits the thickets and the underbrush of the more open woods. These are not to be confused with the smaller Short-tailed Wren, the true House Wren (Troglodytes aedon), that breeds in central and northern Indiana. Other birds, also, have changed their habits. The Purple Martin (Progne subis), Barn Swallow (Chelidon erythrogaster) and Phoebe (Sayornis phoebe) have generally sought after other breeding sites than the cliffs and bluffs where the white men first found their nests. The Chimney Swift (Chaetura pelagica) now prefers an unused chimney to a hollow tree. We have become so accustomed to these sociable birds that it is hard to realize that they have not always been dwellers with man about his home. Some of them, most notably the Eave Swallow (Petrochelidon lunifrons) and the Purple Martin, have been the birds most persecuted by the European House Sparrow (Passer domesticus), generally called "English Sparrow." They have made use of the nests of the former; have occupied the sites of the latter. The result is that comparatively few of either of these birds are left with us.

INFLUENCE OF RIVERS.

The rivers of Indiana penetrate the State from different directions, and each has its influence, be it greater or less, upon the distribution of life. The most prominent streams are the Wabash and its tributaries, and the Whitewater and Kankakee. Lake Michigan touches our limits; and its effect is likewise felt. The extension southward into the upland meadows, between the water courses, of the birds of the open prairies, and the range of southern forms up the valleys of our streams is as though the great spread fingers of two mighty hands were interlocked, the one representing the extension of life southward and the other the projection of southern birds northward.

The region of the Lower Wabash, with its bottoms, cypress swamps and ponds, was the home of many southern birds which found there the northern limit of their range. Among these congenial surroundings were noted such southern forms as the White Ibis (Guara alba), Wood Ibis (Tantalus loculator), Yellow-crowned Night Heron (Nycticorax violaceus), Little Blue Heron (Ardea caerulea), Snowy Heron (Ardea candidiesima), American Egret (Ardea egretta) and Florida Cormorant (Phalacrocorax dilophus floridanus). Some of these there made their homes and reared their young. Other birds ranged farther up the stream and it, and other water-courses, are now known to be routes along which certain species move to breeding grounds farther north.

The extreme effect of a river on the distribution of a bird is illustrated in the case of the Prothonotary Warbler. Prior to 1875, it was regarded as solely a bird of the Southern States, yet its actual range was then, without doubt, practically the same as we now know it. In that year Mr. E. W. Nelson observed it to be common in the Lower Wabash Valley in Illinois (Bull. Essex Inst. Vol. IX, 1877, p. 34). In 1878, Mr. William Brewster found it abundant in Knox and Gibson counties, Indiana (Bull. Nutt. Orn. Club, Vol. III, 1878, p. 153). The natural haunts of these birds are the swampy woods and the thickets along water-courses or about ponds or lakes. As one suitable locality after another was discovered farther northward, it was found to be occupied by these birds. They were reported from Vigo, Clinton and Carroll counties and from just over the State line near Danville, Illinois. They extended up the Mississippi River, sending off numbers of migrants up the different river courses. Some ascended the Kaskaskia and others the Illinois (Loucks Bull. Ill. Lab. N. H., Vol. IV, 1894). The Kankakee, a tributary of the latter stream, comes into northwest Indiana from the west and becomes quite a factor in its influence upon bird life. At Momence, Illinois, its course is blocked by an outcrop of stone. Above this, it is a sluggish stream, at times widening into lakes. Much of its course is bordered by woods. Marshes and swamps alternate with thickets and sloughs along its valley. Amid such attractive surroundings, Prothonotary Warblers find summer quarters and are characteristic birds. They likely reach this valley by way of the Illinois River, though possibly some may come from the Wabash Valley. The divide between the Kankakee Basin and the Lake Michigan Basin is but a slight barrier. Occasionally, these birds are found near the Lake Shore in Lake and Laporte counties, and at places along the St. Joseph River and its tributaries, both in Michigan and Indiana (Cook. Birds of Mich. 1893. p. 110). In St. Joseph County, Michigan, and the counties of Elkhart, Lagrange, Steuben, and in the adjoining county of Dekalb, in this State, they have been found, at some places, breeding commonly. The Prothonotary Warbler has never been reported along the Ohio River above the mouth of the Wabash.

The Sycamore Warbler (Dendroica dominica albilora) is another bird that prefers the vicinity of streams and in its migration follows their courses. It is found not only along the Wabash River, but also along the Ohio and Whitewater. It is common up the Wabash River to Carroll County and has been noted from Lafayette and Ft. Wayne. There is nothing to show that it is found in the Kankakee Valley or reaches the basin of Lake Michigan. It is common up the White River Valley, as far as Indianapolis, and up the Whitewater River to Brookville, ranging to Connersville and Richmond. By one of these routes, it pushes on to southeastern Michigan. There, is has been found in some numbers in the valley of the Raisin River, Monroe County, in Kalamazoo County, and has been reported as not uncommon near Detroit.

The Cerulean Warbler (Dendroica rara) is not a bird living solely along the streams, but appears to prefer the wooded sides of the valleys. It extends its range up the Wabash River to Carroll, Tippecanoe and Wabash counties. It has been found at English Lake near Kouts in the Kankakee Valley. It ranges up the Whitewater River to its upper waters; is found about Muncie; is tolerably common in Dekalb County; and is one of the most common woodland birds in Monroe, Wayne and Ingham counties, Michigan. These localities are probably reached by way of the Whitewater or Miami river. It, like both the Warblers previously referred to, breeds in suitable places throughout its range. Each of these three species frequents different kinds of localities; the Prothonotary Warbler, as noted, prefers the wooded swamps; the Sycamore Warbler seeks the tall timber along the streams, preferably, as its name indicates, the sycamore trees; the Cerulean Warbler occupies the woods of the river valleys, but appears to prefer the wooded hillsides that border them. Each is notably affected in distribution by the water-courses.

EFFECT OF LAKE MICHIGAN.

The effect of a large interior body of water is well illustrated by Lake Michigan. There, on the open water, many kinds of water fowl, that would otherwise go south, remain through the winter. To it, come different forms of sea birds in spring, winter and fall. Among these are Jaegers, the rarer Gulls and some Sea Ducks.

It also attracts such cosmopolitan birds as the Knot (Tringa canutus), Turnstone (Arenaria interpres) and Sanderling (Calidris arenaria). The latter and the Semi-palmated Plover (Ægialitis semipalmata) are found along its shores in considerable numbers in late summer. The Belted Piping Plover (Ægialitis meloda circumcincta), a bird supposed to breed much farther northward, has been found breeding along the pebbly lake beach. The effect of the lake upon the local climate has been observed by farmers. The result is noticeable in the fruiting of plants. Fringing the southern shores of Lake Michigan are sandhills or dunes of varying sizes, some reaching an altitude of more than 150 feet. Upon and near these, grow northern pines and other characteristic vegetation. As would be expected, birds that love homes among the pines are to be found. While comparatively little study has been given to this region, it is known that the Pine Warbler (Dendroica vigorsii) breeds there (Brayton. Proc. Ind. Hort. Soc. 1879. p. 108). Other northern forms have been reported, and it is likely careful investigation will show other interesting facts concerning this district. Where-ever pines grow, the American Crossbills (Loxia curvirostra minor) seem to be more or less regularly found. This is not only true among the sand-dunes near Lake Michigan, but about Lafayette, Bloomington and Brookville. At each of the two first named places, they have been reported as breeding. While this would not be surprising the reports have not been verified. The pines in other restricted areas, notably Pine Hills, Montgomery County, and the Knobs in southern Indiana, are interesting fields for the study of these points.

The most notable influence in the bird-life of our State is the changes that have been wrought through man's influence. The general conditions of migration, breeding and food supply are those common to all regions. They operated in the days of the aborigines as they do this year, differing only in some of their manifestations. The unusual conditions, such as storms, effecting the dispersal of birds, work now as hitherto. There are special conditions manifested in favorable surroundings, attractive bird-homes, and in topographical encouragement, leading them to extend their range. These are strongly illustrated in this State. To him who carefully studies the birds of any locality, these powerful influences are apparent. They are emphasized by their details and their repetition. By grouping the results of local observations, is told the story of the influences acting in the distribution of the birds of the State.

Discoid Pith in Woody Plants.

By F. W. Foxworthy.

The occurrence of a discoid pith, i. e., one which is interrupted at frequent intervals by cross partitions variously known as disks, diaphragms, plates or lamellæ, has been noted by numerous observers in certain of the woody plants.

The first mention of it seems to have been by the Anatomist Grew (Anat. Plantarum. 1682. Pl. 19. f. 4), who described and figured it in *Juglans*.

Ch. Morren, in the Ann. Nat. Hist., Vol. 4, No. 22, 1839, gave a good historical sketch of the observed cases of discoid pith, and described in detail and figured certain forms.

W. C. Williamson (Proc. Man. Lit. and Phil. Soc. for 1851) in a paper "On the Structure and affinities of the plants hitherto known as Sternbergiæ"—described the casts of this kind of pith which had been considered entire fossil plants—with the group name *Sternbergiæ*, and showed their true nature and affinities—as members of the genus *Dadoxylon Brongn.* He also mentioned the occurrence of discoid pith in a number of recent plants.

M. Gris, in his very painstaking work "Sur la moelle les plantes ligneuses" (Ann. des Sci. Nat. ser. 5. No. 14, 1872), described two structurally distinct forms of discoid pith. The first, which he terms *Heterogenous Continuous Diaphragmatic*, has the pith continuous between the disks, e. g. *Liriodendron*.

The second he terms *Heterogenous Discontinuous Diaphragmatic* and, in this, the pith is not continuous between the disks, the interspaces being empty or filled with air, e. g. *Juglans*.

Pith of the first type occurs in *Liriodendron* and *Magnolia species*, in *Asimina* and some other representatives of the *Anonaceæ*, in *Nyssa*, and, according to Solereder (Anatomie der Dicotyledonen, Stuttgart, 1899), in many of the *Ternstrœmiaceæ*, as well as in *Brachynema* (*Ebenaceæ*) and in certain of the *Convolvulaceæ*.

The cells making up these disks are large, irregular in outline, very thick-walled, lignified, and contain starch in winter. The cells filling the interspaces are small, regular, very thin-walled, unlignified and empty.

The formation of the disks takes place at a very early stage in the growth of the twig; they may be seen just back of the growing point in Fig. 1, which is a longitudinal section through a young twig of *Liriodendron.*

The genus *Magnolia* presents some interesting modifications of this type. The genus has been described as always having these partitions in the pith; but, several have pointed out that this statement is incorrect. In the examination of the American and some of the Asiatic species, I have found only two, *M. Virginiana* and *M. fætida*, in which the fully developed disks occurred. In all the other species examined, cells of the sort described as making up the disks occurred scattered singly or in small groups throughout the pith. Baillon, in his Natural History of Plants, says of this: "In the rapidly developed shoots of some Magnolias we have seen these septa reduced to a single cell, nearly central, on which all the surrounding cells of the ordinary parenchyma abut by one end, bent, or drawn out in a quite peculiar fashion."

In Fig. 2, which is a longitudinal section of a twig of *M. tripetala*, these scattered groups of cells are shown; and, Fig. 3 shows the same kind of cells in a cross-section of a twig of the same species.

In *Asimina* the disks seem to be made up of more regular and thicker-walled cells than are found in *Magnolia* and *Liriodendron.*

In the slender woody twigs of *Nyssa*, very strongly developed disks were found, stronger in fact than in any other case examined.

Function of pith of this type:—

No satisfactory explanation of the function of this type of pith has been offered. From superficial examination, the suggestion that its function was one of mechanical support would seem reasonable; but, the fact that the most strongly developed diaphragms were found in the strong and slender twigs of *Nyssa*, while the thick *Magnolia* twigs with their relatively large pith showed the weakest development of this type, seems to indicate that the suggestion of mechanical support is not a sufficient explanation of their function.

The second type of pith has often been mentioned and figured in species of *Juglans*. I have also studied it in *Pterocarya, Celtis, Mohrodendron (Halesia), Forsythia viridissima, Jasminum species, Paulownia*, and

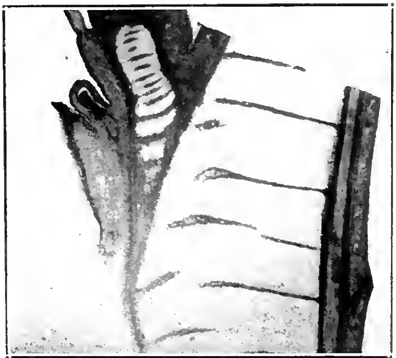


Fig. 1.

Fig. 2.

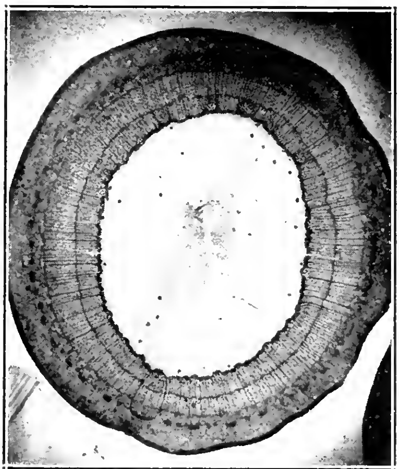


Fig. 3.

