Proceedings of the

Indiana Academy of Science

1905

PROCEEDINGS

OF THE

Indiana Academy of Science

1905.

EDITOR, - - - - E. G. MARTIN.

ASSOCIATE EDITORS:

C. A. WALDO, LYNN B. MCMULLEN,
STANLEY COULTER.

INDIANAPOLIS, IND.
1906.

INDIANAPOLIS:
Wm. B. Burford, Printer
1906.

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
March 5, 1906.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, April 19, 1906.

The within report, so far as the same relates to moneys drawn from the State Treasury, has been examined and found correct.

WARREN BIGLER,
Auditor of State.

APRIL 20, 1906.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

FRED L. GEMMER,
Private Secretary.

Filed in the office of the Secretary of State of the State of Indiana, April 20, 1906.

FRED A. SIMS,
Secretary of State.

Received the within report and delivered to the printer April 20, 1906.

HARRY SLOUGH,
Clerk Printing Bureau.

TABLE OF CONTENTS.

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.

[Indiana Acts 1905.]

Birds.

SECTION 602. It shall be unlawful for any person to kill, trap or possess any wild bird, or to purchase or offer the same for sale, or to destroy the nests or the eggs of any wild bird except as otherwise provided in this section. But this section shall not apply to the following named game birds: The Anatidæ, commonly called swans, geese, brant, river and sea duck; the Rallidæ, commonly known as rails, coots, mudhens, and gallinules; the Limicolæ, commonly known as shore birds, plovers, surf birds, snipe, woodcock, sandpipers, tattlers and curlews; nor to English or European house sparrows, crows, hawks, or other birds of prey. Nor shall this section apply to any person taking birds or their nests or eggs for scientific purposes under permit, as provided in the next section. Any person violating the provisions of this section shall, upon conviction, be fined not less than ten dollars nor more than fifty dollars.

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

OFFICERS—1905-1906.

PRESIDENT,
ROBERT HESSLER.

VICE-PRESIDENT,
D. M. MOTTIER.

SECRETARY,
LYNN B. McMULLEN.

ASSISTANT SECRETARY,
J. H. RANSOM.

PRESS SECRETARY,
CHARLES R. CLARK.

TREASURER,
WILLIAM A. McBETH.

EXECUTIVE COMMITTEE.

Robert Hessler,
D. M. Mottier,
Lynn B. McMullen,
J. H. Ransom,
Charles R. Clark,
William A. McBeth,
John S. Wright,
Carl L. Mees,
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.

*Deceased.

COMMITTEES, 1905-1906.

PROGRAM.

Lynn B. McMullen, J. P. Naylor, W. J. Moenkhaus.

MEMBERSHIP.

J. H. Ransom, W. A. McBeth.

NOMINATIONS.

G. W. Benton, W. J. Moenkhaus, W. S. Blatchley.

AUDITING.

Thomas Gray, A. J. Bigney.

STATE LIBRARY.

G. W. Benton, C. H. Eigenmann, A. W. Butler, W. S. Blatchley, J. C. Arthur.

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.

E. G. Martin, Purdue University, Lafayette.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, Stanley Coulter, Charles R. Dryer, M. B. Thomas, J. C. Arthur.

RELATIONS OF THE ACADEMY TO THE STATE.

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

DISTRIBUTION OF THE PROCEEDINGS.

Thomas Gray, L. J. Rettger, John S. Wright, Donaldson Bodine, D. W. Dennis.

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.
1904-1905	John S. Wright	Lynn B. M'Mullen	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1905-1906	Robert Hessler	Lynn B. M'Mullen	J. H. Ransom	Charles R. Clark	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 especially provided for in this constitution, in the interim between general meetings.

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

BY-LAWS.

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

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

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

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

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

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

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

MEMBERS.

FELLOWS.

R. J. Aley	*1898	Bloomington.
Frank M. Andrews	1904	Bloomington.
J. C. Arthur	1893	Lafayette.
George W. Benton	1896	Indianapolis.
A. J. Bigney	1897	Moore's Hill.
A. W. Bitting	1897	West Lafayette.
Katherine Golden Bitting	1895	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	Santiago, Cuba.
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.
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.
Edwin S. Johonnatt	1904	Terre Haute.
Arthur Kendrick	1898	Terre Haute.
Robert E. Lyons	1896	Bloomington.
W. A. McBeth	1904	Terre Haute.

*Date of election.
**Deceased.

V. F. Marsters	*1893	Bloomington.
C. L. Mees	1894	Terre Haute.
J. A. Miller	1904	Bloomington.
W. J. Moenkhaus	1901	Bloomington.
Joseph Moore	1896	Richmond.
D. M. Mottier	1893	Bloomington.
J. P. Naylor	1903	Greencastle.
W. A. Noyes	1893	Washington, D. C.
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.
Jacob Westlund	1904	Lafayette.
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	Columbia, Mo.
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.

*Date of election.

D. T. MacDougal.................................Bronx Park, New York City.
T. C. Mendenhall ....Worcester, Mass.
Alfred Springer ....Cincinnati, Ohio.
L. M. Underwood...............................New York City.
Robert B. Warder.............................Washington, D. C.
Ernest Walker...................................Clemson College, S. C.

ACTIVE MEMBERS.

George Abbott..................................Indianapolis.
George C. Ashman.............................Frankfort.
Edward Ayres....................................Lafayette.
H. F. Bain ....Urbana, Ill.
Frank Tarkington Baker......................Indianapolis.
Edward Hugh Bangs...........................Indianapolis.
Walter D. Baker................................Indianapolis.
Arthur M. Banta................................Franklin.
Harry E. Barnard..............................Indianapolis.
Victor Hugo Barnett..........................Indianapolis.
J. W. Beede.....................................Bloomington.
Harry Eldridge Bishop.......................Indianapolis.
Lester Black ....Bloomington.
William N. Blanchard ....Greencastle.
Edwin M. Blake................................Lafayette.
Lee F. Bennett..................................Valparaiso.
Charles S. Bond................................Richmond.
Fred. J. Breeze ....Delphi.
E. M. Bruce.....................................Weston, Oregon.
Lewis Clinton Carson........................Bloomington.
Herman S. Chamberlain ....Indianapolis.
E. J. Chansler ....Bicknell.
Otto O. Clayton ....Geneva.
Howard W. Clark ....Chicago, Ill.
H. M. Clem.......................................Bloomington.
George Clements ....Crawfordsville.
Charles Clickener ....Silverwood, R. D. No. 1.
Charles A. Coffey ....Petersburg.
Wilber A. Cogshall...........................Bloomington.

Ulysses O. Cox ....Terre Haute.
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 ....Laporte.
H. J. Davidson ....Baltimore, Md.
Charles C. Deam. ....Bluffton.
Martha Doan ....Westfield.
J. P. Dolan ....Syracuse.
Benjamin W. Douglas ....Indianapolis.
Herman B. Dorner .... Lafayette.
Hans Duden ....Indianapolis.
Arthur E. Dunn..............................Logansport.
Herbert A. Dunn................ ....Logansport.
E. G. Eberhardt ... .Indianapolis.
Frank R. Eldred ....Indianapolis.
M. N. Elrod . ...Columbus.
Samuel G. Evans ....Evansville.
William P. Felver...........................Logansport.
Carlton G. Ferris .. .. Big Rapids, Mich.
E. M. Fisher................................Urmeyville.
Wilbur A. Fiske ... .Richmond.
W. B. Fletcher .... Indianapolis.
Austin Funk......... ....New Albany.
John D. Gabel ....Montpelier.
Andrew W. Gamble.........................Logansport.
Charles W. Garrett ....Pittsburg, Pa.
Robert G. Gillum. ....Terre Haute.
Wilmer Jacob Gittner ....Anderson.
Vernon Gould................................Rochester.
Walter L. Hahn ....Washington, D. C.
Mary T. Harman.............................Odon.
Victor Hendricks ....Indianapolis.
John P. Hetherington............. ....Logansport.
Mary A. Hickman ....Greencastle.

John E. Higdon .... Indianapolis.
Frank R. Higgins .... Terre Haute.
S. Bella Hilands .... Madison.
John J. Hildebrandt .... Logansport.
G. E. Hoffman .... Logansport.
J. D. Hoffman .... Lafayette.
Allen D. Hole. .... Richmond.
Lucius M. Hubbard .... South Bend.
John N. Hurty .... Indianapolis.
C. F. Jackson .... Greencastle.
Dennis Emerson Jackson...... .... Bloomington.
Alex. Johnson .... Ft. Wayne.
Ernest E. Jones .... Kokomo.
Wm. J. Jones, Jr .... West Lafayette.
Chancey Juday .... Boulder, Colo.
O. L. Kelso .... Terre Haute.
Norton A. Kent .... Crawfordsville.
Frank D. Kern .... Lafayette.
Charles T. Knipp .... Urbana, Ill.
Henry H. Lane .... Lebanon.
William E. Lawrence .... Richmond.
V. H. Lockwood .... Indianapolis.
Robert Wesley McBride .... Indianapolis.
Rousseau McClellan .... Indianapolis.
Richard C. McClaskey .... Terre Haute.
N. E. McIndoo .... Bloomington.
Lynn B. McMullen .... Indianapolis.
Edward G. Mahin .... West Lafayette.
James E. Manchester.... .... Vincennes.
Wilfred H. Manwaring .... Bloomington.
E. G. Martin .... Lafayette.
Thomas Edward Mason .... Hodgenville, Ky.
Clark Mick. .... Berkley, Cal.
W. G. Middleton .... Richmond.
G. Rudolph Miller .... Indianapolis.
H. T. Montgomery .... South Bend.
Richard Bishop Moore .... Indianapolis.
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.
Andrew Fletcher Ogle . . . . Bloomington.
D. A. Owen . . . . Franklin.
Ferd Payne . . . . Bloomington.
Rollo J. Peirce . . . . Indianapolis.
Ralph B. Polk . . . . Greenwood.
James A. Price . . . . Ft. Wayne.
Frank A. Preston . . . . Indianapolis.
A. H. Purdue . . . . Fayetteville, Ark.
Rolla R. Ramsey . . . . Bloomington.
Ryland Ratliff . . . . Danville.
Walter S. Ratliff . . . . Richmond.
Albert B. Reagan . . . . Mora, Wash.
Allen J. Reynolds . . . . Emporia, Kansas.
Giles E. Ripley . . . . Decorah, Iowa.
George L. Roberts . . . . Muncie.
D. A. Rothrock . . . . Bloomington.
John F. Schnaible . . . . Lafayette.
E. A. Schultze . . . . Ft. Wayne.
Will Scott . . . . Terre Haute.
Charles Wm. Shannon . . . . Bloomington.
John W. Shepherd . . . . Terre Haute.
Claude Siebenthal . . . . Indianapolis.
Fred Sillery . . . . Indianapolis.
J. R. Slonaker . . . . Madison, Wis.
Essie Alma Smith . . . . Bloomington.
C. Piper Smith . . . . Leland Stanford, Cal.
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.
Albert W. Thompson . . . . Owensville.

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...................................Duluth, Minn.
Frank B. Wade.................................Indianapolis.
Lewis Clinton Ward............................Huntington.
Daniel T. Weir................................Indianapolis.
B. C. Waldemaier..............................West Lafayette.
Fred C. Whitcomb..............................Delphi.
William M. Whitten.............................South Bend.
Albert F. Wiancko.............................Lafayette.
Neil H. Williams..............................Terre Haute.
Guy West Wilson...............................Lafayette.
William Watson Woollen.........................Indianapolis.
Herbert Milton Woolen.........................Indianapolis.
J. F. Woolsey.................................Indianapolis.
Lucy Youse....................................Palo Alto, Cal.
Charles Zeleny................................Bloomington.

Fellows	52
Non-resident members	20
Active members	166
Total	238

Note.—For list of Foreign Correspondents, see Proceedings of 1904.

LIST OF PAPERS APPEARING ON THE PROGRAM OF THE TWENTY-FIRST ANNUAL MEETING,

Held in Shortridge High School, December 1, 1905.

*President's Address—A Consideration of Certain Investigations Needed in Pharmacology .... John S. Wright

GENERAL.

*1. Some Scientific Aspects of Tea Drinking, 5m .... Frank B. Wade
2. The Lummi Indians, 10m .... Albert B. Reagan
3. Radium and Radio-Activity, 10m .... Ryland Ratliff
*4. The Radium Clock, 5m .... Rolla R. Ramsey
*5. The Use of Peat as Fuel, 15m .... Benj. W. Douglass
6. The Molecular Forces in Gelatine, 5m .... Arthur L. Foley
*7. The Chronic Ill Health of Darwin, Huxley, Spencer and George Eliot, 20m., (abstract) .... Robert Hessler
*8. The Wood Pulp Industry, 10m .... M. D. Renkenberger
9. Buzzard's Roost, 10m .... William Watson Woollen
10. Thorium and its Disintegration Products, 20m .... Richard D. Moore
*11. An Account of a Buzzard's Nest with Photographs of the Young up to the Seventy-fourth Day, When They Left the Nest, 10m .... D. W. Dennis
*12. The Solar Eclipse of 1905, 20m. (lantern) .... John A. Miller

PHYSICS, CHEMISTRY, GEOLOGY AND MATHEMATICS.

*13. Irrelevant Factors in the Bitangentals of Plane Algebraic Curves, 10m. Ulysses S. Hanna
*14. On the Weathering of the Subcarboniferous Limestone in the Non-Glaciated Area of Southern Indiana, 10m .... E. R. Cummings
*15. Action of Calcium Chloride Solution on Glass, 5m .... P. N. Evans
16. The Age of the Red-Beds of Oklahoma Territory and the "Panhandle" of Texas, East of the Staked Plains, 10m .... J. W. Beede
17. Methods of Collecting Fossils, 10m .... J. W. Beede
*18. Equivalent-Weight-Determination Apparatus, 5m .... James H. Ransom
19. Result of Heating a Mixture of Manganese Dioxide and Ammonium Nitrate, 10m .... James H. Ransom
*20. Studies in Catalysis, 10m .... James H. Ransom
21. Comparison of the Faunas of the Salem Limestone at Ellettsville, Big Creek and Romona, 10m .... A. W. Thompson
*22. Effect of Radium on Electrolytic Conductivity, 5m .... Ryland Ratliff
23. Summary of Glacial Literature Relating to Glacial Deposits, 10m ... Albert B. Reagan
24. Some Geological Studies on Northwestern Washington and Adjacent British Territory, 10m .... Albert B. Reagan
*25. A Simple Method of Measuring Electrolytic Resistance, 5m .... Rolla R. Ramsey
*26. Some Peculiarities of Electric Sparks Across Short Spark-Gaps, 10m Rolla R. Ramsey
*27. Gas Burners and Standards of Candle Power, 5m .. Rolla R. Ramsey and Hiromitsu Oi
28. Determination of the Latitude of Flower Observatory, 10m .... W. E. Howard
29. Electromagnetic Induction in Various Conductors and Electrolytes, II, 10m .... Arthur L. Foley

30. On the Use of a Copper, Aluminum, Manganese Alloy as a Core in the Rutherford-Marconi Magnetic Detector, 10m .... Arthur L. Foley
31. The Back Electro-Motive Force of the Electric Arc, 10m., Arthur L. Foley and Hiromitsu Oi
32. The Effect of Dragging a Conductor Lengthwise Through a Magnetic Field of Force, 10m .... Arthur L. Foley
33. Interference and Diffraction Fringes Produced by Fluid Streams (lantern), 15m .... Arthur L. Foley and J. H. Haseman
34. Geology of the Public Highways of Monroe County, Indiana, 10m .. Charles W. Shannon
35. Studies of the Preglacial Drainage of the Northern United States, 10m .... H. M. Clem
36. New Derivatives of Salicylic Acid, 10m .... R. E. Lyons and C. E. May
37. The Use of Sodium Peroxide in the Determination of Sulphur, Selenium and Tellurium in Organic Compounds, 5m .... R. E. Lyons and C. C. Carpenter
38. Concerning the Synthesis of Aromatic Selenozines, 5m ... R. E. Lyons and F. Shetterly

BOTANY AND ZOOLOGY.

*39. Preliminary Notes on an Almost Extinct Native Disease—Trembles or Milksickness, 10m .... Robert Hessler
*40. Notes on the International Botanical Congress of 1905, 15m .... J. C. Arthur
*41. Methods Employed in Uredineal Culture Work, 15m .... Frank D. Kern
*42. The Embryology of Melilotus Alba, 10m. (abstract) .... W. J. Young
*43. Oxydase in Wheat Grains, 10m .... Katherine Golden Bitting
*44. Cytase in Wheat Grains, 5m .... Katherine Golden Bitting
45. Notes on Indiana Birds, 10m .... Amos W. Butler
*46. Notes Upon Some Little Known Members of the Indiana Flora, 10m., Charles Piper Smith
47. The Eyes of the Blind Lizard Amphisbaena Punctata, 10m .... Ferd Payne
48. Reversals of Polarity in a Fresh Water Plamarian, 10m .... Mary T. Harman
49. The Fishes of the Rio Guatemala, Based on Collections Made in January and February, 1904, 10m .... Newton Miller
*50. The Direction of Differentiation in a Regenerating Appendage, 10m ... Charles Zeleny
*51. The Regeneration of a Centema-like Organ in Place of the Momentary Eye of the Blind Crayfish, 10m. (abstract) .... Charles Zeleny
52. The Habitat and Life History of the Cuban Blind Fishes (lantern), 15m., C. H. Eigenmann
53. The Origin and Dispersion of South American Fresh Water Fishes (lantern), 30m .... C. H. Eigenmann
54. Portraits of Indiana Fishes (lantern), 10m .... Lester F. Black
*55. A New Species of Campostoma Fern from Indiana, 10m. (abstract) ... John Haseman
56. Northern Indiana Mammals, 10m .... Walter Lewis Hahn
*57. Notes on Some New or Little Known Members of the Indiana Flora, 17m, Guy West Wilson
*58. Rusts of Hamilton and Marion Counties, Indiana, 10m .... Guy West Wilson
*59. The Phycomycetes of Indiana, 12m .... Guy West Wilson
*60. A Travertine Deposit in Tippecanoe County, Indiana, 3m .... Guy West Wilson
*61. Additions to Indiana Flora, No. 2, 5m .... Charles C. Deam
62. Animals and Reptiles of the Rosebud Indian Reservation, South Dakota, 10m .... Albert B. Reagan
63. The Birds of the Rosebud Indian Reservation, South Dakota, 10m ... Albert S. Reagan
64. The Production and Control of Infertility by Inbreeding, 15m ...... W. J. Moenkhaus
65. Some New Physiological Apparatus, 10m .... D. E. Jackson
66. High School Bacteriology, 20m .... Wilfred H. Manwaring
67. Metchnikoff's Theory of Prolonging Life, 15m .... Rudolph Miller
68. A New Method of Showing the Grain of Wood, 5m .... Benj. W. Douglass

*69. An Illustration of Boyle's Law, 5m ....F. M. Andrews
*70. Some Monstrosities in Trillium, 5m .... F. M. Andrems
*71. A Natural Proof that the Root Tip Alone is Sensitive to the Gravitation Stimulus, 5m ....F. M. Andrews
72. Plasmodesmen, 5m.......................................F. M. Andrews
*73. Effect of Alkaloids on Vegetable Protoplasm, 5m ....F. M. Andrews
*74. An Occurrence of Kirtland's Warbler, 3m ....Loren C. Petry
*75. Nitrifying Bacteria, 10m .... A. J. Bigney
*76. A New Form of Microtome Knife, 10m ....E. G. Martin
77. Oxygen Absorption in Heart Tissue—A Preliminary Communication, 10m. E. G. Martin
*78. The Present Status of the Chromosome Controversy, 15m....................................... D. M. Mottier
*79. The Blooming of Cereis Canadensis in September, 5m ....D. M. Mottier
*80. A Peculiar Monstrosity in a Seedling of a Zea Mays, 5m.......................................D. M. Mottier
81. Spore-Like Bodies in Oscillaria sp., 10m.......................................Severance Burrage
82. The Oaks of Indiana, 15m .... Stanley Coulter
*83. The Leesburg Swamp, 10m ....Will Scott
84. Notes on the Crayfish of Wells County, Indiana, 5m ....E. B. Williamson
*85. Note on the Reeurrenee of Brood V ....Walter L. Hahn

*Papers marked with an asterisk appear in the following pages.

PRESIDENT'S ADDRESS.

A CONSIDERATION OF CERTAIN NEEDED INVESTIGATIONS IN PHARMACOLOGY.

By John S. Wright.

(Abstract.)

Under this title the term pharmacology is not used in its restricted sense, meaning pharmaco-dynamics only, but is employed to embrace the botany, chemistry and physiological action of drugs. The suggestions for needed investigations are the result of a critical study of the records of about four hundred drugs used in medicine at present.

In order to arrive at some general conclusions concerning existing knowledge of the commonly used organic drugs, those studied were reviewed, marked and classified in eight groups based on the extent to which they have been investigated, botanically, chemically and physiologically, as follows:

CLASSES BASED ON THE EXTENT OF CHEMICAL KNOWLEDGE.

1. Drugs whose chemical constituents and active principles are regarded as well known—276, or approximately 70 per cent.
2. Drugs whose chemical constituents and active principles are but partially determined—100, or approximately 25 per cent.
3. Drugs whose chemical constituents and active principles are undetermined—25, or approximately 6 per cent.

CLASSES BASED ON THE EXTENT OF KNOWLEDGE OF PHYSIOLOGICAL ACTION.

4. Drugs whose physiological action is well known, or which have been subjects of systematic investigations—175, or approximately 43 per cent.

5. Drugs whose physiological action is partially understood, chiefly through careful clinical reports—140, or approximately 35 per cent.
6. Drugs used empirically or employed for "reputed" action, no satisfactory records of scientific experiments or chemical investigations—82, or approximately 20 per cent.
7. Drugs employed primarily for purposes other than definite physiological effects, such as flavors, colors, etc. (some not used internally at present)—9, or approximately 2 per cent.

* * * * *

8. Drugs of obscure or unknown origin—2, or approximately ½ per cent.

These groups or classes are not marked by hard and fast boundary lines, and perhaps no two students would agree wholly to any single classification, as the personal equation enters largely into the work. A drug which one might regard as sufficiently known chemically and physiologically to be classed as "well known," another would rank as "partially determined," and similar differences of opinion will arise respecting other points involved, so that the classification given above is not offered as an exact record of the knowledge of the representative drugs, but rather as the author's estimation of that knowledge, and as said at the outset, it is given as a basis or reason for the proposal of certain lines of botanical, chemical and physiological investigation.

Lest there be misconception regarding the use of little-known drugs by physicians, it should be remembered that 70 per cent. of all drugs reviewed have been investigated chemically; that 43 per cent. have been subjected to systematic physiological experiments, and that the physiological action of 35 per cent. more is partially understood. Thus it seems that from 70 to 78 per cent. are employed on the basis of demonstrated value. Furthermore, it should be remembered that the 70 to 78 per cent. in number constitutes a very large percentage of the volume of drugs prescribed. While no statistics are available, in the opinion of the author it is over 90 per cent. of the total quantity used.

The Proceedings of the Indiana Academy of Science are primarily intended to disseminate information of special service in the development of the State and its resources. As space is limited, it is necessary to restrict further report of this address to the tables below showing the state of knowledge of drug plants of Indiana.

Indiana Plants Yielding Drugs.

In order that the student may have a wider range in selecting a subject for study this list has been enlarged to include introduced and cultivated species, also a few plants foreign to our soil, but which may be cultivated in gardens for supplying laboratory material. The native species and the introduced and cultivated species are unmarked; those of the last class are indicated by an asterisk (*).

Chemical constituents, active principles and physiological action regarded as well known:

Allium sativum Linn. Garlic, bulb.
*Althaea officianalis Linn. Marshmallow, root.
Anthemis nobilis Linn. Roman chamomile, inflorescence.
Apocynum cannabinum Linn. Black Indian hemp, root.
Arctostaphylos Uva Ursi (Linn.) Sprengel. Uva Ursi, leaves.
Arisæma triphylium (Linn.) Torr. Indian turnip, tuber.
Artemisia Absinthium Linn. Wormwood, leaves and inflorescence.
*Atropa Belladonna Linn. Belladonna, leaves and root.
Carum Carvi Linn. Caraway seed, fruit.
*Carum Petroselinum Benth. Parsley, root and fruit.
Cercis Canadensis Linn. Judas tree, bark.
Chenopodium anthelminticum Linn. American wormseed, seed.
Chimaphila umbellata (Linn.) Nutt. Pipsissewa, herb.
*Claviceps purpurea (Fries) Tulasne. Ergot, sclerotium.
Cochlearia Armoracia Linn. Horseradish, root.
Conium maculatum Linn. Conium, fruit.
Convallaria majalis Linn. Lilly of the Valley, rhizome and rootlets.
Coptis trifolia (Linn.) Salisb. Gold thread, herb.
Delphinium consolida Linn. Larkspur, seed.
*Digitalis purpurea Linn. Digitalis, leaves, flowers and seed.
*Dryopteris Filix-mas Schott and D. Marginalis, Gray. Male fern, rhizome.
Epigea repens Linn. Gravel plant, herb.
Euonymus atropurpureus Jacq. Wahoo, bark.
Gaultheria procumbens Linn. Wintergreen, leaves and inflorescence.
*Gentiana lutea Linn. Gentian, root.
Geranium maculatum Linn. Cranesbill, rhizome.
Humulus Lupulus Linn. Hops, inflorescence.

*Hyoscyamus niger Linn. Henbane, leaves and inflorescence.

Juniperus communis Linn. Juniper berries, fruit.

Lactuca Canadensis Linn. Wild lettuce, leaves and inflorescence.

Lobelia inflata Linn. Lobelia, herb and seed.

Menispermum Canadensis Linn. Yellow parilla, rhizome and roots.

Mentha piperita Linn. Peppermint, leaves and inflorescence.

Monarda fistulosa Linn. Wild bergamot, leaves and inflorescence.

Phytolacca decandra Linn. Poke root and berries.

Podophyllum peltatum Linn. Mandrake, rhizome and roots.

Prunus serotina Ehrh. Cherry, bark.

Quercus alba Linn. White oak, bark.

*Ricinus communis Linn. Castor bean, seed and leaves.

Rubus villosus Aiton R. Canadensis, Linn. and R. trivalis, Michx. Blackberry, root bark.

*Salvia officinalis Linn. Sage, herb.

Sanguinaria Canadensis Linn. Blood root, rhizome.

Sassafras variifolium (Salisbury) O. Kuntze. Sassafras bark, root, bark.

Satureja hortensis Linn. Summer savory, herb.

Taraxacum officinale Weber. Dandelion, root.

Thuja occidentalis Linn. Arbor vitae, leaves.

Thymus vulgaris Linn. Thyme.

Tsuga Canadensis (Linn.) Carr. Hemlock, bark.

Ustilago Maydis Leveille. Ustilago, entire fungous plant.

*Valeriana officinalis Linn. Valerian, rhizome and rootlets.

*Veratrum album Linn. White hellebore, rhizome and rootlets.

Veratrum viride Aiton. Veratrum, rhizome and rootlets.

Chemical constitutents but partially determined; physiological action fairly well known:

*Cactus grandiflorus Linn. Cactus grandiflorus, branches.

Cannabis sativa Linn. var. Americana. American hemp, inflorescence.

Spigelia Marylandica Linn. Pink root, rhizome and rootlets.

Chemical constituents regarded as well known; physiological action not systematically investigated or well understood:

Acorus Calamus Linn. Calamus, rhizome.

Æsculus Hippocastanum Linn. Horse chestnut, bark and seed.

Agropyrum repens (Linn.) Beauv. Couch grass, rhizome.

Aralia racemosa Linn. Spikenard, root.

Arctium Lappa Linn. and some other species of Arctium, Burdock, root and seed.

Asarum Canadense Linn. Canada snake root, rhizome.

Asclepias incarnata Linn. White Indian hemp, root.

Beberis vulgaris Linn. Barberry, bark.

Castanea dentata (Marsh) Sudworth. Chestnut, leaves.

Caulophllum thalictroides (Linn.) Michx. Blue cohosh, rhizome and rootlets.

Ceanothus Americanus Linn. Jersey tea, leaves.

Chelidonium majus Linn. Garden celandine.

Cornus circinata L. Heritier. Green osier, bark.

Cornus florida Linn. Dogwood, bark.

Cypripedium pubescens Swartz and C. parviflorum Salisbury, Ladies' Slipper, rhizome and rootlets.

Epilobium angustifolium Linn. Willow herb, herb.

Eupatorium perfoliatum Linn. Boneset, leaves and inflorescence.

Eupatorium purpureum Linn. Queen of the meadow, rhizome and rootlets.

Galium Aparine Linn. Cleavers, herb.

Helianthus annuus Linn. Sunflower seed.

Hepatica triloba Chaix. Liverwort, herb.

Inula Helenium Linn. Elecampane, rhizome and rootlets.

Heuchera Americana Linn. Alum root, rhizome.

*Kalmia angustifolia Linn. Sheep laurel, leaves.

Liriodendron Tulipifera Linn. Tulip tree, younger bark.

Marrubium vulgare Linn. Horehound, herb.

Matricaria Chamomilla Linn. German chamomile, flowers.

Melissa officinalis Linn. Lemon balm, herb.

Penthorum sedoides Linn. Virginia stonecrop, leaves and inflorescence.

Phoradendron flavescens (Pursh.) Nutt. Mistletoe, leaves and branches.

Phytolacca decandra Linn. Poke berries.

Polygonatum biflorum (Walt.) Ell. Solomon's seal, rhizome.

Polygonum hydropiper Linn. P. hydropiperoides Mich. and P. punctatum Ell. Water pepper, herb.

Populus Balsamifera candicans (Ait.) Gray. Balm Gilead, buds.

Ptelea trifoliata Linn. Wafer ash, root bark.

Rhus glabra Linn. Sumach berries.

Rhus radicans Linn. Poison oak, leaves.

Rumex crispus Linn and some other species of Rumex. Yellow dock, root.

Salix alba Linn. White willow, bark.

Salix nigra Marsh. Black willow, buds and bark.

Sambucus Canadensis Linn. Elder flowers.

Saponaria officinalis Linn. Soapwort, herb.

Scrophularia nodosa var. Marylandica A. Gray. Figwort, herb.

Solanum Dulcamara Linn. Bittersweet, twigs.

Symphtum officinale Linn. Comfrey, root.

Trifolium pratense Linn. Clover (red), tops.

Viola Tricolor Linn. Pansy, herb.

Xanthoxylum Americanum Miller. Prickly ash, bark.

Zea Mays Linn. Cornsilk.

Chemical constituents but partially determined; physiological action not systematically investigated or well understood:

Ailanthus glandulosa Desf. Ailanthus, bark.

Aletris farinosa Linn. Unicorn root, rhizome.

Borago officinalis Linn. Borage, herb.

*Cactus Grandiflorus Linn. Cactus granditlorus, succulent branches.

Castalia odorata (Dryander) Woods and Wood. White pond lily, rhizome.

Cimicifuga racemosa (Linn.) Nutt. Black cohosh, rhizome and rootlets.

Citrullus vulgaris Schrader. Water melon seed.

Dioscorea villosa Linn. Wild yam, rhizome.

Erigeron Canadensis Linn. Flebane, leaves and inflorescence.

Fraxinus Americana Linn. American White ash, bark.

Hamamelis Virginiana Linn. Witch hazel, leaves and bark.

Iris versicolor Linn. Blue flag, rhizome.

Juglans cinerea Linn. Butternut-root, bark.

Juglans nigra Linn. Black walnut, leaves.

Larix laricina (Duroi) Koch. Tamarac, bark deprived of corky layer.

Leonurus Cardiaca Linn. Motherwort, herb.

Liquidambar Styracitlua Linn. Sweet gum, inner bark.

Lycopersicum esculentum Miller. Tomato, herb.

Lycopus Virginicus Linn. Bugleweed, herb.

Nepeta Cataria Linn. Catnep, herb.

Œnothera biennis Linn. Evening primrose, herb.

*Œnanthe Phellandrium Lam. Water fennel, seed and fruit.

*Pæonia officinalis Linn. Peony, rhizome.

Panax quinquefolium Linn. Ginseng, root.

Populus tremuloides Michx. and P. alba, Linn. White poplar, bark.

Prunus Persicaria (Linn.) Seibold and Zuccarina. Peach leaves.

*Ricinus communis Linn. Castor leaves.

Salix nigra, Marsh. Black willow, buds.

Solanum Carolinense Linn. Horse-nettle, berries and root.

Solidago Canadensis Linn. Solidago Canadensis, leaves and inflorescence.

Urtica dioica Linn. Nettle root.

Verbascum Thapsus Linn. Mullein leaves.

Viburnum Prunifolium Linn. Black haw, bark.

Chemical constituents regarded well known; physiological action uninvestigated:

Achillea Millefolium Linn. Yarrow, leaves and inflorescence.

Agropyrum graveolens Linn. Celery seed.

Asclepias Syriaca Linn. Silkweed, root.

Asparagus officinalis Linn. Asparagus, root.

*Carthamnus tinctorius Willd. American saffron, flowers.

Chrysanthemum Parthenium (Linn.) Pers. Feverfew, herb.

Dicentra Canadensis D. C. Turkey corn, tubers.

Equisetum hyemale Linn. Equisetum hyemale, herb.

Hydrangea arborescens Linn. Hydrangea, roots.

Hypericum perforatum Linn. Johnswort, herb.

Mitchella repens Linn. Squaw vine, herb.

Sabbatia angularis (Linn.) Pursh. Centaury, herb.

Solidago odora Aiton. Golden rod, leaves and inflorescence.

Chemical constituents but partially determined; physiological action uninvestigated:

Adiantum pedatum Linn. Maiden hair fern, frond.

Agrimonia Eupatoria Walt. Agrimony, herb.

Ampelopsis quinquefolia Michx. American ivy, bark and small twigs.
Aralia nudicaulis Linn. American sarsaparilla, root.
Avena sativa Linn. Avena sativa, heads.
Calendula officinalis Linn. Calendula flowers and calendula herb.
Capsella Bursa-Pastoris Moench. Shepherd's purse, herb.
Celastrus scandens Linn. False bittersweet, bark.
Chelone glabra Linn. Balmony, herb.
Collinsonia Canadensis Linn. Stoneroot, rhizome.
Epiphegus Virginiana (Linn.) Bart. Beech drops, herb.
Gnaphalium obtusifolium Linn. Life everlasting, herb.
Juglans nigra Linn. Black walnut hulls, epicarp.
Lacinaria spicata (Linn.) Kuntze. Button snake root, tuber.
Nepeta Glechoma Benth. Ground ivy, herb.
Ostrya Virginiana (Mill) Willd. Ironwood, heart wood.
Pimpinella Saxifraga Linn. Saxifrage, root.
Plantago major Linn. Plantain leaves.
Polymnia Uvedalia Linn. Bearsfoot, root.
Scutellaria lateriflora Linn. Scullcap, herb.
Spirea tomentosa Linn. Hard hack, leaves, etc.
Symplocarpus foetidus Nutt. Skunk cabbage, root stock.
Trillium erectum Linn. Bethroot, rhizome.
Viola pedata Linn. Violet herb, leaves, etc.

Chemical constituents undetermined; physiological action not systematically investigated or well understood:

Trifolium repens Linn. White clover, inflorescence.
Xanthoxylum Americanum Miller. Prickly ash, berries.

Chemical constituents undetermined; physiological action uninvestigated:

Æsculus glabra Willd. Buckeye, bark.
Aralia hispida Vent. Dwarf alder, root.
Betonica officinalis Linn. Wood betony, herb.
Cratægus Oxycantha Linn. Hawthorn, "berries."
Gentiana ochroleuca Frœl. Sampson snakeroot, root.
Gentiana quinquefolia Linn. Five-flowered gentian, herb.
Impatiens aurera Muhl. and I. biflora, Welt., herb.

Ligustrum vulgare Linn. Privet, leaves.
Nymphaea advena Soland. Yellow pond lily, root.
Polemonium reptans Linn. Abscess root, root.
Polytrichum juniperinum Hedwig. Haircap moss, entire plant.
Rubus strigosus Michx. Raspberry, leaves.
Senecio aureus Linn. Life root, entire plant.
Sorghum saccharatum (Linn.) Persoon. Broom corn, seed.
Stylosanthes biflora (Linn.) B. S. P. Stylosanthes, herb.
Verbena hastata Linn. Vervain, herb.

Some Scientific Aspects of Tea Drinking.

Frank B. Wade.

An ancient beverage, and one now in more universal use than any other, not even excepting beer, tea has many claims as a wholesome and harmless adjunct to our meals.