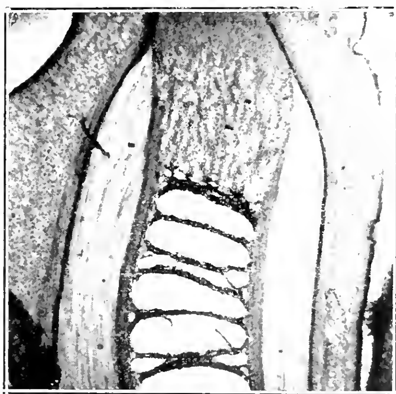


Fig. 4

Actinidia. Besides these, Solereder found it in *Wormia* (*Dilleniaceæ*), *Diplotaxis* (*Cruciferæ*)-*Fouqiera* (*Tamarisc*), *Princepia Chrysobalanaceæ*), *Aucuba* (*Cornaceæ*, only in herbarium material), *Pedalium* (*Pedaliaceæ*), *Daphnyphyllum* (*Daphnyphyllacea*): Williamson also found it in the fossil plants known as *Sternbergiæ* and mentions it as occurring in certain living species of *Pinus*. In some genera, as e. g. *Forsythia* and *Jasminum*, it occurs in some species but not in others.

The cells making up the partitions are thin-walled, empty and often shrunken and the space between the partitions is irregular in outline and extent. Fig. 4, from a twig of *Juglans cinerea*, shows this type.

Function and manner of formation:—

Morren and Williamson both considered that the pith served as a mamilla for the bud and, as the nourishment is exhausted from the pith it separates into disks—beginning first in the immediate vicinity of the bud. The cells in the center of the pith become shrunken and the pith separates into layers. This takes place quite early in the growing season. Morren gives good figures of this process in *Juglans regia*. The fact that twigs of *Celtis* often have the pith very plainly discoid in the region of the nodes but solid in the central part of the long internodes lends support to this view.

Taxonomic value of the occurrence of discoid pith:—

Juglans and *Pterocarya* are definitely separated off from the rest of the *Juglandaceæ* (A. Engler in Engler & Prantl-Nat. Pflanz. Fam. III. I. p. 21) by the possession of discoid pith. In *Liriodendron*, *Asimina*, *Nyssa* *Celtis*, *Mohrodendron*, *Actinidia*, and several others, the presence of discoid pith seems a good generic distinction; but, in certain cases, as, *Forsythia* and *Jasminum*, it is of only specific value.

The New Science Laboratory at Moores Hill College.

By A. J. Bigney.

At the last meeting of the Board of Trustees of Moores Hill College, in June, 1904, they made additional provision for the Science Department by purchasing a large three-story brick building in the town which had been used as a business house. This building is very well adapted to its new purposes. Most of the internal changes have been made and the building occupied except the third story. It is forty-five feet front and seventy feet deep, and three stories high, with a full basement. The basement is used as a furnace room, shop, store-room, and photographic room.

The first floor contains a scientific library, a private room for the instructor, a combined biological laboratory and recitation room, a combined museum and geological laboratory, and one room occupied by the Y. M. C. A. and Y. W. C. A.

The second floor is occupied by the Philoneikean Society as chapter rooms. When the college needs these rooms the Society will vacate them.

The third floor will be occupied by the chemical and physical departments.

The scientific departments now have plenty of room for increasing their efficiency. The museum is growing very rapidly and this building will make it much more serviceable. No movement has been started in recent years that will prove as helpful not only for the college but also for the scientific interests of southeastern Indiana.

The Apache Stick Game.

By Albert B. Reagan.

(Abstract.)

(Original in possession of the Bureau of American Ethnology. Illustrations used by permission of Bureau.)

The Apache stick game is played only by the women. It is played in the winter when there is no farm work to be done; also at any other time when the women are not employed in the daily toil. At this game the women are experts. It is a gambling game, and the women often bet and lose all they have on it, even the clothes on their backs. Most usually, however, only beads and such-like trinkets are staked. Below is a description of the game and the requisites: The game-field, including its rock-circle, the counting sticks, and the three "Setdilth" sticks used in playing the game.

The Game Field.—This field is a level, circular spot, six or seven feet in diameter. This circular area is inclosed in a circle of cobblestones, forty in number. These rocks are arranged in groups of ten each, that is, ten to each quadrant of the circle. The rocks are the tallies: an entire circle of forty tallies constitutes a game. Besides the rocks in the circle, a large flat rock occupies the center of the field. On this rock are hurled the setdilth sticks on their mission of chance, as we shall see later.

The Counting Sticks.—These are small sticks used in marking the tallies gained. One of these is placed between the last rock tally and the next rock in the circle in the direction the player is moving it.

The Setdilth Sticks.—These are three in number. Each is a foot in length and is the half of a green limb or a willow shrub of about an inch in diameter. The bark is left on the round face; its split face is marked by a broad diagonal charcoal mark across the center. These sticks are all held in the hand in a vertical position at the same time, and are hurled endwise upon the center rock to fall with whichever face up chance may direct. Counting the points then begins.

Counting the Points.—The points in the game are decided by the faces of the setdilth sticks that are up after the sticks have fallen. If one split face is up it counts two points; if two split faces, three points; if all three split faces, five points; and if the three rounded faces are up ten points and the player has the privilege of playing again before passing the sticks to the next player.

MARKING THE POINTS GAINED.—Usually four persons play this game. The opposite players are partners. One set of players move the counting

The Setdilth Game—Sticks falling after having bounced on the center rock.

sticks round the stone-circle in one direction (Each player has her own counting sticks whether a partner of another man or not); and their opponents move in the opposite direction. For the points gained in hurling the sticks an equal number of rocks in the circle are counted and the counting stick is moved forward to the position between the last rock tally and the next cobble-stone in the direction the counting stick is being moved. In moving the counting stick, should it chance to be placed in the space between two rocks that an opponent's counting stick is occupying, the opponent's counting stick, that is, the first stick occupying the space is taken up and its owner must begin the game again. Two skilled players will often throw each other back in this manner time after time. This makes the game quite interesting. When a counting stick has completed the entire circle, that is, when it has marked forty successive tallies its owner has the game. A transfer of the staked property follows. Then the betting begins for a new game.

A Note on the Radio-Activity of Strontium Salicylate.

By J. F. Woolsey.

(By title.)

Cuban Notes.

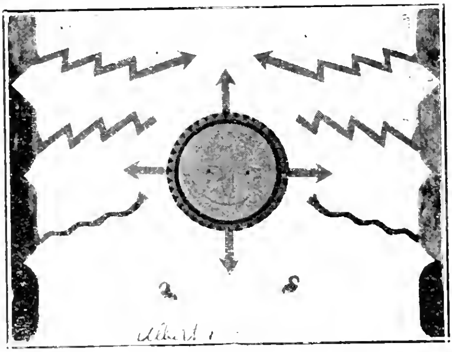
By C. H. Eigenmann.

(By title.)

Some Paintings from One of the Estufas in the Indian Village of Jemez, N. M.

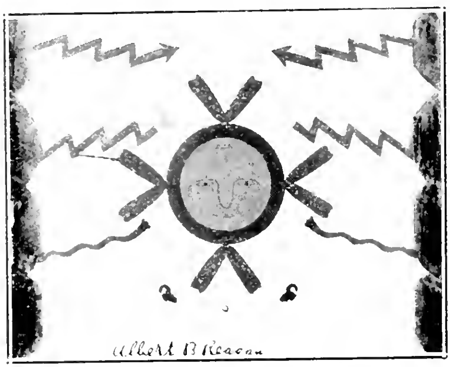
Albert B. Reagan.

Soon after I became U. S. Indian Farmer at Jamez, N. M., the Jamez Indians had a masked dance, and as this dance occurred on mail day they stopped the mail carrier and would not allow him to proceed on his journey. This they did in accordance with their custom not to allow a white man to enter or to pass through the village while they were thus occupied. The stopping of the mail led to the arrest of the Indian Governor, Jose Romero, who, as a result of the preliminary examination, was bound over to the United States grand jury which was to meet the next March, six months after the crime was committed. Taking pity on the Indian, I bailed him out, and took him back to the village. From that time on throughout the winter months the Jamez were very friendly to me and allowed me to visit their performances at will, though they did not send me special invitations to do so. At the trial in March the governor was found guilty and fined the full extent of the law for interfering with the carrying of the mail. As soon as the sentence was handed down, I went to the judge, and after a great deal of argument, persuaded him to suspend the sentence upon the promise of good behavior. So I returned to the village with the governor a second time. In the evening after our return the "Principals" of the place met, and as the greatest favor they could bestow upon me they invited me in the name of their tribe to visit any and all of their ceremonies, both open and secret, stating further that they would let me know whenever they had any special ceremony. This, with but one exception, they carried out to the letter. Acting upon this invitation I visited each of the Estufas at will, often being with the Indians in them sometimes as high as six nights in a week. I also examined the "blind closets" and secret rooms in the dwellings. Thus was I enabled to see many things of interest. Among these are the masks worn by the clown dancers in the masked dance, and the paintings on the inside walls of the Estufas and of the secret rooms. Some of these are here given.



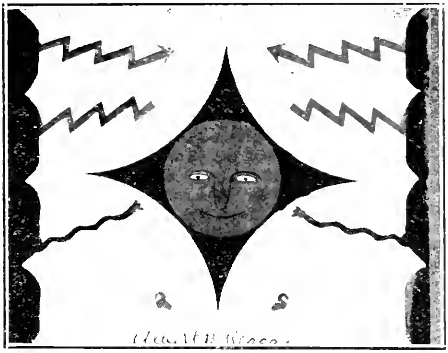
I. Sun-God Section in One of the Estufas at Jemez, N. M.

1. Clouds, the Steps to Heaven. (Dark marginal figures.)
2. The Bolt Lightning that does not strike the earth. (Upper figures.)
3. The Bolt Lightning that strikes the earth. It is the Red Snake or Indian Devil, called Savah by them. (Second figure from the top on each side.)
4. The Flash Lightning, the God of Flowers. (Third figure from top.)
5. The Good Snake, the Blue Snake, the God of Rain. (Lower figures.)
6. The Sun, the father of the universe and the God of all things. By the Indians he is called Patahgatzah or Pay.



II. The Moon-God Section in one of the Estufas at Jemez, N. M.

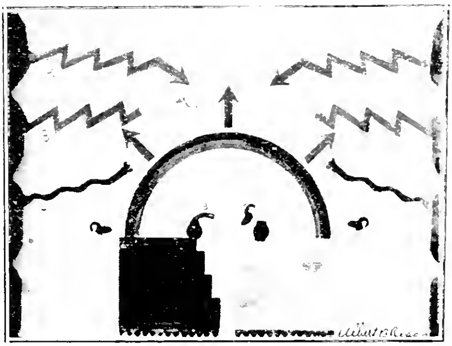
1. Clouds.
2. Bolt Lightning that does not strike the earth.
3. The Red Snake or Indian Devil.
4. The Flash Lightning, the God of Flowers.
5. The Blue Snake, the God of Rain.
6. The Moon, the Mother God of the Universe, called by the Indians Ahtahwahtzah, or Pah.



IV. The Evening Star Section in one of the Estufas at Jemez, N. M.

1. Clouds.
2. Bolt Lightning that does not strike the ground.
3. The Red Snake or Indian Devil.
4. The Flash Lightning or God of Flowers.
5. The Blue Snake, the God of Rain.
6. The Evening Star, the God of the Evening. Jointly with its brother, the Morning Star, it possesses the attributes of Truth and Filial Love. Its Indian name is Homa Wangho.

Note.—The photographer having spoiled the negative of the Morning Star Section, I cannot show a photograph of it here.

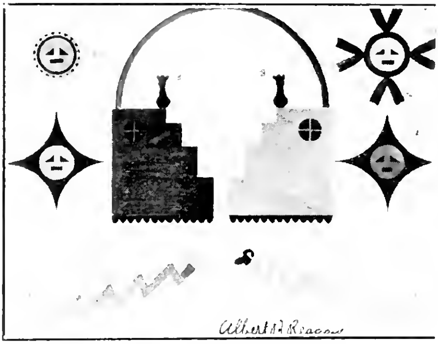


VI. A Rainbow Section in One of the Estufas at Jemez, N. M.

1. Clouds.
2. The Bolt Lightning that does not strike the ground.
3. The Bolt Lightning that strikes the earth. It is the Red Snake or Indian Devil.
4. The Flash Lightning, believed by the Indians to be the producer of bloom, hence the God of Flowers.
5. The Blue Snake, the God of Rain.
6. The Rainbow in the East. (a) Water receptacles of the universe; (b) Clouds, the Steps to Heaven; (c) raindrops; (d) the rainbow arch; (e) dart-heads thrust out by the rainbow as a means of protection.

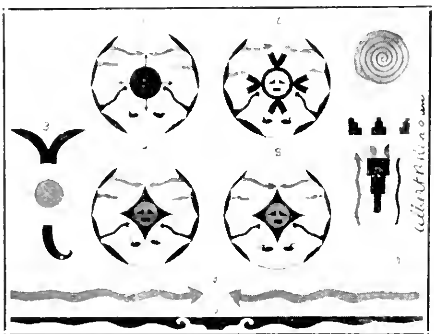
Note.—This is the rainbow in the east. Beneath the arch the representatives of good and evil, the rain snake and the red snake, are in combat. The rain snake, being defeated, is retreating eastward and is taking the clouds with him, hence the rain is over.*

*The Rainbow Section just opposite this section represents the rainbow in the west. It differs from the rainbow section given here in that it has the God of Flowers projecting from the water jars beneath the arch.