Our English cousins, headed by that greatest tea merchant and good sportsman, Sir Thomas Lipton, seem to have come to a better appreciation of "the cup that cheers but not inebriates" than we in America have arrived at. You remember that, in Pickwick Papers, Sam Weller tells us that they drank tea until they "swelled wisibly." Our English friends at one time would even have compelled us to take to their favorite beverage had not a party of well-meaning, but rather hasty, Yankees dumped the first consignment of raw material into Boston harbor. Since then we seem to have retained a rather illogical prejudice against an excellent beverage.

Among its many virtues, not the least is that it supplies, in a harmless form, an adequate amount of water to the system. Physicians are agreed that most of us habitually take too little liquid. Many functional disturbances arising from this lack of water might be removed by acquiring the habit of tea drinking. Another advantage to be derived from the use of tea is in thereby obtaining water which is free from pathogenic bacteria and which is partly softened by boiling. The sterilization of the water and the removal of its "temporary hardness" are unmistakably advantageous in places where there is any suspicion as to the purity of the drinking water or where it is excessively hard.

To persons of sedentary life, with digestive powers not of the strongest, the simple physical advantage of the heat-content of the cup of tea is probably of material aid in facilitating natural digestion. It also acts as a mild stimulant, on account of the presence of the alkaloid theine. Any reasonable use of tea is unlikely to cause serious reaction from this stimulant, and the benefits upon digestion, of the cheerful state of mind produced by it probably more than compensate for any drain produced by it upon the nervous system. In case of personal idiosyncrasy toward tea it should, of course, not be used.

The chief objection to the use of tea seems to me to arise not from the theine content of the infusion, but from its tannic acid content when not rightly prepared. As ordinarily prepared by estimable old ladies the infusion of tea contains small amounts of more or less volatile oil, a small per cent. of theine, some coloring matter, and loads of tannic acid. Last year my landlady happened to be both estimable and orthodox and prepared my tea in the regulation fashion. In order to convince her of the error of her ways I carried over a test tube of lead acetate solution and, calling her attention to my cup of tea, I precipitated a heavy mass of bulky lead tannate in my cup, much to her surprise. On being informed that the result was due to the presence of tannic acid in the tea she exclaimed, "Why! I didn't think my grocer would do such a thing!" I think she never quite forgave that grocer even although I explained to her that the tannic acid grew in the tea plant and that she herself extracted it by long steeping. I had to get a tea ball and make my own infusion at the table to get well-made tea. It is true they called me "Miss" Wade after that, but I knew that the orthodox tea was fit only to tan hides, and I had too much respect for my interior to continue its use.

A short time ago a friend and I visited a celebrated local Chinese tea shop in order to test the quality of the tea. While the genial proprietor, Mr. Moy Kee, slumbered peacefully in his reclining chair my friend and I spied out the land in the rear of the curtain partition. Upon a lighted gas stove a blue granite ware tea kettle was boiling merrily. The proper amount of tea was put in a vessel, the boiling water poured over it and almost immediately poured off into the china teapot in which it was served to us. I do not, myself, particularly like the flavor of Chinese teas, but this tea was well made and very free from astringency. We noticed upon the menu cards two interesting names of teas—"Before the Rain," and "After the Rain." I was at a loss to understand the derivation of these names until next day at dinner, when, in discussing her method of making tea with my new landlady she told me that her method was just like Moy Kee's and that she found it very economical, as you could get an excellent second cup of tea from the grounds by re-extracting them. I knew then that my first cup of tea had been "Before the Rain" and my second cup "After the Rain."

In order to show strikingly the difference in the tannic acid content between tea prepared after the Chinese fashion of quick extraction by boiling water and tea prepared by long steeping I secured ten samples of tea in the open market and extracted 4 grams of each in ½ liter of water by both methods. (See table and photographs.) In the quick extraction process the half liter of boiling water was poured over the 4 grams of tea, allowed to remain 1 minute and then the infusion was quickly strained into a clean flask. In the slow steeping process the half liter of boiling water was poured over the 4 grams of tea and kept at boiling temperature for about 5 minutes, then strained into a clean flask. To each of the twenty infusions excess of lead acetate solution containing a few drops of acetic acid was added. In the ten flasks containing quickly extracted tea scarcely any precipitate was found, while in the ten flasks containing the same kinds of tea extracted by the longer method very voluminous preciptates formed without exception. In other words the tea made by the orthodox method of long steeping contained vastly greater amounts of astringent material of the nature of tannic acid than the other.

Many people habitually drink tea of this description and, having become accustomed to it, do not like tea unless it is "strong enough to float a flat iron." That they enjoy a fair measure of health is only another tribute to the enormous resistive powers of the cells of the stomach lining. That many people are unable to drink tea of this type, and so do not drink any, is, I believe, due to its tannic acid content, not to its content of theine.

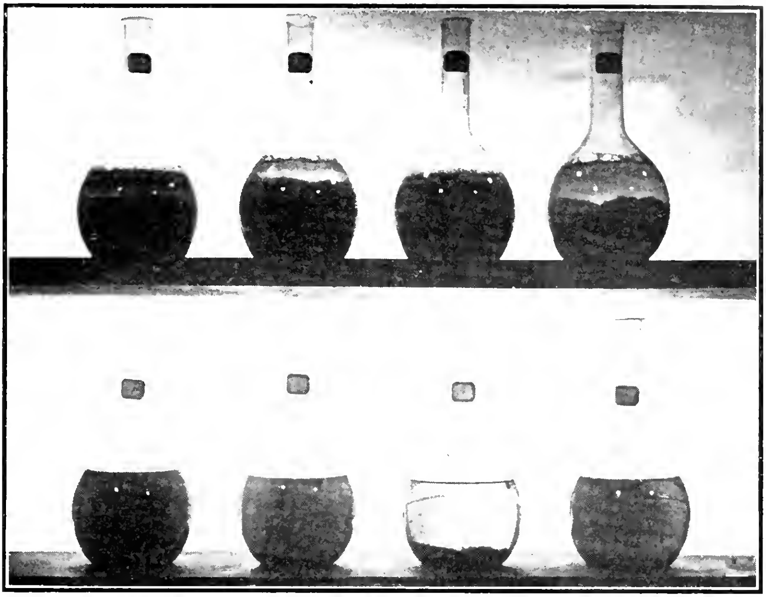
While most teas contain a slightly larger per cent. of theine than coffee does of its alkaloid (caffeine), yet, when we consider the weight per cup of dry material employed in making the two beverages, we see at once that the alkaloid content of the cup of tea is really considerably smaller than that of the cup of coffee. A teaspoonful of tea is liberal for one cup. The ordinary amount of coffee per cup is a tablespoonful. The coffee is denser than the tea, so the relative weights of coffee and tea per cup are about in the proportion of 5 for the coffee to 1 for the tea. Three per cent. is a fair average for the theine in tea and 1 per cent. for the caffeine in coffee, so the amount of alkaloid in the cup of coffee is really greater than in the cup of tea, even if all the alkaloid is extracted in each case. In reality the theine is not as completely extracted by a one-minute exposure to boiling water as the caffeine is by the longer extraction which coffee always receives. So the well made cup of tea is in truth only a delicately flavored and colored cup of hot water.

I think I may then conclude that tea, made by the method of quick extraction with boiling water, affords a wholesome source of fluid to the body while at the same time it gives, on account of its aromatic flavor and slightly stimulating properties, a pleasure to its users which makes it worthy of a far more extended use among us than it has yet reached.

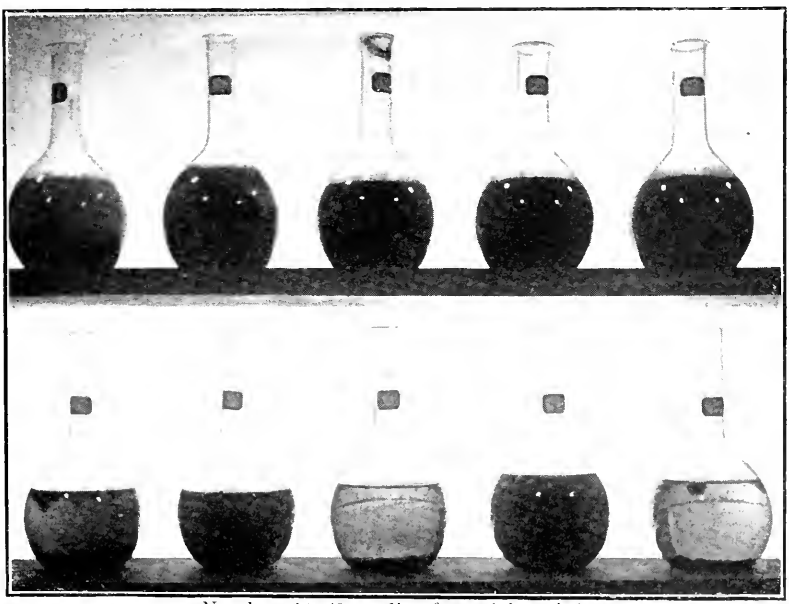
TABLE I.

No.	Name.	Price.	Taste.	Color.
1	Lipton No. 1	$0 60	Mild and pleasant	Black.
*2	No. 1, once used	....	....	
3	Imperial	60	Slightly aromatic, mild	Green.
4	Gunpowder	80	Very aromatic, strong	Green.
5	Needle Japan	80	Flat, astringent	Black.
6	Oolong	80	Slight aroma	Black.
7	Young Hysen	80	Aromatic, mild	Green.
8	Mixed tea	......	Aromatic, mild	Black and Green.
9	Formosa	90	Slightly aromatic, mild	Black.
10	Uncolored Japan	80	Aromatic, slightly astringent	Green.

*No. 2 flask broke. Not shown in photograph.



Numbers 1, 3, 4, 5, reading from left to right.
Upper row in each picture shows result of long boiling.



Numbers 6 to 10, reading from right to left.

The Radium Clock.

By R. R. Ramsey.

R. J. Stutt (Phil. Mag. 6, 588, 1903) has devised a very simple little device to show that a radium preparation takes on a positive charge due to the B-rays. This consists of a radium preparation enclosed in a thin walled glass tube. The tube is suspended in a vacuum tube by means of a quartz rod. To the lower end of the tube a gold leaf is suspended, forming an electroscope. The B-rays cause the tube to become positively charged, the L-rays being absorbed by the glass, the leaves diverge, and if the gold leaf is allowed to touch an earthed plate the charge is taken off and the process of charging begins over again with a regularity which suggests perpetual motion. The term radium clock has been suggested by some one as a name for the device. It was the original intention to exhibit one here today.

The only successful one which I have been able to make is the one I had when the title was sent in. Since the period of this one is about 48 hours, I have concluded your faith would be tried as much with the exhibit as without. However, the tube is on the table. It was my hope to be able to make one in a neat, short tube with a quick period which could be used in front of a lantern. To accomplish this 50 mg. of 10,000 activity radium was placed in the tube. The quartz was discarded and the tube set upon a block of hard rubber in the bottom of a test tube, with the gold leaf hanging alongside of the radium tube. When exhibited to a vacuum of lower pressure than my first tube, the gold leaf refused to move. The tube was prepared again with a quartz rod between the tube and the hard rubber. This also failed to work. Since the gold foil hung alongside the radium the B-rays were partially absorbed by the gold, thus neutralized the charge. At the last moment I was forced to come back to the original form. This has failed to work, probably due to dirt on the quartz rod. The essentials for success are plenty of high activity radium, thin glass, containing tube hermetically sealed, perfect insulation and a good mercury pump.

The Use of Peat as Fuel.

By Benjamin W. Douglass.

Peat is that product of vegetable decay which we find composing the soil of most of the swamps of temperate zones. We may expect to find it any place where bog conditions exist. Europe, Asia and America contain extensive bogs and it is estimated that the total area covered by peat is many times greater than the total area of all known coal fields.

The peat bogs which occupy over 15 per cent. of the area of Ireland have for centuries been the main source of fuel in that island. In fact the term "peat" has become so intimately connected with Ireland that popular fancy has imagined it to be characteristically and exclusively an Irish product. As a matter of fact, a most incomplete survey indicates that the peat fields of America exceed not only those of Ireland, but are larger by nearly a hundred times than the combined bogs of all Europe. Thousands of square miles of peat of the finest quality exist throughout the Northern States and Canada. New England has whole counties of it. The Great Dismal Swamp of Virginia is one continuous peat bed. New York, Ohio, Indiana, Illinois, and the Great Northwest contain deposits of peat, the value of which is as yet almost unsuspected. In the bogs where it occurs it is a closely matted, felt-like substance, very fibrous and usually very wet.

Just as coal and wood exist in many varieties, we find similar variations in peat. In general all peat may be classed under one of two varieties: The black peats, which are composed of the bodies of grasses, sedges, and other large plants, and the brown peats, formed from sphagnum and other mosses. It is the latter variety which forms the immense beds of North America, and for the purposes of this paper it will be understood that we refer only to this brown form.

In its pure state peat contains only such inorganic matter as was present in the bodies of the plants from which it was formed. Impure peat may contain other inorganic matter, as sand, clay, silt which has been washed in from adjacent hills, or deposited by the overflow of streams, as the location of the swamp would indicate.

The use of peat as a fuel by no means limits its range of useful application; ardent experimenters have found many ways of utilizing this humble stuff.

Where thorough drainage is possible, peat lands have proven excellent for agricultural purposes, though in most cases requiring the addition of considerable quantities of potash. As a fertilizer peat has been demonstrated to possess decided value and is so used extensively today. From the more fibrous peats an excellent paper is prepared, large works in Germany being devoted to its manufacture. As a disinfectant

A typical Peat bog.

and deodorizer, powdered peat has been sold, under an assumed name, for some years, and most excellent results have been obtained from it. Indeed the range of possible use of this remarkable substance seems almost limitless. It has been used as a substitute for charcoal in the manufacture of fireworks, coarse heavy cloth has been prepared from it, a recent patent claims its successful use as a substitute for papier-mache, a serviceable cement has been made from its ashes, and within the past year the agriculturists at an Indiana college have suggested the possible value of peat as a stock food.

While the work of demonstrating these possibilities was necessarily very great it has not been so extensive as the experiments which have been made along the line of developing its use as a fuel.

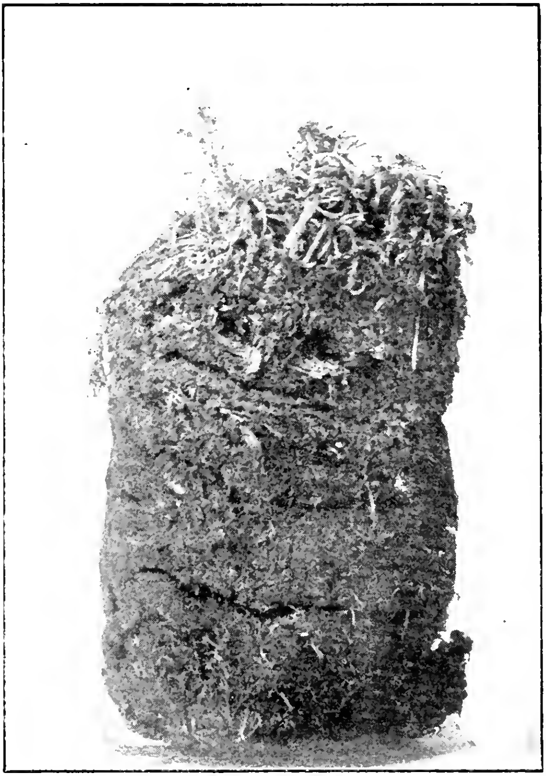
Crude peat, cut from the bogs with spades and piled in the open to dry, has fed the fires of peasantry in Europe for centuries. Extremely light and spongy in character, burning slowly, with only a moderate amount of heat and considerable smoke, it made a very poor fuel

The crude process of Peat mining as practiced in many European countries.

indeed. Its great bulk, its friable character and the readiness with which it absorbed water, made the problem of transporting it almost insurmountable, even had there been a market for so crude a fuel.

As the European forests were destroyed or protected from further destruction by the governments, wood as a fuel became scarce and the price of coal arose accordingly.

As early as 1821 we find that German inventors had directed their attention to the problem of compressing peat. It no doubt seemed a simple problem to those first experimenters, as it has to most of the investigators of more recent times, but it was nearly three-quarters of a



Block of Peat from the surface of a bog, showing the Sphagnum Moss. (Natural size.)

century before any practical process of briquetting peat was devised. Early inventors, not unlike some later ones, thought that peat could be condensed and dried by simple pressure. Hundreds of thousands of dollars were spent in demonstrating the fallacy of this theory, a fallacy that is self-evident when once the character of the material is fairly understood.

As it comes from the bog, peat contains from 75 to 80 per cent. water. The fibrous character of the substance prevents the removal of this water by direct pressure and also accounts for the difficulty experienced in drying the crude material by exposure to the air. Not only is the moisture held between the fibres of the peat but it is contained in the capillary spaces running through the fibres, and any successful process of fuel making must contemplate the destruction of the fibrous nature of the material.

At present, investigators are working on two general processes for the conversion of peat into a marketable fuel. The older of these methods may be called the wet process and consists in breaking and grinding the wet peat until it loses its fibrous structure and becomes almost like clay in its plasticity. It is then moulded into blocks of convenient size and allowed to dry spontaneously. In drying, the briquettes shrink to about one-third their original size and become very dense and hard, and when thoroughly dry contain only from 5 to 10 per cent. moisture. Crude peat, that is, peat as it comes from the bog, can not be dried below about 20 per cent. moisture, owing to its fibrous nature.

Peat prepared in this general manner has long been a commercial article in many European countries. Germany, Holland and Russia use large quantities of it, and I am told that more than two million tons are marketed yearly in Sweden.

Considering the progress which this industry has made in Europe it is surprising that America is only beginning to utilize the vast stores of this fuel with which she is so richly supplied.

In the natural transformation of peat into coal (for coal is but an advanced condition of marsh mud) three fundamental changes take place: the peat is dried, compressed and carbonized. It was an attempt to imitate this natural process which led to the discovery of another way of making peat briquettes. In this "dry process," as it is called, the peat is first artificially dried and pulverized in machines constructed for that purpose. This dry peat powder is then compressed under heavy pressure into a hard and dense briquette. While this process produces a briquette of excellent quality, no compressor has as yet been patented which is a commercial success. The past few years have seen many dry peat-pressing machines offered on the market, all of which have failed either from actual inability to do the work or from too great cost of operation.

Compared with coal, briquettes made by either of the above processes have many advantages to offer. Calorimetric tests show that condensed peat possesses a fuel value equal to the best coal, and practice proves that this fuel is available under ordinary conditions of burning. The best of coal contains slate, shale, iron and other clinker-producing elements. Clinkers inhibit the supply of oxygen (air) and the carbon, unable to burn, goes up the chimney in the form of smoke. On the other hand, the very nature of its origin prevents the possibilty of clinker formation in a peat fire. The ashes of the new fuel, fine and soft as cigar ashes, fall through the grate bars and allow a constant supply of fresh air to pass through the fire, thus securing perfect combustion and practically no smoke.

It has been urged against peat that it contained a high percentage of ash-producing constituents. A marketable peat will contain from two to ten per cent. of ash, pure coal from two to eight per cent. These are the figures of the laboratory. As a matter of fact the average per cent. of ash from a coal fire is from 20 to 35 per cent. and in it is contained not only ashes and clinkers but also quantities of unburned coal—the result of choked grate bars.

The almost universal absence of sulphur in peat renders it a far more wholesome fuel than any of the soft coals. Indeed so mild is the smoke produced from peat that it has been used in emergencies as a substitute for tobacco.

In specific gravity, this condensed fuel will vary from about 1.10 to 1.65. In other words a ton of it will occupy about the same space as a ton of hard coal.

While peat briquettes are not absolutely waterproof, they are relatively so, for when once the fibre of the material is destroyed and it has been allowed to dry, no amount of soaking will reduce it to its original condition.

Recently some attempt has been made to combine peat with various other substances. For one reason or another all of these mixed fuels have failed. One of the most notable of these combinations uses a certain proportion of crude petroleum. As a result a pile of such fuel is constantly liable to spontaneous combustion.

Mixtures of peat and anthracite dust have failed, owing to the necessity of using an expensive "binder" to give the briquettes solidity. Aside from their high cost, binders in fuel of this type have failed for two reasons. The organic binders (as starch) burn more rapidly than the fuel proper, and as a result much unburned matter falls through the grate bars. On the other hand inorganic binders add so materially to the resulting ash as to render their use impractical.

The most successful process of briquetting peat will be found to be the one which is the least complicated, for simplicity will tend not only to economical production but to practical operation as well.

In conclusion it is not too much to predict that the peat fuel industry in America will rival in magnitude the coal industry of today. It is difficult to conceive of the importance which this industry must have in the development of our great Northwest, but it is there, in a region destitute of coal, though rich in every other respect, that we must expect to find the first and most extensive use of peat fuel.

The Chronic Ill Health of Darwin, Huxley, Spencer, and George Eliot.

By Robert Hessler.

(Abstract.)

This paper was an inquiry into the chronic ill health of the individuals mentioned in the title, based on a study of their life and letters, and was illustrated by charts and diagrams. The paper was in line with former ones read before the Academy, and showed how the influence of city dust cropped out in the biographies of men and women.

The ability to live in a dusty city atmosphere differs greatly. Some individuals are scarcely influenced by city dust, others are very susceptible and complain or suffer constantly. The list of disease and symptom names used, especially by Huxley, is suggestive of dust infection—the symptoms subsiding on going away from the city and out into a good atmosphere. The symptom names were shown in groups and their significance pointed out. In a general way, living in a good atmosphere meant health, while living in a polluted one meant ill health. Seeming exceptions should be studied in the light of the experience of living individuals, susceptible to the same influences. In a city the season of the year and the direction and force of the wind have to be considered as factors. The evil influence of the East Wind is frequently referred to; an east wind means the blowing over of the dust and smoke from the heart of the city. City dust may be brought to a country resident, as in a lot of books from a city library; and where the books are read while in a reclining position the evil influence of the dust may be quite marked. A visit to a hall or room crowded with a mass of humanity may be followed by an attack of ill health. Where the symptoms are more or less continuous, nervous manifestations may predominate.

As a rule biographies dwell only lightly on the subject of health and disease and references may be quite vague; the Life and Letters of Huxley are an exception, and are worthy of a close study, especially by those who are influenced by city dust.

The Wood Pulp Industry.

By M. D. Renkenberger.

Wood pulp and the wood pulp industry have come to their present importance within the last twenty-five years. An increased use of paper, of which wood pulp forms a large per cent., appears not only in newspapers and all kinds of common papers but in the manufacture of many useful and ornamental articles. This increased use of wood pulp in the paper industry, together with the fact that the particular kinds of timber used for pulp exist in limited amounts, makes it not only wise but absolutely imperative that the matter of raising trees for pulp wood be considered. Unless, indeed, some substitute is found for wood pulp, this matter must be taken up seriously in the States, and that within a very few years.

The wood pulp industry first appeared as such in the census of 1870. Since then the growth has been rapid and steady, the increase in the value of raw material, for example, in 1900 being more than 59 per cent. over the value of material consumed in 1890. The growth of our export trade in paper and pulp stock has been steady and healthful, amounting in 1900 to a total of $6,674,296, an increase of nearly 500 per cent. during the decade. The grades exported are largely wood papers (especially news), while the usual imports are of the higher grades of book and fancy papers and specialties. The per capita production of paper has increased from 8.1 pounds in 1860 to 56.9 pounds in 1900, the per capita value of which is now over $1.66. One author claims that more wood is consumed in the form of pulp by the great paper making establishments than is used by the combined railway systems of our country.

The raw material for pulp comes chiefly from the spruce and poplar of northern United States and Canada. At the enormous rate at which this one industry is using up existing timber, to say nothing of the vast drain made upon the virgin forests for lumber, fuel, etc., there will soon come a time when either inferior grades will have to be used or a substitute be found. As yet few attempts have been made to raise trees for pulp wood and as the consumption of wood for this purpose is enormous, and as the virgin supply is limited, the writer sees no reason, in view of the steadily raising price of pulp wood, why the growing of trees for pulp can not be made a profitable business in forest culture.

Historical.

From the earliest Egyptian papyrus to the paper of today the predominant characteristic is that it consists of the enduring portion of vegetable growth known as cellulose or pure fiber. All parts of plants have been used for this purpose and a list of raw material used for paper would include linen and cotton rags, jute, hemp, esparto grass, wood pulp, clay, straw, peat, cornstalks, and a half dozen others.

The discovery that wood could be converted into its component fibers and freed from lignin, gums, etc., became the basis of modern paper making and brought the wood pulp industry into prominence in a largely forested country. The German process for making "ground wood" was introduced into this country about the middle of the nineteenth century, the soda process from England a century earlier, and the sulphite process is an American invention of about 1867, and owing to its cheapness in producing a strong cellulose fibre from spruce, its use has increased more rapidly than that of the soda process. The first wood pulp made in this country sold at 8 cents per pound; today the price of "ground wood" pulp is about 1 cent per pound. The scarcity of rags and the cheapness and abundance of the pulp supply in the great forests of spruce and other woods caused the new material to be generally adopted. At first aspen and basswood were preferred for paper making, but as the supply of these woods was quite insufficient for the demand, coniferous wood was tried, and spruce soon came into the first rank for the purpose. This widespread demand, which has steadily increased, has been one of the chief causes of the destruction of large areas of forests—forests, too, in which no steps were taken toward reproduction either natural or artificial. In North America during the three years ending in 1894, 200,000 acres of forests had been denuded to satisfy the demands of 210 paper factories.

Uses of Wood-Pulp.

The principal use to which wood pulp has been put is in the manufacture of the coarser kinds of printing, writing, and wrapping papers. The use of the German process for making a ground wood fiber has steadily increased, to a great extent superseding the use of rags, entirely so in the manufacture of news and wall papers, very largely so in the manufacture of book and wrapping papers and to a considerable proportion in writing and other grades. In fact fifty per cent. of our paper is manufactured from wood pulp.

Wood pulp is used for many other purposes besides paper making, sometimes usefully, at other times with doubtful advantage. Such are: the use of compressed pulp bricks for construction purposes; its use in textiles such as silk and cotton; in panelings and interior house decorations; in celluloid, surgical bandages, car wheels, pulleys, paper boxes, pails, barrels, etc.; for filters in breweries and sugar factories; for fuel, etc. As compared with paper making, however, these other uses of wood pulp are only of subordinate importance and perhaps hardly consume one per cent. of all the wood pulp thrown onto the market.

Raw Material and Preparation.

The raw material of wood pulp is spruce, poplar, and in smaller quantities various other woods such as balsam, hemlock, birch, according to the location of the industry, the process employed, and the kind of paper in which the material is to be used. The variety as to the kinds of trees that have been used with varying success at various times and places is extensive; such are soft pine (hard pine containing too much resin), fir, spruce, balsam, hemlock, birch, large-toothed aspen, cottonwood, Carolina poplar, buckeye, basswood, box elder, quaking asp, beech, bamboo, linn, willow, soft maple, catalpa and perhaps others—in fact any tree can be used, it is merely a question of relative value and relative expense. The kinds of timber most largely used in pulp manufacture are soft, easily worked, light both in weight and color, possessed of long fibers, not fading easily, and containing little resin or other infiltrations. It will be seen that spruce among conifers and poplar among broad-leaved trees possess the requisite qualities in a remarkable degree. In the United States spruce forms 76 per cent. of all wood for both mechanical pulp and chemical fiber. Poplar being softer (and used most for soda fiber) forms 12.9 per cent. of all woods consumed in making different kinds of pulp. Other unspecified woods for pulp or fiber make up the remaining 11.1 per cent.

In the preparation of pulp, the wood should be worked up green and the bark and defective parts must first be taken off. There are two principal methods of reducing wood to pulp—the mechanical and the chemical. These two methods give different results as regards paper manufacture, the product of the mechanical method, termed "paper pulp" being more granular, whilst that of the chemical method, termed "cellulose," is more fibrous, and hence stronger. In making the mechanical pulp, the wood is cut into suitable lengths for grinding, the bark removed, and the blocks held by hydraulic pressure against the edge of a rapidly revolving sandstone and by attrition reduced to a mushy consistency. The fiber as thus ground is passed through filterers of various fineness. The fibrous mass is now brought to another machine, where the water is pressed out, and it is cut into slabs, baled, and shipped to regular paper mills without drying. The pulp so made is the basis of all lower grades of paper. As already noted, the pulp industry has become an integral part of the paper business, over half of the ground wood produced being made into paper on the spot.

By the chemical process, which is more recent and more costly, but which produces a much longer fiber, the finely ground wood fragments are placed in large boiling tanks or digestors, lined inside with lead or other acid-resisting material. Chemical pulp or "cellulose" is of two kinds, depending upon the use of caustic soda (alkali) or calcium sulphite (acid) to macerate the wood. It should be remembered that all chemical processes of wood pulp manufacture are based upon the underlying principle that the middle lamella and infiltrated material which surrounds and holds together the individual fibers of wood is soluble and produces a chemical reaction with certain aqueous solutions, notably that of the bisulphite of lime. The problem is to apply the macerating liquid under conditions which will completely and quickly eliminate the infiltrated substances without unnecessarily weakening the fiber, and for this purpose the solution must be applied at a high but carefully governed temperature and under a mechanical pressure that will force the chemical solution into every pore of the woody structure, thus permitting it to attack the non-cellulose matter in which the fiber is embedded and by which it is permeated. The matrix thus loosened and dissolved is removed by washing with water.

Where sulphite of lime is used, the wood fragments are boiled in sulphurous acid from 24 to 60 hours under a pressure of about three atmospheres. The soft, crumbling, reddish-yellow pieces are then pounded, washed, filtered, and pressed into sheets about the thickness of pasteboard.

When soda is used, the woods employed are usually softer, of mellower fiber, and without much strength. The process is similar to that of sulphite, except that in place of sulphurous acid a solution of caustic soda is used in the digestors. There are various other methods by which attempts have been made to separate the wood fibers, most interesting of which perhaps is Kellner's electrical process, in which the wood, boiling in a solution, commonly salt, is subjected to electrical discharges. The value of this process has not been ascertained, however. Of all the chemical methods in use the sulphite method is by far the cheapest and most satisfactory.

Characteristics and Advantages of Wood-Fibered Paper.

Ground wood with an admixture of from 10-25 per cent. of the chemical fiber is used for newspaper stock, wrapping paper, and for many of the lower grades of book, magazine and writing papers. For the very best grades of paper, whether for printing or writing, an admixture of sulphite with rag pulp is necessary. For permanent records the author is of the opinion that only rag pulp, and that of the best quality, should be used. It is true that in from 15 to 20 years the "wood pulp" books, papers, etc., will be greatly deteriorated and that for permanence some other substance must be used. A writer in a recent number of the "Outlook" suggests that publishing houses should print a special edition of each publication on a special quality of durable paper, suitably resistant both to chemical and mechanical wear and tear and thus preserve them for posterity. Whether or not the people of our country are careless in this matter, the fact remains that papers made from wood pulp and especially mechanical fiber, are perishable, and that within a very short time. Notwithstanding the great desirability for permanent copies of all our good publications, the larger majority of printed matter will continue to be discarded after the first reading—newspapers entirely so and magazines and even books to a large degree at least at the end of six months or a year. It is quite probable that the same prodigality would exist if our papers were made of the scarcer rag pulp, but wood pulp is not only cheaper than pulp made from rags, but it takes impressions better, wears out type less and decreases the possibility of spreading contagious diseases.

Future Needs and Possibilities of the Wood-Pulp Industry.

Having given a more or less incomplete account of the production, uses, supply, and present status of wood pulp let us now notice what this enormous industry means to our limited forested areas. Some idea of the rapid destruction of our spruce forests for pulp purposes can be got from the following: "A prominent New York newspaper uses 150 tons of paper daily. To produce this amount of paper 225 cords of spruce wood are consumed. It requires 1½ cords of wood to produce one ton of paper pulp. As the spruce ordinarily occurs in our northern mountains it averages about 5 cords to the acre." This means that every day, for this one newspaper alone, 45 acres of our mountain spruce are being consumed. Of course in the best spruce stands, such as those of Saxony and Bavaria, where large quantities of spruce are raised for pulp, it grows in dense, pure stands and yields many times as much as the average acre in this country, at the lowest about 20 cords. Even at that a single edition of a metropolitan Sunday paper would use up more than 10 acres of the very best spruce stand.

And again, from the Scientific American of November 14, 1903: "It has been estimated that nine novels had a total sale of 1,600,000 copies. This means 2,000,000 pounds of paper. The average spruce three yields a little less than half a cord of wood, which is equivalent to 500 pounds of paper. In other words, these nine novels swept away 4,000 trees. Is it any wonder that those interested in forestry look with anxiety upon the paper mill?"

Paradoxical as it may seem however, in those countries that are growing pulp timbers, the paper pulp manufacturer is the most powerful ally of the forester in that he uses the thinnings of the forest which begin while the forest is still young and continue throughout its whole existence.

The situation of the pulp manufacturer is well given by one of our most active foresters, John Gifford, who says: "The pulp manufacturer's plant represents the investment of perhaps a million dollars, while the plant of the lumberman is worth only about ten or twenty thousand dollars. The lumberman owns the land not for the land's sake, nor for the amount and quality of timber the land is capable of producing, but for the crop which covers it. He buys it, uses it, and then abandons it. He pays taxes on it only during the process of reduction. The pulp man on the other hand, is tied to the soil. His heavy investment makes him fearful as to future supplies. For this reason, with commendable foresight, some of the pulp men are buying the land with the timber, and are beginning to work the woods in such a way that future supplies may be assured." It is foolish to suppose that our natural forests under present management and weak attempts at planting will furnish a supply of pulp wood for the future use of the people. Extensive correspondence with paper pulp manufacturers in several States, including Minnesota, Wisconsin, Michigan, New York, Ontario, Pennsylvania, and Indiana, reveals the fact that all agree that the supply of our best pulp timber must shortly give out, but few consider the matter seriously enough to suggest any definite plans or directions for the present. At this date, however, the author is informed that the United States Forest Service has begun the investigation of the wood pulp industry, but have not yet proceeded sufficiently far to warrant a report on the subject. Our own State, too, according to the statement of the secretary of the State Forestry Board, intends to demonstrate on the Forest Reservation in Clark County that growing timber for pulp industries would be a profitable thing on the cheap lands of the State. Indeed, land fitted for agricultural purposes could not profitably be used for any branch of forest culture. Such waste lands as could be profitably utilized in growing pulp wood exist in thousands of acres all over our country. There are the numerous burnt-over slash lands of our pine States; the arid wastes of many of our Southwestern States; the unused agricultural lands of the New England States, and the innumerable other tracts of unused, low-lying, light-soiled areas throughout the valleys of the Missouri, Ohio and Mississippi rivers. As nurse trees, in shelter belts, sand fixers, windbreaks, etc., trees which make good pulp might also be grown.

In view of the facts: (1) that the demand for pulp timber has increased wonderfully in the last few years, (2) that the price of raw material, according to a well known authority, has increased 150 per cent. within the last seven years, (3) that the native supply is limited and can not last many years, (4) that the importable supply is inadequate in those countries from which we could ship it profitably, and in countries such as Canada, blessed with a great abundance of pulp timber, the prohibitive tariff is so high (over $4.00 per cord) that we can not possibly afford to have it brought in, (5) there is only a small probability that an abundant and successful substitute can be found for the use of wood pulp in papers;

—in view of the above facts and of the abundance of unused land in our country, the author is encouraged to believe that the time will soon come when the growing of pulp timbers will be one of our recognized industries, and therefore has some hope of results from the application of the following suggestions.

Suggestions, Recommendations, Estimates, Etc.

Of the trees used for paper pulp, spruce, hemlock, and poplar are the most widely used and collectively furnish perhaps 90 per cent. of all wood used either for ground wood or chemical fiber. Spruce is used mostly for "ground wood" and sulphite pulp, forming as ground wood almost the entire substance in newspapers, and as sulphite fiber from 10 to 25 per cent. of the stock in the better grades of printing and writing papers. Spruce now brings from $9 to $11 per cord, and as it is rapidly becoming a substitute for pine, its value will rise. It is recommended that spruce be planted either in pure stands or mixed with poplar or hemlock on the numerous burnt-over, non-agricultural lands in our north-central States. According to a paper manufacturer of competent authority, the virgin spruce forests of northern New York which were cut over from 20 to 30 years ago are now affording spruce trees from 12 to 20 inches in diameter and are being used for paper pulp with good results.

Hemlock, and especially the western hemlock, makes a good sulphite pulp, and, as the spruce supply fails, is steadily taking its place not only as a lumber substitute, but, on account of its high cellulose content, in the wood pulp industry also. References to figures and statements in well known publications will substantiate the statement that the growing of spruce and hemlock for pulp wood on the available tracts would be a profitable industry.