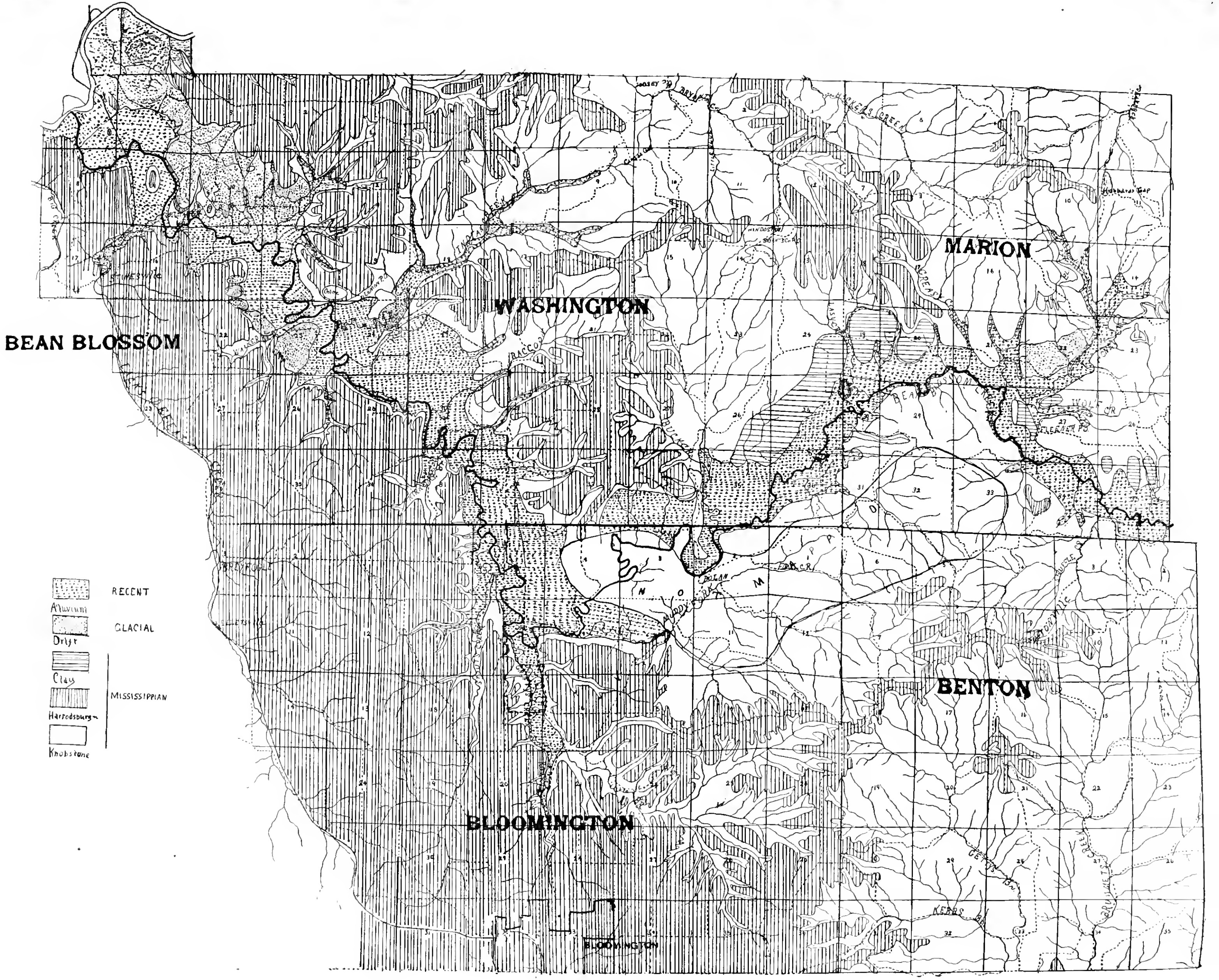
VII. A Wall Painting in a Secret Dark Room in One of the Indian Houses at Jemez, N. M.

1. Sun. (In left-hand upper corner.)
2. Moon. (In right-hand upper corner.)
3. Morning Star.
4. Evening Star.
5. Rainbow in the West.
6. The Red Snake.
7. The Blue Snake, the God of Rain.
8. The Flash Lightning, the God of Flowers. It is projecting from the water receptacles of the universe. The step-like figures below the water-jars are clouds from which raindrops, represented by black points, are dropping.



VIII A Miscellaneous Group.

1. The Sun as carved on a bowlder on the trail between Zia and Jemez, N. M.; also on a rock near White River, Ariz.
2. A Sun drawing in an Estufa at Santa Anna, N. M.
3. A Getlu, probably a representation of a comet. It was used as a handpiece in the masked dance of March 17, 1900. (Used here by permission of the Bureau of American Ethnology.)
4. A Head Ornament worn by a male column dancer in the masked dances at Jemez, N. M.
5. A Sun Mask worn by a sun clown in the masked dances at Jemez.
6. A Moon Mask worn by a moon clown in the masked dances at Jemez.
7. A Morning Star Mask worn by a morning star clown in the masked dances at Jemez.
8. An Evening Star Mask worn by an evening star clown in the masked dances at Jemez.
9. The Bolt Lightning drawn on the beam at the entrance of an Estufa at Santa Anna, N. M.
10. The White Snakes drawn on the center beam in the south Estufa at Jemez, N. M.



BEAN BLOSSOM
WASHINGTON
MARION
BENTON
BLOOMINGTON
RECENT
Alluvium
GLACIAL
Drift
Clay
MISSISSIPPIAN
Harrodsburg
Knobstone
BLOOMINGTON

Geology of Monroe County, Indiana, North of the Latitude of Bloomington.

By Albert B. Reagan.

This work was undertaken as independent research work in stratigraphic geology in Indiana University, in the summer of 1903, at the suggestion of Dr. J. W. Beede.

In 1880 Mr. G. K. Green published a paper entitled "Geology of Monroe County,"* in which he discusses the stratigraphy of the county, giving several sections and lists of fossils and a very generalized geological map of the county. Mr. C. E. Siebenthal has given a lengthy description of a considerable part of the the region here under consideration in his report on the "Bedford Oölitic Limestone."** Prof. V. F. Marsters describes the geography of Bean Blossom Creek in an article entitled "Topography and Geography of Bean Blossom Valley, Monroe County, Indiana."*** These papers will be discussed when the subjects with which they deal are taken up.

GENERAL REMARKS.

The rocks of this region, with the exception of the Glacial and post-glacial, are Mississippian in age. At the close of the Mississippian period or in the later Carboniferous time the region was raised above the sea. With the exception of a few cases due to local warping its strata dip gently to the southwest. After the area was elevated, the erosive agencies thoroughly dissected the region. The master stream, Bean Blossom Creek, and its numerous tributaries incised for themselves canyon-like valleys. Then on reaching grade, they widened their inner valley floors. On these floors the streams meandered, until a glacier, which crossed the northern part of the county, dammed the lower Bean Blossom and laked the region. Since the retreat of the glacier, side tributaries have, for the most part, recut their channels through the glacial debris to their former level; and

*2d Ann. Rep. Bureau Statistics and Geology, Indiana, pp. 427-449, 1880.

**21st Ann. Rep. Geol. Nat. Res. Ind. pp. 293.

*** Proc. Ind. Acad. Sci. 1902 (for 1901), pp. 222-237.

Bean Blossom is now aggrading its channel. The region thus dissected by stream-cutting presents an intricate mass of small, deep canyon-like valleys separated by sharp ridges.

STRUCTURE.

The Mississippian rocks of northern Monroe County are divided into the following formations beginning at the top: Mitchell limestone, Salem (Bedford) limestone, Harrodsburg limestone and the Knobstone (the latter including the Riverside sandstone and the New Providence shales). These formations are exposed in the order named as one passes across the county from west to east. The dip is to the south of west.

SECTIONS.*

Section 1.—From Stout's Creek east to the top of the divide on the half section line of Section 8, Bloomington Township:

		Feet.
Harrodsburg limestone—		
1.	Unseen	20
2.	Thin-bedded limestone	15
3.	Very thin-bedded, gray limestone (crinoid stems abundant).	5
4.	Thin-bedded limestone	10
5.	Massive limestone forming base of cliff	20
Knobstone—		
6.	Massive sandstone	20
7.	Shaly sandstone and sandy shale	32
8.	Unseen	25
	Total	147

Section 2—On small creek near northwest corner of northeast ¼ Section 7, Bloomington Township:

		Feet.
Oölitic—		
1.	Unexposed	70
Harrodsburg limestone—		
2.	Thin-bedded limestone (Spirifer)	2
3.	Unseen	12

*The strata of the sections are numbered from the top downward.

		Feet.
4.	Dark, irregular, non-fossiliferous limestone weathering rough. (There are rusty particles in this stone which forms the falls in the stream.)	10
5.	Limestone	4
6.	Rather massive, dark, iron-gray limestone forming second fall	2

Knobstone—

7.	Very hard, thin-bedded, light-colored sandstone	4
8.	Massive, hard sandstone	4
9.	Thin-bedded limestone grading into massive sandstone. Forms third fall	25
10.	Unseen. Sandstone?	5
11.	Sandstone	5
12.	Massive, thin-bedded, soft, light-colored sandstone	20
13.	Light-colored sandstone weathering to yellow and brown	10
14.	Shaly sandstone and sandy shale	20
15.	Unseen	20
	Total	213

Section 3—On the west line of Section 5, Bloomington Township, near southwest corner:

Knobstone—

		Feet.	Inches.
1.	Massive sandstone with reddish-brown bands	4	0
2.	Laminated white sandstone with reddish-brown bands	5	0
3.	Massive light-colored sandstone	2	0
4.	Laminated soft, brown sandstone with reddish-brown bands	0	8
5.	Shaly sandstone	9	4
6.	Massive, rather soft, light-colored sandstone. Weathered surface dirty brown, rough, pitted	10	0
	Total	31	0

Section 4—Near the northwest corner of the southeast ¼ of the northeast ¼ of Section 25, Bloomington Township:

Harrodsburg limestone—

		Feet.	*Inches*
1.	Light to dark gray limestone	5	0
2.	Very thin-bedded, rough, non-fossiliferous limestone	12	0
3.	Unseen. Limestone?	10	0
4.	Dark gray limestone weathering rough and pitted. Very fossiliferous	0	2
5.	Thin-bedded limestone, gray in color and weathering a pitted surface	5	0
6.	Laminated, thin-bedded, fine-grained, gray limestone	0	6
7.	Unseen	5	0
8.	Thin-bedded, course, iron-gray limestone weathering rough. Forms an escarpment	10	0
	Knobstone—		
9.	Sandstone	40	0
	Total	87	8

Section 5—Just east of Andrew Stine's residence, one and one-half miles east of Stinesville.

Glacial—

		Feet.	*Inches.*
1.	Unseen	2	0
2.	Cross-bedded brown sand, indurated at the top	12	0
3.	Unseen	5	0
4.	Very finely laminated, yellow sand, banded with brown	0	4
5.	Closely compacted gravel composed mostly of angular fragments, many of which are foreign to the region	1	0
6.	Irregularly stratified sand (moulding)	5	0
7.	Uncemented, light-brown sand	25	0
8.	Reddish-brown sandy clay	5	0
	Harrodsburg limestone—		
9.	Limestone forming precipice in ravine	0	4
10.	Very hard, thin-bedded, dark-gray sandstone	5	0
11.	Very hard, bluish-gray sandstone	15	0

		Feet	Inches.
12.	Thinly-bedded gray sandstone, banded with streaks of white	0	4
13.	Thin-bedded, light-colored sandstone	10	0
14.	Sandstone	35	0
15.	Unseen	20	0
	Total	140	8

The sand represented in the upper part of this section was deposited at the foot of the glacier. The mouth of the little stream was closed by the ice and its basin laked, allowing the deposit of the stratified material. The stream has since cut a gorge through the center of the deposit. The lateral extent of the deposit is not great because the little lake was small and narrow.

Section 6—In railroad cut 1 mile north of Stinesville:

Thicknesses, in part, estimated.

Harrodsburg limestone—

		Feet.	Inches.
1.	Massive to thin-bedded limestone	40	0

Knobstone—

		Feet.	Inches.
2	Very hard, rough-feeling, granular, calcareous sandstone weathering to a rusty brown	0	3
3.	Bluish-gray, massive sandstone	3	0
4.	Bluish-gray sandstone filled with chert and geodes	0	8
5.	Soft, blue sandstone	0	3
6.	Calcareous, fossiliferous, somewhat cherty sandstone	0	6
7.	Bluish-gray, very soft shale	0	8
8.	Thin-bedded, soft, very light-brown sandstone	2	0
9.	Stratum of chert concretions	0	4
10.	Massive, brown sandstone weathering dark and pitted	6	0
	Total	53	8

Section 7.—On the road an eighth of a mile west of Bowman Schoolhouse, Bean Blossom Township:

Glacial

	Feet.	Inches.
1. Yellowish, jointy clay with small rock fragments and occasional bands of brown moulding sand one to six inches thick	12	0
2. Very light-brown sand, when wet (white when dry), and extremely fine	40	0

Section 8.—On the road west of the Able Schoolhouse, just east of Mr. Maple's residence, Bean Blossom Township:

	Feet.
Glacial material—	
1. Yellow clay grading into moulding sand	15
2. Light-colored clayey sand	10
3. Yellow sand	10
4. Light-colored sand with occasional bands of gravel and a few bowlders	55
5. Yellow clayey sand	4
6. Gravel	3
Knobstone—	
7. Sandstone	2
Total	99

Section 9.—Township line, ¾-mile north of Lemon P. O.
A section in delta deposit. Glacial—

	Feet.
1. Yellow clay	3
2. Thinly-bedded, finely-stratified, yellow to light-brown clay breaking down to a hard yellowish-brown clayey earth	3
3. Yellow, laminated, extremely fine moulding sand, banded with bands of yellow, brown and white indurated material	10
Total	16

Section 10.—North and south section line, 420 yards west of Lemon P. O., on the south side of the ridge.