In this country the poplars furnish 12.9 per cent. of all woods used for pulp of all kinds, being chiefly used for soda fiber mixed with from 10-20 per cent. of stronger pulp. Poplar pulp forms the chief material for such papers as the Ladies' Home Journal and Youth's Companion. Sulphite pulp alone would make too harsh a paper, while soda pulp alone would make too weak a paper. Mixed together in the proper proportions, however, a paper characterized first by strength, second by softness and delicacy is produced. The use of poplar for pulp is rapidly spreading in the east-central States, great quantities being shipped in from the Carolinas and adjoining States. A forester of one State has recently said:

"If I could replace the maples in the State forest by poplars today I would do it gladly. It would be worth thousands of dollars to the State." Considering the rapid growth and ease of propagation of the Populus family, there seems ample excuse for estimating its probable success on the cheap lands of our own State. In fact the author feels confident that such trees as aspen, cottonwood, and its subvariety, Carolina poplar, can not only be grown at a reasonable profit, but will make productive the capital locked up in our low-priced, non-agricultural lands. The practicability of planting depends upon the possibility of protecting the land and the return to be expected. The question of protection from insects, stock, fire, etc., must be answered with respect to the individual case. For the land which can be protected there remain to be considered the cost of planting, the rate of growth, and the probable returns.

Estimates of Cost and Returns per Acre for Cottonwood.

The estimate following is intended to cover the cost and returns for one acre of planted cottonwood on the cheap unused lands of Indiana. Other members of the Populus family, such as aspen, may be planted on waste areas with practically the same cost and yield. As cottonwood does not form sufficient shade to keep out weeds and grasses, the Federal Forest Service advises that the understory should consist of box elder, hackberry, white elm, osage orange, or such shrubs as wild plum, choke cherry, wild currants and gooseberries.

The cottonwood seedlings, preferably yearlings, or better, cuttings, can be obtained cheaply from nurserymen or may be collected by the planter from the sandbars along streams. The seedlings or cuttings should be planted where they are to remain permanently. Planting is a very simple operation. It may be advantageously performed by a man and a boy working together. The man, by driving a spade into the ground, makes a slit, into which the boy slips a tree behind the spade; the man then withdraws the spade, trampling the soil about the tree as he advances to plant the next one.

Cottonwood plantations should be protected for at least five years from grazing animals, and five or six plowed furrows free from weeds should be maintained around the grove to keep out fire. If the undergrowth recommended by the Forestry Service is not planted, cultivation for two or three years will be necessary.

For the sake of definiteness, it is assumed that at the end of 20 years the stand will be sold on the stump for pulp wood. Indiana waste land suitable for such purposes is classed as worth perhaps $12 per acre, although the author is informed that many tracts in Greene, Monroe, Brown, Lawrence, Owen and southern Putnam and Park counties can be bought for less than $12 per acre. For purposes of taxation, the forestry law of 1899 appraises such land at $1 per acre, making the taxes practically nil. It will require 680 seedlings to plant the acre at a distance of 8 by 8 feet. The cost of these is estimated at $2. After the land is cleared, at the end of 20 years, the value doubtless will be as great as at the beginning, but the value of the land is not taken into consideration. Should $12 be added to the $120 which it is estimated could be secured for the timber product, it would simply increase by that amount the profits of the transaction. The statement following shows the items and amount of the investment for one acre:

Expenses on 1 acre for 20 years—

Cost of seedlings	$2 04
Cost of transplanting at $4.50 per 1,000	3 06
Value of land	12 00
Taxes at $1.80 per $100	36
Cultivation for 2 years	2 40*
Total	$19 86

Amount at 3 per cent. compound interest, $35.87.

At the age of 20 years the average cottonwood is 14 inches in diameter with a height of 50 feet. Studies made by the Forestry Bureau on cottonwood as a planted forest have shown that the yield in average cases has been at least 30 cords per acre in 20 years. Other practical foresters would harvest the crop in 10 or 12 years, thus securing less cords per acre, but owing to the shorter period of investment a higher annual per cent. on money invested. Under the 20-year plan, the 30 cords would sell on the stump at not less than $4 per cord, bringing $120. Deducting from this sum the amount at 3 per cent. compound interest, $35.87, there remains $84.13 as a return on the investment over and above that received from a 3 per cent. compound interest loan. This is equivalent to a return of $4.20 per year from the time of planting to the time

* This expense may be eliminated if cover is planted as recommended above.

of cutting, a very satisfactory return considering the fact that it is secured from land which is practically useless for any other purpose, and which without a timber crop would be a source of constant expense for taxes. The pulp wood crop not only gives a fair margin over and above ordinary investments but it makes productive the capital locked up in the land.

In this estimate the cost is the record of actual facts; the assessed valuation, such as could be obtained under the present forestry law of Indiana; the rate of interest, the average per cent. that money returns to its owner above taxes; the rate of growth, the average of planted cottonwood in the Mississippi Valley and the price less than that which has already been received where fair access was had to market.

Since the estimate is based upon present conditions, it more nearly applies to a plantation established 20 years ago, and to be marketed now, than to one established now and to be marketed 20 years in the future. Wood prices, according to B. E. Fernow in the Forestry Quarterly, vol. III, No. 1, have steadily risen and are now rising much faster than in the period before 1890. This same authority says further that the rate of increase in wood prices in general will be at least at the rate of 2 to 3 per cent. per annum for the next 20 years. This means that the return on the investment would be proportionately greater.

Besides the financial advantages from raising pulp trees, the general advantageous influences incident to forested areas would be more largely secured and our State would be more diligently doing her share towards the proper reforestation of areas which should naturally be in forest. The progress is encouraging, investigations are being made and many others are being planned. Both pulp men and foresters are taking an increased interest in the matter, and in many other ways the indications are that the industry of growing pulp wood will eventually occupy a prominent place among the profitable employments in the States and Provinces bordering our Great Lakes.

At this point the author wishes to express his indebtedness to the botanical department of Wabash College for substantial aid in collecting statistics and in numerous other ways materially assisting in the preparation of this report.

Crawfordsville, Dec. 1, 1905.

Notes and Photographs of the Development of a Buzzard.

By D. W. Dennis and W. C. Petry.

Throughout southwestern Ohio and southeastern Indiana the turkey buzzard, Cathartes aura, is a common bird, but the nests are seldom found. Accordingly we were glad to learn in April, 1905, that during each of the preceding four summers a pair of these birds had nested only a few miles away. We expected that the nest would be again used, and on the 22d of April visited the place; we found that two eggs had been laid and that incubation was in progress. The bird on the nest hissed when approached, and would not leave the nest until forcibly disturbed; she then ran out and flew away, but soared about overhead until we went away, when she almost immediately returned to the nest.

This nesting site is about four miles east of New Paris, Ohio; it is near a small creek and in a very hilly country. It is at least a half mile from any house or highway, on the edge of a rather open woodland. The nest itself was in a hollow sycamore log (Fig. 1) nearly five feet in diameter at the butt; the cavity extends back about eight feet, where it has a diameter of about two feet, and there it terminates abruptly. This cavity contained a quantity of dirt and rotten wood, but nothing from which to make a nest had been carried in. A hollow had been scratched in the debris at the extreme end of the cavity and the eggs laid in it. They were rather conical in shape, a little larger than a hen's eggs, and were white, splotched with brown.

On May 17th both eggs hatched. The young birds were very helpless; they could not stand in an upright position for about three weeks. That part of the head and neck usually bare in buzzards and a line down the center of the throat and breast were bare. The bill was very large and its tip was sharply hooked. After the young were hatched the old birds were never seen about the nest, though they were frequently seen "oozing" around overhead.

We were unable to learn when the young were fed. On May 27th we went with a party of students to examine and photograph the birds and nest. After photographing the nesting place (Fig. 1) the camera was placed in the end of the log and a flash light of the young birds in the nest was secured (Fig. 2). The birds were then removed from the nest, photographed at closer range a number of times (Fig. 3), and replaced in the nest. They offered no resistance whatever and seemed little if at all frightened.

On June 3d and June 9th other photographs (Figs. 4 and 5) were taken. The birds had by this time become larger and much more active than before; on the latter date when they were placed in the end of the log they at once hurried to the darkest corner. Also on this latter date they first attempted to defend themselves by vomiting up a portion of their food. It may be easily guessed that this is a very efficient means of defense.

On June 13th, when we next visited the nest, we found but one bird in it. The tenant of the farm afterward told us that several days before he had noticed that one of the birds was dead and had removed it from the nest. The remaining one was in no way injured and we were unable to learn what had killed the other. We removed and photographed the living one (Fig. 6). At this time, 32 days after hatching, the black primaries and tail feathers were beginning to appear but were not conspicuous enough to show in the photograph.

By July 1st the black primaries had become very noticeable, as shown by Fig. 7. When the bird had been pulled to the end of the log with a stick, it was usually seized by the tips of the wings and carried out to the front of the camera, which had previously been set up in a suitable place. When it had been set down it would always stretch its wings to their full extent before folding them. Figure 8, taken when the wings were thus extended, shows well the black feathers in the back, wings and tail.

Figs. 9 and 10, taken July 9th, and July 15th, respectively, show the gradual change from white to black. By the latter date the back had become almost entirely black, but the breast and belly were still pure white. The bill had become more slender and more sharply hooked. The bird would now strike vigorously with its bill at anything that disturbed it.

Fig. 11 was taken July 23d. This was 67 days after hatching; the wings and back were entirely black and there were many black feathers on the breast and belly. The head was bare with the exception of short down on the back part. The bill was still of a dark color, though changing toward reddish.

On July 30th, when we returned, the bird was in the stump at the butt end of the log; it was easily caught and placed in a position favorable for photographing, when suddenly it sprang off the log and flew away; its flight was difficult and at no time more than 20 feet above the ground; after flying about 100 yards it alighted on a fence; we at once followed it with the camera, hoping to get close enough to get a good picture, but whenever we approached within about 50 feet it would again fly. We finally secured a picture (Fig. 12) at about 40 feet distance. At this time, 74 days after hatching, the bird was almost entirely black, and fully as large as an adult bird; a little of the white down still remained on the sides, about the neck and legs and on the under sides of the wings; from a distance one would have been unable to distinguish it from an adult.

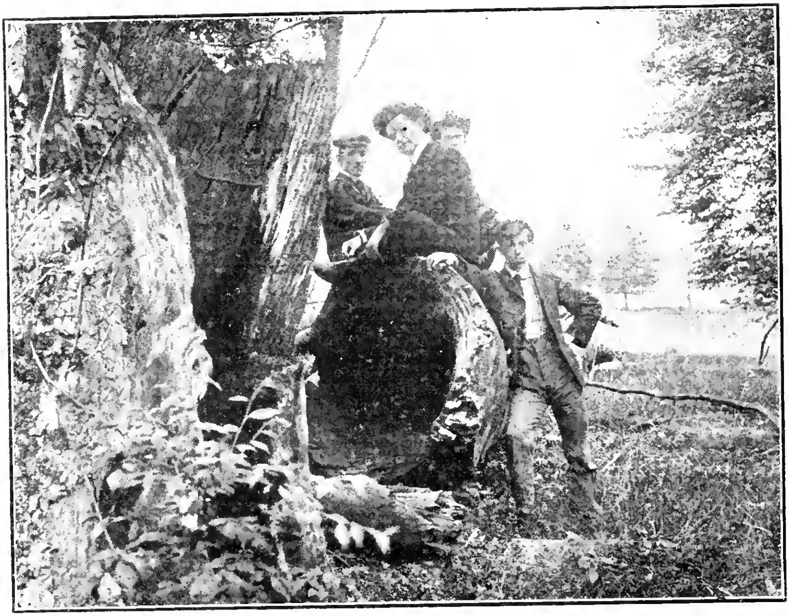


Fig. 1.

Fig. 2.

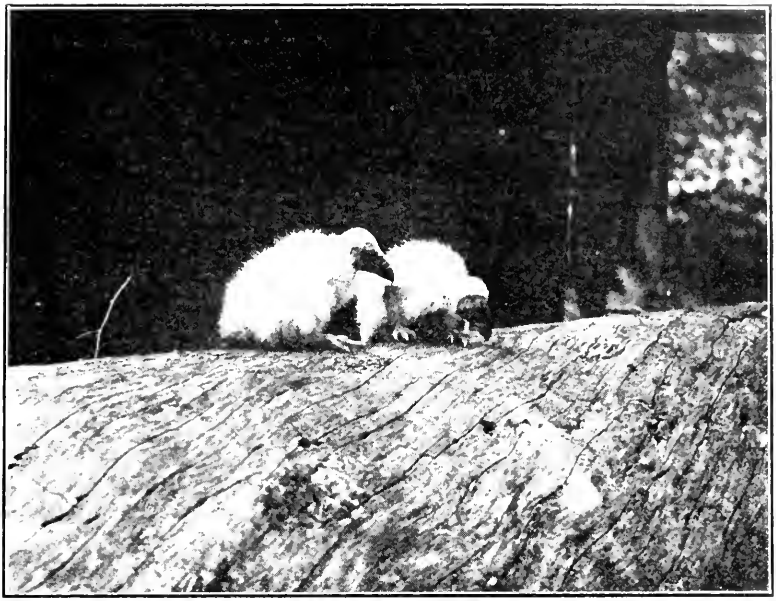


Fig. 3.

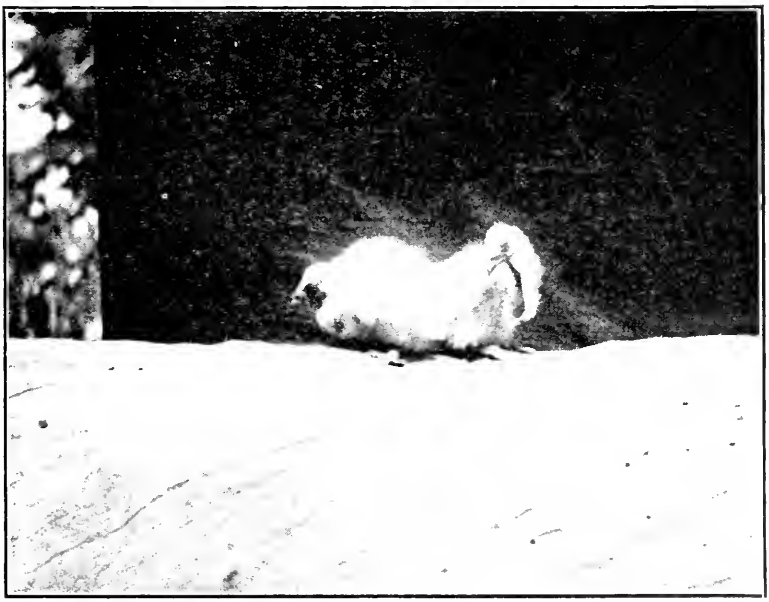


Fig. 4.

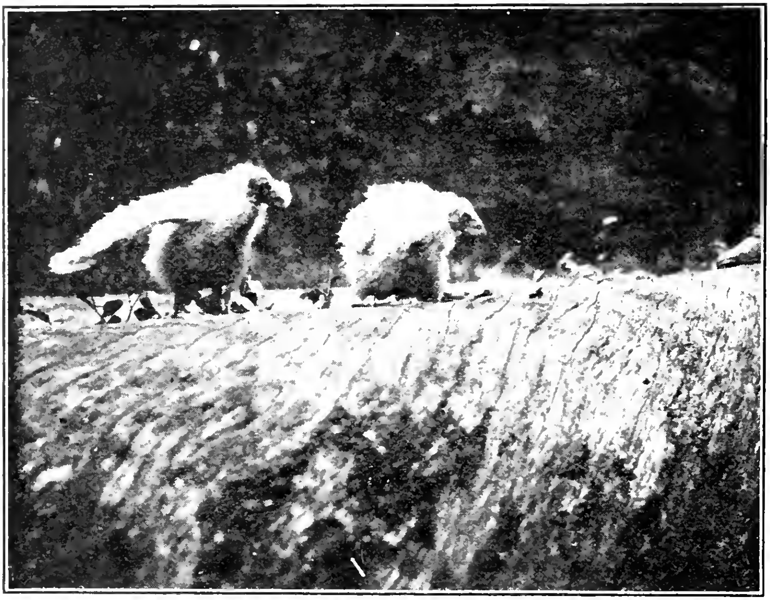


Fig. 5.

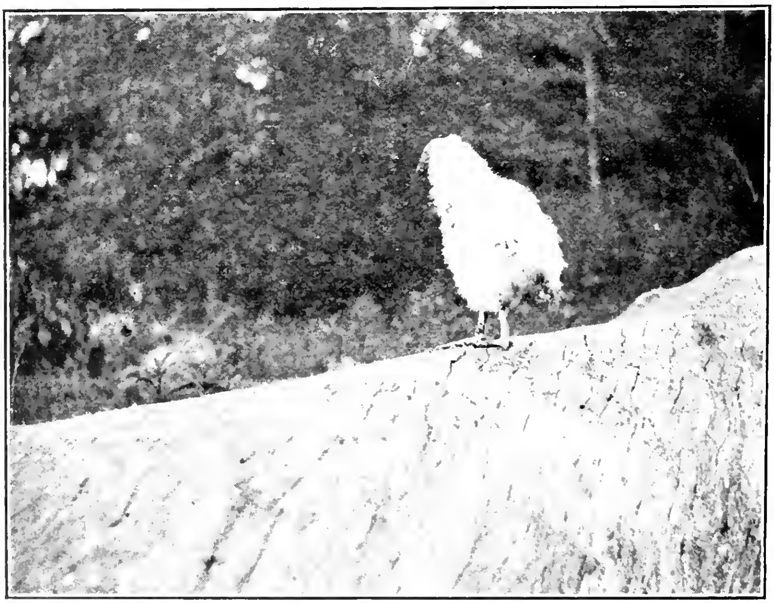


Fig. 6.

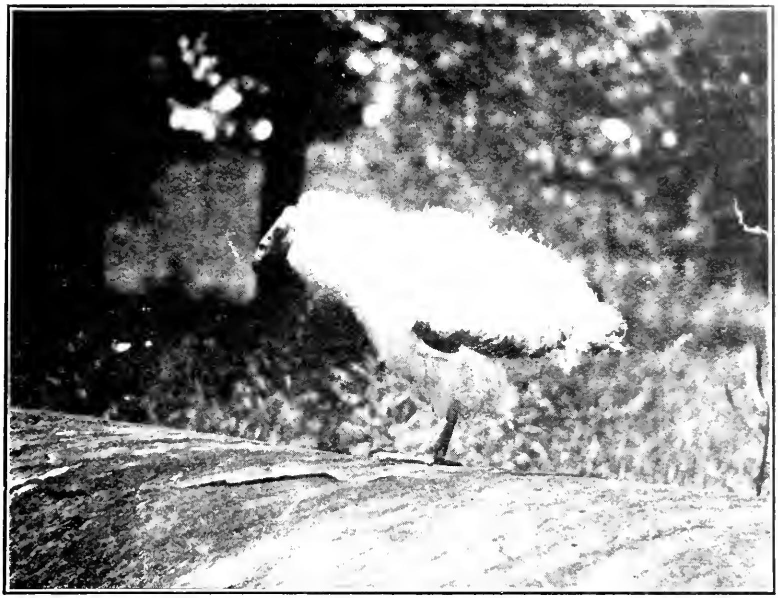


Fig. 7.

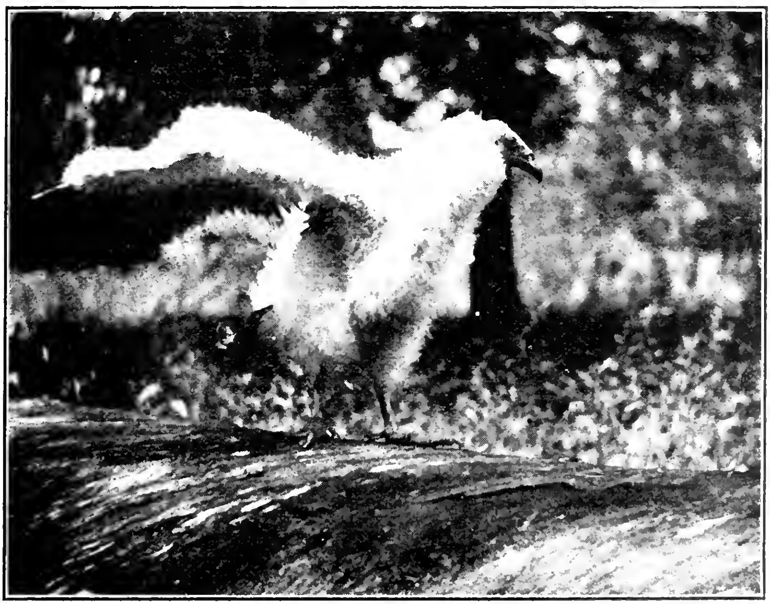


Fig. 8.

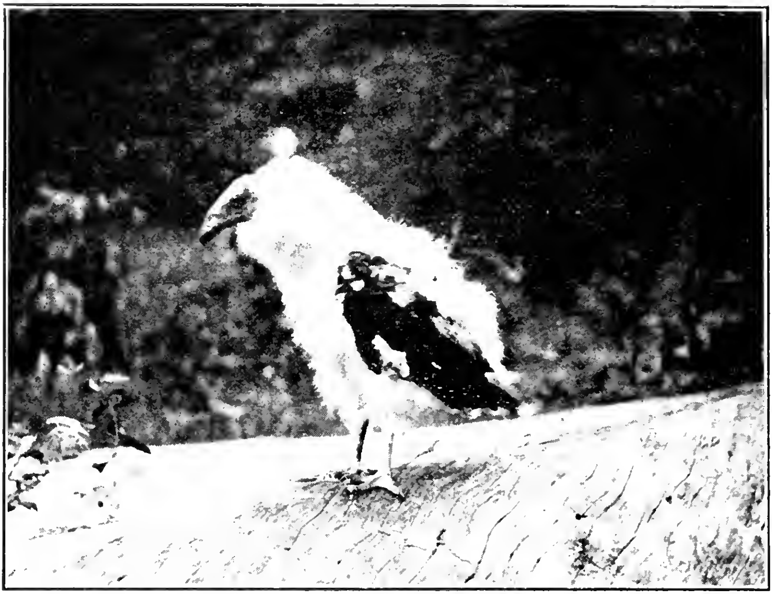


Fig. 9.

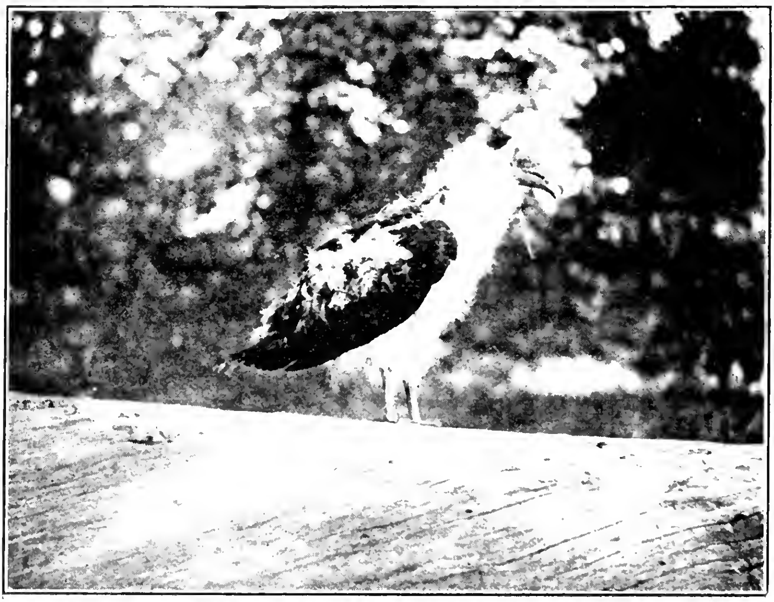


Fig. 10.

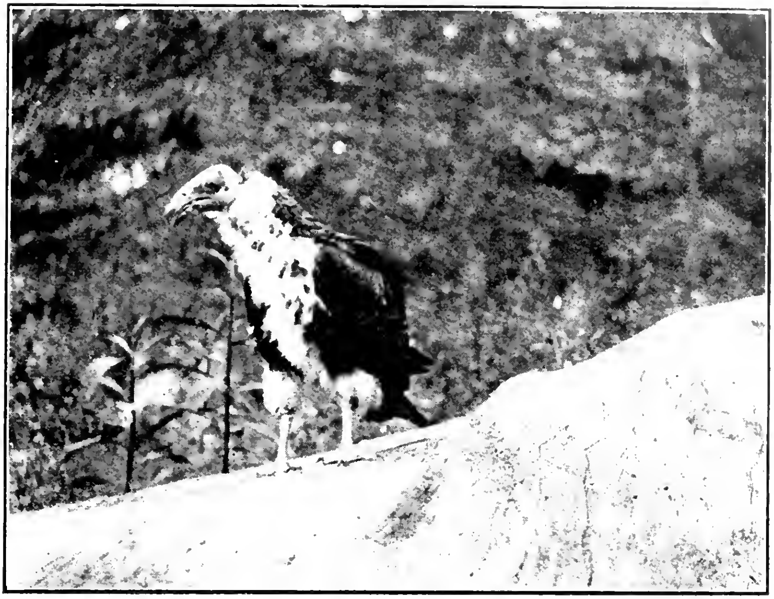


Fig. 11.

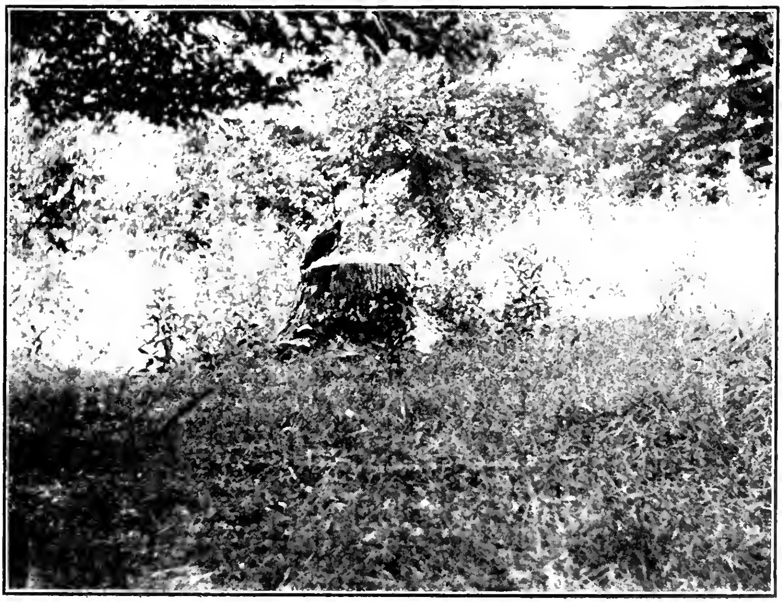


Fig. 12.

Observations of the Total Solar Eclipse of August 30th, 1905.

By John A. Miller, Indiana University.

Early in the year 1905 the Observatory of Madrid published detailed information regarding the eclipse that was to occur on August 30th of that year. Among other things this "Memoria" contained the results of a long series of observations of the prevailing meteorological conditions of many stations well distributed along the path of totality in Spain. The state of the sky in the immediate vicinity of the sun had been observed daily from 12:30 to 1:30 p. m. (the time at which the eclipse occurred) from the 15th of August till the 15th of September. The results of these observations, as well as the data gathered by the regularly established meteorological stations, touching the mean relative humidity, mean temperature, the velocity and direction of the prevailing winds, etc., had been tabulated. From these data it appeared that the probability of clear weather in the eastern half of the belt was exceptionally large, and indications for good eclipse weather were perhaps best in the regions near Ateca, Almazán and Daroca. The eastern half of the belt of totality in Spain held about 50 eclipse stations, established by astronomers from every nation of Europe, from the United States, and Mexico. The Lick Observatory expedition was located near Ateca; the United States Naval Observatory at Daroca. The observers from Kirkwood Observatory, Indiana University, Bloomington, Indiana, chose Almazán, Spain a small town northeast of Madrid in the Province of Soria. The approximate position of this station is longitude=13 m. 56 sec. W. of Greenwich, latitude=41° 10′.

The party consisted of Professor W. A. Cogshall, of Indiana University; Messrs E. C. Slipher, F. A. Crull, and C. J. Bulleit, students of the university; Professor A. F. Kuersteiner, Mrs. Miller, and myself. We were assisted in the manipulation of our instruments on the day of the eclipse by Mr. and Mrs. Charles W. Thompson of California, and Señores Louis Nebot, Francisco Jodra, Victor Jiemenez, and Esteban Milla, of Almazán.

The observations planned were: (1) Photographs of the corona; (2) a photographic search for intra-mercurial planets; (3) a photograph of the spectrum of each of the flashes, and a photograph of the spectrum of the corona during totality.

For photographing the corona we used four different cameras. The first was a "tintype" lens kindly loaned us by Mr. Spratt of Bloomington. It has an aperture of two and one-half inches and a focal length of eight inches. Three plates were exposed in this camera and on them we hoped

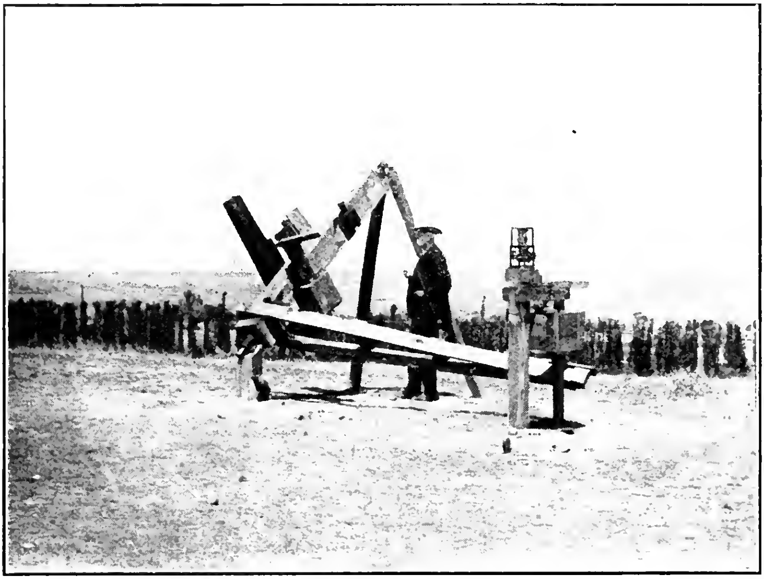


Fig. I. The Polar Axis Carrying the Short Focus Cameras.

to get long, faint coronal streamers. The second was a portrait lens of the Petzval pattern, of five inches aperture and focal length twenty-eight inches. This is an exceedingly good lens and gives superb definition over a small area and is very rapid. In this camera we exposed five plates, varying the exposure from two to 84 seconds, hoping to get detail of the outer corona and in the longer exposures to detect the presence of faint streamers. The lens of the third camera is the visual objective of the old telescope used by the late Professor Kirkwood and others for many college generations. Its diameter is three and one-half inches and its focal length fifty inches. In this camera we exposed four plates. These three cameras, together with a spectrescope, were mounted on a wooden polar axis that was built at the camp.

The objective of the fourth camera has a diameter of nine inches and a focal length of 60 feet. This lens was constructed by Mr. O. L. Petitdidier. The front lens is of the ordinary crown glass, and the back lens of a boro-silicarte flint. Quoting Petitdidier from a letter to the writer: "From the point of view of constants they (the pieces of glass) leave nothing to be desired, as the proportional dispersion is practically the same in all parts of the spectrum, so that we should have a perfect achromatic." When the samples of the boro-silicate came, however, it was found that it had a decidedly yellow tinge. It was found also that its composition was unstable, and that it oxidized very rapidly in the presence of moisture. After a conference with Mr. Petitdidier, however, we decided to have our lens made of the boro-silicate flint, and to seal it in an air-tight box as soon as it was finished, and to open the box only a few days before the eclipse. Petitdidier had much difficulty in polishing the lens, owing to the fact that it oxidized so rapidly. He found after much experimenting, a solution that would remove the oxidation without affecting the surface. It was with some misgiving that we shipped the lens, but we found on opening it that it had not tarnished in two months, and the surface on the day of the eclipse was as perfect as the day the lens was finished. The air was very humid on the days following the eclipse, and the boro-silicate flint had begun to tarnish slightly when the lens was packed for shipment home.

This camera was mounted horizontally and fed with a coelostat. A light-tight tube, the outer and inner walls of which were of white canvas and building paper respectively, and which were separated four inches, led from the objective to a dark room in which the plates were exposed. Neither the plates nor the lens was in contact with the tube. The entire instrument was covered with an A tent of white canvas. The plate-holders containing the plates were fastened to a large hexagon, which the operator could revolve at will upon an axis which was parallel to the earth's axis. It was provided with a stop which enabled the operator to bring the plates for the successive exposures quickly and accurately into position. All the slides had been drawn from the plate holders before totality began. The hexagon as well as most of the mechanical parts of the coelostat, were designed and constructed by Professor Cogshall. Six exposures were made in this camera, of duration one-half second, two seconds, forty seconds, one minute, fifteen seconds, and one-half second. The plates used were Seed's 27, gilt edge, heavily backed.

If there be intra-mercurial planets, and if they, as do all other bodies of the solar system, move in the plane of the equator of the body around which they are revolving, and, if they are from the sun about the distance

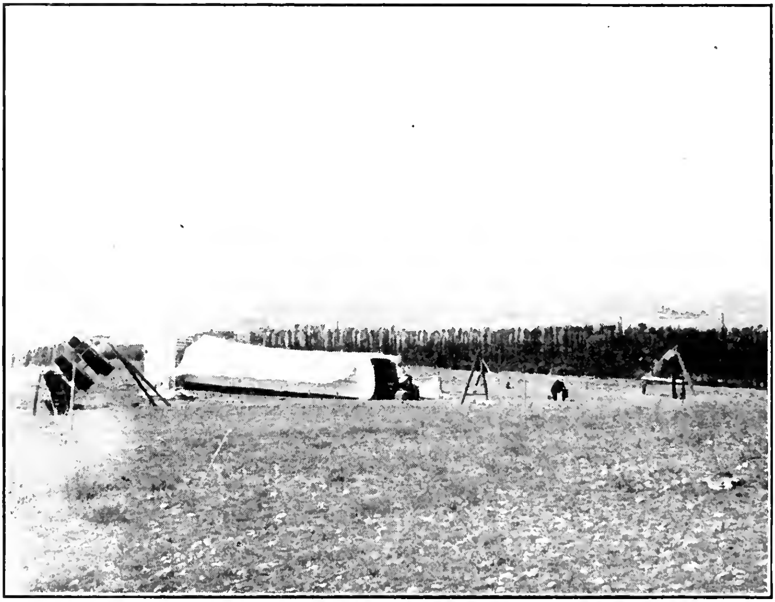


Fig. II. General view of the camp. Intra-Mercurial cameras to the left, the sixty-foot camera in the center and short focus cameras to the right.

required by Bode's Law, the major axis of their apparent paths as seen from the earth on the day of the eclipse should have subtended an angle of 23° and the minor axis about 3°. We decided to photograph this region in duplicate. For this purpose we used six cameras of 136 inches focal length, four of which had an aperture of 3½ inches and were made by Petitdidier, and two of which had an aperture of 3 inches. These were built by the Alvan Clark and Sons Corporation. These lenses were corrected for the minimum focus $\lambda = 4750$, which is well within the region for which the Seed 27 plates, which we used, are most sensitive. All the cameras were mounted on the same polar axis. They were mounted in pairs, each pair covering in duplicate six and one-half degrees, so that the three pairs covered in duplicate a region along the sun's equator twenty degrees long and six degrees wide. By a series of experiments we had found that a plate exposed in one of these cameras for three minutes and forty-five seconds, at a time when the sky was as dark as

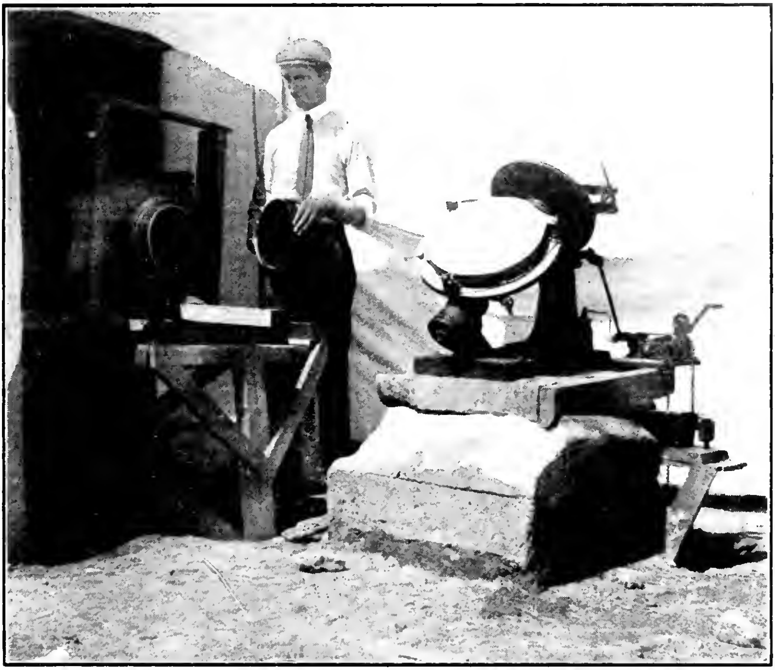


Fig. III. The coelostat and nine-inch lense of the sixty-foot camera.

it was estimated it would be at the time of totality though fogged somewhat by the skylight would show more and fainter stars than if exposed for a shorter time. We had made exposures varying from one to four minutes in the vicinity of Regulus when it was near the meridian beginning when Polaris was just visible to the unaided eye. We decided to expose the plates for the intra-mercurial planet for three minutes and twenty seconds.