Harrodsburg limestone—

		Feet.	*Inches*
1.	Thin bedded, bluish-yellow limestone	5	0
2.	Thin-bedded, gray to brown limestone, poor in fossils and weathering pitted	20	0
3.	Brown to gray, rather hard limestone, composed of crinoid stems and Bryozoa	5	0
4.	Yellow, non-fossiliferous limestone with rusty particles	0	6
5.	Blue-gray limestone weathering yellow and brown	5	0
6.	Very hard, speckled limestone	0	6
7.	Very hard, rough, gray limestone, composed largely of crinoid stems	2	0
8.	Yellowish-blue limestone	1	0
9.	Massive, hard, fossiliferous limestone	4	0
10.	Limestone	10	0
11.	Thin-bedded, very hard, fossiliferous limestone (crinoids and Bryozoa)	1	0
	Knobstone—		
12.	Sandstone	45	0
13.	Unseen	30	0
	Total	129	0

Section 11.—Near Mr. C. C. Fulford's home on Indian Creek, half a mile west of Canada Gap:

Knobstone. Thickness estimated—

		Feet.
1.	Sandstone grading into coarse shales	100
2.	Bluish-gray, very soft shale	25
	Total	125

Section 12.—Up ravine near the northeast corner of northwest ¼ of Section 3, Bean Blossom Township, near Mr. Samuel Kid's residence:

Harrodsburg limestone—

		Feet.
1.	Massive, white to gray, hard limestone with many geodes..	15
2.	Thin-bedded, very fossiliferous, iron-gray limestone........ (Bellerophon, Productus and Spirifer.)	4

Knobstone—

3.	Thin-bedded, rusty sandstone with geodes...............	4
4.	Massive, bluish sandstone..............................	3
5.	Thin-bedded, blue sandstone............................	3
6.	Massive, bluish-gray sandstone.........................	5
7.	Very thin-bedded, shaly sandstone, weathering to white sandy clay	20
8.	Thin-bedded sandstone	35
9.	Massive sandstone	10
	Total	99

Section 13.—Ellet's Hill, ¾ mile west of Lemon Schoolhouse, south of the west side of Ellet's graveyard.

Oölite—

		Feet.
1.	Fine-grained, whitish-gray, oölite, like that quarried at Stinesville and Bedford................................	25
2.	Massive, coarse-grained, dark-gray oölite................	10

Harrodsburg limestone—

3.	Limestone	65

Knobstone—

4.	Sandstone and sandy shale..............................	100
	Total	200

Section 14.—In ravine north of Mrs. W. E. Wood's house near the center of the north line of the south east ¼ Section 32, Washington Township:

Harrodsburg limestone—

1.	Mostly thin-bedded, very hard, steel-gray limestone with crinoid stems	10

Knobstone—

		Feet.
2.	Soft, brown, massive sandstone	10
3.	Thin-bedded, bluish-gray, soft sandstone shaling on weathering	45
4.	Shale	20
5.	Unexposed	10
6.	Yellowish-brown sandstone	5
7.	Not exposed	10
8.	Thin-bedded, yellowish-brown sandstone	2
9.	Covered	15
	Total	127

Section 15.—45 rods west of township line on Hindostan road near Mr. T. J. Farr's house:

Harrodsburg limestone—

		Feet.
1.	Hard, rough, dark-gray limestone containing fossils	15
2.	Covered slope	5
3.	Hard, gray limestone weathering rough, dark, and pitted	5
4.	Thin-bedded, hard, cherty, fossiliferous limestone	10
Knobstone—		
5.	Sandstone	4
	Total	39

Section 16.—Ravine west of road, one-half mile south of Bean Blossom Church, north of Unionville:

		Feet.
1.	Oölitic limestone	
2.	Very hard, thin-bedded, light-gray limestone, weathering rough and pitted. Contains fossils	20
Knobstone—		
3.	Sandstone, varying from shaly to massive, very soft, blue, weathering yellow and brown	90
4.	Covered slope	10

Stobo limestone, lens—

		Feet.
5.	Hard, rough, gray, crinoidal limestone	1
6.	Hard, gray limestone, few fossils	15
7.	Hard, gray limestone with rusty particles and crinoid stems	5
8.	Soft, blue, sandy shale	10+
	Total	151

STRATIGRAPHY.

The Knobstone is the surface rock over the greater part of the region here considered. It extends from Brown County west to the Harrodsburg limestone contact which extends in a general northwest and southeast direction, crossing the country east of Bloomington. Northeast of this line, however, there are several detached patches of limestone resting on the Knobstone. The entire thickness of the Knobstone is not exposed in this area; but according to Mr. Siebenthal it is about 600 feet. The formation, as far as examined, is composed of a series of alternating, friable, arenaceous shales and sandstones. On the whole the formation is non-fossiliferous. At intervals, however, as at Stobo Post Office, there are intercalated, lenticular beds of limestone and calcareous septaria with rich faunas. This formation, on account of its incoherent, loosely-cemented, easily-eroded condition, has been cut up into a confused tangle of crooked ridges and deep hollows which trend in all directions. Commercially the Knobstone is of little value on account of its friable condition, but the arenaceous shales may be of value in the making of brick and cement.

The Harrodsburg limestone lies on the Knobstone and below the Salem (Bedford) limestone. In the main, it forms a belt from three to five miles in width along the eastern outcrop of the Salem limestone or oölite, and is bordered on the east by the broken hills of the Knobstone. This limestone once covered the entire region east of the oölitic contact, as is attested by its patchy remains in various parts of the county. The triangle between Bean Blossom Creek and White River from Mt. Tabor east to within one mile of Canada Gap is capped with it. A large, irregular, much lobed area of it occurs as the surface rock in the vicinity of the Farr schoolhouse east of Hindostan, and another just west of Hubbard's Gap. East of the railroad, about two miles southeast of Gosport, a small area of this formation is half submerged in glacial sand. Another small triangular area, with strata dipping to the east, lies on the east side of a ridge a mile south of the Bean Blossom Church. Besides the patches mentioned, there are several other small ones of this formation in the area. In addition to these, main lobes extend to the east from the limestone belt for several miles. One of these lobes extends in a linear strip to Unionville. From there it turns back toward the northwest for three miles. This strip is the watershed of the region through which it extends. On the limestone lobes are located most of the roads in the Knobstone region. The Harrodsburg limestone as exposed on Ellet's hill is 65 feet thick. Its lower portions are limestones containing a great number of geodes, or "mutton heads," which range in size from a pea to a bowlder two feet in diameter. Above the geode layers the stone contains pyrite, is somewhat crystalline, and is tinted with blue, gray, or green.

This limestone is thin-bedded. The bedding planes separating the strata are, in many instances, lenticular, intercalated masses of chert. The strata were found to be more massive toward the top of the formation. Also as the top of the formation is approached the limestone gives up its molluscan fauna and takes on a Byrozoan fauna.

"The contact of the Harrodsburg and oölitic limestones is almost always marked by a 'crowfoot' (stylolite), with which are associated masses of silicified oölitic fossils and black siliceous masses."*

To the present time the Harrodsburg limestone has proved of commercial value only for macadamizing purposes.

The Salem limestone lies above the Harrodsburg limestone and beneath the Mitchell limestone. It forms a belt about three miles in width. It begins near Gosport and extends beyond Bloomington, embracing the quarry districts of Big Creek, Stinesville, Elletsville and Bloomington. Beside the belt strip there are several detached areas. One caps Ellet's hill, near Lemon Post Office. This latter patch covers an area of about ten acres. The oölite of this patch is of average thickness and is of fair quality. It is massive, free from lamination and bedding planes.

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*Siebenthal, loc. cit. p. 298.

Analyses of Salem limestone:

Sample 1 from Adams quarry—

	Pcct.
Residue insoluble in acid	.44
Lime (CaO)	52.76
Magnesia (MgO)	1.04
Carbon dioxide (CO_2)	43.80
Alumina and ferric oxide (Al_2O_3, Fe_2O_3)	1.57
SO_3	.06
Total	99.67

Sample 2. Johnson quarry, Bloomington

	Pcct.
Residue insoluble in acid	.77
Lime (CaO)	54.67
Magnesia (MgO)	.60
Carbon dioxide (CO_2)	43.04
Alumina and ferric oxide (Al_2O_3, Fe_2O_3)	.42
Phosphorus peroxide (P_2O_5)	.19
SO_3	.19
Total	99.88

For exhaustive treatment of the Salem (Bedford) limestone the reader is referred to Siebenthal's article already mentioned.

THE GLACIAL DEPOSITS.

The glacial deposits, so far as the writer's observations extend are: Glacial till, outwash and eolian deposits, bench or terrace deposits and delta deposits.

GLACIAL TILL.

The drift deposit was first observed on Jack's Defeat Creek in the neighborhood of the old Dutch church. From there it continues in a northeasterly direction, crossing Bean Blossom Creek near the mouth of Camden Branch. According to Siebenthal's description* it then bends south of Lost Ridge, near the mouth of Indian Creek, and follows the course

*21st Geol. Rep. Ind. p. 300.

of the latter creek to Canada Gap, continuing in the same direction and, passing a half mile south of Godsey Post Office, it crosses into Morgan County three-quarters of a mile east of Godsey. Swinging southeastward it re-enters Monroe County where Hacker's Creek leaves it, extending up that creek to the neighborhood of Hacker's schoolhouse. From here eastward the drift limit becomes harder to trace. The ice-sheet must have been very thin, since the topography shows little, if any, modification. Scattered erratics are found all over the ridge dividing the waters of Roberts' Creek from the headwaters of Honey and Hacker's creeks. It seems probable that the foot of the ice-sheet rested on this hill, and that the drift found in the head waters of Honey Creek was carried there by the water resulting from the melting of the glacier. Many large granite bowlders from one to three feet in diameter are found along the small stream leading north from Hubbard's Gap, in Sec. 11 (10 N., 1 E.), and along the other tributaries of Roberts' Creek. In section two of the same township heavy deposits of sand, gravel and till lie against the hillsides. In the neighborhood of Godsey Post Office the same phenomena may be seen. Heavy beds of gravel and till lie against the hillsides bordering their slopes on the south. In Canada Gap, section 9 (10 N., 1 W.), the evidences of ice occupation are plain though the quantity of drift material is very limited. The territory between Indian Creek and Bean Blossom Creek and White River displays evidence of ice occupation in many places in modified topography and deposits of till, sand and gravel. Till, sand and gravel occur in the valleys leading south from Hubbard's Gap in the vicinity of Fleener Post Office, and patches of these same materials are occasionally met with south of the divide east of that gap. On the whole the drift is thick in the valleys and thin on the hills. This light drift on the hills indicates that the ice-sheet which crossed them was comparatively thin.

OUT-WASH AND EOLIAN DEPOSITS.

North of Mount Tabor and between there and Gosport, as well as the south slope of the hills between Mount Tabor and Ellet's hill are covered with a heavy deposit of sand. A sand apparently identical with the above caps several hills and fills several preglacial ravines on the south side of Bean Brossom Creek near Andrew Stine's residence about two miles east of Stinesville. The sand near Andrew Stine's residence was evidently deposited in water. That it was of glacial origin is attested by the fact that it is banded with erratic gravel. The sand here is cross-bedded, stratified and, in several instances, finely laminated. The lamination and stratification, however, are not constant. Towards the top of this sand the stratification ceases. This top seems to have been of eolian origin. This sand was deposited as an out-wash in front of the advancing glacier after it had filled the channel of Bean Blossom. That it was deposited in front of the advancing ice-sheet is clearly shown by evidence that after its deposition the glacier passed over it, crushing it under its weight until now the sand is almost as compact as the Knobstone formation beneath it. Still further evidence that the sand was deposited just in front of the ice-sheet is the fact that the Bean Blossom was filled at that point with ice. Had it been filled with sand instead of ice to the level of the present deposits some remnants of the sand would still remain on the south side of the inner valley of Bean Blossom Creek, which is not the case. The sand in the vicinity of Mt. Tabor and Gosport is very fine and flour-like. It usually forms a loose or slightly compact, massive bed twenty or more feet in thickness. Occasionally it shows indications of stratification, but at no place is the stratification constant. In speaking of this sand Mr. Siebenthal says that it seems to have been deposited from high water resulting from a melting ice sheet.* It is therefore out wash material. How it came to be deposited as it is, however, is quite a mystery. The deposit is V-shaped with the apex to the west. A limestone ridge separates its legs. On this ridge the sand is thin and suggests by its distribution that it might be eolian in origin. It seems clear, then, that the sand on the south side of the ridge must have come around the west end of the ridge instead of over it, and that the whole deposit was laid down in the slack water between Bean Blossom Creek and White River at the time of the high water that accompanied the melting of the ice-sheet. This opinion is strengthened by the fact that the sand plain gets lower and lower toward the east instead of higher as it would had the sand come over the ridge. This conclusion is further strengthened by the fact that this sand does not occur on the current, or south side of the Bean Blossom as it probably would had it not been deposited in slack water. The sand, on the whole, seems to have been an eddy deposit.