The weather on the day of the eclipse was disappointing. For two hours before totality the entire sky was covered by light, though unbroken, clouds. At the time of totality, however, the clouds in the immediate vicinity of the sun appeared to break away, and the inner corona shone through light, drifting clouds. No clear sky was visible, however, within several degrees of the sun, neither Mercury nor Regulus could be seen from this station. During the morning a moderate wind prevailed, the general direction being W. N. W. The first contact was, neglecting seconds, at 11:41. The weather conditions during the eclipse, as observed and recorded by Mr. Thompson were as follows:

Local M. Time.	Temperature.	Direction of Wind.	
11:41	First contact	.....	Very slight wind.
12:00	18°5 C.	N. W.	Very slight wind.
12:15	18.2	N. W.	Very slight wind.
12:30	17.1	W. by S.	Wind dying away.
12:45	16.1	No wind.	
12:59	Totality	began.	No wind.
1:03	Totality	ends.	No wind.
1:06	15.0	S. W.	Very slight wind.
1:15	15.0	W.	
1:30	15.5	W.	
1:45	16.0	W. N. W.	Wind increasing.
2:00	16.5	W. N. W.	Brisk wind.
2:15	17.2	W. by N.	Brisk winds.
2:21	Eclipse	ends.	

Considering the weather conditions, our plates are very satisfactory. The shortest exposure, showing the prominences, suffered very little. The very bright group on the eastern edge of the sun is particularly well defined, and the negatives made of it with the long-focus camera hold a wealth of detail. The longer short exposures with the long-focus as well as the short-focus cameras show considerable coronæ detail, while the longest exposures have that part of the corona uncovered by the clouds much overexposed, while the clouds made it impossible to register any extended streamers. All the plates lack the definiteness that would have resulted from good seeing. The longest extension of the corona that we obtained was about three-fourths the sun's diameter.

The exposures of one-half second with the 60-foot lens showed the prominences overexposed, while the exposure of two seconds was too short to register more than a suggestion of the inner corona. The exposures given in the 50-inch camera, viz., 24 seconds, 29 seconds, 184 seconds, and 25 seconds, were about right, and the results obtained with this

Manuel, The Carpenter.

lens are more satisfactory than any others with the short-focus lenses. The exposures given in the portrait lens, viz., 2, 24, 29, 84, and 16 seconds, were too long. All plates exposed except the fourth in the portrait lens, which was a lantern slide, were Seed 27, and all were heavily backed to prevent halation. Of the small cameras the negatives of portrait lens, suffered most, because the part of the corona that we hoped they might contain was covered by the clouds. The negatives made with the fifty-inch camera are particularly good and hold a wealth of complex detail. An examination of these negatives shows that the coronal structure is more complex than in 1900. In particular that the polar streamers instead of being radial, are bent and interlaced, and in every case long coronal streamers are above the prominences.

The plates exposed for the intra-mercurial planets are heavily fogged, as one would expect from a sky covered with bright clouds, but not so badly as to obscure faint star-images. I believe that a plate of the sensitiveness of the Seed's 27, which we used, can be exposed three minutes

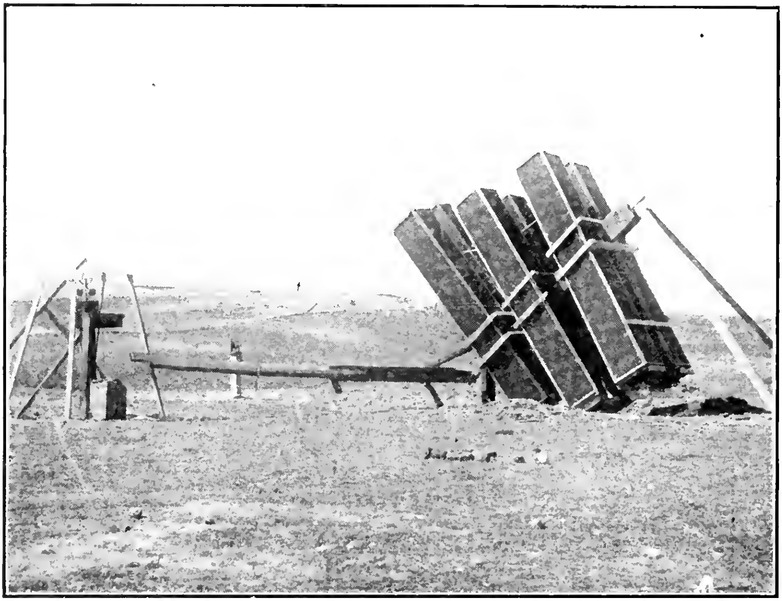


Fig. IV. The Intra-Mercurial Planet Cameras.

without serious fog at a time of a total solar eclipse. Our sky was so cloudy that it is unreasonable to expect star-images on these plates. We examined two of them hurriedly (the ones on which Regulus should have appeared), but found no star-images. The photograph of the corona on one of the intra-mercurial plates showed longer extension than on any other plate we exposed—due perhaps to the shifting of the clouds during the long exposure.

The corona impressed me as being brighter than in 1900. The effect on the clouds of the light from the eclipsed sun was peculiarly striking, and from a spectator's point of view was very beautiful.

The indescribable deep blue of the great clouds, bordered with what any one but an eclipse observer would call a silver lining, was totally unlike anything I have ever seen, and was strikingly beautiful.

The expedition is under many obligations. The Indiana University, The Indianapolis News and the Reader Magazine bore the expenses of the expedition. While the authorities of the university and the managers of the News gave kindly counsel and aid, Professor Cogshall, conjointly with the writer, worked incessantly for the success of the undertaking from the beginning to the end. Messrs. Slipher, Crull and Bulleit were with us three weeks before the eclipse occurred and rendered daily and indispensable assistance; while the entire staff of observers contributed materially to the success of our plans. The Spanish government admitted our instruments free of duty, the alcalde (mayor) of Almazán rendered timely and efficient aid in the selection of the site for our camp, and in the protection of our instruments. Benj. H. Ridgely, American Consul-General at Barcelona, manifested in every way a kindly and intelligent interest in the work of the expedition.

Corona of August 29, 1905, exposure in the Kirkwood 30 inch camera, magnified.

Irrelevant Factors in Bitangentials of Plane Algebraic Curves.

By U. S. Hanna.

Three years ago I presented a paper to the mathematical section of the Academy dealing with the proof of a formula used by Mr. Heal in an article published in the Annals of Mathematics, vol. VI, page 64. This formula was used by Heal in freeing a bitangential of the plane quintic, which he had developed in a previous paper in the Annals, vol. V, page 33, from an irrelevant factor, the square of the hessian of the quintic. Since then I have continued the study of the subject and wish to present an interesting result in the light of Heal's work.

Taking the general equation in the symbolic notation

$$(a_1 x_1 + a_2 x_2 + a_3 x_3)^n = a_x^n = b_x^n = c_x^n = \cdots = 0, \quad \ldots\ldots(1)$$

for the n-ic and deriving the first polar, with respect to the n-ic, of any point y, we have

$$(a_1 x_1 + a_2 x_2 + a_3 x_3)^{n-1} (a_1 y_1 + a_2 y_2 + a_3 y_3) = a_x^{n-1} a_y = 0, \ldots.(2)$$

Any point on the line through the points x and y may be represented by $\lambda x + \mu y$, where λ and μ have a fixed ratio for any particular point. If x be a point on the n-ic and y be a point on the tangent to the n-ic at the point x, then we have equations (1) and (2) satisfied by the points x and y respectively, and equation (2), as an equation in y, represents the tangent to the n-ic at x. If, in addition to these conditions, the point $\lambda x + \mu y$ lie on the n-ic, we must have from (1)

$$\left\{a_{\lambda x+\mu y}\right\}^n = (\lambda a_x + \mu a_y)^n = 0,$$

from which, by virtue of (1) and (2), we get

$$\frac{n(n-1)}{2!} a_x^{n-2} a_y^2 \lambda^{n-2} + \frac{n(n-1)(n-2)}{3!} a_x^{n-3} a_y^3 \lambda^{n-3} \mu + \cdots +$$

$$n a_x a_y^{n-1} \lambda \mu^{n-3} + a_y^n \mu^{n-2} = 0. \ \ldots (3)$$

Equation (3) is an (n-2)-ic in λ and μ which gives the positions of the remaining n-2 intersections of the tangent to the n-ic at x with the n-ic itself. In order that this tangent be a bitangent the discriminant of equation (3) must vanish. This discriminant is a function of x and y, and if y can be expressed in terms of x, then the discriminant becomes a bitangential of the n–ic. It has been shown by Jacobi and Clebsch that this is always possible.

We shall write equation (3) as

$$A_0 \lambda^{n-2} + (n-2) A_1 \lambda^{n-3} \mu + \frac{(n-2)(n-3)}{2\,!} A_2 \lambda^{n-4} \mu^2 + \cdots +$$
$$(n-2) A_{n-3} \lambda \mu^{n-3} + A_{n-2} \mu^{n-2} = o, \ldots (4)$$

where we have

$$A_0 = \frac{n(n-1)}{1\,.\,2} a_x^{n-2} a_y^2, \quad A_1 = \frac{n(n-1)}{2\,.\,3} a_x^{n-3} a_y^3, \quad \cdots\cdots$$
$$A_r = \frac{n(n-1)}{(r+1)(r+2)} a_x^{n-r-2} a_y^{r+2}.$$

If equation (4) is a quadratic, that is, if the n–ic is a quartic, the discriminant of (4) is

$$-\frac{4}{A_0^2}(A_0 A_2 - A_1^2) = O,$$

and after y is expressed in terms of x there is no irrelevant factor.

If the n–ic be the quintic, the discriminant of (4) is

$$-\frac{27}{A_0^6}(G^2 + 4 H^3) = O,$$

where we put $H = A_0 A_2 - A_1^2$ and $G = A_0^2 A_3 - 3 A_0 A_1 A_2 + 2 A_1^3$, and the y can easily be expressed in terms of x for the functions G and H, but the result contains the square of the hessian of the quintic as an irrelevant factor. This factor can be discarded without difficulty by putting

$$G^2 + 4 H^3 = A_0^2 \left\{ (A_0 A_3 - A_1 A_2)^2 - 4 (A_0 A_2 - A_1^2)(A_1 A_3 - A_2^2) \right\},$$

and then expressing y in terms of x for each parenthesis separately.

If the n–ic be the sextic, the discriminant of (4) is

$$\frac{256}{A_0^6}(I^3 - 27J^2) = O,$$

where $I = A_0 A_4 - 4 A A_1, A_3 + 3A_2^2$ and $A_0^3 J = A_0 H I - G^2 - 4H^3$.

There is no difficulty in expressing y in terms of x for the function I, and therefore, by multiplying and dividing the discriminant by A_0^6, we can immediately write a bitangential of the sextic by substituting the results obtained for the quartic and quintic in

$$\frac{256}{A_0^{12}} \left\{ A_0^6 I^3 - 27 (A_0 H I - G^2 - 4 H^3) \right\} = O.$$

But this bitangential of the sextic contains the sixth power of the hessian of the sextic as an irrelevant factor. In order to free it from this factor, we put

$$J = (A_0 A_2 - A_1^2) A_4 - (A_0 A_3 - A_1 A_2) A_3 + (A_1 A_3 - A_2^2) A_2,$$

and then express y in terms of x for the function J. The work involved in this last step is very long and tedious. These results can be used in developing a bitangential of the septic, but two additional functions will have to be developed, the work in which is almost beyond the range of possibility.

On the Weathering of the Subcarboniferous Limestones of Southern Indiana.

By E. R. Cumings.

The subcarboniferous (Mississippian) limestones of southern Indiana comprise three formations known in the ascending order as the Harrodsburg, Salem (Bedford) and Mitchell limestones, and having a combined thickness of at least 350 feet. These rocks are in the main very pure carbonate of lime. Some shaly layers are to be found in the Harrodsburg and Mitchell limestones which may contain very little lime; and the Harrodsburg is rather lower in the per cent. of lime carbonate than the other two formations. Analyses of the Salem limestone show from 97.9 per cent. to 98.4 per cent. $CaCo_3$, with the balance consisting of magnesium carbonate, and oxides of iron and aluminum, with traces of silica and other substances. Analyses of Mitchell limestone show from 96.65 per cent. $CaCo_3$ to 99.04 per cent., with the balance consisting of magnesium carbonate, iron, aluminum, and silica as in the Salem limestone. Satisfactory analyses of the Harrodsburg limestone are not at hand. Of these limestones the Salem is the most constant in composition and is on the average the highest in per cent. of $CaCo_3$.

In texture the three limestones vary widely. The Harrodsburg is rather thin bedded, coarse-grained, fossiliferous, in some cases decidedly crystalline in structure, and contains geodes abundantly, in the lower portion especially, and bands and knots of chert. There are layers and lenses of shale. The Salem limestone, on the contrary, is, as is well known, almost without bedding planes. It is a massive, oölitic or granular-crystalline, close-grained rock frequently cross-laminated and quite free from geodes and chert. Its fossils are usually minute, foraminifera and small ostracods predominating. The Mitchell limestone is in the main thin-bedded, hard, fine-grained, sometimes almost lithographic, with frequent alternations of shaly layers. It is in general unfossiliferous. Bands and knots of chert are very common, but geodes are infrequent.

All these limestones are conspicuously jointed. The Mitchell shows the cleanest and most numerous joint planes; but the best examples of deeply opened joints are to be found in the Salem. The joints run nearly east and west and north and south. In other words, one set runs with the dip, and the other with the strike. The dip joints are the most conspicuous.

The weathering of these limestones does not differ in essential features from that of limestones in general, except as it is influenced by local conditions of temperature, rainfall and drainage, and by the exceptional purity of the rocks. It is to be expected that a nearly pure carbonate of lime, in a region of rather copious rainfall and mild climate would weather almost entirely by solution and other chemical processes, rather than by mechanical processes. The limestones in question exhibit the effects of solution on such an extensive scale as to warrant calling particular attention to them; and it is for this reason that the present paper has been prepared. To this end attention has been called to the composition, texture and structure of these rocks, even at the expense of repeating descriptions already many times recorded in the literature of Indiana geology. It is only by understanding the intrinsic nature of a rock that we can correctly appreciate and explain its metamorphism, whether it be in the zone of weathering or in the deeper zones.

The chief agent of weathering in the present case is meteoric water charged with CO_2 and with organic acids (humic acids). The normal annual rainfall in the region under consideration is 42 inches (somewhat more in the southern counties), rather evenly distributed throughout the year. The largest average precipitation has been in the month of July, while the minimum has been in the fall months—September, October, November. The mean annual temperature is 52° F. The topography of the limestone region excepting its eastern and western borders is undulating, and of rather mild relief. Rolling uplands in which the larger streams are rather deeply intrenched are the characteristic features. The conditions are therefore such as to admit of a comparatively copious entrance of water into the rock and free egress at lower levels into the main streams. Such conditions favor solution. Solution has also been favored in the past by the heavily forested condition of the region before its settlement by the white race.

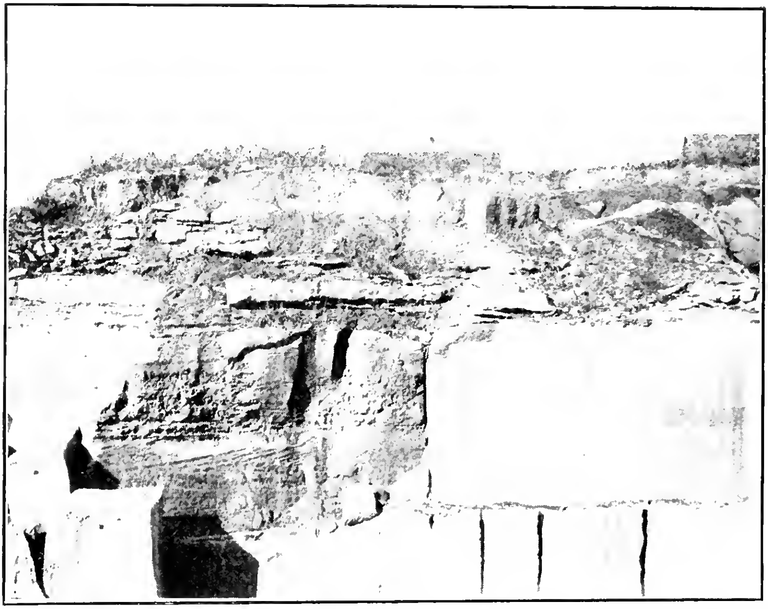
The water which finds its way to lower levels in the rock than can be tapped by the local drainage is frequently returned to the surface along joint planes in the deep valleys on the western border of the region. A notable instance of this is the French Lick Valley, which must derive its mineral waters, now rendered famous by extensive exploitation, from the uplands of the Mitchell limestone, some fifteen or twenty miles to the eastward. These waters, which reach the deeper zones of flow, are always strongly impregnated with mineral salts. Much of the mineral water of the French Lick Valley comes from a depth of 400 to 500 feet. Owing to the depth to which it descends and distance which it travels, the water has been brought into intimate contact through a considerable interval of time with these eminently soluble limestones and its highly mineralized condition is an evidence of the vast amount of material removed from them, most of which, however, has undoubtedly been derived from a comparatively superficial zone.

The most conspicuous effects of solution are those produced at or near the surface of the rock, and it is these that the photographs presented herewith illustrate. In quarry openings where the rock has been taken down along a joint plane, so as to expose the wall of one of these avenues of ground-water, the effects of solution are shown in greatest perfection of detail. The dip joints are often greatly enlarged, their walls pitted and honeycombed, and traversed by arborescent systems of small openings through which the carbonated waters have eaten their way; and the once solid rock is reduced to a crumbling earthy substance stained and rusted with iron. Where two joints (dip and strike) intersect, the enlargement is apt to be greatest, giving origin to funnels, narrowing gradually downward, and showing in a beautiful way the method of formation of sinkholes, which are only such funnels of solution grown large.

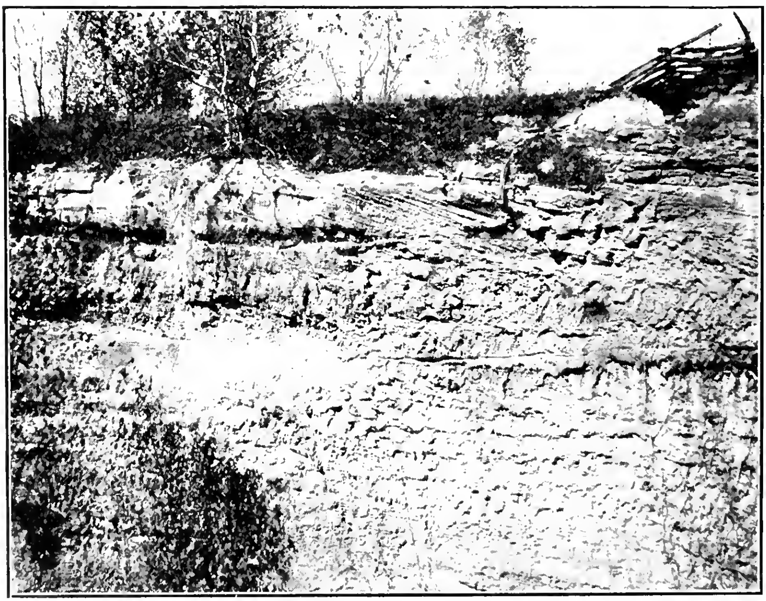
Where the surface of the limestone has been denuded of soil, for quarrying purposes, it is found to be corroded to a remarkable extent. Every dip joint now becomes a ragged furrow, and between joints the rock rises in hummocky ridges, the hog-backs of quarrymen. Points and knobs and mushroom-like projections meet the eye at every turn—bewildering in variety and impossible to describe. The hog-backs frequently stand as high as a man's head, and their flanks are scarred and scored by the all pervasive attack of the dissolving water.

Except where the activities of man or nature have removed it, a blanket of red soil overlies and hides this marvelous complex of corroded rock. The red soil or clay is the minute remnant of the original rock, left after the lime carbonate has been carried away in solution by the water. It is the insoluble residue. So complete has been the removal of the lime that this residual soil requires the addition of lime to render it fertile. A handful of soil may be treated with acid without giving an appreciable effervescence, even though the soil be taken from within an inch of the limestone. Analysis of this clay reveals about 67 per cent. to 80 per cent. silica, 8 per cent. to 14 per cent. aluminum, 6 per cent. or 7 per cent. iron oxide (Fe_2O_3), and very small percents of lime, magnesia, soda and potash, etc. The iron is responsible for the intensely red color of the clay. The process which has produced this soil is the solution of the limestone with oxidation of the iron which exists in minute quantities in the original rock as a protoxide. The surface of the limestone beneath the soil, besides being rough and ragged as explained above, is usually minutely roughened, though sometimes fairly smooth, especially in the Mitchell limestone. In some cases, especially in the Salem limestone, the rock in contact with the overlying soil is rotted and discolored beyond recognition and shows a graded passage from sound unmodified rock below to soil above. Where layers of shaly rock occur, as in the Mitchell, they are often so rotted that while they retain much of their original appearance and stratification, they may be removed with pick and shovel as easily as any clay. Sometimes a layer of limestone overlying a layer of shale is left as an isolated chain of boulders in the general mass of residual soil. The deepest accumulation of residual soil seen by the writer is in the cut on the Illinois Central Railroad in the northwest edge of Bloomington, where it is 30 feet deep. Usually it is not more than five or six feet deep. Over the Mitchell and Harrodsburg limestones the soil contains chert, and, in the latter rock, geodes in abundance, because of the relative insolubility of these substances. Where blocks of Salem limestone are exposed at the surface to the rain they become deeply furrowed by the solvent action of the rainwater running over their flanks. The faces of old ledges, long exposed to the weather, are scarred and seamed by this action and extensively honeycombed, owing to the unequal solubility of the rock. In these holes and pockets on the rock surface small plants find lodgment and by the mechanical action of their roots and the chemical action of the products of their decay, greatly aid the process of disintegration.

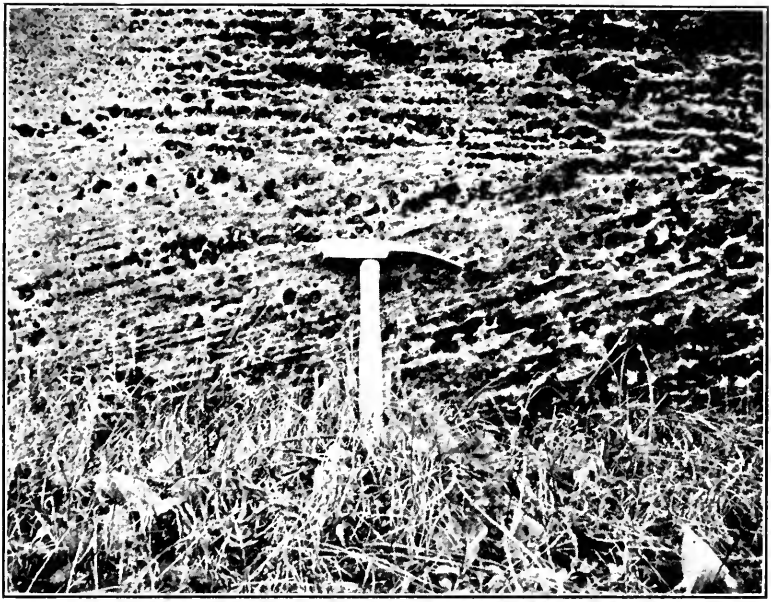
The effects thus far described are seen to best advantage in the exposures of the Salem limestone. The Mitchell shows to a pre-eminent degree the deeper-seated effects of solution in the formation of caverns and underground streams. Everywhere the surface of the country occupied by the Mitchell limestone is dotted over with sinkholes, and the hill-sides along the larger streams abound in springs and entrances of caves. Some of the caves, such as Marengo and Wyandotte, have attained wide fame. The Mitchell is, as indicated above, conspicuously jointed but fine grained. The groundwater is compelled to traverse the joints rather than the pores of the rock, and it is this, in the writer's opinion, that has caused the more extensive development of caves in the Mitchell than in the Salem limestone, since the two must be about equally soluble. It is the concentration of solution along joints and bedding planes that gives rise to caves. The Mitchell has both an elaborate system of joints and numerous relatively impervious layers to serve as cave floors. Neither of these conditions would avail, however, without the third condition, adequate drainage, which has been supplied by the intrenching of the main streams as explained above.



No. 1. Hunter Quarry, Bloomington, Ind., showing fresh quarry face to right and weathered joint face to left. Salem limestone.

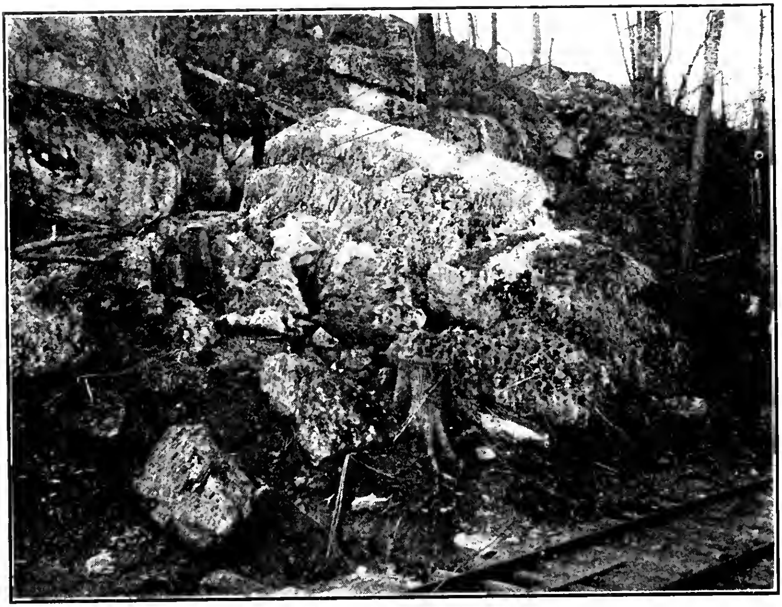


No. 2. Old Quarry, one mile west of Stinesville, showing weathered joint face. Salem limestone.



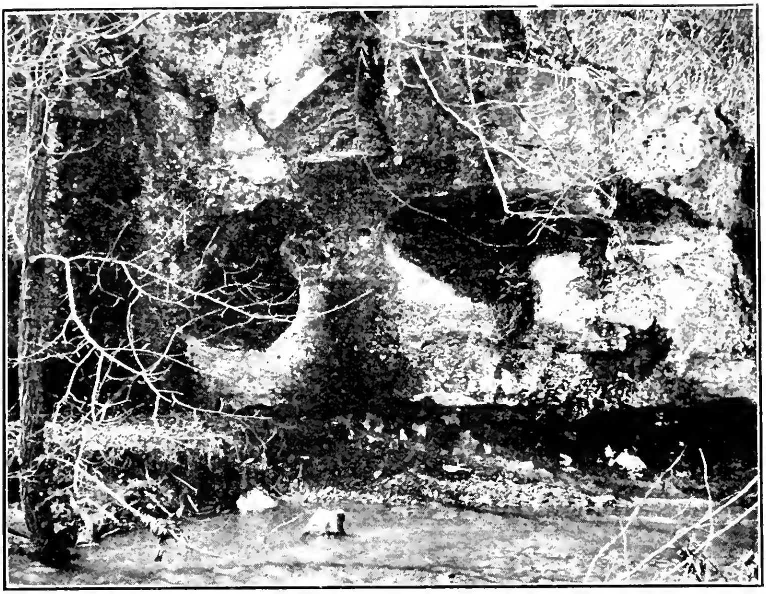
No. 3. Honeycombing and etching out of cross-bedded limestone. Old Quarry one mile west of Stinesville.

No. 4. Honeycombing of Salem limestone and lodgment of plants in solution holes. Oliver Quarry, Clear Creek.

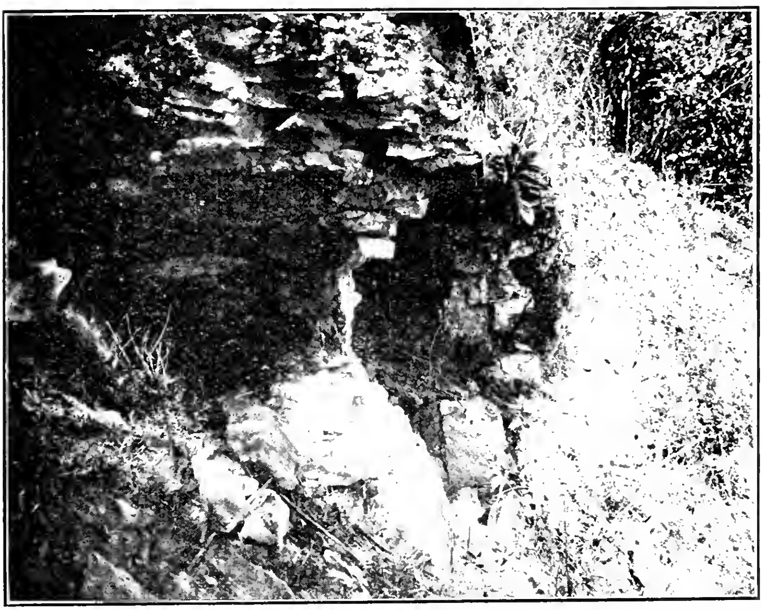


No. 5. Weathered blocks of Salem limestone fallen from cliff on Clear Creek, Ind. Oliver Quarry.

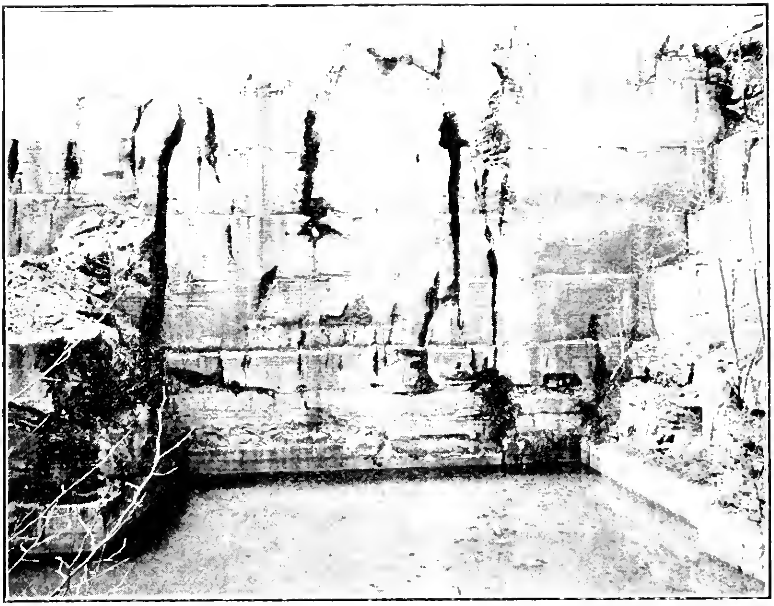
No. 6. Detail of a portion of No. 5, showing honeycombing.



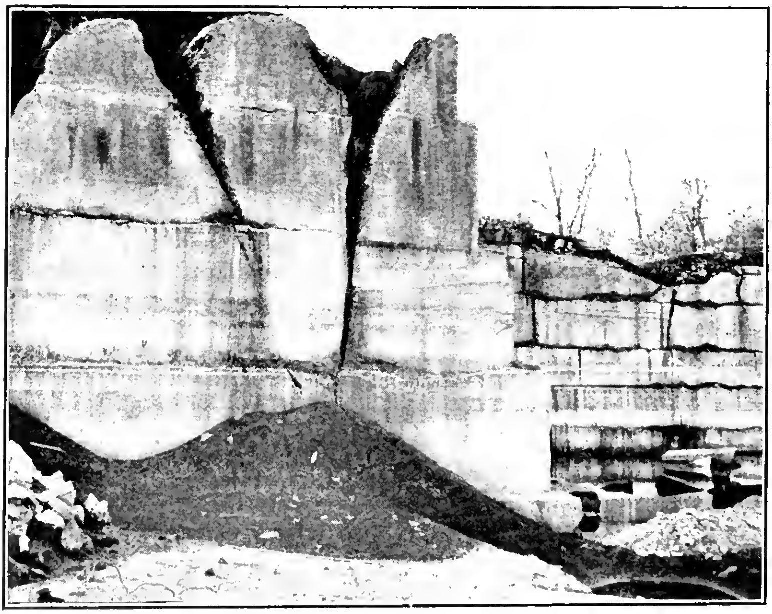
No. 7. Large cavities formed by solution. Salem limestone, Big Creek, near Stinesville, Ind.



No. 8. Large cavity formed by solution and frost action. Harrodsburg limestone, near Stinesville, Ind.

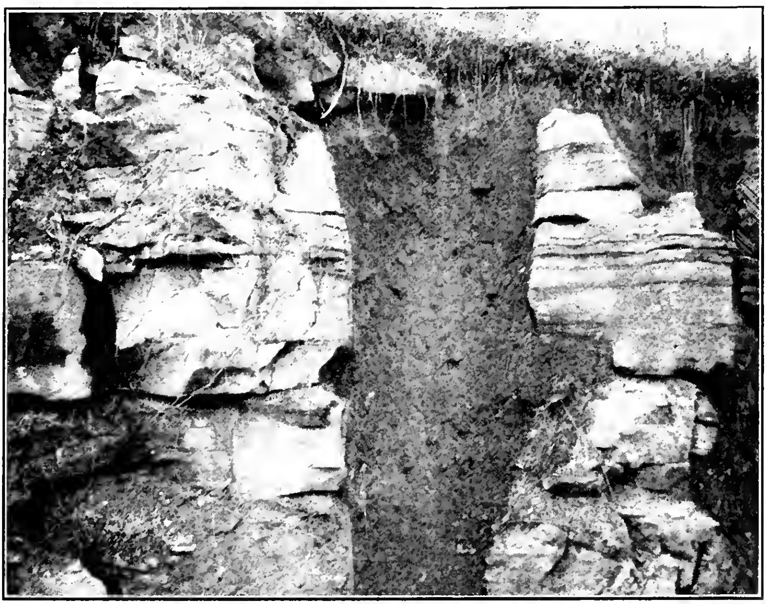


No. 9. Old Quarry on Big Creek west of Stinesville, Ind., showing joints enlarged by solution. Salem limestone.

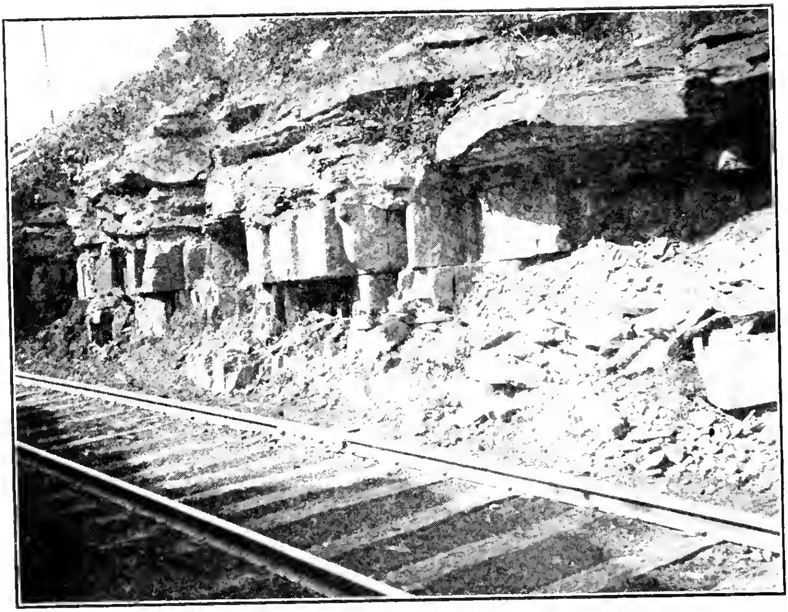


No. 10. Hunter Quarry near Bloomington, Ind., showing joints enlarged by solution. Salem limestone.

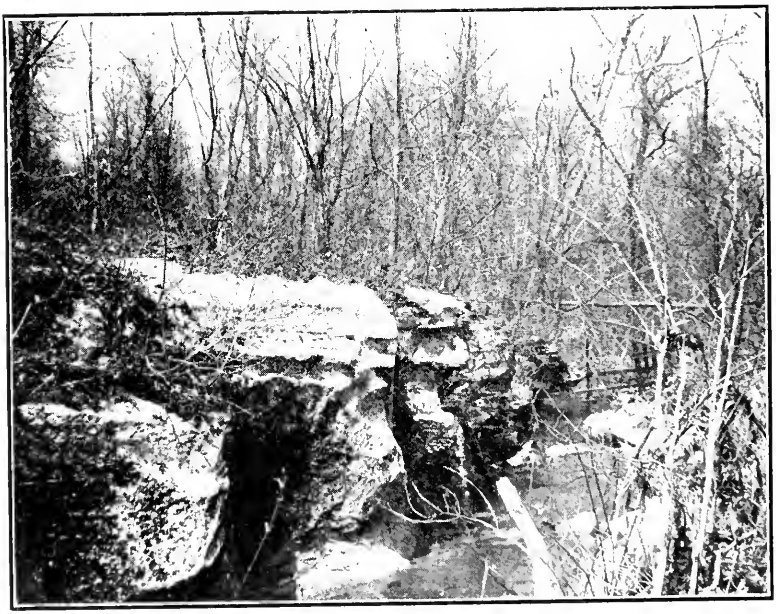
No. 11. Old Quarry one mile west of Stinesville, showing joint enlarged by solution. Salem limestone.



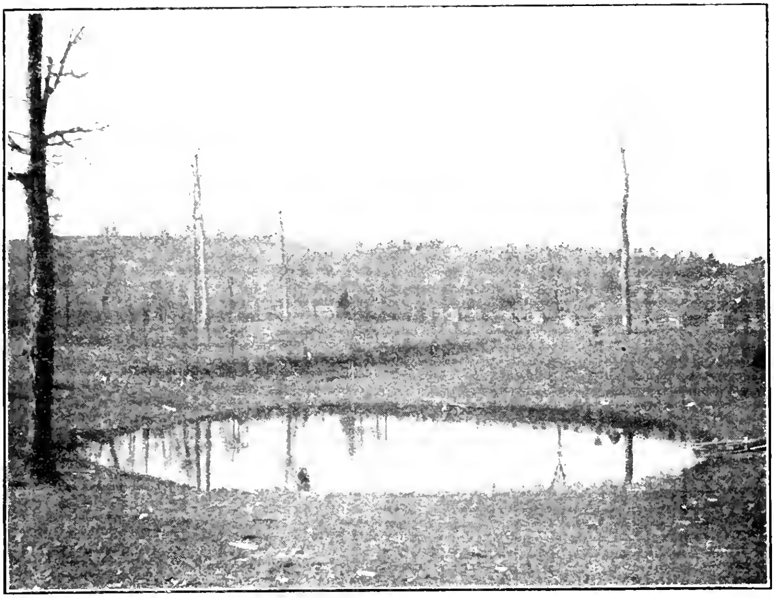
No. 12. Joint enlarged by solution and filled with residual soil, near West Baden, Ind. Mitchell limestone.



No. 13. Cut on the C., I. & L. R. R. in northwest edge of Bloomington, showing jointing of Mitchell limestone.

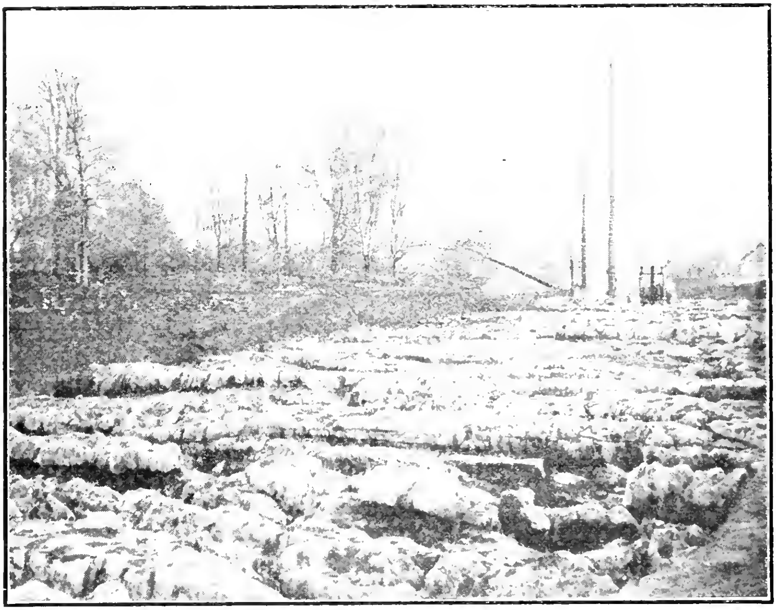


No. 14. Exposure of Salem limestone on Big Creek near Stinesville, showing jointing.

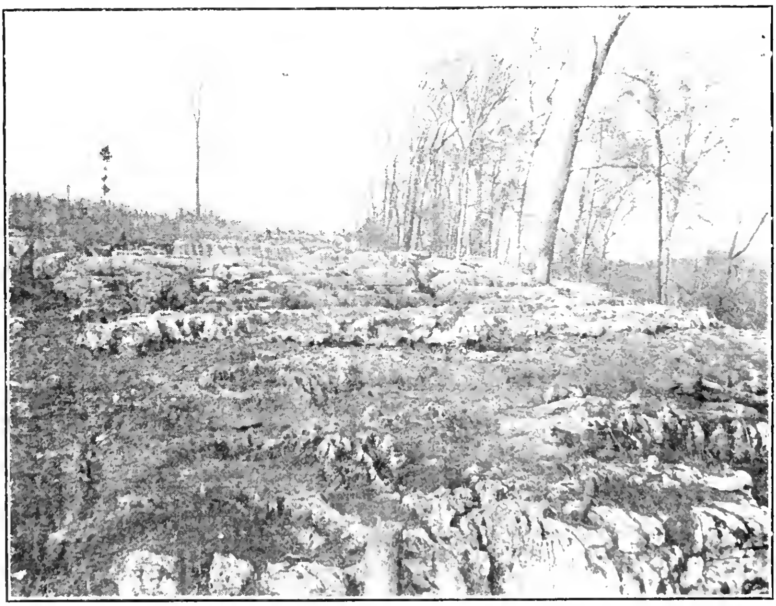


No. 15. Sinkhole, Whitehall pike west of Bloomington, Ind., in the Mitchell limestone.

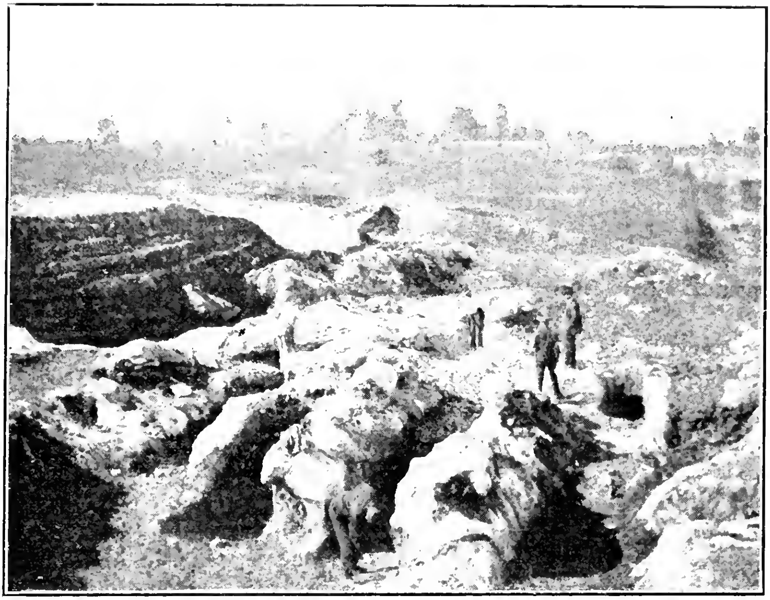
No. 16. Entrance to Donaldson Cave, Mitchell, Ind., in Mitchell limestone.



No. 17. Corroded surface of Salem limestone. Quarry near Stinesville.



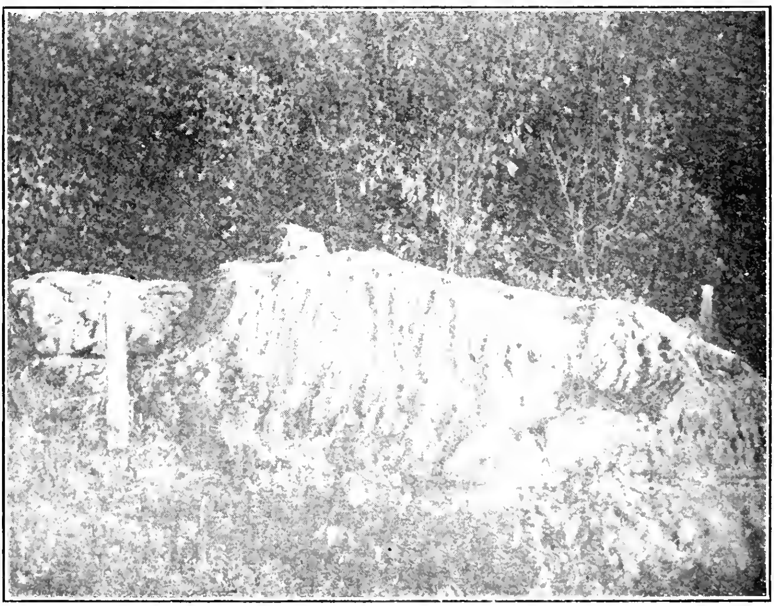
No. 18. Corroded surface of Salem limestone. Oliver Quarry, Clear Creek.



No. 19. Corroded surface of Salem limestone. Quarry near Sanders, Ind.

No 20. Corroded surface of Salem limestone. Quarry near Sanders, Ind.

No. 21. Pinnacles formed by solution. Top of Harrodsburg limestone in R. R. cut on Clear Creek.



No. 22. Block of Salem limestone furrowed by rainwater

Action of Calcium Chloride Solution on Glass.

By P. N. Evans.

In the course of some recent experiments on boiler corrosion the author had occasion to place various dilute solutions in contact with iron wire in glass bottles and heat them in an autoclave containing water up to 200 pounds steam pressure, which corresponds to about 200 degrees Centigrade. The heating was continued for periods ranging from three to seven hours.

The solutions were all about fifteenth-equivalent-normal in strength, and included the following substances, separately: sodium nitrate, ammonium nitrate, calcium nitrate, nitric acid, sodium chloride, calcium chloride, magnesium chloride. In each case 250 cc. of the solution was heated in a 500-cubic-centimeter bottle.

In most cases the bottles were appreciably attacked by the solutions, so that the glass stoppers could not be removed and the bottles were noticeably etched inside, sometimes with the formation of scaly matter on the bottles and in the enclosed water.

The effect was very much the most pronounced in the case of the calcium chloride. The solution was heated for 6 hours in a bottle of clear glass of good quality, weighing empty about 275 grams. On opening the autoclave the bottle was found to have been eaten through near the bottom and the rest largely covered with a gelatinous layer which hardened in a few days to an opaque coating. The piece of iron wire in the solution throughout the heating had gained very slightly in weight and in tensile strength. Also, about 90 grams of loose scaly material was found, and the solution, which had been perfectly neutral, had become strongly alkaline. Apparently fully half of the glass had been acted upon, so that this very dilute calcium chloride solution, containing less than 1.5 grams of calcium chloride, had in about 6 hours chemically attacked over 100 grams of glass.

In seeking an explanation of the results, the various constituents of a calcium chloride solution may be considered. These include, according to generally accepted modern theories, water, calcium chloride molecules, perhaps some hydrated calcium chloride molecules, calcium ions, chlorine ions, calcium hydroxide molecules, hydrochloric acid molecules, hydrogen ions, hydroxyl ions.

Of these ingredients water can hardly be the active agent, or equally marked results would have been obtained in the other cases; of the other chemical substances present, all but calcium chloride molecules—anhydrous and hydrated—were present in approximately equal quantities in other solutions tested without corresponding results. The action, then, must be considered catalytic, on account of the quantities involved, and induced by calcium chloride molecules, anhydrous or hydrated, and is apparently the hydrolysis of the silicates of the glass, with the formation of more or less hydrated silica and free bases.

Determination of Equivalent Weights of Metals.

James H. Ransom.

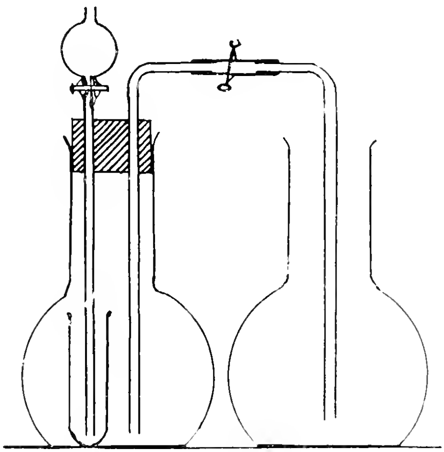
Some years ago I presented to the State Science Teachers' Association a description of an apparatus for determining the equivalent weights of the metals. The object was to devise an apparatus so simple and inexpensive that it might be used in every high school. That apparatus, which consists only of a flask and stopper, gives fairly accurate results, and where more complicated apparatus is not available it may well be used instead of giving up the determination of at least one of these most important chemical constants.

In colleges, however, where a greater variety of apparatus is available, it has seemed desirable to use apparatus which necessitates more care in its adjustment. It is desirable because the student becomes interested in working with complicated pieces, and on that account recalls more vividly the thought back of the method. Also I have found that with the apparatus about to be described the students of average ability obtain results more nearly in agreement with one another and with the theory.

The pieces of apparatus needed are two litre flasks, a two-hole rubber stopper, separating funnel, test-tube, pinch-cock, glass tubing and rubber connection. The accompanying sketch shows the apparatus when ready for use.

A weighed quantity (.6 to 1.0 grm.) of pure zinc is put into a test-tube and this put into one of the litre flasks. The flask is filled with water which has been slightly warmed to expel the dissolved air. The stopper, carrying the separating funnel with the tube long enough to reach to the bottom of the test-tube, and also carrying a tube bent to a right angle and reaching nearly to the bottom of the flask, is adjusted in the flask so that the tube of the funnel will enter the test-tube and reach nearly to the zinc. When pressing the stopper into place the exit tube should be closed with the pinch-cock and the funnel stop-cock opened so that water will fill the tube of the funnel up to the stop-cock or above. Now by allowing water to flow from the funnel into the flask the exit tube may also be filled with water. When this has been accomplished the apparatus is tested for leaks by closing the stop-cock and opening the pinch-cock. Should there be a leak, water will siphon out. No water should remain in the bulb of the funnel.

When the apparatus is tight an accurately measured volume (15 to 20 cc) of concentrated hydrochloric acid (dilute acid can be used with magnesium) is put into the separating funnel; the exit tube is put into the second flask which has previously had its sides dampened with water. About one half of the acid is now allowed to flow into the tube containing the zinc. A rapid evolution of hydrogen occurs which drives



water over into the second flask. When the action slows down more acid is run in, care being taken that at the end the surface of the acid is just at the stop-cock. When all the metal has dissolved (it may take one-half hour) the surfaces of the liquids in the two flasks are brought to a level by raising or lowering one of them, and while level the pinch-cock on the exit tube is closed. The stopper is now withdrawn from the generating flask and the temperature of the water in it is taken. Also the reading of the barometer is noted. The volume of the water in the receiving flask is carefully measured and from its volume the volume of the acid used is deducted. The remainder is the volume of hydrogen produced during the action. This is corrected to standard conditions, and from the corrected volume and the weight of zinc used the weight of zinc necessary to produce 11.2 litres of hydrogen is calculated. (11.2 litres of hydrogen weigh one gram).

The accuracy of the method was tested by Mr. Kimerline, a sophomore student in chemistry, who made three determinations each of three metals. The average of the closely agreeing results is as follows: aluminum, 9.02 (theory 9.03); magnesium, 12.08 (theory 12.18); zinc, 32.55 (theory 32.7). In a class of 70 freshmen who had worked in the laboratory only 18 hours, and using horn-pan balances, the average of 37 results picked at random was 31.9.

The apparatus apparently gives good results even in the hands of inexperienced men.

Studies in Catalysis.

By James H. Ransom.

In 1902 there was presented to this Academy by Mr. E. G. Mahin, working in my laboratory, a paper dealing with the action of heat on mixtures of manganese dioxide and potassium chlorate. In this paper it was shown that the nature of the reaction as well as the temperature of decomposition depended on the purity of the oxide, in that the purer and drier the material the higher the temperature of rapid decomposition and the smaller the amount of chlorine and chlorine oxides. The study of this action has been continued by the writer, and some new data accumulated.

Instead of using the purified commercial article, manganese dioxide was prepared in the laboratory by heating chemically pure manganous nitrate to a high temperature as long as decomposition occurred, and then washing out all soluble material. After this treatment the residue was dried for some hours at a high temperature in vacuo. It was then preserved in glass-stoppered bottles in a desiccator. Prepared in this way the oxide is not hygroscopic.

One to two grams of potassium chlorate, free from chlorides, was mixed with about the same weight of the manganese dioxide and the mixture heated in an air-bath, the temperature being controlled with a gas regulator. With the purified material there was observed little or no decomposition at 170° (as Mahin found), and only at 245° to 260° was the action at all perceptible. At 300° to 310° the action completed itself in a few minutes. It was observed that while little oxygen was evolved below 245° the residue gave a test for chlorides, though the tests made before heating gave wholly negative results. Some of the experiments showed less loss in weight during heating than that corresponding to the chloride found by titration against standard silver nitrate. Occasionally, however, the loss was even greater than that calculated so that it was felt that great reliance could not be placed in the difference in weight, especially as the tubes were often heated continuously for some days. The evidence of decomposition rests, therefore, on the formation of chloride.

After these facts were established twenty experiments were performed to find the amount of chloride produced at different temperatures; and to determine, if possible, the lowest temperature at which any chloride would be formed. The temperatures varied in the different experiments between 90° and 200°, and the time of heating from one hour to 21 days. Chlorides were found in each of the 20 experiments, and the amount varied somewhat regularly with the increase of temperature and the time of heating. At 90°-93°, the lowest temperature used, the amount of chloride formed in 14 days was .22 per cent. of that theoretically possible.

In order to show whether the pure chlorate would decompose at all under these conditions some of it was heated in the same manner as that described above. The heating was continued for nine days at 106°-109°. But not a trace of a chloride was produced.

It is interesting to note that decomposition begins 200° below that at which it is sufficiently rapid to be easily observed. But this is in line with the modern idea that the velocity of an action is a function of the temperature. And this observation has its parallel in the fact that 200° below its ignition point hydrogen combines with oxygen in quantities sufficient to be determined.

It has been found also that mixtures of manganese dioxide and potassium perchlorate produce oxygen at a temperature much lower than that necessary to decompose the perchlorate alone. The amount of oxygen is quite appreciable at 310°, but does not become rapid at 360°—a temperature below that at which the perchlorate begins to evolve oxygen.

In order to compare the action of other catalytic agents at low temperatures mixtures of potassium chlorate and platinum black were heated at two temperatures; one sample for 6 days at 145°-150°, the other for 7 days at 95°-100°. Both tubes lost in weight and both gave evidence of considerable amounts of chloride produced. I hope soon to get results at higher temperatures. But at these temperatures manganese dioxide and platinum black are almost identical in their effect on the decomposition of potassium chlorate.

In the near future the study of the action of other oxides at low temperatures will be undertaken in order to get comparative results.

At the beginning of the investigation on catalysis it was believed that many of the actions would prove to be of a purely chemical nature. At the present time there is no evidence that such is the case; but rather that we are dealing with cases of true contact action.

Effect of Radium on Electrolytic Conductivity.

By Ryland Ratliff.

The material used was one-tenth of a gram of "Curie" radium chloride of 10,000 strength placed at the disposal of the writer through the kindness of Dr. Foley and the other Indiana University authorities.

A number of the usual experiments were first performed to test the quality of the material. These included photographing the fluorescent action of the radium upon small diamonds and Willhemite. In these and kindred experiments good results were obtained.

Two attempts were made to obtain a photograph of the spectrum by means of the Rowland concave and Brashear mounting. In the first exposure of 90 hours the radium chloride was placed directly in front of the slit which was made unusually wide (probably too wide). A second exposure of 162 hours was made by placing the radium slightly to one side of the slit and the fluorescing Willhemite directly in front of it. In this trial the slit was made narrower but was considerably wider than in ordinary spectrum work. Neither exposure yielded any effect other than a slight fogging of the plate. The remainder of the work was devoted to the problem, as above stated, of determining the effect upon electrolytic conductivity.

The apparatus employed is represented diagrammatically in Fig. 1.

Glass tubes I and II filled with the electrolytic solution are introduced into the two arms of the Wheatstone bridge BD and CD. The copper disks d_1 and d_2 are placed as nearly as possible the same distance apart as d_3 and d_4. Then when resistances R and R_1 are made the same the bridge will of course be balanced approximately. R and R_1 were usually made of from 800 to 1,200 ohms each. With the bridge balanced the radium is placed as near as practicable to I or II and the direction and amount of deflection in each case is noted.

Theoretically the back E. M. F. should be the same in each tube, but it was found to be impossible to get it so in practice for any considerable time. Hence the greatest difficulty in the way of definite positive conclusive results is due to the drift of the needle. A Rowland D'Arsonval galvanometer with a sensitiveness of one megohm was employed in the major part of the work.

The tubes were first filled with an almost saturated solution of Cu So_4. On working for two days with this electrolyte trying many different adjustments it was found that the back or electrolytic E. M. F. was so variable that no reliable results could be secured. The only thing determined positively was that lengthening the distance between the disks in I caused a deflection E. and lengthening that in II produced a deflection W.

On filling the tubes with pure distilled water the results were somewhat more definite. With the disks 1½ cm. apart the following data

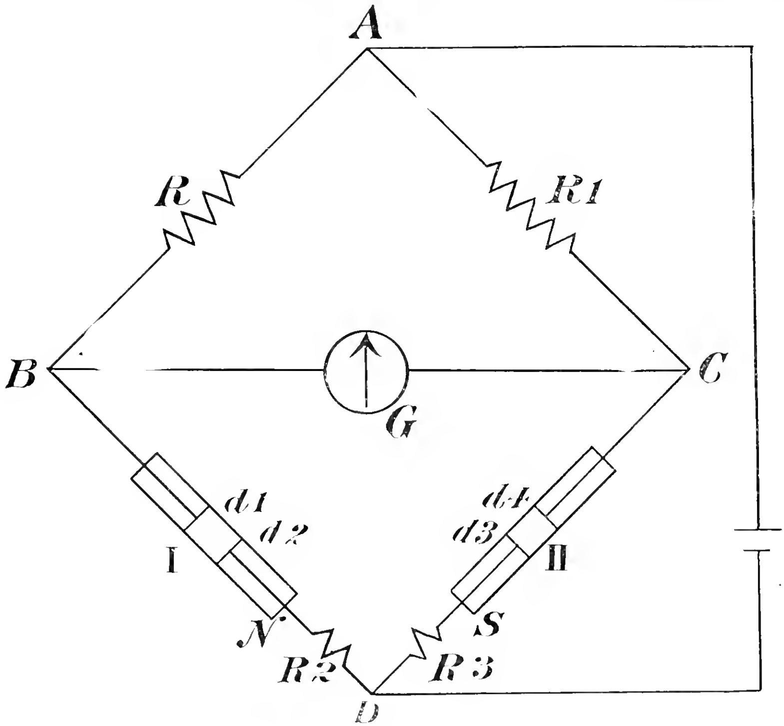


Figure 1.

Dimensions of essential parts of apparatus of Figure 1.
(1) Glass tubes, I and II.
Length of each, 10 cm.
Internal diameter of each, 17 mm.
(2) Copper discs, d1, d2, d3, and d4.
Diameter of each, 16 mm.
Thickness of each, 1 mm.

were obtained: (1) On closing circuit, deflection (W) was first 38, then settled at 22, on standing at 22 several seconds, radium placed nearest H gave deflection (E) to 34½. On removal deflection was W.

Since an E deflection indicates a decrease in the resistance of H the first results secured seemed fairly definite. To make sure the movements were not due to the E. M. F. of the electrolyte, weights were placed on the keys by which the battery and galvanometer circuits were both kept closed for a considerable time until the needle had ceased to drift. Four additional readings were taken, the five sets of readings being as follows: in all the lists of readings deflections indicating a decrease of resistance by the presence of the radium are marked +, those indicating an increase are marked −:

TABLE I.

Reading.	Reading on addition of radium.	Deflection.	Reading on removal of radium.	Deflection.
(1) 22	34.5	+12.5	W	+
(2) 23	42	+19	41.7	+.3
(3) 41.4	41.7	+ .3	41.65	+ .05
(4) 41.65	41.65	0	41.65	0
(5) 41.2	41.7	+ .5	41.7	0

Two drops of H_2SO_4 were added to the water with which the tubes were now filled. This of course greatly increased the conductivity. It also made it much more difficult to balance the bridge. In securing the data given in table II the radium was placed alternately upon the two tubes, N and S.

TABLE II.

Reading at beginning.	Radium on N	Result.	Radium on S.	Result.
33.5	33.5	0	33.85	+ .35
	34.1	— .25	34.5	+ .4
	34.4	+ .1	34.5	+ .1

The results only of the readings will be given in the succeeding lists. The tubes were now enclosed in pasteboard boxes to prevent effects due to light and heat. Each box had a hole just large enough for the insertion of the radium.

TABLE III.

Radium added.	Radium removed.
+ .7	0
+ .10	+ .15
+ .10	+ .13
— .13	+ 2.
— .05	+ .05
+ .6	— .1

It was observed that with a given adjustment the drift of the needle was often tolerably constant, and, for a considerable period in the same direction. Sufficient additional resistance was now introduced at R_2 to cause the needle to drift in the opposite direction so that the influence of the radium would be exerted against the drift.

TABLE IV.

Radium added.	Radium removed.
— .7	+ .9
—1.8	+1.6
+ .4	+2.5
+3.	0
+3.	—3.

A solution of $AgNO_3$ was next used as the electrolyte. The Ag and Cu made a battery to such a degree that no consistent results could be obtained. A considerable amount of Ag was deposited on the Cu electrodes. Evidently a very dilute solution would be more likely to give results. The most satisfactory solution used was made by diluting 3 cc. of the $Cu\ SO_4$ solution used at first to 100 cc.

In Table V the radium was placed alternately upon N and S and readings taken every two minutes.

TABLE V.

Radium on S.	Radium on N.
— .6	— .8
+1.8	+ 2.
— .7	— .1
+1.6	— .9
— .6	+1.5

TABLE VI.

Radium on S.	Radium on N.
+ .85	— .6
+1.6	—1 15
+ .10	— 75
+ .55	— .25
+ .4	+ .5
+ .2	— .75
+ .25	— .35
+ .5	— .4
+ .15	— 05
+ .5	0
+ .4	— .5
+ .2	— .15
+ .3	0
+ .5	0
+ .35	— 2
+ .10	0
+ .06	+ .02
+ .65	+ .05
+ .15	+ .07
+ .3	— .1
+ .15	— 2
+ .15	0
+ .4	0
+ .25	0
+ .07	
+ .22	
+ .1	
.0	
+ .1	
0	
+ .1	

Several of the lists, especially Table VI, show the effect of the drift of the needle.

A number of efforts were made to overcome this difficulty, none of which were entirely successful.

One entire day was spent trying to get data for a curve which would show the influence of this ever present but very variable factor. In the first four readings of Table VII the drift was taken every five or six minutes and the succeeding readings were with the radium, readings every minute.

TABLE VII.

Time.	Deflection.	Amount of deflection.
6 min.	40.25 to 40.8	+ .17
5 min.	40.8 to 41.3	+ .5
6 min.	41.3 to 41	— .3
5 min.	41 to 41.3	+ .3

	Radium on S. Deflection.	Result.		Radium on N.	Result.
1.	41.3 to 41.6	+ .3	2.	41.9 to 41.9	0
	41.6 to 41.75	+ .15		41.9 to 42.1	— 2
	41.75 to 41.9	+ .15		42.1 to 42.1	0
3.	42 1 to 42.5	+ .4	4.	42.82 to 42.8	+ .02
	42.5 to 42.75	+ .25		42.8 to 42.75	+ .05
	42.75 to 42.82	+ .07		42.75 to 42.68	+ .07
5.	42.68 to 42.29	+ .22	6.	43 to 43.1	— .1
	42.9 to 43	+ .1		43.1 to 43.3	— .2
	43 to 43	0		43.3 to 43.3	0

If the average drift was really no greater than that obtained when special effort was made to determine its amount it was not sufficient to balance the considerable excess of positive readings.

Summary: Of the total number of readings, 61 per cent. indicated positive results, 26 per cent. were negative, and 13 per cent. were zero, i. e., gave no deflection. Of the total amount of the deflections (omitting the rather questionably large ones in Table I), 82 per cent. were positive and 18 per cent. negative. Including those of Table I, 90 per cent. were positive.

A Simple Method of Measuring Electrolytic Resistance.

By R. R. Ramsey.

In measuring the resistance of electrolytes the back e. m. f. or polarization of the cell is always a troublesome source of error. The potential of the terminals of an electrolytic cell is never the same unless the temperature, concentration, and purity are absolutely the same at both electrodes. To avoid this error various methods have been used, such as the alternating current and telephone method.

While working with electrolytic cells it occurred to me that the ever-present and troublesome e. m. f. might be utilized in a very simple manner for resistance measurement. This method consists of placing the

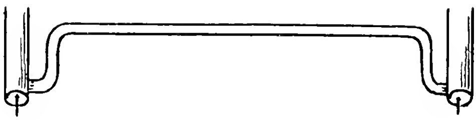


Figure 1.

cell in series with a resistance box and mirror galvanometer and taking readings of the galvanometer deflection with several resistances in the box. From these readings the cell resistance can be determined by solving for Rc in the two equations,

$$Kd_1 = \frac{E}{R. + Rg + Rc}$$

and

$$Kd_2 = \frac{E}{R_2 + Rg + Rc}$$

Rg, the galvanometer resistance being known. A preferable method is to plot box resistance as a basis and the reciprocals of galvanometer deflection as ordinates. The intercept on the X axis being Rc + Rg, from which Rc can be found.

The specific resistance can be found from the resistance and the dimensions of the cell which can be determined by filling with mercury or water.

The cell was made as in Fig. 1, the electrodes being made of cadmium amalgam. By placing the two ends in water baths the two ends can be kept at a constant small difference of temperature, thus keeping the e. m. f. constant. The following data and curve (Fig. II) are for a cell filled with 10 per cent. solution of cadmium sulphate.

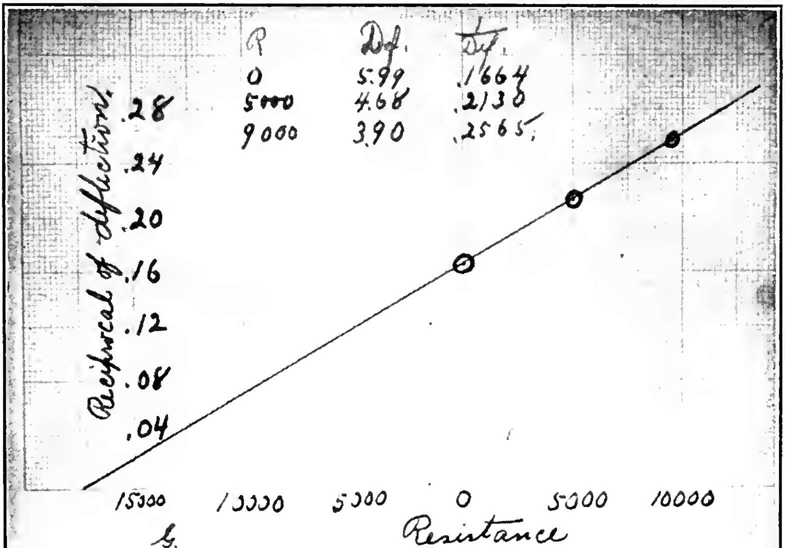


Fig II

Length of cell .... 99 cm.
Cross section .... .277 sq. cm.

Box Resistance.	Galv. Def.	$\frac{1}{\text{Def.}}$
0 ohms.	5.99	.166
5000	4.68	.213
9000	390	.256

From curve Rc + Rg = 17470 ohms.

Rg = 225.

$$\text{Sp. Resistance } \rho = \frac{17470 \times .277}{99.} = 48.3 \text{ ohms.}$$

Some Peculiarities of Electric Sparks Across Short Spark Gaps.

By R. R. Ramsey.

Bloudlot, in his work on N-rays, used a very feeble spark gap. In our attempts to repeat Bloudlot's work Mr. W. P. Haseman and I found some very interesting phenomena which affected the sparking distance and consequently the intensity of the spark. The fact that we were not able to repeat Bloudlot's experiments has led me to make some further investigation.

T. J. Bowlker (Phil. Mag., 8, p. 487, 1904), has worked with long spark-gaps, 1 cm. to 10 cm. in length, and has obtained some very curious results.

The work here described was with a spark gap between platinum wires .45 mm. in diameter and never more than ¼ mm. apart.

The spark-gap was provided with a micrometer so as to make length anything desirable. The gap was connected to the secondary coil of a 1-inch induction coil. The current in the primary coil was cut down by means of resistance until the sparking distance was very small. The gap was opened to the point where the sparking just ceased and the effects of various objects were tried. When one's hand or finger was brought within 1 cm. of the gap the sparks appeared. This was attributed to heat. A lighted match had the same effect as did one's breath or a current of hot air. A rod of glass or of brass which had been in the same room caused the effect. Any object brought near the gap caused an increase of the number of sparks.

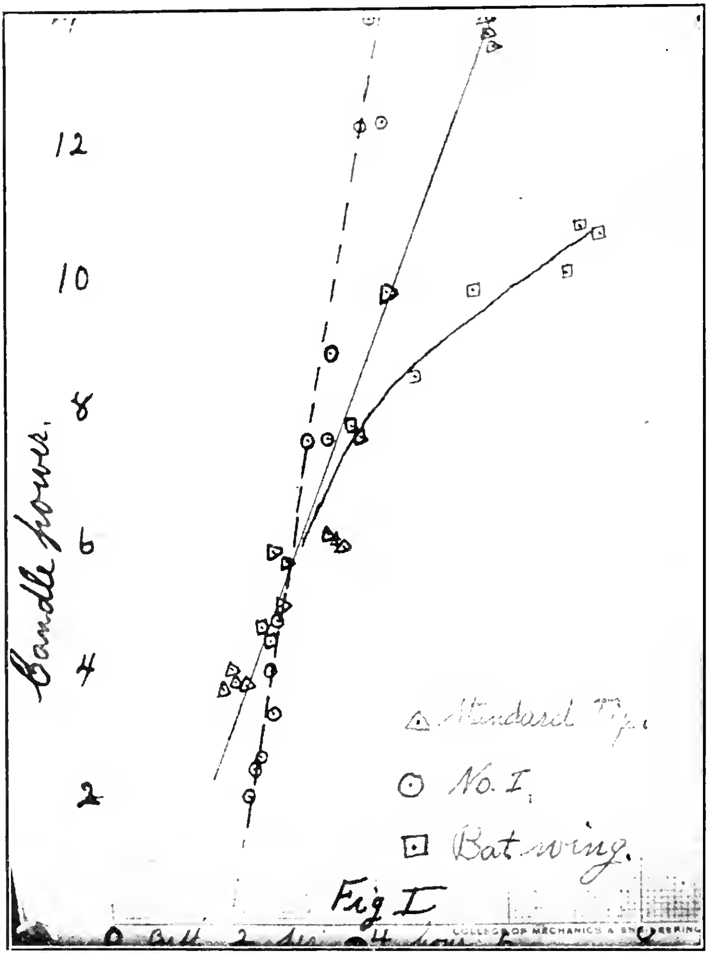
A No. 20 copper wire 15 cm. long caused an increase when brought near the gap or when it was allowed to touch one of the electrodes a short distance from the gap. The effect was more noticeable when the wire was in contact with the negative terminal. Touching the electrode five centimeters from the wire had no effect. The effect was more marked when the wire was at right angles to the gap than when placed parallel to the gap.

Gas Burners and Standards of Candle-Power.