*Op. cit.

BENCH OR TERRACE DEPOSITS.

These deposits have been described both by Mr. Siebenthal and Professor Marsters. In speaking of them Mr. Siebenthal says: "Terraces occur in the valley of Bean Blossom Creek above the crossing of the drift limit. Drift deposits occur below that, but are irregular in height and have not the level top of terraces. The terraces range from mere knolls to benches a mile wide. The lower portions of these beds consist of sand and erratic gravel with sand and smaller gravel above, and over all sandy clay and loam. These terraces seem to have been deposited by high waters which must have resulted from the melting of the glacier which covered the head waters of the creek in Brown County, and the drainage of the glacier which crossed its lower course. The various tributaries of Bean Blossom Creek have similar deposits in a smaller way, the materials of which are, however, of local origin. The fact that the drift material of foreign origin is confined to the creek itself, argues that it was derived from the glacier occupying the upper course of the creek."

In speaking of the same terraces Professor V. F. Marsters says:*

"Rimming the valley slopes are to be found a number of benches of variable widths, with surfaces sometimes as flat as a floor or with an exceedingly gentle decline valleyward, with outer edges lobate in shape and descending with a marked angle to the level of the valley floor. These occur at various points within the limits of Monroe County, invariably situated on the north and east sides of the valley, and varying in elevation from twenty feet in the lower part of the stream to seventy or more feet in the upper part of the valley near the east line of Monroe County. In all the cases examined they were found to be composed of mixtures of clay and sand undoubtedly derived from the disintegrated rock formations constituting the surface of the uplands. No glacial debris of any sort was found either on the surface or in any of the sections or cuts in the benches noted within the limits of Monroe County."

It will be readily seen that the two authors quoted above differ from each other concerning the origin of the bench material. Mr. Siebenthal says in substance, that it is of glacial origin; and Professor Marsters gives a directly opposite view, stating that no glacial material of any

*Proc. Ind. Acad. Sci. for 1901, p. 225.

kind was found in any terrace within the limits of Monroe County. The difference of opinion may be explained in part, by the fact that Mr. Siebenthal has included the delta plains in his terraces and Professor Marsters has omitted them, as is found later in his paper.

To turn to the terraces themselves, the most of them are capped with ten or more feet of a mixture of clay and sand undoubtedly derived from the disintegrated rocks constituting the surface of the uplands. Some of the other benches are capped with glacial material; others with both glacial and residual material. Underneath the loose material are always to be found friable sandstone, or more frequently sandy shales many feet above the water in Bean Blossom Creek. The bench lying between Mt. Tabor and Ellet's hill is composed of shale and shaly sandstone except at the top. The sandstones and shales are exposed at several places along the road leading east from Mt. Tabor as well as in the ravines north of the road. The top is capped by a thin layer of sand or sandy clay. The bench on which Pleasant Valley Church is situated is all shale except the top part which is composed of a few feet of residual clay on which rest ten feet of erratic gravel and clay. The bench on the north side of Bean Blossom Creek, beginning almost one-half mile east of Bean Blossom Church and extending to the Brown County line is composed of blue shale resting upon which are ten to twelve feet of residual clays.

The benches seem to be due not to glacial agencies in the main, but to the bench-weathering of the arenaceous shales of the region, together with the formation of small side deltas which have become confluent. This opinion is strengthened by the following facts: (1) The terraces are higher above the creek bed at the east than at the west, when if they had resulted from a laking of the basin as Mr. Siebenthal supposes they were, they would have been higher at the west. (2) The material did not come from the foot of the glacier in Brown County, as this author supposes, because the finer material is along and just west of the Brown County line, the coarser, farther down the creek. (3) While the benches rise toward the east the deltas of the larger tributaries do not always do so, thus leaving gaps that would have been filled had the bench material come down the creek from the glacier which crossed its upper tributaries. (4) The benches rise toward the east with the rise of the shales.

In preglacial time Bean Blossom Creek, as we shall see later, cut its channel to base level. At that time all its tributaries likewise cut to grade. Both the creek and its tributaries began to meander and to etch back their valley sides. The thin Harrodsburg limestone being removed as well as the upper Knobstone, the shaly slopes, weathering flat, became, with the modifications mentioned above, the terraces of today.

This subject will be further investigated in the near future. At that time it is hoped that the origin of the terraces can be more definitely determined.

After the ponding of Bean Blossom Creek the tributaries silted up their channels which became miniature estuaries. They then began to form deltas in the lake and in the slack water regions. The western tributaries, for example, Buck Creek, built their deltas in a direct line toward the center of the lake. This demonstrates that the water in which the delta was built was free from strong currents. The deltas of the eastern tributaries swing westward, often forming an east and west bar, now a ridge, thus indicating that these tributaries entered a swollen, westerly-moving stream. The eastern deltas also attest that Bean Blossom Creek was not then ponded but was a slowly moving stream reaching from bluff to bluff. When the estuaries were all filled and the deltas had reached the level of the benches the tributaries spread their debris over the benches as well, so that today it is hard to tell, so far as topographical appearance goes, where the terraces leave off and the deltas begin. Two of the most conspicuous deltas are those of Buck and Wolf creeks. In writing about these Prof. Marsters says:*

"Besides the portion of each creek, wriggling across the valley bottom, there are rather long and narrow strips or delta-like accumulations similar in content to the benches already described, and extending from the valley slope to within a few yards of the Bean Blossom channel which hugs the south slope of its valley. The surface does not attain the characteristic flatness of the rimming benches, but is slightly irregular in relief and increasingly so towards the slope to which it is attached. This is especially true for the Buck Creek case, but not for the Wolf Creek. The increasing irregularity may be in part due to the nearly complete burial of a projecting spur, whose top is barely coated over with the delta deposits now spread almost across the entire width of Bean Blossom; but it must be said that no outcrops of limestone or sandstone, such as make the slopes of the valley, have been discovered within its limits. On the other hand, the irregularity of relief may have been produced by

* Loc. cit. p. 235.

the piling up of the great load of silt within Bean Blossom by the tributary, but did not succeed in building it up to the lake level; in other words, it is an incomplete delta, or bar.

The Wolf Creek case differs from the former only in having a moderately flat top, or at least the higher flats on it attain about the same level, thus suggested that it was built up nearer to water level, and hence more even and uniform in relief. These differ from the rimming benches only in that they *extend across the valley floor*, while the former, being made by smaller streams close to each other, have built a series of small benches or deltas which have become confluent, and hence continuous *along the valley side*."

The delta material is derived from the disintegrated rocks of the adjacent uplands or is of glacial origin or is of both glacial and residual debris according to the source of the tributary and the proximity of the foot of the ice-sheet. The ice-sheet entered both Canada and Hubbard's gaps and at several places between these two gaps its foot rested on top of the Bean Blossom Creek—White River divide. Consequently glacial material is to be found in the deltas of Indian and Honey creeks leading south from these respective gaps. Below are sections from some of the most conspicuous deltas of the area:

Sections taken on the Buck Creek delta:

Section 1.—Well on Dolan road one mile north of Dolan.

	Feet.
1. Yellow clay	18

Section 2.—Well on Dolan road, one-half mile north of Dolan.

	Feet.
1. Black soil	1
2. White sand	6
3. Yellow clay	15

Section 3.—On A. Oliver's place on the Dolan road one mile north of Dolan. A well was once dug here through yellow clay for 47 feet.

Section 4.—Solomon Laughlin's well about a mile south of Dolan.

	Feet.
1. Clay and sand	36
2. Solid rock	?

Section 5.—On the road on the half section line between sections 34 and 35, Washington township, one and three-fourths miles north of Dolan.

		Feet.
1.	Yellow clay breaking down to yellow earth	5
2.	Whitish-yellow clay	1
3.	Yellow clay	1
4.	Whitish, laminated clay becoming very hard on exposure	5
5.	Yellow jointed clay	5
6.	Yellow to brown jointed clay	5
7.	Shale	1+

No glacial material of any sort was found in this delta.

INDIAN CREEK DELTA.

Section 1.—Well at Lemon Post Office.

The section here was composed entirely of loose material. The bottom of the well was in loose erratic gravel at a depth of 20 feet.

Section 2.—Marion Coater's well, forty rods east of Lemon Post Office.

		Feet.	Inches.
1.	Black earth	2	0
2.	Yellow clay	8	0
3.	Yellow coarse sand	0	8
4.	Gumbo clay	14	0
5.	Fine quicksand	3+	

The Indian Creek delta is composed more or less of glacial material, as is shown by the sections. This, of course, was anticipated as the stream heads in Canada Gap.

Sections taken in the vicinity of the Honey Creek delta.

Section 1.—Well north of the road one-eighth of a mile east of Pleasant Valley Church.

		Feet.
1.	Clay	5
2.	Erratic gravel	7

Section 2.—Another section near the preceding one.

		Feet.
1.	Gravel	18
	Bowlder stratum	4

Like the Indian Creek delta this delta contains glacial material. The glacial material came through Hubbard's Gap.

A section taken on a delta at the mill south of Dolan gave the following:

		Feet.
1.	Bedded, jointed yellow clay banded with red, burns red...	20
2.	Bedded, laminated, jointed blue clay, hard when dry, soft when wet	5
3.	Very soft, massive, blue clay, burning white..............	20

POST GLACIAL DEPOSITS.

Under this head will be considered the alluvium and the alluvial fan deposits.

Alluvium.

At the close of glacial times Bean Blossom Creek and its tributaries recut their channels to an unknown depth. Then a process of meandering and slight aggrading set in, which has continued to the present time. As a result the creek and its tributaries have developed large alluvial plains. The alluvial plain of Bean Blossom will average a mile in width throughout Monroe County, while many of its branches have bottoms a quarter to a half mile wide in their lower courses. The depth of the alluvial deposits was not ascertained, but in lower Bean Blossom Valley they are probably quite thick. The best farms of the region are located on these plains.

Alluvial Fans.

A number of small V-shaped valleys with very steep channels were found traversing the steepest, southern slopes of Bean Blossom Valley. These on reaching the valley-floor spread out their debris in the form of alluvial fans, their channels disappearing altogether where the fan intercepts the valley floor. The fans project but a few yards beyond the mouths of the valleys. These are evidently fans as they do not possess the flat tops and steep outer margins of the deltas. That they are post-glacial is evident from the fact that some of the little valleys have cut their channels through glacial debris. The one just east of Andrew Stine's house will serve as an example. In addition to this the fans are built on the alluvial floor of the creek which has been made since glacial times.

PHYSIOGRAPHY.

SPRINGS.

The springs of the area are to be found mostly in the limestone regions. They owe their origin to underground drainage. None are mineral springs so far as the writer knows. They furnish the water supply for the city of Bloomington and supply the water for domestic use throughout the region where they are found.

ABANDONED SWAMPS.

About three-quarters of a mile north of the Lemon schoolhouse, on the top of the north bench of Ellet's hill, is a deposit of iron ore gravel. This limonite is scattered over a large area and is evidence of the existence of a large swamp which has now dwindled down to a pond. This swamp probably dates back to glacial times. It was most likely formed between the foot of the ice-sheet and the ridge that terminates Ellet's hill at the south.

SALT LICKS.

Several salt licks are to be found in Indian Creek and Bean Blossom valleys. They seem to be evidence of saline shales beneath the valley floors.

BOULDERS NOT GLACIAL IN ORIGIN.

In a ravine just north of Ellet's hill, about a mile northwest of Lemon Post Office, are several large bowlders some of which will weigh several tons. These bowlders are not glacial in origin because they are neither scratched nor worn, but are large concretions weathered from the adjacent sandstones of the ravine. That this conclusion is correct is attested by the fact that a half-weatheredout concretion of large size is in situ projecting from the sandstone wall of the ravine near by. The concretions are largely composed of silica and are very hard.*

LOST RIDGES.

Standing in line with a point between White River on the left and Bean Blossom Creek on the right in section 5, Bean Blossom Township, is a subcircular knob called Indian or Pasture Mound. This mound being

*In the vicinity of these bowlders were several granite bowlders of glacial origin.

in line with the mound to the north and being composed of the same kind of material suggests that the two were once continuous and are yet continuous beneath the valley floor.

South of Bean Blossom Creek, opposite the railroad cut in section 9 of the same township, there is another ridge standing in line with the projecting "mainland" east of Jack's Defeat Creek. It is almost a third of a mile in length, about 400 yards wide and some 80 feet above the valley floor. It seems to have been a ridge between Jack's Defeat and Bean Blossom creeks before the aggrading of the valley floor caused the former creek to change its channel to the east through a former wind gap in the ridge. This left the ridge isolated.

North of the Bean Blossom, in section 24 of this same township, there is another conspicuous ridge known as "Lost Ridge." It is in line with the "main land" to the north, from which it is separated by only about a hundred yards of flat floor, through which a small stream runs from the Bean Blossom Valley to join Indian Creek. In this case, as in the previous one, the trend of the slope and the trend of the adjacent valley slope, together with the fact that the composition of the rocks is identical, suggest attachment beneath the present valley floor. There are several other similar islands in the Bean Blossom Valley.