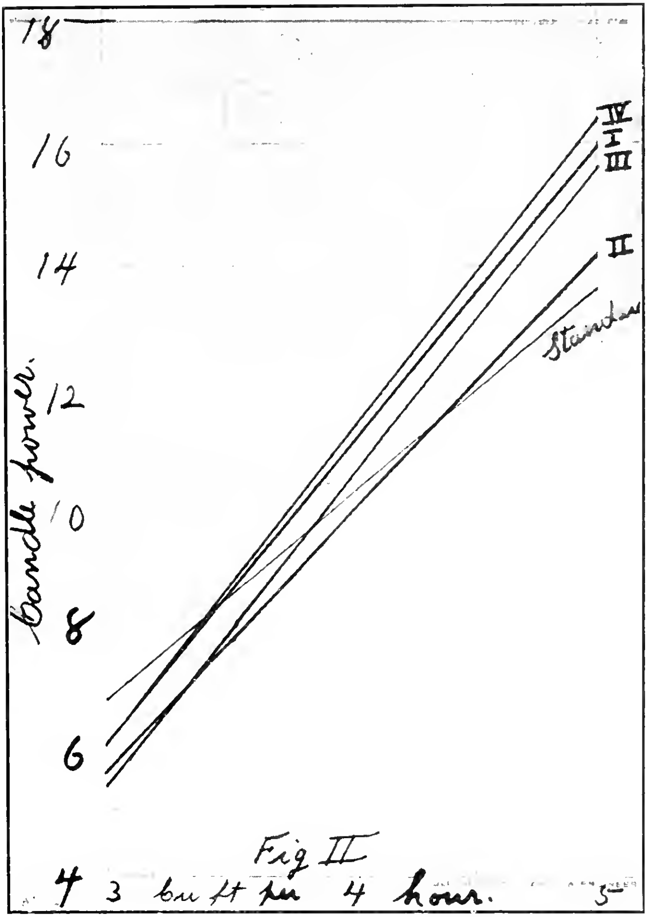
By R. R. Ramsey and Hiromitsu Oi.

It seems to be taken by common consent that 16-candle-power gas means that the candle-power of the lamp burning the particular gas should be 16 candle-power when the rate of consumption is 5 cubic feet per hour at 1-inch water pressure. The kind of burner used is more or less an open question. The fishtail burner is specified by some of the older authorities. The common practice of gas companies seems to be to use an Argand or circular burner with a chimney. The question "What is the candle-power of the gas?" is one of considerable moment at the present time. Dr. Foley, of the Department of Physics, Indiana University, has been employed by the city of Bloomington during the last two years to make monthly reports of the gas supplied to the city. As a result of these measurements suit has been brought to annul the franchise of the gas company. Indianapolis has its gas troubles. Almost every city seems to have more or less trouble with gas. The fact that the burner used on the Bloomington gas company photometer gave higher values than a standard fishtail burner and that commercial Argand burners gave results consistent with the fishtail burner, suggested the experiments which were carried out by Mr. Oi. The work consisted in changing the air supply and the number of openings in the commercial Argand gas burners and comparing the candle-power to the candle-power given by the standard fishtail. The Argand burner used had 36 openings in a circle of 2.2 cm. diameter and used a chimney 5 cm. in diameter. The one used by the gas company had 24 holes in a circle $\frac{2}{3}$ the diameter of the commercial burner, and used a chimney $\frac{2}{3}$ the diameter of the commercial chimney. The air supply in the burner was largely through the center, while the commercial was supplied about equally inside and outside the cylindrical flame. The supply of gas was regulated by regulating the pressure of the gas by an automatic regulator. The results will be given by means of curves where candle-power is plotted against the consumption in cubic feet. Since the quality of the gas was variable a curve for the standard fishtail was taken for each set of observations. Fig. I gives the curves for three burners with the actual values shown by points. The points in triangles △ are for the standard fishtail tip. Points in squares ⊡ are for a slotted lava tip or bat-wing burner. Points in circle ⊙ are for Argand burner No. 1.

In Fig. II are the mean values reduced to a standard basis, namely, 13.6 cubic feet gas, the mean values of the gas throughout the experi-



ments as shown by the standard fishtail burner. Burner No. I was a commercial burner, with the air supply almost all cut off from the outside of the cylindrical flame. Burner No. II was a commercial, with the holes closed with copper plugs, or 18 holes open. Burner No. III had one-third the holes closed, or 24 holes open. Burner No. IV had 24 holes and almost all the outside air cut off. No. V was a combination of Nos. I and III. From the curve we see that with 13.6 candle-power gas (standard tip) No. II gives 14.2 candle-power, No. III gives 15.6, No. I gives 16 candle-power, and No. IV gives 16.4 candle-power.



If by simply manipulating the burner 13.6 candle-power gas can be raised to 16.4 candle-power, or 20 per cent., it is high time that some definite and authoritative action is taken to define the standards for gas measurement.

Preliminary Notes on an Almost Extinct Native Disease. Trembles or Milk-Sickness.

By Robert Hessler.

(Abstract.)

The paper gave a detailed account of a five-year search for the cause of the above named affection—known as "trembles" in animals, or as "milk-sickness" when transmitted to man by the milk of an affected animal or on eating the flesh.

The disease was formerly common and severe, but today cases are seldom seen. Five years ago a number of cattle were affected and died, a farmer's family also suffered after using the milk of a cow whose calf died of the trembles; the family recovered.

In the fall of 1905 two horses grazing in an infected area became sick; one died, the other recovered under active medicinal treatment. From the blood of the latter pure cultures of a fungus were obtained. (Cultures in tubes were exhibited.)

On the first examination, October 10, 1905, the blood contained spore-like bodies in abundance and small yeast-like bodies enclosed in poly-nuclear leucocytes; the former rapidly decreased and disappeared in a few days, while the yeast-like bodies increased and later on diminished and disappeared by the time the horse recovered (November 19).

Drawings of the organisms in the blood and of cultures in hanging drops were shown. The pathogeny is now being worked out; the occurrence of the fungus in nature (in certain wet shaded ravines) will be investigated in the future.

Notes on the International Botanical Congress of 1905.

By J. C. Arthur.

International botanical congresses have been held at different times during the last half century. They have originated under various auspices, and for various purposes, but until the one held in Vienna during the last summer none had had direct connection with a preceding congress. Heretofore at each such gathering papers have been read, suggestions made, and resolutions passed, but no mandatory power was exercised. For want of a stable and self-perpetuating organization based upon a system of representation having the approval of botanists in general, it has been impossible to make rules for guidance in any line of botanical activity which any large number of botanists would accept as authoritative.

At the congress held in Paris in 1900 steps were taken to make the organization a permanent one, the proper officers and committees were appointed, and the adjournment was taken to meet again in Vienna in 1905. There are many ways in which a properly constituted body speaking with authority could be of inestimable service in directing the activity of the botanical world. But in one matter there has been for a long time a practically unanimous opinion. It is believed that only by means of such an organization can order be brought out of the present state of confusion, annoyance, and endless discord that exists in regard to the "hispid question" of nomenclature. For a long time modern botanical nomenclature was guided by the dictum of the De Candolles, representing the French people, and the Hookers, and in America Asa Gray, representing the English people. But as knowledge and the numbers of workers increased the subject became too great to be dominated by individuals, and control passed to the great centers of activity, Berlin for the Germans, Kew for the English, Geneva for the French, and what has been denominated the Neo-American school, with its center in New York, for most Americans; although a few strong individual workers still are able to be heard in opposition to all of these. The convenience of a uniform set of names for plants, and the inconvenience of repeated changes and lack of recognized authority, are too great to let this confused state of affairs continue indefinitely. The hackneyed theme of nomenclature was therefore a prominent incentive for the establishment of an international society, and in the arrangement of its first deliberate program received large attention.

The meeting at Vienna began on Sunday, June 11, 1905, with the opening exercises of the exhibition held in connection with the congress. This was a large exhibition and very attractive and interesting, both to botanists and the general public. It contained extensive displays of apparatus, books, charts, colored plates, special herbarium sets, dried and living fungi and algae, pure cultures of various kinds illustrating particular kinds of investigations, historical matter, such as manuscripts, portraits and the working outfit of early botanists, and numerous other classes of objects, too many to be even enumerated. Each morning of the following week a demonstration in some line of work made a valuable feature in itself. Probably no single botanical display has ever equalled this one in the variety and value of its objects or in sustained interest.

The formal opening of the congress took place on Monday morning in the great hall of the university with much ceremony and pomp. In the afternoon the nomenclature section of the congress was organized in the lecture room at the botanical garden. Every morning and afternoon during the remainder of the week the congress listened to scientific papers by eminent scholars of Europe and America, and every afternoon for five days the nomenclature section met promptly and worked late in a most methodical, businesslike manner, trying to solve some of its problems.

The social events of the week were a notable part of the congress. They opened with a reception on Sunday evening; and every evening following had receptions, parties at the opera or in the park or at the Rathskeller in bewildering profusion. Many short excursions to places of scientific interest were also arranged for the latter part of some of the afternoons. The visiting ladies, presumably not deeply engrossed by the scientific side of the congress, were taken out for drives and to visit art galleries, etc., in the forenoon, attended teas and listened to music in the afternoon, and joined the men in the evening. Among the social features must be classed the long excursions arranged by the congress, a number preceding, and others following the week of the sessions, each occupying from a few days to a month or more.

All the events and exercises of the congress, unless we except the nomenclature section, bore a close resemblance to the large gatherings of scientific bodies which are now common on both sides of the Atlantic. The deliberations over nomenclature partook much more of the nature of a business organization. Each participant was the accredited representative of one or more botanical establishments or societies, or was a government representative, and was entitled to a corresponding number of votes. Each participant had before him a quarto pamphlet of one hundred and sixty pages, printed in four columns. This had been prepared by a commission appointed at the Paris congress of 1900. In one column were the rules of nomenclature adopted at the Paris congress of 1867, which have been the only general rules for guidance in the naming of plants botanists have so far had, which by the growth of the science greatly needed revision, if indeed they did not require complete rewriting. In another column were the modifications or additions suggested by various societies and individuals since the appointment of the commission. The third column contained various comments, and the fourth column embodied the recommendations of the commission. This guiding document was wholly in French, and the official language of the congress was also French. On each side of the presiding officer sat a vice-president, one repeating motions and remarks in English, and the other in German, whenever deemed necessary, that all might fully understand the proceedings and vote effectively. No language was barred in discussion, but practically only French, German and English were heard, and these in nearly equal proportion.

Great earnestness was manifested; this with the lively debate, rapid passage of motions, and the strain of listening to three intermixed languages made it a memorable occasion to the hundred or more participants. But the interest was deeper than the surface or the day. The most influential workers in systematic botany, with the exception of Englishmen, who stand strangely aloof from participation in any organized efforts, were lending their best endeavors to effect a substantial advance in nomenclatorial practice. From the American standpoint the results were not all that were hoped for, action being particularly conservative. But there has been a distinct advance, and of such a nature that the evolution of a substantial system is confidently assured through the future activity of the society.

The first action of the organized body was to exclude cryptogams, mosses and liverworts from present consideration and place these groups in the hands of a special committee for a future report. A committee was also appointed to consider the nomenclature of fossil plants. In the main the rules of 1867 were approved, and the working of the law of priority strengthened. What to Americans seem like undue concessions to the old order of things were the decisions to exempt from the rule some 400 generic names now in use, and to disqualify specific names which duplicate the generic name, as Linaria Linaria, etc. It was voted by a moderate majority that beginning with 1908 descriptions must be in Latin to constitute publication, except in works whose publication was begun before that date and not fully completed. It is believed by American botanists that the greatest shortcoming of the congress was the failure to recognize the value of generic types, which constitute an advance in systematic methods that is certain to find favor as soon as well understood.

The proceedings of the congress will appear in due course of time in two printed volumes, the first containing the decisions regarding nomenclature, and the second the scientific papers read.

If one were to name the most important achievement of this congress, it would undoubtedly be the promotion of fraternity among active botanists in such a manner as to lead to effective organization. Over 600 members of the congress were registered, of which fully two-thirds may be denominated professional botanists, and half of these were men whose names are known to everyone familiar with current botanical literature. It was a more truly representative gathering than ever before discussed botanical problems of world-wide interest. Those in attendance considered the meeting highly successful, and this spirit of good-will toward the movement for a permanent authoritative organization is one of the bright auguries for the advancement of botanical science in many ways. The next meeting of the congress will be at Brussels in 1910, and the meeting following that may confidently be expected to be held in America.

Methods Employed in Uredineal Culture Work.

By Frank D. Kern.

The first researches which proved a positive relationship between the different fruit-forms of the Uredinales not only played an important role in the classification of these fungi, but invested a further study with much interest. A flowering plant which would produce even two separate and distinct sorts of fruit would indeed be a curiosity, and yet these parasites exhibit from one to four kinds of fruiting bodies, and many of them, seemingly to vary their existence, possess the power of living upon two entirely unlike hosts. Further attempts at classification, as well as all economic efforts to control the pests have demonstrated a necessity for a more intimate knowledge of the life-history of these parasitic plants. The connection between the different stages in a life cycle is best shown by means of cultures, and the scientific importance of these inoculation experiments can not be overestimated.

Among the immediate advantages to be gained is the connecting of unattached aecia with their later stages, and to ascertain the range of hosts. Some rusts are doubtless restricted to single species of hosts, both for their aecial and telial forms, but since cultures have shown that some heteroecious species may have their aecial hosts belonging even to different families of plants, it is evident that exact relationships can be established only by morphological characters and field observations, affirmed by artificial cultures. In the autoecious species it is sometimes impossible to tell how many spore forms there may be. Such a specimen can not be placed in its proper species on account of the close resemblance of some isolated spore forms. Cultures offer a ready solution to this problem.

Although the various processes in the cultivation of the rusts are comparatively simple, so little has ever been said regarding the apparatus and methods employed that a more detailed account does not seem out of place.

The spring months are the period when most of the work must be done, as this is the normal germinating period for the resting spores, and is also the active growing season for the host plants. Any sort of spores can be employed for the experiments and the methods vary accordingly. A smaller portion of the work, with urediniospores and teliospores which germinate at once, may be carried on through the summer months and early autumn.

The best success has been attained through the sowing of teliospores which give rise to pycnia and aecia in turn. All grass and sedge rusts furnish telial material, and since they are, with a single exception, known to be heteroecious, any collection affords culture material. Teliospores are usually resting spores and normally retain their viability through the winter. Collections made in the fall and kept in a warm, dry room during the winter usually fail to germinate. The freezing temperature of the outdoor atmosphere does not seem to be detrimental, and some plan to prevent the specimens from thoroughly drying is a necessity. Cloth packets are to be preferred to paper, as they do not take up moisture so rapidly and allow a better circulation of air. These packets may be hung out of doors, or an unheated shed without a floor seems to furnish good conditions. The material put up in this manner may be sprayed occasionally in the fall and winter, but an effort must be made to keep them in a uniform condition. Collections made in the early spring after they have wintered over in the field usually show vigorous germination. Late spring collections are of less value, as the most vigorous are liable to have grown in the field. Spores collected as early as July and August have been brought to germination and have been sown with success, but October and November collections survive through the winter better. In the spring the packets are brought into a warm room some little time before conditions outside are favorable for growth, and after a few days of warmth and moisture some of the spores will show signs of growth. The packets may be sprayed and thrown together in heaps, but they must be spread out and aired and caution taken to prevent molds from starting. The material in germinating condition is carefully separated from that not yet ready to germinate.

If negative results are to be given any weight the spores must be tested just before a sowing is made to ascertain if they are in germinating condition. Teliospores of Pucciniaceous species are tested by means of a hanging drop culture. In a space of twenty-four hours viable spores push out germinating tubes which are readily made out with the microscope under the ordinary high power. Melampsoraceous species are best tested in a moist chamber, such as a Petri dish, without being removed from the host. Growth can be detected by the unaided eye, or with a hand lens, by means of the light yellow sporidia which cover the sori, making them appear pulverulent instead of waxy. Teliospores of such species as the Coleosporiums germinate as soon as mature, which is in the fall of the year. They are sown when fresh and if suspended over a slide in a moist chamber, the sporidia drop upon it, and their germination can in turn be observed with the aid of the microscope.

For indoor experiments, small but vigorous growing potted plants are used as trial hosts. Since the pots must be handled, it is desirable to select plants with as small roots as possible and still have them maintain their vigor. The tops are placed under bell-jars when the spores are sown, and in order to have them cover more readily all extra foliage is carefully pruned away. A few young and vigorous leaves are all that is required.

The manner of applying the spores to the plants differs slightly according to the kind of spores. If they are aeciospores the leaves bearing the aecia are suspended over the portions to be infected, in such a manner that as the spores fall from the cups they will light upon the desired area. In all cases the host plant is first sprayed, the parts which will not wet being rubbed with the fingers until water will adhere. The spores do not need to be placed in water, in fact they should not be. Teliospores readily begin the germination process in water but seldom form their sporidia there. A moist surface and a saturated atmosphere are necessary factors for the germination of all kinds of spores. Urediniospores and teliospores are removed with a knife or scalpel blade, care being taken to apply the edge to the sorus in such a manner as to loosen the spore by breaking the pedicle, leaving the cell-wall uninjured. If certain areas to which the spores are applied be marked by pieces of thread the watch, which must be maintained for the first sign of infection, will be greatly facilitated.

To secure reliable results, it must be positively made out that a plant is free from infection when a sowing is made. Wild or native plants brought in from the field or garden should remain in the greenhouse a period of eight or ten days so as to preclude a possibility of outside infection.

After the application of the spores the whole plant is covered with a bell-jar and set in a shaded place for a period of three days. The bell-jar prevents rapid evaporation, thereby securing the necessary condition of moisture during the germination time of the spores. A certain amount of warmth is desirable, but during the whole period the plants should be screened from the direct rays of the sun. The bell-jars are temporarily removed each day to allow a change of air and are sprayed on the inside with an atomizer before being replaced. After the second day the plants can be sprayed, but previous to this there is danger of washing away the spores before there has been an opportunity for infection. On the third day the bell-jar is removed and the plant changed to a location where there is more light, in order that growth may be more normal and observation made easier.

A label, bearing the date of the sowing and the name of the species of rust, is a very valuable aid to the observer of results. If the infection is a successful one the first signs are usually noticeable in five to ten days, although some species require fifteen days or even longer. Ordinary Puccinia and Uromyces species, such as the grass and sedge rusts, usually develop pycnia in six or eight days, the aecia following about an equal length of time. Some species, having only teliospores, show signs of infection in four or five days by means of yellow spots, requiring twelve to fourteen days to develop spores. Uredinia sometimes do not follow the sowing of aeciospores for a period of fifteen days or more, while they will reproduce themselves in five or six. The Gymnosporangiums show pycnia in a few days and the mycelium may keep on producing pycnia for a considerable period, but a month or two passes before the aecia appear. Many of the species which produce their aecia on the evergreens germinate their teliospores in the fall, but there will be no visible sign until the aecia develop the next spring, as the pycnia are very inconspicuous.

The procedure throughout is a simple one. No sterilization is necessary, only care and cleanliness. The bell-jars are ready for use a second time after a thorough washing. All organic matter should be removed so as to avoid the starting of molds. No bits of rusted material can be left on the pots or shelves near the plants without the liability of a stray infection. As soon as a developing spore form becomes mature it should be removed for the herbarium or separated from the plants not yet showing infection. In all cases where it is the object to test the range of a species it is always wise to carry a controlled experiment with as nearly similar conditions as possible. A success in one case and a failure in the other can then usually be relied on as representing the actual state of affairs. If a plant fails to show any results within the reasonable time it is best not to use it again until a sufficient number of days of grace have passed, as there is always a possibility of a belated infection.

It will be seen that care in execution and accuracy of observation are the main features in this work, costly apparatus not being required, and it is hoped that this brief description of the operations may be of service to those interested in this modern method of studying and classifying this group of fungi.

The Embryology of Melilotus Alba.

By W. J. Young.

In the space assigned to this paper it will be possible to give but a brief outline of the development and nutrition of the flower, embryo sac and embryo, trusting to the plates to make clear the points not sufficiently explained in the text.

In the flower of Melilotus alba, the common white sweet clover, there are two factors which interfere with the orderly successive development of the floral organs; the one is mechanical and is due to the crowding of the flowers on the side of a stem axis, the other is physiological and ecological and depends upon the relative use of parts at different times in the development of the flower; the one interferes with the simultaneous appearance of the parts of the same cycle, the other with the acropetal succession.

Melilotus forms an exception to most of Leguminosae so far examined, since the megaspore mother cell develops into the embryo sac without first undergoing tetrad division. The development of the latter differs from typical cases only in details. When the eight-celled stage is reached, the embryo sac elongates rapidly toward the chalaza at the same time curving strongly, and the three antipodal cells disappear. The egg cell occupies a position lateral to the synergids. The polar nuclei lie close together near the egg apparatus. Their fusion takes place just prior to fertilization, before the pollen tube reaches the ovule.

After fertilization the primary endosperm nucleus undergoes several divisions before the egg cell begins to divide. The latter then undergoes two transverse divisions, resulting in a terminal cell which develops into the embryo and two other cells which give rise to a conspicuous suspensor. The embryo follows in the main the Capsella type of development, but with two important differences, viz., much later differentiation of the dermatogen, plerome, and periblem, and the absence of a hypophysis derived from the terminal cell of the suspensor.

Lack of space prevents more than the merest glance at the facts observed regarding the nutrition of the embryo sac and embryo. In its earliest stages, the embryo sac grows at the expense of the tissue of the nucellus. As it becomes mature it is surrounded by a definite layer of active looking cells, derived from the inner integument, forming a nutritive jacket. This stage is characterized by the storage of reserve food to supply the rapid growth which follows fertilization. Starch is deposited in the placenta and very abundantly in the micropylar region of both integuments. The funiculus contains no starch, since it is the path by which food material enters the ovule and it is important that it should not be blocked by a store of reserve food.

After fertilization the nutritive jacket becomes even more strongly developed, especially in the chalazal region on the side of the sac nearest the funiculus. The cells of the inner layer have a characteristic appearance. They are rounded and turgid, their protoplasm is vacuolated and forms a thick layer lining the inner ends of the cells. They give evidence of great activity which would seem to justify the conclusion that they are the cells most concerned at this time in the nutrition of the embryo sac. Later there appears in this region a thick mass of endosperm which, acting as an haustorium, rapidly digests and absorbs all tissue with which it comes in contact, and the nutritive jacket is naturally the first part destroyed. The location of the starch-bearing and non-starch-bearing areas at this stage seems to justify the following conclusions: Food material enters the ovule in solution and is partly stored up and partly passed on to the chalazal region of the embryo sac. Moreover the stored-up food supply is drawn upon by the nutritive jacket in the chalazal region. Starch does not appear in the embryo until just before the cotyledons appear, when a small quantity is found in the base of the embryo and also in the suspensor. In later stages there is a scanty supply of starch in the periblem.

In the latest stages examined starch was found in varying quantities in all parts of the tissue outside the embryo sac. The ovule, which might now be called the seed, was surrounded by a thick membrane of columnar cells extending even across the funiculus. Inside this columnar layer in the region of the funiculus is a flattened, fan-shaped mass of tracheid-like cells of irregular form having reticulate markings on their walls. These absorb food material through the funiculus and pass it on to the surrounding tissues, and especially through a vascular bundle, the raphe, to the chalazal region of the embryo sac. Surrounding the tracheid-like cells in the later stages are large cells separated by intercellular spaces, which contain, besides starch, rather large granules which give the test for proteids.

Summary and Conclusion.

The following conclusions result from the above observations:

1. The order of appearance of the primordia of the floral organs is sepals, stamens, carpel, petals, although the last three may appear simultaneously.

2. The energy of the plant is directed at first to the development of the stamens and carpel at the expense of the petals.

3. The archesporium becomes differentiated at a rather late stage.

4. The tapetum divides but a limited number of times.

5. The megaspore mother cell gives rise to the embryo sac directly.

6. The early development of the embryo sac is typical.

7. The antipodals disappear at a very early stage.

8. The embryo sac increases much in size before fertilization and replaces all the tissue within the integuments.

9. The egg cell is placed laterally to the synergids. The latter have striated tips.

10. The polar nuclei do not fuse until just before fertilization. The latter is a rapid process.

11. The ovule is at first anatropous, later campylotropous.

12. The fertilized egg does not divide until there are several endosperm nuclei in the embryo sac.

13. In the three-celled proembryo the terminal cell gives rise to the entire embryo and the second cell to the mass of the suspensor.

14. The early stages in the development of the embryo are of the Capsella type. The dermatogen, however, appears at a later stage.

15. There is no hypophysis.

16. The embryo sac is nourished by means of a nutritive jacket derived from the inner integument.

17. The food material which enters the ovule through the funiculus is partly deposited in the surrounding tissues and partly passed on to the chalazal region of the embryo sac.

18. A mass of endosperm in the chalazal region of the embryo sac acts as an haustorium in the later stages and digests the surrounding tissue.

19. After the formation of the seed coat nutritive material passes from the parenchyma of the funiculus by diffusion through the columnar cells of the seed coat into the tracheid-like cells, which partly distribute it to the surrounding tissue and partly pass it on through a vascular bundle to the chalazal region of the embryo sac.

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Explanation of Figures.

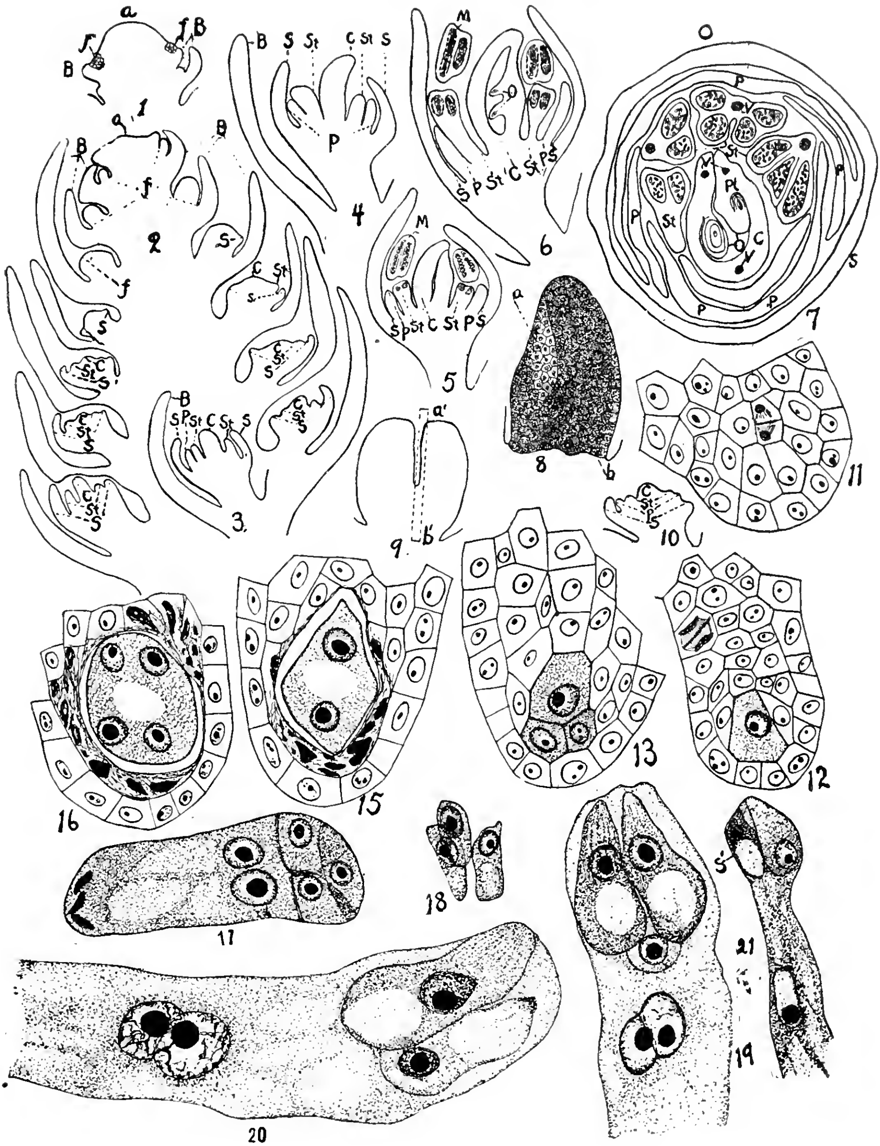
1. Stem tip (a) showing origin of flowers (f) in axils of bracts (B) X 125.
2. Stem tip, later stage, showing origin of flowers and the primordia of the floral organs; (f) flower, (B) bract, (S) sepal, (St) stamen, (c) carpel. X 125.
3. Single flower at a slightly later stage when the petal (P) appears. X 125.
4. Still later stage, indexed as above. The stamens and carpel are enlarging while the petals remain small. X 125.
5. Later stage, the cavity of the ovary appearing; (M) microsporangium. X 125.

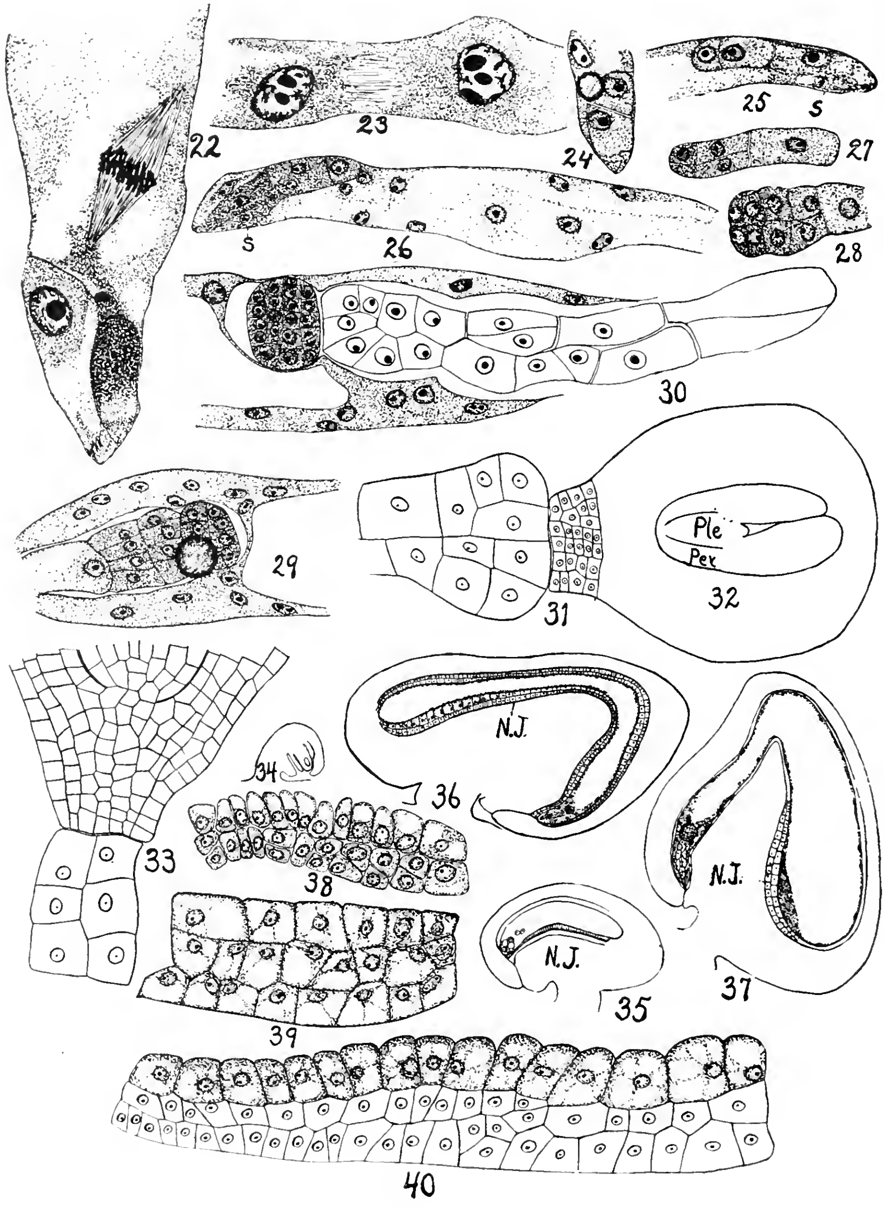
6. Still later, the ovules (O) have appeared. X 125.
7. Transverse section of a bud at about the time the embryo sac begins to enlarge; (S) calyx, (P) petals, (St)) stamens, (c) carpel, (Pl) placenta, (V) vascular bundle. X 75.
8. Longitudinal section of carpel, same stage as Fig. 9. The microtome section included about the area between the lines a'b'. X 345.
9. Section of carpel along the line ab, Fig. 8. The folding together of the sides is nearly completed. X 345.
10. Young flower showing nearly simultaneous appearance of petals, stamens and carpel. X 125.
11. Young ovule, sporagenous tissue not yet differentiated. X 1460.
12. Archesporial cell. X 1460.
13. Spore mother cell and tapetum. X 1460.
15. Embryo sac, two-cell stage. X 1460.
16. Embryo sac, four-cell stage. X 1460.
17. Embryo sac, eight-cell stage. Cells of egg apparatus cut from the remainder of the sac. Antipodals beginning to degenerate. X 1460.
18. Young egg apparatus before differentiation of egg. X 1460.
19. Mature embryo sac. The egg cell lies back of the synergids. Polar nuclei fusing. X 1460.
20. Same stage as Fig. 19 but showing the position of the egg lateral to the synergids. X 1460.
21. Embryo sac immediately after fertilization. Neither the egg cell nor the primary endosperm nucleus has divided. (S) synergid. X 610.
22. First division of primary endosperm nucleus. Egg cell still undivided. X 1460.
23. First division of primary endosperm nucleus. Telephase. X 1460.
24. Proembryo of two cells. X 610.
25. Proembryo of three cells; (s) synergid. X 610.
26. Same stage as Fig. 25 showing endosperm with radiating character of the protoplasm surrounding the nuclei. X 610.
27. Embryo of two cells. X 610.
28. Embryo of eight cells. X 610.
29. Embryo composed of two layers of cells. X 610.
30. Embryo at a little later stage when the dermatogen begins to be distinguished. X 610.

31. Embryo just before appearance of cotyledons. X 610.
32. Embryo after appearance of cotlyedons; (Ple) plerome, (Per) periblem. X 125.
33. Base of embryo of about the same stage as Fig. 32 showing plerome, periblem and relation of embryo to suspensor. X 610.
34. Young ovule of anatropous type. X 125.
35. Ovule at time of fertilization, campylotropous type; (N. J.) nutritive jacket. X 125.
36. Ovule a short time after fertilization, showing the curvature of the embryo sac and the extensive development of the nutritive jacket. X 125.
37. Later stage, embryo sac much curved, with mass of endosperm in chalazal region. X 75.
38. Nutritive jacket, same stage as Fig. 35. X 610.
39. Nutritive jacket, same stage as Fig. 36, micropylar region. X 610.
40. Nutritive jacket, same stage as Fig. 36, chalazal region. X 610.
41. Mass of endosperm serving as an haustorium in chalazal region of embryo sac. Same stage as Fig. 37. X 610.
42. Section in region of the funiculus in the plane of the mass of tracheid-like cells; (T) tracheid-like cells, (V) raphe, (c) columnar cells of seed coat. The section is in the plane indicated by the line a'b'; Fig. 43 X 345.
43. Same as Fig. 42 but slightly earlier and in a plane perpendicular to it as indicated by the line ab, (T) tracheid-like cells, (C) columnar cells of seed coat, (C') columnar cells of funiculus, (E) parenchyma of funiculus in path of food supply. X 610.

44-50. Distribution of starch in ovule. Amount of starch is indicated by the thickness of stippling.

44. At about the megaspore stage. 345.
45. At the time when the embryo sac begins to enlarge. X 345.
46. At the time of fertilization. X 125.
47. Soon after fertilization. X 125.
48. At a considerably later stage. X 125.
49. In embryo just before formation of cotyledons. X 75.
50. In ovule and embryo at a much later stage; (C) columnar cells of seed coat, (V) raphe, (T) tracheid-like cells, (P) reserve proteid. X 75.

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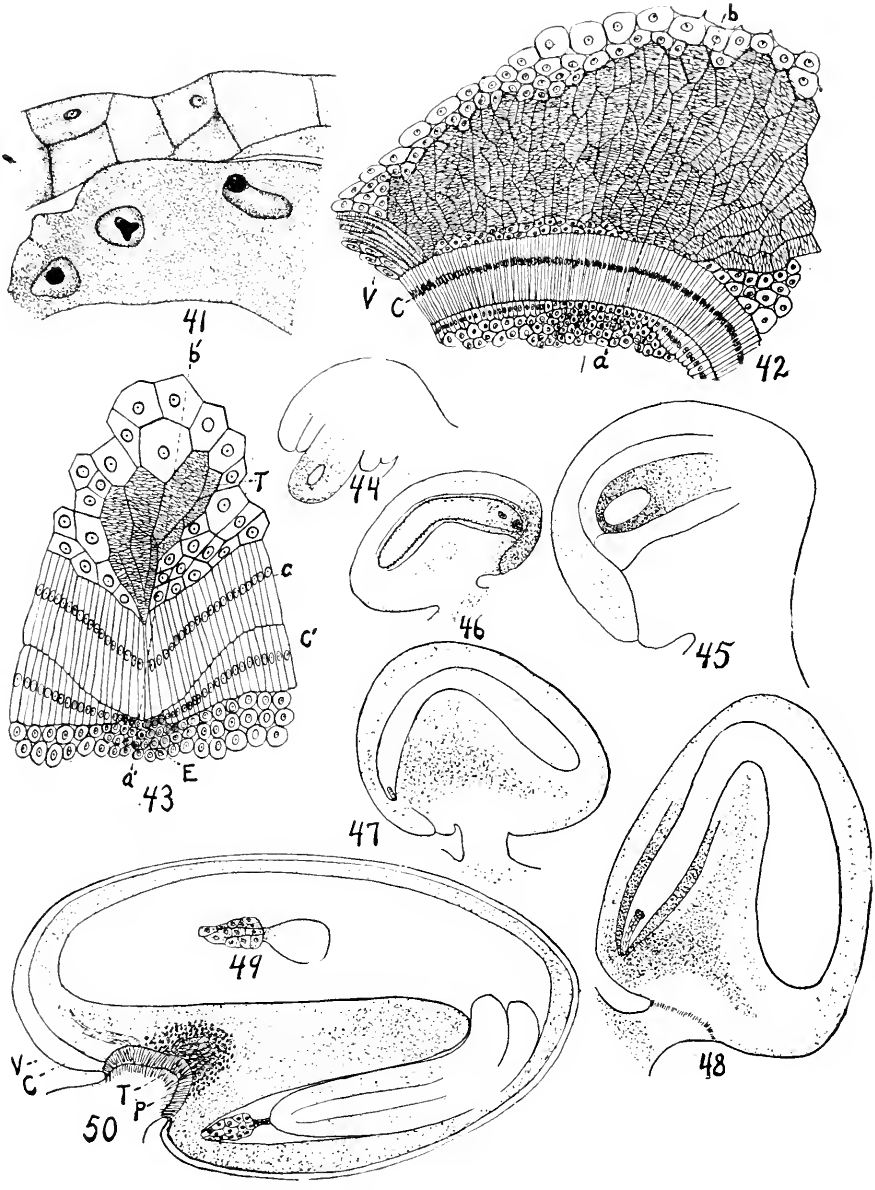
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Oxydase in Wheat Grains.

By Katherine Golden Bitting.

In many seeds the embryo is provided with a store of reserve food formed by the parent plant before the separation of the seed. In the dormant seeds the enzymes are usually in minute quantities as they are not needed, but when the food is needed during the germinative process, the enzymes are more strongly developed, the embryo dveloping itself, and also developing enzymes to provide food in suitable form.

A series of experiments were conducted to determine the enzymes present in dormant wheat seed, and its parts, and also in the germinated seed. The material for the experiments was obtained from a flour mill, and consisted of whole wheat flour, ordinary white flour, bran, shorts, and the unground grain.

Water extracts were made, 60 grams of flour being used with 100 cubic centimeters of distilled water, with the whole flour, and the white flour, 150 cubic centimeters of water with the shorts, and 240 cubic centimeters of water with the bran. The amount of water was varied in order to make them of as nearly as possible equal moisture, the shorts and the bran requiring more than the others. The mixtures were allowed to stand for 12 hours, and were then filtered. Powdered thymol was used to prevent decomposition. Glycerine extracts were also made, but were so much weaker in their action than the water extracts, that they were abandoned.

To determine the changes in enzymic action due to the germinative process, wheat was germinated for different periods, the grain being placed on moist paper under a bell jar, and kept at room temperature. At the end of the given period the grain was pounded in a mortar, then the enzymes were extracted for three days with water to which chloroform was added, after which the extracts were filtered. The periods of germination were three, five, six, and ten days respectively. Fifty grams of wheat grains were used in each case, and for the extraction 200 cubic centimeters of distilled water.

The extracts were slightly acid from the ungerminated grain, as shown by litmus, and more strongly acid from the germinated grains.

In obtaining the extracts from the various parts of the grain, the resulting liquids showed differences in color. The extract from the white flour was colorless, while that from the whole wheat was a straw color, that from the bran was slightly darker, and from the shorts darker still, so that one could recognize the extracts from their colors. The extracts from the germinated wheat grain were a pronounced brown color, the colors varying in depth with the time of germination up to six days, the six days being the darkest, beyond that no differences were appreciable. This was uniform in all the extracts made, so that like the extracts from the parts of the grain, the extracts from the germinated grains could be separated from one another by the degree of discoloration. Then again, sections of the wheat seeds, of the water lily petiole, and of the castor bean stem showed similar degrees of discoloration when placed in the solutions.

To test the oxidation, 5 cubic centimeters of each of the extracts from the different parts of the grain were taken and a few drops of guaiac tincture added, after which they were allowed to stand for some hours. In all there was a blue discoloration, but varying in degree. The white flour extracts showed a faint blue color, the whole wheat extract had a deeper tint of blue, while the bran and shorts extracts showed a decided blue color.

In testing the extracts from the germinated grain, 25 cubic centimeters of each were taken and precipitated with 85 cubic centimeters of 96 per cent. alcohol, then allowed to stand 36 hours, after which the precipitate was filtered off. The precipitate was dried on the filter at 35 degrees C., then redissolved in 25 cubic centimeters of distilled water. These solutions were then tested with the guaiac tincture, and all gave a decided blue color throughout the whole liquid.

The solutions were then tested with hydroquinone and pyrocatechin, polyphenols which are readily oxidized. At the same time for control purposes, equal quantities of the solutions but without the addition of the phenols, and also equal quantities of distilled water plus the phenols, respectively, were kept under similar conditions. The results are shown in the following table:

Extract.	Phenol.	Time.	Color.
Ungerminated............	Hydroquinon	12 hours......	Light reddish brown.
Germinated 3 days	Hydroquinon	12 hours......	Reddish brown.
Germinated 6 days	Hydroquinon	12 hours.....	Deep reddish brown.
Ungerminated............	Pyrocatechin	12 hours......	Reddish brown.
Germinated 3 days	Pyrocatechin	12 hours......	Deep reddish brown.
Germinated 6 days	Pyrocatechin	12 hours......	Deeper reddish brown.
Ungerminated............	....	12 hours......	Pale straw.
Germinated 3 days	....	12 hours......	Deeper shade.
Germinated 6 days	....	12 hours......	Still deeper shade.
Dissolved in water	Hydroquinon	12 hours......	Colorless.
Dissolved in water	Pyrocatechin	12 hours......	Colorless.

The discoloration became apparent in the solutions with pyrocatechin in about 15 minutes, while the same extent of discoloration was not apparent in the solutions with hydroquinon for an hour. The table gives the results at the end of twelve hours, but the solutions were kept for a week. The longer they stood, the darker they became, the hydroquinon being of a wine red color, while the pyrocatechin solutions were of a brown color. At the end ot four days, the six days extract with pyrocatechin was almost black. The experiments were carried on at room temperature. The solutions remained clear, no precipitates forming.

Temperature Tests.

To determine the temperature at which the enzyme was destroyed, the three extracts were heated to 60 degrees C. The tubes containing the extracts were placed in the steam sterilizer, a corresponding amount of water being placed in another tube in which was placed a thermometer. The extracts were kept in the sterilizer for one minute after the thermometer registered 60 degrees C.

Another set was tested but the temperature raised to 100 degrees C. Pyrocatechin was used with the enzyme, as, in the other tests, it gave a more rapid response than the hydroquinon.

60 Degrees C.—A slight darkening was apparent in twenty minutes. The longer they were kept, the darker they became, until at the end of four days they had a rich, deep brown color. They also showed the varia-

tions as to the ungerminated extracts being the lightest, the six days germination extract being the darkest, the three days germination extract being a shade between the two.

100 Degrees C.—These solutions were a little slower in responding, the discoloration not being apparent for 30 minutes, but showed similar discolorations to those extracts raised to only 60 degrees C. At the end of four days they were slightly lighter in shade than the corresponding extracts at 60 degrees C.

100 Degrees C.—To avoid any chance of error, the same quantities of the extracts were again taken, but heated over the direct flame of a Bunsen burner until the solutions boiled vigorously. They were then cooled rapidly in the snow, after which the pyrocatechin was added. At the same time two tubes of distilled water were boiled over the flame, and also had the pyrocatechin added, one being cooled before the addition, the other being quite warm.

The extracts plus the pyrocatechin behaved exactly the same as the extracts heated in the steam sterilizer. The solutions of distilled water plus the pyrocatechin remained clear and colorless.

100 Degrees C.—In the first set of experiments with the extracts from the various parts of the flour, the white flour extract gave the weakest color reaction, seeming to indicate either weakest or smallest quantity of enzyme. An equal quantity to that used in the other experiments was boiled over the direct flame for two minutes. Another quantity was taken but not boiled, both had pyrocatechin added to them. The boiling caused a white precipitate to form.

The discoloration was slow in appearing, it being fully three hours before there was a certainty in regard to it. Then it had a reddish appearance, like apple must when exposed to the air. In twenty-four hours there was a decided red color, but the boiled solution was slightly darker than the unboiled. The unboiled solution also formed a precipitate, both precipitates showing the coloration of the liquids. At the end of three days the color remained the peculiar red, but darker, the beiled one being considerably darker.

There was next tried some white flour extract and some six days germination extract, these two extracts being at the extremes of the discolorations, the former showing the lightest, the latter the darkest in the extracts, and in their action on the phenols. The extracts were placed in the autoclav, and kept until the indicator registered a pressure of ten pounds, the temperature being 112 degrees C. It required thirty minutes to reach this pressure. The solutions were taken out as quickly as possible and cooled in the snow at once, after which pyrocatechin was added to each. The white flour extract had a white precipitate formed by the heat action, but this was an unpurified extract. The six days germination extract remained clear. A slight reddening appeared in the white flour, and a slight darkening in the other. (They were compared with extracts without the pyrocatechin.) This became more marked, the longer the extract stood. At the end of seven days the discoloration was quite marked.

The action of the oxydases is a very interesting and practical subject, as their action explains many puzzling phenomena, which were formerly classed as oxidations, but the cause and conditions of which were unknown. The composition of the oxydases is unknown, and consequently it is impossible to determine the number of oxydases—if there be numbers of them—except by the differences in reactions and conditions. From considering oxidation as a purely physiological process, as exemplified by respiration, and which only took place through vital processes, one has to consider oxidation from the opposite extreme.*

The most common manifestations of the action of oxydases are the discolorations of beets, carrots, apples, and many plant tissues and juices, besides the browning of wines and other liquids. The juice of the plant Rhus vernicifera from which lac varnish is made contains an oxydase which is, perhaps, the most widely known. Many of these have been investigated, and have been found to have certain points in common, though differing in others. They are all susceptible to the reaction of the medium, and also the temperatures at which they are rendered inactive vary within certain limits. The browning of wines is prevented by a temperature between 70 and 80 degrees C. or by Pasteurization at 60 to 62 degrees.† A large number of oxydizing enzymes which are found in different plants and animals are mentioned by Oppenheimer‡, the most resistive of which succumb to boiling temperature.

The enzyme which exists in the wheat grain, both in the quiescent and germinated grains, from the differences in degree of discoloration of extracts, and also action on phenols, exists in least amount in the white

*Pozzi-Escot, M. E. Les Diastases at Leures Applications, 1900.
†Lafar, F. Technical Mycology, p. 401, 1898.
‡Oppenheimer, C. Ferments and their Actions, 1901.

flour, and greatest amount in the shorts, that is, the endosperm has least, and the embryo most. This accounts for the discoloration of flour containing the embryo. The enzyme must be increased in amount or intensity during the process of germination, and up to six days germination, the extracts become darker, and the action on phenols also gives the same degrees of difference. The enzyme is more resistive to heat than those already noted. Bertrand and Bourquelot* say the oxydase extracted from Russula foetens Pers. is so resistive to heat that it has to be boiled some time before being destroyed.

Boutroux† has separated an oxydase from dough by soaking dough with twice its weight of water for half an hour, extracting by means of a press, then clearing by filtering through a Chamberlain filter. The extract was at first clear, then a precipitate formed, after which it turned brown, becoming black in the course of some weeks. His oxydase, however, lost its activity at 100 degrees C.

That the oxydase extracted by Boutroux is identical with the present one extracted from the various flours and grain is very probable. The difference in its resistance to heat may be due to a different kind of wheat, or to influences of environment.

Whether it be necessary to have a diastase present, as is claimed by Raciborski‡, it is impossible to determine, for the methods of separating the oxydases will also cause the separation of diastase and other ferments, and there is no known method of separating the majority of enzymes from one another.

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*Green, J. H. The Soluble Ferments and Fermentation, 1901.

†Boutroux, L. LePain et la Panification, 1897.

‡Raciborski. Ber. der deut. bot. Ges. XVI. 119, 1898.

Cytase in Wheat Grains.

By Katherine Golden Bitting.

The presence of cytase was tested on sections of the wheat grain, the petiole of the water lily, *Nymphae odorata*, and the stem of the castor bean, *Ricinus communis*. The cells of the endosperm of the grain were so full of starch granules that the changes in the walls were difficult to see. In the other sections there is considerable collenchyma developed, which is very clear and distinct, and any changes in its structure are easily followed. The extracts from the ungerminated grain, and from three to six days germinations were the ones which gave the most satisfactory results.

The first tests were made using hollow chambers in slides, so that the changes might be followed under the microscope. These proved unsatisfactory as the section went to the bottom of the chamber and only the low powers could be used. Preparation dishes were then used, 5 cubic centimeters of the extract being used and chloroform for an antiseptic, with the sections immersed. A control was also kept, using distilled water instead of an extract. After three days the following changes were noted:

Water Lily Extract, ungerminated seeds—

Collenchyma. Thickened walls much swollen, middle lamella distinct, like a bright thread through thickening.

Parenchyma. Walls swollen, middle lamella distinct, intercellular spaces nearly obliterated.

Xylem. No change.

Water Lily Extract, three days germination—

Collenchyma. Thickened walls nearly fill cavity of cells, cavities showing as narrow canals.

Parenchyma. Walls swollen.

Xylem. No change.

Water Lily Extract, six days germination—

Collenchyma. Structureless mass, separate cells indistinguishable.

Parenchyma. Cells entirely separated, middle lamella gone.

The sections were so badly disorganized in this last that they could not be transferred to a slide. The observations were made on the remnants.

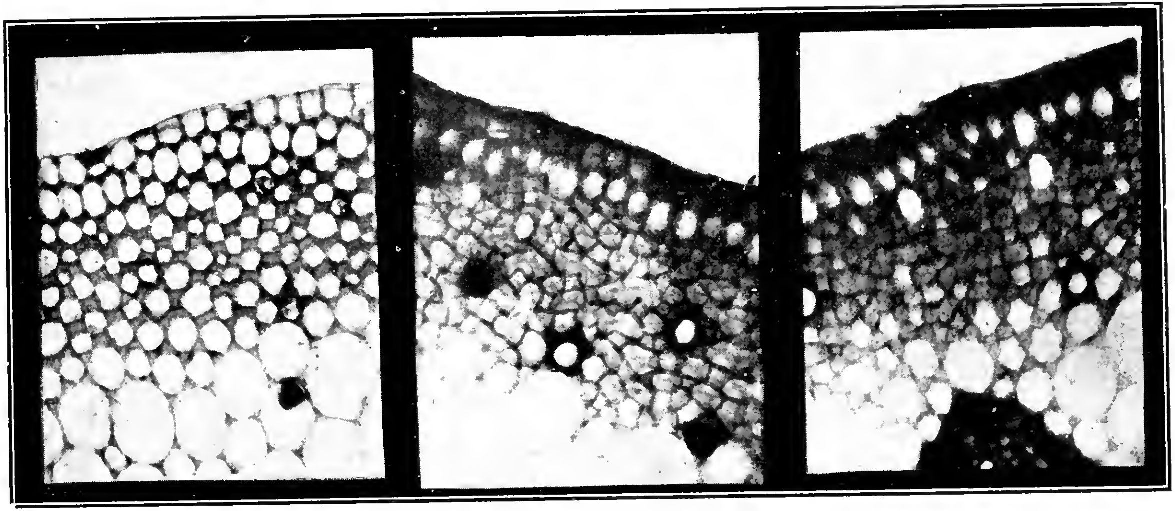
The castor bean is more resistive to the action of the cytase than is the water lily. The tissues of the castor bean showed practically the same effects as those of the water lily, but not quite so advanced.

The endosperm of the wheat sections was more susceptible to the action of the cytase than were the other sections. In the three days germination extract, parts of the endosperm had dropped out, so the sections could not be disturbed, while in the six days extract, only remnants were left adhering to the aleurone layer. The aleurone layer and the outer coats were unaffected. The middle lamella of the cells was attacked first, as was shown by the cells separating whole from one another.

Sections were tested in the extracts from the flours, but were acted on more slowly than those outlined, the white flour extract giving in nine days, results equal to those obtained from the ungerminated extract in three days.

The sections were made from alcoholic material, so that there was no protoplasmic action. Chloroform was used to prevent bacterial growth.

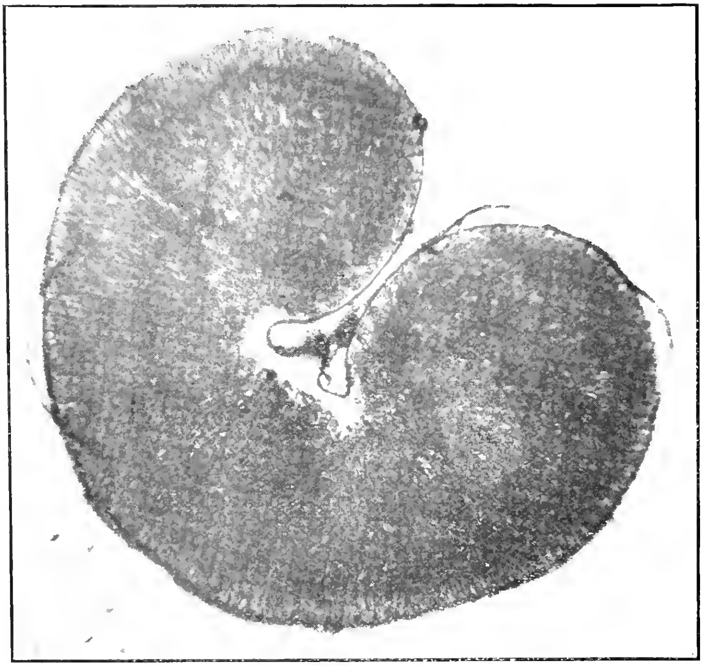
Seeds which had germinated for varying numbers of days were sectioned. In these, action was not so far advanced as in the sections placed in the extracts. For instance, seeds germinated for six days, when embedded in paraffin, and cut on the microtome, parts of the endosperm still remained as a granular mass.



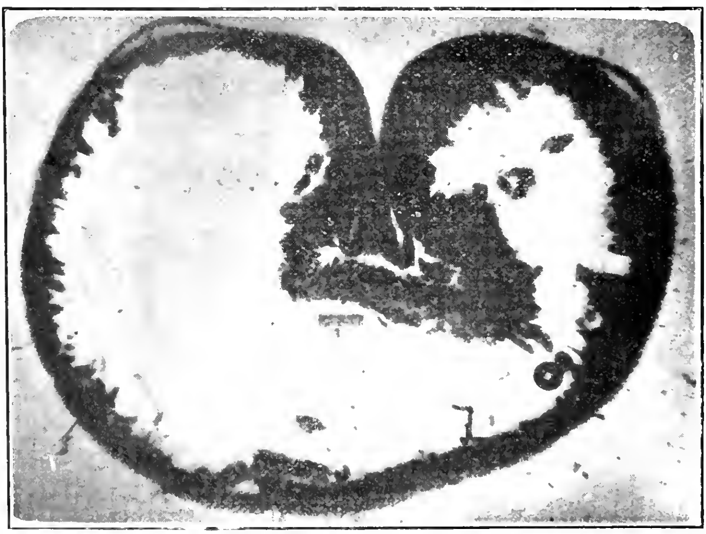
Collenchyma treated with Cytase.

1. Normal. 2. Three days action. 3. Five days action.

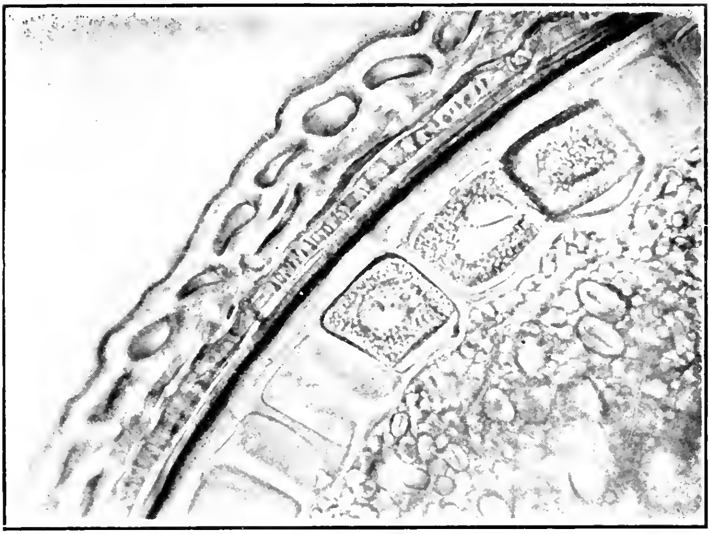
Sections of wheat grain treated with cytase.



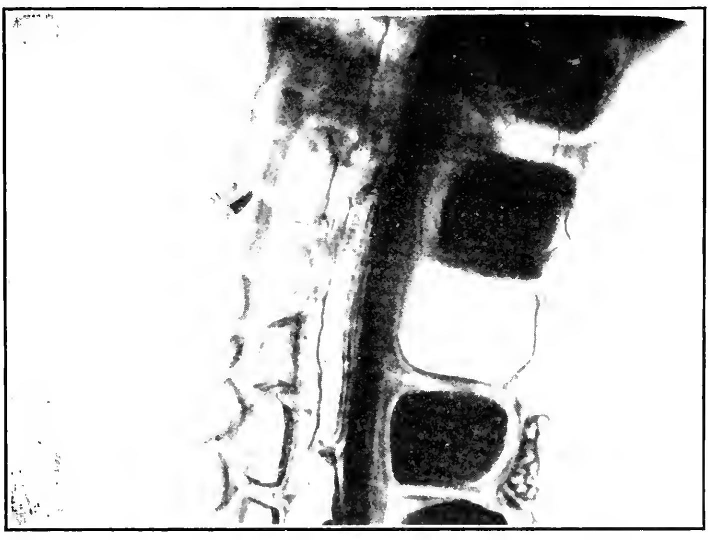
1. Section before treatment.



2. Section after treatment.



3. Section before treatment, showing outer coats and aleurone layer.



4. Section after treatment, showing outer coats and aleurone layer.

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

(PAPER NUMBER THREE.)

By Charles Piper Smith.

Since offering my second paper under the above heading, my friend, Mr. Harley H. Bartlett, has been able to come to definite conclusion concerning certain of our Indiana collections not worked upon in time for inclusion in my last report. As before, his decisions are the result of careful study and comparison at the Gray Herbarium, where he has received the assistance of Mr. Fernald and Dr. Robinson whenever occasion demanded. Through the kindness of Dr. Schneck, Mr. Bartlett has had the pleasure of examining that gentleman's specimens of the genus Juncus, and I comply with my friend's request to note certain facts gleaned from his study of this interesting collection.

Specimens verifying these records are in the herbarium of Mr. Bartlett, except in the cases where it is specifically stated that no specimens were preserved.

Sorghum Halepense (L.) Willd. (Marion County.)

Occasional about Indianapolis. Included in the State Catalogue,* but no definite station noted. Taken August 20, 1904, by Mr. Bartlett.

Cyperus rivularis Kunth. (Marion County.)

Taken along Fall Creek, August 20, 1903, by Mr. Bartlett. In sandy soil; rare.

Carex pallescens L. (Madison County.)

A sedge so named by Mr. Bartlett was taken by me August 10, 1904, at a springy place by the File Works, Anderson. As this species is not recorded from Indiana, additional material is desired, since the material preserved is limited to the fruiting heads and perigynia in my seed collection.

Carex cephaloidea Dewey. (Tippecanoe County.)

Mature fruit of a sedge was obtained by me June 7, 1904, along the "Monon," just south of Lafayette. The characters of the whole plant were noted and later the material was referred to this species,

*Flowering Plants and Ferns of Indiana in State Geol. Report, 1899; 626.

by use of Britton and Brown's Flora. Specimens were not preserved, but the material placed in my seed collection has been worked upon by Mr. Bartlett, who reports that as far as can be determined from the fruiting heads and perigynia alone, my determination is correct. Only three or four tussocks of this sedge were noted, and the plant may owe its presence there to railroad introduction. The species has not been reported from the State.

Carex cephalophora Muhl. (Marion, Madison and Delaware Counties.)

Taken by me in these counties in 1904. Kosciusko and Vigo seem to be the only other counties from which this species is recorded.

Carex festucacea Willd. (Pulaski County.)

Mature fruit, etc., so determined by me was taken one mile south of Ripley post-office. Mr. Bartlett reports that this determination also seems to be correct. The sedge was abundant along ditches by the roadside, and ought to be common elsewhere in the State, although as yet unrecorded.

Juncus tenuis anthelatus Wiegand. (Posey County.)

Plants so determined by Mr. Bartlett were sent to him by Dr. Schneck, by whom they were collected June 7, 1881.

Juncus monostichus Bartlett.* (Madison County.)

This species was described from material collected by the writer August 6, 1904, south of Anderson. Using Britton and Brown's Flora, I could not identify the plant, but thought that it might be J. secundus Beauv. or J. dichotomus Ell. I turned the material over to Mr. Bartlett, who found it most nearly related to J. Greenei Oakes & Tuckerman, as shown by its seed characters. Since the original description was published, Mr. Bartlett has found that capsules of the type contain at least as many as thirty seeds, which means a greater productiveness than at first supposed. (C. P. Smith No. 140, in Herb. Bartlett and Gray Herb.)

Juncus dichotomus Ell. (Posey County.)

Of the Schneck Junci, the only Wabash Valley plant labeled J. dichotomus proved to be immature J. tenuis, so this species should be dropped from the State Catalogue (p. 675).

Juncus brachycarpus Engelm. (Wabash County, Ill.)

In Dr. Schneck's collection, from Mt. Carmel, Ill. Should be looked for on the Indiana side of the river.

*Rhodora, 8: 50, 1904.

Nasturtium sessiliflorum Nutt. (Tippecanoe and Marion Counties.)
Reported in State Catalogue (p. 767) as "occurring only in the southwestern counties." I found it abundant over several acres of the Wabash bottom-land south of Lafayette, June 2, 1903. Mr. Dorner and I found also a few stray plants along the stream in "Happy Hollow," West Lafayette, later in the same month and year. The plants were all matured and through blooming at these dates. Mr. Bartlett took the species July 30, 1904, near Indianapolis, the flowering period being then about over.

Cardamine parviflora Pursh. (Clark County.)
Found on the "Knobs" of the State Forest Reservation, May 26, 1904. Plants on exposed knob-tops and slopes were simple or nearly so and from one to three inches high. In more shaded spots, lower down, were much-branched plants three to ten inches high. (C. P. Smith No. 118, in Herb. Bartlett.)

Cardamine flexuosa With. (Tippecanoe and Marion Counties.)
Not in the State Catalogue, but may have been reported at the last meeting of the Academy, of which the "Proceedings" have not yet reached me. Taken near Lafayette by Miss Gates, Mr. Dorner, and myself, in May 1903. Taken about the same time, near Indianapolis, by Mr. Bartlett. In looking through a collection made several years ago, near Indianapolis, Mr. Bartlett noted one sheet of this plant labeled "Sisymbrium officinale."

Agrimonia pumila Muhl. (Marion County.)
Taken by Mr. Bartlett August 14, 1904, near Indianapolis. This adds to my Clark County record of 1903.* Mr. Bartlett thinks that this so-called species is a mere depauperate form of A. microcarpa Wallr. I at first considered my Clark County plant to be a form of A. mollis (T. & G.) Britton, with which I found it growing.

Lupinus perennis occidentalis Wats. (Laporte County.)
This is the form about Michigan City. Taken June 18, 1904; determined by Mr. Bartlett, and verified by Dr. B. L. Robinson. The typical L. perennis L. was taken by me between Mishawaka and South Bend, June 17, 1904 (No. 126). The variety blooms a little later than the type. (C. P. Smith No. 130, in Herb. Bartlett.)

*Proc. Ind. Acad. Sci., 1903; 134.

Oxalis cymosa Small. (Marion County.)

This is the common "sour-grass" about Indianapolis. O. stricta L. is also present, but is rather rare.

Gaura parviflora Dougl. (Marion County.)

Just before leaving Indianapolis, September, 1904, I ran across what is believed to be this species along Harding Street between the Terre Haute divisions of the Big Four and the Vandalia Lines. The plant was abundant and conspicuous. It was in fruit and it took some search to get even a belated sprig with a few flowers; but such was obtained and referred to Britton and Brown's Flora, the identification seeming to be unquestionable. Specimens were not preserved, except the mature fruit which is now in my seed collection. This species is native from Nebraska and Oregon to Mexico, and belongs to the list of western plants brought eastward by the railroads. Its abundance at this place indicated that it would hold its own if not soon exterminated by building and street improvement.

Sanicula trifoliata Bicknell. (Marion County.)

Taken by Mr. Bartlett July 4, 1903. Reported from Indiana by Britton and Brown, but not included in the State Catalogue. Mr. Bartlett comments, "This plant grows on river bluffs and wooded hillsides, whereas S. Canadensis is generally found in wooded bottom-land. The two species appear to intergrade somewhat with one another, but never, so far as observed, with S. Marylandica."

Apocynum cannabinum glaberrimum DC. (Marion County.)

Confined to gravel shores along White River. Taken August 24, 1903, by Mr. Bartlett.

Ruellia ciliosa Pursh. (Madison County.)

Specimens taken along White River, at Anderson, August 6, 1904, have all the leaves verticileate in threes. Such variation from strictly opposite leaves is very rare in the Acanthaceae. (C. P. Smith No. 141, in Herb. Bartlett.)

Galium Claytoni Michx. (Marion County.)

Taken July 10, 1904, by Mr. Bartlett, near Indianapolis.

Vernonia Drummondii Schuttlw. (Marion County.)

Taken at Mallott Park, August 14, 1904, by Mr. Bartlett. This is a State record and eastward extension of range.

The Direction of Differentiation in a Regenerating Appendage.

By Charles Zeleny.

(Abstract.)

When an appendage possessing the power of regeneration is removed a proliferation of new cells takes place at the cut surface. At first the structures of the new appendage can not be recognized in this cell mass, but gradually the various parts appear. The problem presented for solution is the determination of the manner of this differentiation. Do all the parts of the new appendage appear simultaneously? If not, is the progression of the differentiation from the tip inward, from the base outward, or from the middle toward both ends? Or finally, is the method more complex than any one of these?

The antennule of the common brook sow-bug (Asellus) was chosen as a suitable object for the study of the problem because the structural differences in its various segments are unusually great. A study of the early stages of the regeneration shows that the first segmental partitions appear at the base. These are followed very soon by others at the tip, and from this time on the new segments appear near the middle of the organ. The region of new growth is then located in one of the middle segments. Differentiation therefore proceeds from both base and tip toward the middle of the appendage.

An examination of the growing antennule of young animals shows the same method of development.

The Regeneration of an Antenna-like Organ in Place of the Vestigial Eye of the Blind Crayfish.

By Charles Zeleny.

(Abstract.)

The right eye stalk was removed in nine specimens of the blind crayfish. A year after the operation three were alive. Two of these showed no regeneration, but the third had developed an antenna-like organ in place of the removed one. The new organ consists of a slender feeler-like process covered with hairs and has the appearance of a functional tactile organ. The terminal third is unsegmented but the basal two-thirds is divided into segments.

The result is of interest because it furnishes the only instance as far as I know of the development of an apparently functional organ in place of a removed non-functional one.

CAMPOSTOMA BREVIS.

By J. D. HASEMAN.

July 29, 1904, a class from the Indiana University Biological Station took a trip to the Wabash River to a point three miles above Wabash, Indiana. On examining the material I found, among many specimens of Campostoma, that seven were different from the common species, anomalum.

Later, I took a similar specimen from Deed's Creek, which is a small tributary to Tippecanoe River, three miles north of Winona Lake.

Type; a specimen 7.5 cm. long to base of caudal. No. —— I. U., Wabash River.

Cotype; a specimen 9.25 cm. long to base of caudal. No. —— I. U., Wabash River.

Cotype; a specimen 8.1 cm. long to base of caudal. No. —— I. U., Wabash River.

Cotypes; 2 specimens 6.5 cm. long to base of caudal. No. —— I. U., Wabash River.

Cotype; a specimen 7.8 cm. long to base of caudal. No. —— I. U., Wabash River.

Cotype; a specimen 7 cm. long to base of caudal. No. —— I. U., Deed's Creek.

D. 8; A. 7; scales 7-53-6; 22 scales before the dorsal; lateral line complete (50 or 51 pores) equidistant from the dorsal and ventrals; depth equals the length of the head and is contained 4.25 times in length of body; eye 4-5 in head; a large anal papilla; a breast plate between ventrals; a dark band in middle of dorsal and a faint one in anal; the alimentary canal is about 2½ times the length of body.

The scales are more readily deciduous in anomalum than in the new species, and anomalum is a little darker and has a darker peritoneum than "brevis." The alimentary canal of the new species is not half as long as that of anomalum and almost twice the diameter.

Comparison of Brevis and Anomalum.

	Campostoma brevis.	Campostoma anomalum.
Length of body to base of caudal	82 mm.	81.5 mm.
Length of head	19 mm.	19 mm.
Diameter of eye	4.5 mm.	4.5 mm.
Length of pectoral	14.5 mm.	16 mm.
Length of ventral	11.5 mm.	12 mm.
Length of anal....	13 mm.	13 mm.
Length of dorsal	15.5 mm.	15.5 mm.
Length of snout..............	7 mm.	7 mm.
Rays in dorsal	8.	8.
Rays in anal	7.	7.
Scales along lateral line	56 scales and 52 pores. The 93 mm. specimen and all others have 53 scales.	53 scales and 51 pores.
Back of eye to origin of anal.........	47 mm.	47 mm.
Greatest depth of body	18 mm.	20 mm.
Diameter of alimentary canal	1.5 to 2 mm.	1 mm.
Length of alimentary canal	150 mm.	360 mm.*
Folds on or about alimentary canal ..	About 11 longitudinal folds.	About 20 circular folds.

*In a 72 mm. specimen I got the entire intestines in a continuous string, which was 530 mm. long.

The chief differences between this species and anomalum are the length, character and arrangement of the alimentary canal. It may be named brevis in allusion to its comparatively short alimentary tract. The intestines of anomalum are always dark and break quite easily, while those of the new species are white and not so fragile. The intestines of anomalum contain principally mud, while those of the new species contain practically no mud; they are also more solid and wrapped up in fatty tissue. The alimentary canal of anomalum wraps around the air bladder many times, while the alimentary canal of brevis does not go around the air bladder more than one to two times; and the other folds are not spiral but longitudinal. The eyes are not quite as dark (in two fresh specimens I observed a reddish tinge in upper edge of the eye). Compared with anomalum, the tail of the new species is a little stouter and its mouth is a little larger and more terminal, and the abdomen is not so thick. It has no dark vertebral line; no distinct opercular spot; and the lateral line is more distinct and passes over and under the eyes. But, as before stated, the main difference is in the alimentary canal.

Anomalum is certainly a mud-eater, while the diet of brevis is not altogether confined to mud; some had grassy substances in their alimentary canals. The difference is not a sexual difference. I examined several males and females of anomalum, and all of them had the peculiar arrangement of the alimentary canal of the typical anomalum. Number 8095 of Indiana University Museum is identical with the new species. It was taken in Tennessee by S. E. Meek, and was not examined internally.

Notes on Some New or Little-Known Members of the Indiana Flora.

By Guy West Wilson.

In preparing the present paper all notices of species of general and well known distribution in the State have been omitted and only those of more particular interest included. These plants naturally fall into three groups: first, those which have not previously been recorded as members of our flora; second, those which have been recognized as members of our flora since the publication of Dr. Coulter's Catalogue; third, those which are recognized in that catalogue, but known only from a limited region of the State or from a very few localities.

The nomenclature adopted is that of Britton's Manual. Synonyms are given only in case of species which bear a different name in Gray's Manual from that employed here, or which have been previously reported from the State under another name. The twenty-seven species which are recorded for the first time as members of the Indiana flora are marked with an asterisk (*).