These bits of relief are "islands" surrounded by alluvial material. They strongly attest that the Bean Blossom Valley has been aggraded very considerably.

Half Submerged Points and Peninsulas.

Several tied-on, peninsula-like ridges, known as knobs and points, project from the valley walls into the valley of Bean Blossom Creek, with the connecting neck almost submerged beneath the alluvium of the valley. They also attest to the aggrading of the valley.

Abandoned Valleys.

In the glacial region on the south side of Bean Blossom Creek several of the short valleys that were filled with glacial debris still remain filled. The glacial filling of the other valleys have been removed wholly or in part. Those which remain filled have had no springs at their heads since glacial times. Since much of the drainage of that part of the county is underground drainage the little valleys have remained filled.

Young Valleys.

The steep-graded, V-shaped valleys of the south side of the Bean Blossom Valley have already been described in this article and shown to be postglacial. In writing of these valleys Prof. Marsters says:*

"Traversing the steepest slopes of Bean Blossom are to be found numerous V-shaped valleys, with remarkably steep channels, ending their lower course at the point of intersection of the valley floor with the adjacent slope. In all cases small alluvial fans are built on the valley floor with their apex projecting but a few feet or yards at most beyond the mouths of the young valleys. In none of the observed cases was it found that the level of the valley floor would extend into the mouth of the young valley. It is therefore believed that the greater part of the cutting of these young valleys may date subsequent to the preglacial filling. The fact that alluvial fans and not deltas with steep outer edges and flat tops occur at their mouths, suggest that they have been constructed since tha laking of the valley, and hence are regarded postglacial."

Reversed Drainage Due to Aggrading.

In section 24, Bean Blossom Township, the little stream which flows through the little gap between the "mainland" and Lost Ridge normally should flow direct to Bean Blossom Creek instead of into Indian Creek. Its head waters are in Bean Blossom Valley proper, not in Indian Creek Valley. The reversal of drainage is due to the aggrading of Bean Blossom Creek, so that the fall is greater through the gap.

Change of Channel Due to Aggrading.

Jack's Defeat Creek, running northeast from Stinesville, from all appearances normally ran just east of the Monon Railroad track between the "mainland" and the lost ridge, previously described, to join the master stream. With the aggrading of Bean Blossom Creek this little creek likewise aggraded itself until, having dammed its lower course with debris, it turned east and joined Bean Blossom farther up stream.

Abandoned Channels.

There are two abandoned channels of considerable size in the region. The one, that of Jack's Defeat Creek, between the "main land" and the

*Loc. cit. p. 236.

lost ridge just east of the railroad, has already been mentioned. The other channel extends from the top of the divide just north of the Abel schoolhouse west to the limestone ridge that is half submerged beneath the sand just east of the railroad track in section 5, Bean Blossom Township. It is about a mile in width and extends from the Bean Blossom Valley north to the White River Valley. The bed of this channel, which is now filled with glacial sand, is at least twenty-five feet below the present surface, as is attested by the sections taken in the wells of the region. The origin of this channel is still undetermined. The data at hand seem to suggest that after the retreat of the ice-sheet from the immediate vicinity, an ice-gorge dammed White River and compelled it to cut a new channel. After the breaking of the ice dam the river, as the new channel was not as deep as the old, abandoned the new and resumed the old channel. As it was being abandoned the new channel became a slack water region in which was deposited the sand which now fills it.

Wind Gaps.

There are many wind gaps in the area. They are the result of the degrading action of small streams on opposite sides of a divide. The streams have etched back their respective channels until they have cut through the divide, thus forming a wind gap. Conspicuous among these are Canada and Hubbard's gaps. These two gaps are both on the divide between White River and Bean Blossom Creek. They were both in existence in glacial times as they have glacial material deposited in them. In each rested the foot of the ice-sheet, and through each was carried south into the Bean Blossom Valley large quantities of glacial debris as has been shown in the discussion of the deltas of Indian and Honey creeks; the latter creek heading in Hubbard's Gap and the former in Canada Gap. These gaps are in interest now as they furnish prospective routes for steam and electric railways.

Bean Blossom Creek.

Bean Blossom Creek enters Monroe County from the east a little south of the northeast corner of the county and flows a little south of west to the northwest corner of Bloomington Township.* Here it changes its direction to a northwest course. It continues in this direction until it

*The change in the course of this creek is due to its sheering off to the northwest on coming in contact with the harder Harrodsburg and Salem limestones. Its lower course follows the trend of these out-crops.

enters White River a mile below Gosport. Throughout the county it has a wide, flat-floored picturesque inner valley, averaging a mile in width, the sides of which range from 100 to 200 feet in height. In this valley the present diminutive creek persists in keeping to the southwest side. The slopes of the valley usually range somewhere between 25° and 40°; the steeper slopes being usually on the south side, the south slopes of Ellet's hill and Mt. Tabor north of the creek being the only examples to the contrary. Rimming the valley slopes are a number of benches of variable widths, as has been previously noted, while projecting above the alluvium of the valley are hummocks and ridges, "islands" whose content is precisely the same as the country rock on either side of the valley. Beside these, tongues, promontories and tied-on ridges project into the valley.

This stream has had a varied history as has been already roughly outlined. It will be discussed under three heads, Preglacial, Glacial, and Postglacial history.

Preglacial History of Bean Blossom Creek.

At the close of the Mississippian period, or later in preglacial time, Bean Blossom Creek incised its channel to a depth much below its present level. That the incision was made in preglacial time is indicated by the following facts: (1) The old valley is now half filled with debris some of which is glacial in origin. (2) Its tributaries to the north as well as the wind gaps due to preglacial drainage likewise have glacial debris in them. (3) The glacier which crossed the northwestern part of Monroe County passed over and filled the creek, as is evidenced by the sand and glacial drift left in its valley. That the channel was deeper in preglacial time than now is demonstrated by the following evidence: The creek now meanders on a flat floor a mile in width. The floor, which is composed of alluvium for the most part, is still being aggraded. (2) Wells dug in the valley floor north of the channel, show that the loose material has great thickness. Mr. James Hughes' well, at his home on the road one mile east of Mt. Tabor nearly in the center of the southeast quarter of section 10, is 65 feet deep, yet it does not penetrate the entire thickness of the valley filling at that place. (3) Many of the meander-cut slopes have been largely buried beneath the valley filling. (4) Many of the tributary valleys, such as Jack's Defeat Creek, are aggraded for some distance up stream.

After incising the valley and widening it by meander cutting, Bean Blossom Creek began to aggrade its channel and at the close of the preglacial time had filled it nearly to the level it is today. The evidence in favor of such a conclusion is as follows: (1) At all points where the creek was protected from the invasion of glacial debris by promontories, such as Mt. Tabor and Ellet's hill, it still flows on the north side of its valley At all other places it was driven to the south side by glacial debris. (2) The greater part of the clay and silt occupying the valley floor is of precisely the same kind as that covering the unglaciated highlands and valley slopes. It is evident that this filling simply represents the wash and soil-creep from the slopes and uplands on either side of the valley. (3) At the mouth of the creek where the glacier crossed the country only a patchy film of sand associated with bowlders composed partly of crystalline rocks cover the underlying clays, silts, etc.

This conclusion agrees with the following statement of Prof. Marsters concerning the preglacial filling of the valley:

"Inasmuch as the greater part of the clay and silt occupying the valley floor is precisely the same in kind as that covering the unglaciated uplands and valley slopes, it is evident that this filling simply represents the wash and soil-creep from the slopes and uplands on either side. Moreover, the rate of filling was so far in excess of the ability of the stream to carry off its load that the preglacial valley became clogged with the waste to such a degree that the stream now occupying the valley floor is for much of its course quite unable to spread its meanders over the entire width; only at the narrowest sections does Bean Blossom succeed in occupying the entire valley from slope to slope.

"Inasmuch as the filling of Bean Blossom at its mouth and for some little distance up stream is covered over by a patchy film of glacial sand associated with bowlders, composed partly of crystalline rocks, the underlying clays, silts, etc., antedate the glacial coating. Moreover, the occurrence of benches (to be associated with the glacial history) resting upon the valley filling also point to the same conclusion, that the present filling of the valley, less the benches and the glacial sands, etc., near the mouth of the valley, is preglacial."

The valley fillings, less the glacial sand, are, therefore, mostly preglacial.

Glacial History of Bean Blossom Creek.

As has been previously stated Bean Blossom Creek was laked by the ice-sheet which crossed its lower course. At the time of its laking there were deposited in its valley the deltas together with the loose materials that now cover the benches on either side.*

Post-Glacial History of Bean Blossom Creek.

Since glacial time Bean Blossom has been a diminutive, meandering creek in a broad, flat-floored valley, and throughout all postglacial time it has persisted in keeping to the south or west side of its valley. Evidently it does not fit its present valley. This fact suggests that the creek has not been able, on account of its diminutive size and the lack of time, to do much constructive work since the ice retreated. It is now at grade for ten miles above its mouth and must be actually aggrading its channel.

We quote Prof. Marsters for a more detailed description of this topic.**

"Since the close of the laking stage Bean Blossom River has developed a meandering course on its broad floor. Only in the narrowest sections of the valley has it succeeded in spreading its meander belt across the entire floor. For the most part it keeps to the west or south side of the valley, and yet still assumes a meandering habit for considerable stretches. In other words, the stream does not fit the present dimensions of the broad valley, which, accordingly, must have been brought about by other conditions than that resulting from lateral cutting, by a mature stream. Cross sections of the valley at its broadest places reveal a slight curvature of surface in the center and occasional abandoned meandering channels. This slight variation from a plain surface suggests flood plain construction. Whether this constructive work antedates the glacial episode of Bean Blossom is not certain, but it would seem from the data at hand, that the present postglacial Bean Blossom has not had time or the ability to do much constructive work since pleistocene time."

Two more things of interest in connection with Bean Blossom Creek remain to be explained. They are: (1) The reason for the channel of the creek keeping to its south bank, and (2) the reason why the slopes on the south side of the valley are steeper than those on the north.

*See Marsters, loc. cit. for further discussion of this subject.

**Loc. cit. p. 236.

The explanation of the former seems to be that the branches from the north carried in much more material than those from the south. The tributaries from the north are more numerous and larger than those from the south and carried into the valley great quantities of glacial material from the foot of the ice-sheet or material from the slopes near its foot. This caused a greater accumulation of sediment on the north side of the valley, and the deltas thus formed drove the stream to the south side of the valley. The deltas of Buck and Wolf creeks, for example, extend nearly across the valley to the south side. Where Mt. Tabor, or Ellet's Hill, protected the valley from glacial or upland sediments from the north, the channel finds its way to the north bluff. To sum up, it seems from the foregoing statements that the creek keeps to its south bluff because of accumulated material from its tributaries in the north side of the valley.

The answer to the other question, Why are the valley slopes steeper south of Bean Blossom than north of it? seems to be as follows: It was observed that the variation in the slope had a direct relation to the minuteness of dissection, or the spacing of the streams crossing it, and that the closer the streams are to each other, the more subdued the slope. As a greater number of streams cross the valley slope on the north side of the valley we find the more subdued slopes on that side. In addition to this the stream occupying the south side of the valley has confined its side-cutting to that side which has tended to keep these bluffs steeper.

Mineral Resources.

The principal mineral resources are rock, sands and clays. The rocks having been mentioned as to use and value, the sands and clays remain to be discussed.

Sand.

The sand of the area is in the vicinity of Mt. Tabor, and between that point and Gosport. This sand is very fine and flour-like and, consequently, it is not a plastering sand. However, it is a good quality of moulding sand and may be used for paving purposes. For these purposes it has been satisfactorily tried, several car loads being used. There is, besides detached patches, a continuous sand area covering several square miles to a depth of 20 to 40 feet.

Clays.

The residual clay derived from the breaking down of the Harrodsburg limestone is very stiff and of a deep red color. The clay resulting from the decomposition of the Knobstone shales is usually blue except on weathered surfaces, where it is light yellow. All the other clays of the region, those of the deltas being good examples, are yellow.

The blue clay is derived from the blue stone and shale of the Knobstone. Only three patches of this clay were noticed, one north of Bean Blossom Creek near the Brown County line, one just across Honey Creek on the road east of Fleener, the other in the delta (bench) south of Muddy Flat Creek, about a half mile south of Dolan. There are probably several other patches of this clay in the area, but as my investigations did not have reference to clays, no particular search was made for them. The clay of the first two patches mentioned is residual, while that of the last is probably stream wash and about 25 feet deep. On being burned in a kiln it burns white. The foreman of the tile mill at Dolan states that it is a good potter's clay. In burning tile the blue clay is mixed with equal parts of the yellow clay. This mixture produces a tile of fair quality.

Both the delta and bench formations in the Bean Blossom Valley are yellow above and sometimes down to a depth of 20 feet. This clay is the same in appearance as the yellow clay at Dolan that is made into tile. It is the opinion of the writer that a large tile and brick industry could be built up in this valley.

Indiana University, December 31, 1903.

Geology of the Fort Apache Region, Arizona.

By Albert B. Reagan.

(By title.)

What is the Age of the Aubrey Limestone of the Rocky Mountains?

By Albert B. Reagan.

The Carboniferous rocks of the Rocky Mountains are divided lithologically and palaeontologically into two distinct groups: The Red Wall and the Aubrey groups. The Red Wall is divided on palaeontological grounds into the Upper and Lower Red Wall, and the Aubrey on stratigraphical and lithological grounds into the Upper and Lower Aubrey. The Upper Aubrey is usually called the Aubrey Sandstone, the Lower Aubrey the Aubrey Limestone. In this paper it is the writer's purpose to establish the age of the last named group.

This group of rocks rests conformably upon the Upper Red Wall and shows conclusively by its position that it is Palaeozoic. Then as the Upper Red Wall is Coal Measures in age (see paper on "The Fossils of the Upper Red Wall Compared with those of the Kansas Coal Measures"), the Aubrey Limestone must be either Upper Carboniferous or Permian. Its position immediately above the Red Wall suggests the former; that is, that it is Upper Carboniferous. This conclusion is attested by the fossils identified from the group. They are: *Seminula argentia, Productus punctatus, Productus semi-reticulatus, Productus costatus (?), a Productus closely allied to if not, P. portlockianus, Spirifer cameratus, Bellerophon, Spirifer lineatus, Euomphalus pernodosus, Aviculopecten occidentalis Aviculopecten, a Hemipronites* (Gilbert), *Meekella striata-costata, etc.*

These fossils were all obtained in the first 100 feet of the Aubrey Limestone. They are all Upper Carboniferous, not Permeo-Carboniferous, in age, and therefore establish the age of the rocks in which they are found to be Upper Carboniferous beyond a doubt.

Note.— A few shells *(Pleurophorus, Schizodus,* and *Bakerella)* found by Mr. Gilbert (U. S. Geographical Surveys west of the 100th meridian, vol. 3, page 177) in the topmost layer of the Aubrey Limestone suggests the Permeo-Carboniferous of the Mississippi Valley. This would seem to imply that the Aubrey Sandstone which is conformably superimposed on the Aubrey Limestone is Permeo-Carboniferous in age.

Some Fossils from the Lower Aubrey and Upper Red Wall Limestones in the Vicinity of Fort Apache, Arizona.

By Albert B. Reagan.

The Fort Apache region, Arizona, is the home of the White Mountain Apache Indians. The region, as described in the November number of the American Geologist for 1903, is included between the parallels 33° 15′ and 34° 15′, and the meridians 109° 30′ and 111°. In this region, practically all the geological ages are represented from the Archaean to recent. The Carboniferous Age, to which the fossils belong, is represented by the Aubrey and Red Wall groups of rocks. Each of these groups is separated geologically and stratigraphically into two divisions; the Aubrey into the Upper and Lower Aubrey, and the Red Wall into the Upper and Lower Red Wall. The fossils were collected from the Upper Red Wall and Lower Aubrey divisions. Those from each division were collected separately, and their exact position will be given in the description.

FUSULINA FISCHER (1837).

FUSULINA SECALICA.

Plate, Figs. 1 a, b.

White's description (in part): Shell varying from terete to subglobose, assuming all intermediate fusiform shapes, generally somewhat obtusely pointed, usually having the appearance of being slightly twisted at the ends; septal furrows moderately distinct, extending in more or less direct lines longitudinally, but are a little deflected just at the ends; centrifugal apertures about twice as high as the thickness of the cell-wall covering them, more than twice as broad as high, and of nearly uniform size throughout the whole coil.

The locular or external aperture is seldom clearly shown upon the fossils. It was apparently linear the full length of the shell until closed by a new longitudinal septum at each side, leaving only a new centrifugal aperture at the middle, in line with the others. Volutions from five to eight; septa from twenty to thirty in outer volution; septa nearly straight at their outer or external edges, but laterally undulating at their inner edges, where they join the outer surface of the next volution within, as may be seen in specimens that have had a part of their outer volution removed by weathering.

Dimensions very variable.

Position and Locality.—Strata of the Upper Red Wall, north bank of White River, twelve miles southwest of Fort Apache, Arizona. A few specimens of this species were also seen at several other places in the Fort Apache region as follows: At the crossing of the government trail on Carrixo Creek, on west bank of Cibucu Creek, one mile north of U. S. Indian farmer's residence, and on the east edge of the bluff one half mile northwest of agent's residence at White River, Arizona.

CAMPHOPHYLLUM.

[Milne Edwards and Haime, Brit. Foss. Corals, Pl. LXVIII (1850).]

CAMPHOPHYLLUM TORQUUM.

Plate, Figs. 2 a, b, c.

Simple, usually large, conical to subcylindrical corallum, which in the case of specimens under three inches in length is usually bent or geniculated, but in larger specimens is nearly straight. Epitheca thin, with small encircling wrinkles and strong undulations of growth. Calice not seen. Septa very numerous, strictly radial in arrangement, extending about two-thirds the distance from the exterior toward the center, stout and usually straight within the outer vesicular zone, but becoming attenuated and somewhat curved or a little flexuous in crossing the vesicular area, where they alternate with an equal number of very short, thin ones. Visceral chamber filled with numerous imperfectly developed tabulæ, which pass nearly horizontally across the cavity with a more or less upward arching. Vesicular dissepiments highly developed in the periferal portion, forming numerous obliquely ascending small vesicles. Entire length unknown.

Range and Distribution.—Red Wall Group, Fort Apache, White River, Salt River, Carrixo Creek at the crossing of the government trail, and on Cibicu Creek, one mile north of the U. S. Indian farmer's residence, Arizona.

ACERVULARIA Schweigg.

ACERVULARIA DAVIDSONI Milne—Edwards and Haime.

[Pal. Foss. des Terr. Pal. P. 418, Pl. 9, Figs. 4-4 b (18—).]*

Coral composite, astræiform and massive, composed of unequally sized, usually five or six-sided corallites, having both an outer and an interior, slightly undulated or zigzag wall. The outer wall is thin; the inner wall is rarely well defined; the surface sinks, at first gradually and then abruptly, to form the cup, the diameter of which is about one-fifth of an inch. The bottom of the true calice is flat to slightly elevated. The septæ are radially arranged, and are stout and finely denticulate, there being about seven denticulations in the space of one line. They are usually about forty-two in number, and for the most part, extend into the true calice. The tabulæ are abundant in the central area; the dissepiments abundant in the periferal zone. The diameter of the larger corallites is about one-half inch.

This species is most nearly allied to *A. Profunda* Hall, from which it is distinguished by the larger size of the corallites, the greater constancy in the size of the calices, the less number and less conspicuous denticulation of the septa, and in the zigzag undulations of the outer walls.

Range and Distribution.—Devonion formation, on the government trail, four miles east of Canyon Creek, Arizona; on the John Dazen trail, three-fourths mile southeast of the cliff houses near Oak Creek, and along the rim of the Tonto basin, Arizona; at the falls of the Ohio and at Sandusky, Ohio, etc.

CERIOCRINUS?

Plate, Fig. 3.

The specimens referred to this genus are a few detached plates and are insufficient to fully identify even the genus.

Position and Locality.—Upper Red Wall, north bank of White River Canyon, twelve miles southwest of Fort Apache, Gila County, Arizona.

ARCHÆOCIDARIS McCoy.

ARCHÆOCIDARIS.

Plate, Fig. 7.

The specimens here called *Archæocidaris* are some fragments. They are too imperfect for identification of the species; but, though much worn, are sufficient to identify the genus.

*For a figure of the fossil here described the reader is referred to plate XXX of the November number of the American Geologist for 1903.

Position and Locality.—Upper Red Wall, north side of White River Canyon, twelve miles southwest of Fort Apache, Arizona.

FENESTELLA?

Plate, Fig. 4.

Bryozoa; reverse side, branches ridged, long and generally straight; dissepiments from one-fourth to one-half the size of the branches; surface covered with a porous calcareous covering.

Position and Locality.—Upper Red Wall, near Fort Apache, Arizona.

PUGNAX HALL (1893).

PUGNAX UTA.

Plate, Figs. 8 a, b.

Meek's description: Shell small, more or less variable in form, often subtrigonial, generally wider than long, more or less gibbous; front truncated, or sometimes sinuous in outline; anterior lateral margins rounded in outline; posterior lateral margins convex or nearly straight and converging toward the beak at an angle of from 90° to 120°. Dorsal valve more convex than the other, greatest convexity near the middle or between it and the front, which has a broad, rather deep, marginal sinus for the reception of the corresponding projection of the front of the other valve; mesial fold somewhat flattened, but slightly prominent, and rarely traceable back of the middle of the valve; generally composed of three but sometimes four—rarely more—plications; side rounding down rapidly on each side of the mesial fold, and each occupied by about three or four plications; beak curving strongly beneath that of the other valve; interior with a faint linear mesial ridge, on each side of which is a raised curved line enclosing an ovate space, occupied by the abductor muscular impressions. Ventral valve distinctly less convex than the other, with a broad, shallow, short sinus, occupied by about two or three plications; anterior lateral margins on each side of sinus, with from two to four plications; beak moderately prominent, and more or less arched, rather pointed; foramen small."

Position and Locality.—Upper Red Wall, north bank of White River, twelve miles southwest of Fort Apache, Arizona.

AMBROCŒLIA Hall (1860).

AMBROCŒLIA PLANOCONVEXA Shumard.

Plate, Figs. 9 a, b, c.

White's description*: "Shell very small; breadth varying from a little more to a little less than the length; hinge-line of considerable length, but always shorter than the full width of the shell in front of it; lateral and front borders regularly and continuously rounded.

The dorsal valve would be almost circular but for its truncation by the hinge-line; nearly flat, but slightly convex at the umbo, and sometimes slightly concave at the front; beak minute, not prominent; area very narrow.

Ventral valve capacious, especially its posterior portion, which extends much behind the hinge-line, and ends in a prominent strongly incurving pointed beak; area very narrow, high, concave, mesial sinus absent, but in its place there is usually a slight flattening at the front and sometimes an indistinctly impressed line is to be seen extending from beak to front.

Surface apparently smooth, but under a lens it is seen to be finely granular, the apparent granules being the bases of minute striæ; a few concentric lines of growth are observable upon both valves."

Position and Locality.—Strata of the Upper Red Wall, north bank of White River Canyon, twelve miles southwest of Fort Apache, Arizona.

RETICULARIA McCoy (1844).

RETICULARIA PERPLEXA.

Plate, Figs. 10 a, b.

Shell ordinary size, nearly circular in outline; breadth a little more and convexity a little less than the length; hinge-line shorter than the full width of the shell in front of it; lateral and front borders regularly and continuously rounded; cardinal area distinct, arched, and moderately high.

Ventral valve convex, extending much behind the hinge-line in a prominent, strongly incurved beak; area small; mesial sinus absent, but in its place there is a slight flattening at the front and three indistinctly impressed lines are to be seen extending from front to beak. This flattening gives to the shell a slight sinuosity.

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*White, U. S. Geog. Surv. W. of the 100th meridian, Vol. IV, P. 135, Pl. 3, Figs. 10 a, b, c

Dorsal valve circular in outline except where truncated by the hinge-line; regularly convex; beak less prominent than that of the other valve, extending beyond the hinge-line; area very narrow.

Surface marked by very numerous almost indistinct radiating costæ and by somewhat strong concentric markings.

Position and Locality.—Upper Red Wall Group, north bank of White River Canyon, twelve miles southwest of Fort Apache, Arizona.

DIELUSMA King (1859).

DIELUSMA BOUVIDINES (Morton).

Plate, Fig. 11.

White's description (in part)*: Shell ovate or elongate-ovate in outline; sides behind the middle laterally compressed. Ventral valve strongly arcuate from front to beak, the curvature being greatest behind the middle, rather more capacious than the other valve; beak prominent, incurved; foramen moderately, not squarely, truncating the beak, but opening obliquely backward, mesial sinus broad, and more or less distinct at the anterior part of the valve, but becoming obsolete at or behind the middle. Dorsal valve generally almost straight along the median line from front margin to a little behind the middle, from which part it gently curves to the beak; gently and somewhat uniformly convex from side to side, without a mesial fold.

Surface nearly smooth; shell structure finely punctate.

Position and Locality.—Upper Red Wall Group, Fort Apache, Arizona.

SEMINULA McCoy (1844).

SEMINULA ARGENTIA Shepard.

Plate, Figs. 12 a, b, c, e.

Shell varying considerable in outline, generally subovate; seldom as wide as long, usually moderately gibbous, but sometimes old shells are much inflated. Ventral valve generally a little more capacious than the dorsal; beak rather prominent, incurved; mesial sinus usually not very deep, and becoming obsolete about the middle.

*U. S. Geog. Surv. W. of the 100th meridian, Vol. IV, P. 144, Pl. XI, Figs. 10 a, b, c.

Dorsal valve somewhat uniformly convex, but most prominently so near the umbo; beak small, slightly prominent, mesial fold entirely wanting as a rule. Surface marked by faint traces of radiating striæ and by occasional imbricating lines of growth.

Range and Distribution.—Upper Red Wall group and Lower Aubrey; Carrixo Creek, at the confluence of White and Black rivers, and on either side of White River in Maricopa County, and at Fort Apache and at Jemez, New Mexico, White River, Arizona, etc. Common throughout the upper carboniferous of America and in England and India in the sub-carboniferous also. Its range also extends into the Permian.

MYALINA de Konnick, 1844.

MYALINA?

Plate, Fig. 13.

The specimen here figured in outline is too badly crushed to warrant a description, but is obviously a member of the genus Myalina.

Position and Locality.—Upper strata of the Upper Red Wall, south side of White River Canyon, one mile west of Fort Apache, Arizona.

EUOMPHALUS Sowbery (1815).

EUOMPHALUS PERNODOSUS Meek and Worthen.

Plate, Figs. 14 a, b, c, e

White's description* (in part): "Shell rather above medium size when full grown, nearly discoidal, the spire being only very slightly elevated, and the inner portion of it being quite flat, or evenly depressed. Test thick, volutions five or six, the upper side flattened and sloping gently inward to the distinct suture, outer side flattened, convex, under side rounding; the angles formed by the upper and outer sides constitute a distinct carina which is rugose or corrugated upon the outer volution; upon the under side of the volutions there is a row of moderately large, rounded nodes, separated by spaces of about their own width, those of the last half of the outer volution being obsolete;" umbilicus not seen.

*U. S. Geog. Surv. W. of the 100th meridian, Vol. IV, P. 158, Pl. 12, Figs. 2 a, b, c.

PLATE EXPLANATION.

Fig. 1. Fusulina secalica....................................

1 a. A specimen showing the septal furrows and the centrifugal aperture.

1 b. Some weathered specimens.

Fig. 2. Camphophylum torquum....................................

2 a. Longitudinal view of a portion of a coral.

2 b. Cross section.

2 c. A longitudinal section showing tabulae.

Fig. 3. Some crinoid plates....................................

Fig. 4. Fenestella ? ....

Fig. 5. ? Rhombopera ? ....

Fig. 6. Hemeitrypa ?....................................

Fig. 7. Archaeocidaris spines...... ....

Fig. 8. Pugnax uta ....

8 a. Ventral valve.

8 b. Dorsal valve.

Fig. 9. Ambocaelia planoconvexa ... .

9 a. Dorsal view.

9 b. Ventral view.

9 c. Side view.

Fig. 10. Reticularia perplexa ....

10 a. Ventral valve.

10 b. Dorsal valve.

Fig. 11. Dielasma bovidines, dorsal view................. ....

Fig. 12. Seminula argentia ... .

12 a. Ventral valve showing sinus.

12 b, f and g. Dorsal views.

12 c. Dorsal view of a young specimen.

12 e. Side view.

12 m. An old specimen.

Fig. 13. Myalina ? Outline only....................................

Fig. 14 a, b, c, e. Fragments of an Euomphalus pernodosus...........

Fig. 15. Productus punctatus ....

15 a. A portion of the dorsal valve.

15 b. Inside of dorsal valve, showing muscular impressions.

12 m


1a
1b
10a
11
4
14e
3
5
6
2a
15b
7
12f
9a
9b
12c
9c
12g
12e
2b
13
14a
8a
8b
2c
14b
12a
15a
10b
14c
12b

Position and Locality.—In limestone strata at top of the lower Aubrey group, Aubrey Cliff, one mile northeast of White River, and at the crossing of the government trail on Carrixo Creek, Arizona.

CALAMARLÆ.

CALAMITES.

CALAMITES CANNÆFORMIS.

Long, slender, tapering reed-like stem, jointed and having a large pith. Its exterior surface is finely striated, but the striæ are not continuous, but are interrupted at the joints by a "break." The striæ on each side of said "joint break" correspond to each other. Each stria has a small pinhead-like projection on it near its upper extremity. The bark which was left in the cast is about 1-132 of an inch in thickness. It seemed to be fibrous. The striæ impressions and the grooves between the striæ which were filled with the bark tissue show very distinctly, the latter being ridges on the inside of the bark, the former depressions. The leaves were strap-like (?) the stem is flattened and in its longer diameter, three feet above the ground it exceeded five inches. At its lower end the joints grow rapidly smaller and shorter, so that this end is conical, but so curved as to represent a dog's tearing tooth. From these lower tapering joints came out the small roots which nourished this peculiar tree and which were still found imbedded in the clayey stratum by the writer. The top of the stem was not found but it most likely was cone-like.

Habitat.—West of Cibicu Creek and one mile north of the Phœnix-Fort Apache trail, Arizona. The specimen above described was found imbedded in a shaley white sandstone, underlaid with a thin stratum of clay, into which the lower part of the above-mentioned tree extended. The location is on the east side of the mesa to the west of the aforementioned Cibicu Creek, and about 42 feet below its summit.*

The specimen here described was sent to the university at Albuquerque, N. M., and is now in the collection there.

The Sun or Gunelpiya Medicine Disk.

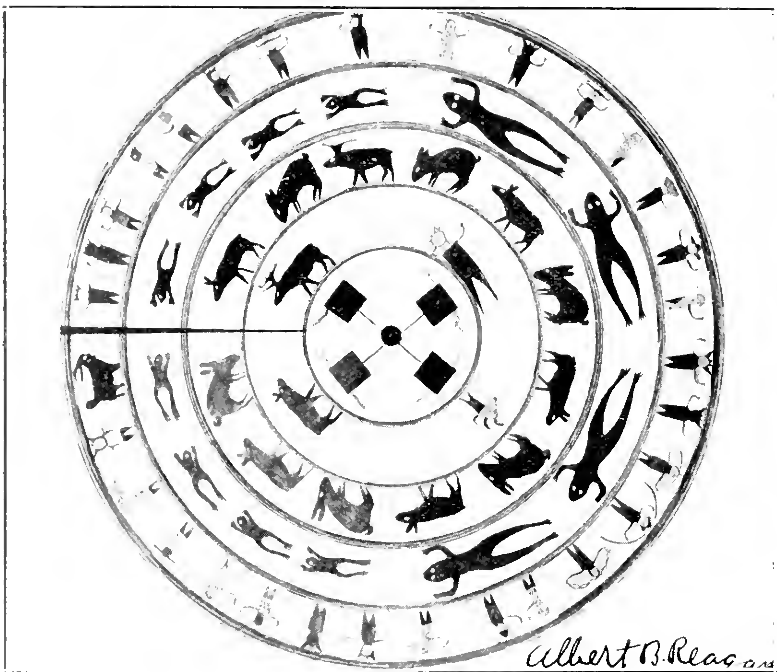
By Albert B. Reagan.

This disk is used as a last resort in the Apache medicine ceremonies. It is drawn on a leveled, sanded spot of ground some sixteen feet in diameter. The materials used in painting the figures are obtained as follows: The green is ground up leaves; the red, ground up sandstone; the yellow ground up limestone; the black, powdered charcoal. The rings separating the concentric spaces are rainbow circles. The central figure is the sun, and the squares associated with the sun are the medicine blocks. The first and second concentric spaces from the central area represent land; the space in which the frogs are swimming, water; and the outer concentric space, the abode of the gods.

This drawing is an Apache prayer in an elaborate form. In it they have all the gods of the universe represented, and on the mercy of these gods they throw the patient. As has been stated this is a last resort. The gods can either make the sick one well or take him to themselves, that is, to the Happy Hunting Ground.

When this drawing is completed, which is always at about four o'clock in the afternoon of the same day in which it was commenced, the patient is carried and placed on the central figure with face toward the evening sun. A medicine dancer wearing a ghost hat then enters the medicine circle, and, carrying a bowl partly filled with water in one hand, he takes a pinch of dust from each of the representative figures and puts it into the bowl. Having completed his dust-gathering, he proceeds to the sick one and daubs him all over with the muddied water. This being completed, he sends a hissing breath through his hands, thus expelling sick to the four quarters of the earth. He then leaves the medicine circle and gallops off into obscurity. When he has departed the chief medicine man, after sprinkling the patient with cattail flag pollen as he prays to the gods, takes up the bowl of muddied water left by the ghost dancer, and daubs the patient as the ghost dancer had daubed him before, while those present chant a medicine song to the gods. When he has completed his task, the oldest woman present takes the muddied bowl and continues the daubing process. Her act completes the ceremony. The sick one is then carried from the scene and all who wish, gather dust from the representatives of the gods and put it into some containing receptacle, usually a tobacco sack. The dust gathering being completed, the medicine disk is at once obliterated. It must be made, used, and destroyed in a day.

On the night following the Gunelpiya medicine disk performances, the ghost dance is given for the benefit of the sick one. The next day the patient usually dies.



The Sun or Gunelpiya Medicine Disk.

The Fossils of the Red Wall Compared with Those of the Kansas Coal Measures.

By Albert B. Reagan.

For the purpose of definitely determining the age of the upper half of the Red Wall limestone of the Rocky Mountains the writer has prepared the following tabulated comparison of the fossils of that series of rocks with those of the Kansas Coal Measures. The Kansas fossils were taken from Dr. J. W. Beede's Carboniferous Invertebrates of Kansas (Univ. Geol. Surv. of Kansas, vol. VI, pp. 1-187, plates 1-22). Some of the Upper Red Wall fossils were identified by Prof. Meek (see Gilbert's Report, U. S. Geog. Surv. w. of the 100th meridian, vol. III, p. 178); some by Prof. White (see White's Report in vol. IV, U. S. Geog. Surv. w. of the 100th meridian); the others by the writer, under the direction of Dr. Beede of the University of Indiana. The fossils identified by Meek are marked (1), those by White (2).

RED WALL FOSSILS.	KANSAS FOSSILS.
Fusulina secalica.	Fusulina secalica.
	Anolopra anna.
Camphophyllum torquum.	Camphophyllum torquum.
	Limopteria alata.
	Trachypora austini.
Archæocidaris ?	Archæocidaris agassiz.
Archæocidaris tudifer.[1]	Archæocidaris tudifer.
Derbya ?	Derbya bennetti.
Derbya crassa.	Derbya crassa.
	Derbya cymbula.
	Derbya biloba.
Derbya Kuokuk.	Derbya Kuokuk.
Derbya affinis.	
	Chonetes granulifer.
Chonetes mesolobus.[1]	Chonetes mesolobus.
	Chonetes glaber.
	Chonetes vernemlianus.
	Productus pertenius.
	Productus symmetricus

Productus nebrascensis	Productus nebrascensis.
Porductus costatus.[1, 2]	Productus costatus.
	Productus longispinus.
Productus semi-reticulatus.[2]	Productus semi-reticulatus.
Productus prattenianus.[1]	Productus cora.
Productus. ?	Productus sp.*
Productus, like P. portlockienus.	
Reticularia perplexa.	Reticularia perplexa.
Ambocœlia planoconvexa.	Ambocœlia planoconvexa.
Spirifera kentuckensis.	Spiriferina kentuckyensis.*
Hemipronites crinistria.	
Hemipronites crassus.[2]	
Spirifer cameratus.	Spirifer cameratus.
	Enteletes hemiplicata.
Pugnax uta.	Pugnax uta.
	Pugnax rockymontana
Meekella striatacostata.	Meekella striatacostata
	Aviculopecten hertzeri.
	Aviculopecten providencensis.
	Aviculopecten sculptilis.
Aviculopecten interlineatus.[1, 2]	Aviculopecten interlineatus.
Aviculopecten occidentalis.	Aviculopecten occidentalis.
	Aviculopecten carboniferus.
	Aviculopecten McCoyi.
	Aviculopecten germanus.
Aviculopecten ?	Aviculopecten sp.*
Monoteria mariam.[1]	Limopteria mariam.
Myalina sp.	Myalina sp.
Myalina (?) swallovi.[1]	Myalina swallovi.
Nuculana (?).	Nuculana bellistriata.
Schizodus (?)[1] sp.	Schizodus wheeleri.
	Schizodus hari.
Rhombopora sp.	Rhombopora lepidodendroides.
Fenestella shumardi.[1]	Fenestella shumardi.
Fenestella sp.	Fenestella sp.
Polypora stragulata.[1]	Polypora sp.
Glauconome nereides.	Pinnatopora tenuilineata.
Synocladia biseralis.	

Fistulipora nodulifera.	Fistuipora nodulifera.
Modiola (?) ?	Modiola sulbelliptica.
Murchisonia sp.	Murchisonia sp.
Platysomus[2] sp.	
Phillipsia[2] sp.	Phillipsia sp.*
Nautilus occidentalis.	Nautilus planovolvis.
Euomphalus (like E. nodosus).[2]	Euomphalus sp.*
Euomphalus pernodosus.	Euomphalus pernodosus.*
Macrocheilus[2] sp.	
Pleurotomeria[2] sp.	Pleurotomeria tabulata.
	Pleurotomeria sp.
Bellerophon crassus.	Bellerophon crassus.
Dielasma bovidines.	Dielisma bovidines.
Seminula argentia.	Seminula argentia.

Of the 36 genera of the Upper Red Wall tabulated above, 32 are represented in the fossils of the Kansas Coal Measures, and of the 32 species identified 26 are identical. The tabulated comparison, therefore, determines the age of the Upper Red Wall of Arizona to be practically the same as that of the Kansas Coal Measures.

NOTE.—The species and genera marked (*) were taken from Bulletin 211 of the U. S. Geological Survey. Some of the other Kansas species (not marked) were taken from Dr. Beede's Report, Kansas University Science Bulletin, Vol. I, No. 7, September, 1902.

NOTICE.

Owing to the limitations of the appropriation and the length of the paper, it was found necessary to defer until 1904 the publication of the paper described below:

ECOLOGICAL NOTES ON THE BIRDS OCCURRING WITHIN A RADIUS OF FIVE MILES OF THE INDIANA UNIVERSITY CAMPUS.

BY WALDO LEE MCATEE.

With Photographic Illustrations by CLARENCE GUY LITTELL.

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