1. *Lycopodium porophilum* Lloyd & Underwood. Rock Club-moss.

The only reference in any paper on the Indiana flora to this species is by Dr. Coulter in the Proceedings of the Academy for 1901 (p. 301), where the distinguishing characters of this species and its range are quoted from Britton's Manual with the following remark: "The familiarity of Dr. Underwood with the Pteridophytes of the State places this reference beyond question." There is a specimen of this species in the Herbarium of DePauw University, which was collected by Dr. MacDougal and originally labeled L. selago. The specimen was collected at Fern, Putnam County, where the plant grows sparingly on sandstone cliffs in company with L. lucidulum. This is the type locality of this species.

2. *Canadensis Marsh Taxus.* American Yew.

"Found only in Putnam County, associated with *Tsuga canadensis*," according to the State Catalogue (p. 618). A specimen in the herbarium of the Eli Lily Company, collected by Walter H. Evans, extends its range to the southern part of Montgomery County.

3. *Echinodorus cordifolius* (L.) Griesb. Upright Bur-head.

"Reported only from the southern part of the State and probably not extending far northward, as the species is southern in its mass distribution." (State Catalogue, p. 624.) The only citation given is Vigo County. This species occurs in abundance in a wet river bottom in Tippecanoe County, where it was collected in midsummer.

*4. *Panicum capillare gattingeri* Nash.

Hamilton County, with the typical form. Probably of wider distribution in the State.

5. *Chaetochloa verticillata* (L.) Scribn. (Ixophorus v.) Fox-tail Grass.

In waste places about dwellings, Tippecanoe County. Previously reported only from Marion County. (State Catalogue, p. 630.)

6. *Aristida oligantha* Michx.

Common along the Monon Railroad in Putnam County, growing in sandy soil. "Found in the counties bordering on the Ohio and lower Wabash rivers." (State Catalogue, p. 633.) Probably a railroad migrant, but now well established.

*7. *Bromus purgans* L.

Putnam County, in thickets. In his elaboration of the Gramineae for Britton's Manual Nash has included this species with B. ciliatus, from which it is easily distinguished by having the flowering glumes pubescent throughout, remarking that "the form known as var. *purgans* * * * may be distinct." Later he has separated the two species in Small's Flora of the Southern States. Probably of general distribution in the State.

*8. *Bromus erectus* Huds. Upright Brome-grass.

Tippecanoe County. This is the determination by the Bureau of Plant Industry of a specimen sent by Mr. Fisher of the Experiment Station during the present season.

9. *Bromus tectorum* L. Downy Brome-grass.

Putnam County, common along railroads and in waste places. Previously reported from Lake, Madison and Tippecanoe counties. (Proc. Ind. Acad. Sci. 1900: 137; 1904: 301.)

*10. *Lolium temulentum* L. Darnel.

Tippecanoe County. Streets of Lafayette, apparently introduced with grass seeds.

11. *Hordeum pusilum* Nutt. Little Barley.

Putnam County, common in waste places about towns. Previously reported from Tippecanoe County by Dorner. (Proc. Ind. Acad. Sci. 1903: 118.)

12. *Cyperus rivularis* Kunth. Shining Cyperus.

Putnam County, along streams. Previously reported "only from the northern part of the State * * * Round Lake (Deam.)." (State Catalogue, p. 649.)

13. *Kyllinga pumila* Michx.

Putnam and Tippecanoe counties. Vigo County is the most northern locality from which this species is recorded in the State Catalogue. (p. 651.)

*14. *Scripus cyperinus eriophorum* (Michx.) Britton.

Hamilton County, in swamps.

15. *Eriophorum polystachyon* L. Tall Cotton-grass.

"Occurring in very wet grounds in Putnam County, upon the authority of Dr. MacDougal. So far as has come to my knowledge, the only record for the State." (State Catalogue, p. 655.) The specimen in the herbarium of DePauw University which should verify this citation is *Scripus cyperinus*. The species is to be retained as a member of our flora, however, as it has been collected in Lake County by E. J. Hill.

16. *Carex lupuliformis* Sartwell.

Hamilton County. Previously reported only from the lake region of northern Indiana. (State Catalogue, p. 658.)

17. *Carex retrorsa* Schwein.

Hamilton County. Previously reported only from the southwestern part of the State. (State Catalogue, p. 658.)

*18. *Carex typhnoides* Schwein. Cat-tail Sedge.

Hamilton and Tippecanoe counties in swamps. A beautiful sedge which has probably been confused with *C. squarrosa*, as the present species is not given in Gray's Manual. The material from the two localities shows quite a wide range in the size of the spikes, the latter being short enough to suggest a large head of *C. squarrosa*, while the former are long enough to suggest a small cat-tail flag.

*19. *Carex prasina* Wahl. Drooping Sedge.

Putnam County, in wet woods and along streams.

*20. *Carex amphibola* Steud. Narrow-leaved Sedge.

Hamilton and Putnam counties, in dry soil.

21. *Tradescantia brevicaulis* Raf. Low Spiderwort.

Putnam County, on the brow of dry hills. Previously reported from Tippecanoe County by Dorner. (Proc. Ind. Acad. Sci. 1903: 118.) These citations materially extend the range of this species, which is given by Britton as Illinois, Kentucky and Missouri.

*22. *Tradescantia reflexa* Raf. Reflexed Spiderwort.

Tippecanoe County, along the Wabash Railroad east of Lafayette, where it is well established. Probably a railroad migrant, as its mass distribution is western. This species is easily distinguished from its relatives by its bluish, glaucous vegetation.

23. *Juncus bufonius* L. Toad Rush.

Hamilton, Putnam and Tippecanoe counties, common in wet places along streets and highways. Previously reported only from the northern part of the State. (Proc. Ind. Acad. Sci. 1900: 138.)

*24. *Juncus dudleyi* Wiegand. Dudley's Rush.

Hamilton County, in wet places. With the habit of J. tenuis, from which it is readly distinguished by the yellowish, cartilaginous margins of its leaf sheaths, the latter species having whitish, membranous margins.

*25. *Juncus secundus* Beauv. Second Rush.

Putnam County, very rare in dry pastures. The mass distribution is east of the Allegheny Mountains, and its occurrence inland by no means frequent.

26. *Hemerocallis fulva* L. Day Lily.

Tippecanoe County, along small streams. No locality in the northern half of the State is given for this species in the State Catalogue. (p. 679.)

27. *Populus grandidentata* Michx. Great-toothed Aspen.

Clay, Hamilton and Putnam counties. The former citation is based on a specimen in the herbarium of DePauw University which was collected by Dr. MacDougal, while the other two are from personal collections. According to the State Catalogue (p. 701) this tree has been reported only from the lower Wabash Valley.

28. *Humulus lupulus* L. Hop.

This species is given in the State Catalogue as an escape from cultivation, which is doubtless true of some of the stations of this plant within the State. In other localities it is evidently a native. Among these is a region of very low bottom land near White River in Hamilton County, where wild hops of a good quality are by no means rare. Some of the older residents of the county say that in the days when the greater part of this region was still unsettled that annual trips were made to the swamps of this region for the purpose of gathering the family supply of hops. This region furnished the hop vines which are still growing at some of the older homesteads.

*29. *Humulus japonica* Sieb. & Zucc. Japanese Hop.

Tippecanoe County, about dumps in Lafayette, where it produces seeds freely.

30. *Asarum acuminatum* (Ashe) Bicknell.

Putnam County, with *A. canadensis* and of about equal abundance. First recorded as a member of our flora by Mr. Dorner, who collected it in Tippecanoe County. (Proc. Ind. Acad. Sci. 1903: 118.)

31. *Chenopodium murale* L. Nettle-leaved Goosefoot.

Hamilton County. This weed has been introduced into the country districts in the packing of grocery boxes. It is also quite common in waste places about towns. Previously reported from Tippecanoe County by Mr. Stewart. (Proc. Ind. Acad. Sci. 1901: 283.)

32. *Atriplex patula* L. Spreading Orachne.

Hamilton, Marion and Tippecanoe counties. In the first two counties this is a common weed along country roads while it is very common in waste places about Indianapolis and Lafayette. According to Britton's Manual this species is confined principally to the eastern states. Previously reported from Marion and Steuben counties. (Proc. Ind. Acad. Sci. 1904: 303.)

*33. *Atriplex hortense* L. Garden Orachne.

Hamilton County, growing in waste places about towns.

34. *Allonia nyctaginea* Michx. Wild Four-o-Clock.

Tippecanoe County. Well established along the Wabash Railroad both east and west of Lafayette. Previously reported from Hamilton, Putnam and Marion counties. In all the localities which have come under my observation this is truly a railroad weed. (State Catalogue, p. 733, Proc. Ind. Acad. Sci. 1904: 223.)

35. *Fumaria officinalis* L. Fumitory.

Putnam County. Previously reported only from the eastern part of the State. (State Catalogue, p. 763.)

*36. *Lepidium campestre* (L.) R. Br. Field Cress.

Putnam County, roadsides.

37. *Sisymbrium altissimum* L. Tumbling Mustard.

Hamilton, Putnam and Tippecanoe counties. The first notice of this species in Indiana occurs in the Proceedings of the Academy for 1901 (p. 300) where it is reported by Dr. Hessler as "growing along the State Line Railroad east of Lake Cicott, Cass County," and by H. W. Clark from Marshall County. In the Proceedings for 1903 (p. 134) Mr. Smith reports that a single specimen was taken along the Monon Railroad near the State Fair Grounds at Indianapolis. These records point to a wide distribution over the State as a railroad weed. This is one of the most important migrants which has entered our State in recent years, as it is one of the worst weeds of the grain fields of the northwest. So important indeed is this weed that it has received considerable attention both in experiment station and government publications. The station in Tippecanoe County indicates that the species has probably been brought in with grain, as it is found along the switch by one of the elevators.

38. *Barbarea stricta* Andrz.

This species is admitted to the State Catalogue on the authority of Dr. MacDougal, who reported it from Putnam County, but on account of range probabilities "it is somewhat doubtfully included." (State Catalogue, p. 766.) This species is quite abundant along a small stream in the central part of Putnam County.

39. *Roripa sinuata* (Nutt.) A. S. Hitchcock.

This species is also admitted to the State Catalogue tentatively on the authority of a specimen collected in Putnam County by Dr. MacDougal. (State Catalogue, p. 766.) This species is well established at a single station on the Big Four Railroad west of Greencastle where it has been able to maintain itself for the past fifteen years.

40. *Cardamine pennsylvanica* Muhl. Smooth Bitter Cress.

Previously reported by C. C. Deam from Wells County. (Proc. Ind. Acad. Sci. 1900: 139.) This species is probably of general occurrence throughout the State, but has been confused with *C. hirsuta*, from which it differs in the entire absence of pubescence. The reference to the latter species from Hamilton and Putnam counties in the State Catalogue (p. 768) should be transferred to the species under consideration as all the material in the herbarium of DePauw University and in my own collection from these localities belongs here. I have been unable to find a single specimen of *C. hirsuta* in either county.

*41. *Coringia orientalis* (L.) Dumort. Hare's Ear. *Treacle Mustard*

Putnam and Tippecanoe counties, along the Monon Railroad.

*42. *Heuchera hirsuticaulis* (Wheelock) Rydb. Hirsute Heuchera.

Putnam County, in dry woods and thickets. This species is intermediate between *H. villosa* and *H. americana*, from the former of which it is easily distinguished by the shallow, rounded lobes of its leaves, and from the latter by its hirsute scape. Previously reported from Steuben County. (Proc. Ind. Acad. Sci. 1904: 220.)

43. *Ribes gracile* Michx. Missouri Gooseberry.

Hamilton and Marion counties. This species is by no means common in this portion of the State. Previously reported from Vigo, Tippecanoe and Kosciusko counties. (State Catalogue, p. 778.)

44. *Ribes rubrum* L. Red Currant.

Putnam County, sparingly escaped from cultivation.

45. *Fragaria americana* (Porter) Britton. American Strawberry.

Putnam County, in hilly woods. Previously reported from Wells County by Mr. Deam. (Proc. Ind. Acad. Sci. 1900: 140.)

*46. *Potentilla sulphurea* Lam. Rough-fruited Cinquefoil.

Putnam County, streets of Greencastle and adjoining pastures, apparently introduced in lawn grass seed and now well established in a limited area.

*47. *Rosa arkansana* Porter. Arkansas Rose.

Putnam County. This western rose is established at a number of points along the embankment of the Big Four Railroad east of Greencastle.

*48. *Pyrus communis* L. Scrub Pear.

Hamilton and Putnam counties, in red clay soil. Within the course of a few years abandoned fields in the hill counties are covered with a growth of blackberries, hickory and pears. Fruiting trees are not uncommon.

*49. *Amygdalis persica* L. Peach.

Putnam County. A number of bearing trees are to be found about the dumps and in the woods where seeds have been thrown.

50. *Babtisia tinctoria* (L.) R. Br. Wild Indigo.

Tippecanoe County. A single plant of this species was found late in the fall at the brow of a hill in company with *Andropogon* and *Lithospermum*. The only locality given in the State Catalogue is Steuben County. (p. 799.)

51. *Geranium pusilum* Burm. f. Small-flowered Cranes-bill.

In the Proceedings of the Academy for 1903 (p. 118) Mr. Dorner says: "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." The station in question appears to be well established and spreading, exterminating the grass.

*52. *Oxalis corniculata* L. Yellow Procumbent Wood-sorrel.

Putnam County, along the Big Four Railroad west of Greencastle. Britton gives the range of this species as "in ballast about eastern seaports, and frequently growing on the ground in greenhouses * * * Recently found in Ontario." The plant is also found in the warm regions of both hemispheres.

53. *Hypereum maculatum* Walt. Spotted St. John's-wort

Hamilton County. Previously reported from Steuben and Marion counties. (State Catalogue, p. 839; Proc. Ind. Acad. Sci. 1903: 134.)

54. *Sarothra gentionoides* L. Pine-weed.

Fulton County. Material collected by Dr. Underwood is in the herbarium of DePauw University.

*55. *Viola palmata sororia* (Willd.) Pollard.

Putnam County, in rich woods.

*56. *Viola papilionacea domestica* (Bicknell) Pollard. Field Violet.
Putnam County, in cultivated fields. Not common.

57. *Passiflora lutea* L. Yellow Passion Flower.
Putnam County, on the embankment of the Big Four Railroad west of Greencastle. The most northern record for the State. (State Catalogue, p. 846.)

58. *Onagra biennis grandiflora* (Ait.) Lindl. (Oenothera b. g.)
Putnam County, along the Big Four Railroad. The only previous mention of this species in the State is found on page 179 of the Proceedings of the Academy for 1901, where it is recorded that "a patch, probably of recent introduction, of var. grandiflora was found in moist ground near Warsaw."

59. *Anogra albicaulus* (Pursh.) Britton. Prairie Evening Primrose.
Tippecanoe County. The State Catalogue (p. 852) classes this species as "an exceptional form occasionally occurring in the southern counties. Its northern limit in the State seems to be Hamilton County." This showy flower was collected at two stations in the vicinity of Lafayette the past summer. It was rather abundant in a meadow east of the city and several plants were found along the Belt Railroad about a mile distant.

60. *Circaea lutetiana* L. Enchanter's Nightshade.
The texts with one accord speak of the plants of this genus as white flowered. This, however, is inaccurate, as the present species shows a marked variation in this respect. While the flowers are typically white there are all the intermediate shades up to a bright pink. The first part of the flower to change its color is the outside of the sepals, then the entire sepal, and last of all the petals. Dr. Coulter tells me that he has seen this form rather frequently in this State and in New York during the past summer. I have collected the red flowered form in a single locality in Hamilton County.

61. *Anagallis arvensis* L. Poor Man's Weatherglass.
Putnam County. A specimen of this species collected in Putnam County by Miss Amelia Ellis is in the herbarium of DePauw University. The most northern record given in the State Catalogue is Monroe County. (P. 873.)

62. *Obolaria virginica* L. Pennywort.
Putnam County, on a wooded hillside. The most northern locality previously reported in the State is Vigo County. (State Catalogue, p. 879.)

63. *Gonobolus leavis* Michx. (Ampelinus alibidus (*Nutt*) *Britt.;* Enslenia a.) Climbing Milkweed,
Hamilton and Tippecanoe counties. "Confined to the southern counties, its northern record being Vigo County." (State Catalogue, p. 884.) Each of these stations is of interest, as they very materially extend the range of this species in the State. The Hamilton County locality was in an abandoned roadway which had in latter years become a fence row. The soil is red clay and the locality about a mile from the river. The plant maintained itself for a number of years and began to spread to the adjacent fields. It was at last eradicated by the landowner. The vine is abundant in the bottoms of the Wabash River near Lafayette, where it is a bad weed in cornfields. This species is probably of wider distribution in the State than the recorded localities would indicate, as it is very easily overlooked on account of the superficial resemblance of its leaves to those of *Ipomoea pandurata* with which it grows.

64. *Macrocalyx nyctalea* (L.) Kuntze.
Tippecanoe County. A clump of this plant was found near the bank of the Wabash River near Lafayette. Previously recorded only from Vigo and Knox counties. (State Catalogue, p. 893.)*

*65. *Stachys ambigua* (A. Gr.) Britton. (*S. hyssipifolius ambigua* Gray.)
Putnam and Tippecanoe counties, in swamps and along streams.

66. *Melissa oficinalis* L. Bee Balm.
Hamilton County.

*67. *Ruellia strepens micrantha* (Engelm. & Gray) Britton. (R. s. cleistantha *A. Gray.*)
Hamilton and Marion counties. This is the commonest form of this species in the central part of the State.

68. *Lonicera sempervirens* L. Honeysuckle.
Tippecanoe County, on dry hillsides. Not previously reported "north of Wayne County." (State Catalogue, p. 944.)

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*Since found common about Lafayette. June, 1906.

69. *Tragopogon porrifolius* L. Oyster Plant.

Putnam County, in waste places about Greencastle. Previously reported from Wells County by Deam. (Proc. Ind. Acad. Sci. 1900: 142.)

*70. *Silphium terebinthinaceum pinnatifidum* (Ell.) A. Gr.

Hamilton County. The citation of the species (State Catalogue, p. 982), is incorrect, as the specimens have laciniate radical leaves.

71. *Helianthus petiolaris* Nutt.

Tippecanoe County, along the Big Four Railroad west of Lafayette. Previously reported from Lake County. (Proc. Ind. Acad. Sci. 1900: 141.)

72. *Synosma suaveolens* (L.) Raf.

Hamilton County. The material first collected of this species was defective, and so determined as *Coleosanthus grandiflorus* and reported to Dr. Coulter. Later collections of material made a correct determination possible. The latter species should, therefore, be stricken out of the doubtful list of Indiana plants. (State Catalogue, p. 608.)

73. *Centauria cyanus* L. Blue Bottle.

Tippecanoe County, in cultivated ground and about dumps.

*74. *Centauria solstitialis* L. Yellow Star Thistle.

Dearborn County. This plant was sent to the experiment station under date of October 16, 1905, by Lute Helm of Moores Hill, who reported it as a weed in alfalfa fields. It is an old world plant which is sparingly naturalized in the Southern States. It can be readily distinguished from *C. calcitrapa* by its yellow flowers. This species is not included in Britton's Manual.

Lafayette, Ind., November, 1905.

Rust of Hamilton and Marion Counties, Indiana.

By Guy West Wilson.

The present catalogue of *Uredinales* is based chiefly upon a collection of thirty-eight species made in the southern part of Hamilton and the northern part of Marion counties between the 3d of August and the 2d of September of the present season. The hosts number forty-four, of which *Aster paniculatus* and *Avena sativa* were the most prolific, the former harboring three and the latter two species. Previously but two species, *Gymnoconia interstitialis* and *Dicaeoma canaliculata*, had been collected in this region. The former did not reappear in this collection, thus making the total number of species to date thirty-nine. This, however, can be regarded merely as a preliminary catalogue, as the collecting season was too short and the time which could be devoted to the work too limited to make an exhaustive collection. A number of other species have been observed in previous years, but as no specimens were collected they are not included in the present list. Careful collecting in this region would probably double the number of species and would certainly greatly extend the list of hosts for those already collected, as the host plants of forty-five other Indiana rusts as well as some thirty-five additional hosts of those here enumerated occur in this region.

Of the species catalogued, twelve may be classed as injurious, as their hosts are cultivated plants. A few other species occur upon plants which are cultivated elsewhere, and in such localities would be properly classed as injurious, while in the present instance they might even be considered beneficial species. Among the injurious species first place belongs to the grain rusts *(Dicaeoma poculiforme* and *D. rhamni)*, which often seriously reduce the yield of small grains. Of scarcely less importance is the blackberry rust *(Gymnoconia interstitialis)*, which was disastrously abundant in this region a half dozen years ago. So great was its ravages that a considerable acreage of blackberries which were cultivated for market had to be removed. The rust was not seen this season and was not abundant last, so the fruitgrowers are again putting out blackberries.* The Carolina poplar, which is used as a shade tree in towns, is sometimes seriously

*Abundant on wild sps. of *Rubus* in May, 1906.

affected by a rust *(Melampsora medusæ)*. The clover rust *(Caeomurus trifolii)* was found sparingly on alsike clover and abundantly on red clover, causing some damage to the crop in places. The asparagus rust *(Dicaeoma asparagi)*, so far as it was observed, occurs only upon wild plants, and as this vegetable is not cultivated extensively in the infested region it has little economic importance save as a menace to the occasional asparagus beds in the vicinity. The corn rust *(Dicaeoma sorghi)* was very abundant this season, but is not credited with any serious damage.

The five remaining species are to be regarded as injurious or not according to the host which they infest. The most important of these is the bean rust *(Caeomurus phaseoli)*, which was collected on corn beans and seen abundantly on dwarf beans, which it damaged to a considerable extent. This rust also occurs abundantly on a wild bean *(Straphostyles helvola)* which is a serious pest in low river bottoms. The various wild sunflowers as well as the common species *(Helianthus annuus)* are often seriously affected by a rust *(Dicaeoma helianthi)*. By the middle of August the plants of the common sunflower in some sections of Indianapolis were almost defoliated, and such leaves as did remain were rendered unsightly by this rust. Had only that multitude of sunflowers which abound in the river bottoms and about the dumps of the city been infected, this rust would deserve a place among the beneficial species. All the wild species of aster are used for ornament, especially in country gardens, hence the three aster rusts *(Coleosporium solidaginis, Dicaeoma asteris* and *D. caricisasteris)* assume the rôle of injurious species. This is especially true of the last species, which often sadly disfigures its host.

A number of species occur upon weeds of greater or less importance and so are to be considered beneficial, inasmuch as they assist in keeping these pests in check. Of these the rust of the wild morning-glory *(Dicaeoma convolvuli)* and of the bind weed *(Dicaeoma polygoni-convolvuli)* are probably the most important, as their hosts are among the worst of the rust-bearing weeds of the region. The rust of the cocklebur and horse weed *(Dicaeoma xanthii)* also deserves mention. The iron weed rust *(Coleosporium vernoniæ)* is common and often entirely covers the lower surface of the leaves of its host to the serious injury of the latter.

At the time this collection was made conditions favored the detailed study of the rust flora of a limited area, to wit, section 5, range 4 east.

township 17 north. This section has an area of about seven hundred acres and is bounded on three sides and crossed from north to south by public highways. The land is gently rolling with a sandy loam soil and a red clay subsoil. In the northwest quarter is what was once a lake but is now a flourishing cornfield, on the western border of which a few small bogs remain unditched. This region is drained by a ditch which is partly open, and which crosses the low black lands of the southeastern quarter of the section. Of the forty or fifty acres of timber land scarcely an acre can be said to be in a state of nature, while the greater portion of this area is closely pastured and part of it is in process of clearing. The present population is sixty-six and is entirely agricultural. The staple crops are corn, wheat, oats, timothy and clover. Some fruit and a few vegetables are grown for market, but usually for home consumption only. The ornamentals are those usually found about country homes. The farms are kept as free from weeds as in the average Indiana neighborhood. Such a region is scarcely an inviting collecting ground and would often be passed by as unworthy of attention, yet it yielded thirty-six species of rusts on forty-three hosts. These are marked with an asterisk (*) in the catalogue.

The nomenclature of host plants is that of Britton's Manual, while the rusts are named in accordance with the usually accepted nomenclature. Synonyms are given for hosts when they have a different name in Gray's Manual and for the rusts when the last published notice of these was under a different name from that used in this catalogue. Reference to previous publication in the Proceedings of the Academy are by year and page. A set of specimens of this collection has been deposited in the herbarium of Dr. Arthur, who has kindly verified all determinations.

Order UREDINIALES.

Family Coleosporiaceae.

1. Coleosporium solidaginis (*Schw.*) *Thuem.*

 *On Aster ericoides L. Hamilton.

 *On Aster paniculatus Lam. Hamilton.

 *On Solidago canadensis L. Hamilton, Marion.

2 Coleosporium vernoniæ *B. and C.*

 *On Vernonia fasiculatus Michx. Hamilton.

Family MELAMPSORACEAE.

3. PUCCINIASTRUM AGRIMONIAE (*DC.*) *Diet.*

*On Agrimonia mollis (T. & G.) Britt. (*A. parviflora* Ait.) Hamilton.

4. MELAMPSORA BIGELOWII *Thuem.* (*M. farinosa* (Pers.) Schrœt.)

On Salix cordata Muhl. Hamilton.

*On Salix fluviatilis Nutt. (*S. longifolia* Muhl.) Hamilton, Marion.

5. MELAMPSORA MEDUSAE *Thuem.*

*On Populus deltoides Marsh. (*P. monilifera* Muhl.) Hamilton, Marion.

Family PUCCINIACEAE.

6. GYMNOCONIA INTERSTITIALIS (*Schl.*) *Lagh.* (*Puccia interstitialis* Schl.) Tranzschel.)

*On all species of Rubus. Hamilton. 1894 : 157.

7. CAEOMURUS CALADII (*Schw.*) *Kuntze.*

On Arisaema dracontium (L.) Schott. Hamilton.

*On Arisaema triphyllum (L.) Torr. Hamilton.

8. CAEOMURUS EUPHORBIAE (*Schw.*) *Kuntze.*

On Euphorbia dentata Michx. Hamilton, Marion.

*On Euphorbia humistrata Engelm. Hamilton.

*On Euphorbia maculata L. Hamilton.

*On Euphorbia nutans Lag. (*E. hypericifolia* Gr.) Hamilton, Marion.

9. CAEOMURUS HEDYSARI-PANICULATI (*Schw.*) *Arth.*

*On Meibomia sessilifolia (Torr.) Kuntze.? (*Desmodium s.*). Hamilton.

*On Meibomia viridiflora (L.) Kuntze. (*Desmodium v.*) Hamilton, Marion.

10. CAEOMURUS HOWEI (*Pk.*) *Kuntze.*

*On Asclepias syriaca L. (*A. cornuti* Dec.) Hamilton, Marion.

11. CAEOMURUS JUNCI (*Schw.*) *Kuntze.*

*On Juncus tenuis Willd. Hamilton, Marion.

12. CAEOMURUS PERIGYNIUS (*Halst.*) *Kuntze.*

*On Carex utriculata Boot. Hamilton.

13. CAEOMURUS PHASEOLI (*Pers.*) *Arth.*

*On Phaseolus vulgaris L. Hamilton.

On Strophostyles helvola (L.) Britt. (*Phaseolus diversifolius* Pers.) Marion.

14. Caeomurus Polygoni (*Pers.*) *Kuntze.*
*On Polygonum aviculare L. Hamilton.
15. Caeomurus trifolii (*Hedw.*) *Gray*
*On Trifolium hybridum L. Hamilton.
*On Trifolium pratense L. Hamilton, Marion.
16. Dicaeoma angustatum (*Pk.*) *Kuntze.*
*On Scripus atrovirens Muhl. Hamilton.
17. Dicaeoma asparagi (*DC.*) *Kuntze.*
On Asparagus officinale L. Hamilton.
18. Dicaeoma asteris (*Duby*) *Kuntze.*
*On Aster paniculatus Lam. Hamilton.
19. Dicaeoma canaliculata (*Schw.*) *Kuntze.* (*Puccinia indusiata* D. & H.)
*On Cyperus strigosus L. Hamilton. 1894 : 157.
20. Dicaeoma caracis-asteris *Arth.*
*On Aster paniculatus Lam. Hamilton.
21. Dicaeoma caracis-solidaginis *Arth.*
*On Carex conoidea Schkuhr. Hamilton.
22. Dicaeoma circaeae (*Pers.*) *Kuntze.*
*On Circaea lutetiana L. Hamilton.
23. Dicaeoma convolvuli (*Pers.*) *Kuntze.*
On Convolvulus sepium L. Hamilton, Marion.
24. Dicaeoma dayi (*Clint.*) *Kuntze.*
*On Sterionema ciliatum (L.) Raf. Hamilton.
25. Dicaeoma emaculatum (*Schw.*) *Kuntze.*
*On Panicum capillare L. Hamilton.
26. Dicaeoma helianthi (*Schw.*) *Kuntze.*
On Helianthus annuus L. Hamilton, Marion.
On Helianthus tuberosus L. Marion.
*On Helianthus sp. Hamilton.
27. Dicaeoma lateripes (*B. and R.*) *Kuntze.*
On Ruellia stripens L. Hamilton.
28. Dicaeoma menthae (*Pers.*) *Gray.*
*On Agastache nepetioides (L.) Kuntze. (*Lophanthus n.*) Hamilton.
*On Blephia hirsuta (Pursh.) Torr. Hamilton.
On Mentha canadensis L. Hamilton.
On Monarda fistulosa L. Hamilton.
29. Dicaeoma muhlenbergiae (*A. & H.*) *Arth.*
*On Muhlenbergia diffusa Schreb. Hamilton.

30. Dicaeoma poculiforme (*Jacq.*) *Kuntze*.
*On Agrostis alba L. Hamilton.
*On Avena sativa L. Hamilton.
*On Triticum vulgare L. Hamilton.

31. Dicaeoma podophylli (*Schw.*) *Kuntze*.
*On Podophyllum peltatum L. Hamilton.

32. Dicaeoma pologoni-amphibii (*Pers.*) *Arth.*
*On Polygonum emersum (Michx.) Britt. (*P. muhlenbergii* Wats.) Hamilton.

33. Dicaeoma polygoni-convolvuli (*Hedw.*) *Arth.*
*On Polygonum convolvulus L. Hamilton, Marion.

34. Dicaeoma punctatum (*Str.*) *Arth.*
*On Galium concinctum T. & G. Hamilton.
*On Galium trifidum L. Hamilton.
On Galium tinctorium L. Hamilton.

35. Dicaeoma rhamni (*Gmel.*) *Kuntze*.
*On Avena sativa L. Hamilton.

36. Dicaeoma sorghi (*Schw.*) *Kuntze*.
*On Zea mays L. Hamilton, Marion.

37. Dicaeoma taraxaci (*Plowr.*) *Kuntze*.
*On Taraxacum taraxacum (L.) Karst. (*T. officinale* Weber.) Hamilton, Marion.

38. Dicaeoma xanthii (*Schw.*) *Kuntze*.
*On Ambrosia trifida L. Hamilton.
On Xanthium canadense Mill. Hamilton, Marion.

39. Gymnosporangium globosum *Farl.*
*On Crataegus punctata Jacq. Hamilton.

Lafayette, Ind., November, 1905.

A Travertine Deposit in Tippecanoe County, Indiana.

By Guy West Wilson.

On the west bank of the Wabash River, near the Indiana Soldiers' Home, a steep bluff skirts the stream. A short distance below the "Tecumseh Trail" the slope has been greatly modified by the action of the seep water which trickles down the bank and makes a small marsh near the level of the river. This region of a few square rods extent is the lodging place of the leaves and twigs from the forest trees above, thus materially impeding the flow of the small amount of seep water, which is highly charged with carbonate of lime, causing it to make a deposit. As this mass has been undistrubed for a number of years a considerable amount of travertine has been formed. The surface, and consequently the more recent, portion of the mass is quite soft, crumbling easily in the hand, while the deeper and older portion is hard enough to resist a sharp blow with a small hammer.

An examination of fragments of this travertine shows that at the present time our own flora is being preserved in fossil form. The deposit of lime is rapid enough to preserve the leaves and twigs of neighboring trees and of the herbaceous plants of the immediate vicinity. The former are principally oaks and maples whose leaves can be recognized both by their form and by the arrangement of their principal veins. The latter are chiefly grasses and sedges, although fragments of a few other swamp plants also occur. In the more moist portions of the region a sterile moss grows in abundance and is quickly encrusted with lime, forming a large bulk of the travertine at this point, and resembling certain of the chain corals *(Halysitidae)*. Some of the moss noticed were growing at the tip while completely encrusted at the base.

A large area of this portion of the formation is covered by a luxuriant growth of one of the thalose liverworts, *Conocephalus conicus* Dumort. As the substratum upon which this plant grows is less compact than in other portions of the deposit its fossil remains, which are the most interesting of all those which were noticed, are not so perfect as might have been the case had the plant grown on a firmer substratum. Those found were merely fragments of the tips of the thallus and were thin casts without the markings which are characteristic of the upper surface, and without the rhizoids of the under surface. There was, indeed, nothing to distinguish the casts from those which might have been formed by any member of the group, except the fact that they agreed in size and form with the unmixed colony of this species which grows immediately above them.

Lafayette, Ind., November, 1905.

Additions to Indiana Flora, No. 2.

By Chas. C. Deam.

The species herein listed have been identified by competent authority, and mostly by the Department of Agriculture, Washington, D. C.

Botrychium obliquum Muhl.

Wells County, September 13, 1896; Steuben County, August 21, 1904.

Dryopteris filix-mas (L.) Schott.

Wells County, July 20, 1902. This species was included in Coulter's list, but no locality was cited.

Dryopteris bootti (Tuckerm.) Underwood.

Wells County, July 23, 1905.

Panicum gattingeri Nash.

Franklin County, August 23, 1903.

Panicum philadelphicum Trin.

Steuben County, August 11, 1903.

Panicum minimum (Engelm.) St.

Steuben County, August 12, 1903.

Eatonia pubescens Scrib. and Mer.

Orange County, May 25, 1901.

Elymus robustum Scrib. and Sml.

Wells County, September 1, 1904; Franklin County, August 23, 1903.

Juncus dudleyi Wiegand.

Steuben County, June 16, 1903.

Juncoides campestris multiflora Celak.

Orange County, May 25, 1901.

Tradescantia reflexa Raf.

Steuben County, June 16, 1903.

Salix fragilis L.

Steuben County, August 13, 1903.

Salix fragilis X *alba* Wimmer.

Wells County, May 7, 1899.

Roripa sylvestris (L.) Bess.

Fountain County, June 5, 1905.

Sophia intermedia Rydb.

Lawrence County, May 26, 1901.

Cassia medsgeri Shafer.

Wells County, August 27, 1905.

Meibomia illinoensis (A. Gray) Kuntze.

Steuben County, August 11, 1903.

Ptelea mesochora Greene.

Noble County, August 9, 1905.

Viola crassula Greene.

Steuben County, May 28, 1905.

Lactuca virosa L.

Steuben County, August 12, 1903; Wells County, September 6, 1903; Allen County, August 22, 1904.

Lactuca spicata integrifolia (A. Gray) Britton.

Wells County, September 17, 1905; Blackford County, September 3, 1905.

Euthamia hirtella Greene.

Wells County, August 27, 1905; Steuben County, September 9, 1903; Kosciusko County, August 24, 1905; Blackford County, September 3, 1905.

Mariana Mariana (L.) Hill.

Wells County, July 10, 1905. This is a migrant, being found in a cultivated field.

Some Monstrosities in Trillium.*

By Frank Marion Andrews.

The genus Trillium occasionally shows interesting variations, not only in the form, but especially in the number of the parts of the foliar and floral parts. These changes in form and phyllody are especially conspicuous about this region in the species Trillium sessile and Trillium recurvatum. Of these some notable variations have been observed. Two specimens were found growing within a meter of one another, one being Trillium sessile and the other Trilliam recurvatum. In both of these specimens no trace of the usual stamens or pistil were present. All parts of the flowers were completely transformed into floral leaves, which in Trillium recurvatum were considerably larger, with the exception of the central ones, than the usual parts of normal flowers growing near them. In Trillium recurvatum the number of these leaves in the flowers without reproductive organs was twenty-three (23) and in the Trillium sessile fourteen (14). No gradation from petals to stamens was observed in these specimens, such as is sometimes seen in the Nymphaceae. The number of sepals and floral leaves, the venation and other features were normal in both of the specimens above named.

A third interesting variation was seen in another specimen of the Trillium sessile in which the usual parts were present, but varied in number. To enumerate—there were four floral leaves, somewhat smaller than in normal specimens, three small sepals, four large partly greenish petals, three small stamens and four styles. This change in the size and especially the number of very close successive whorls of the foliar and floral leaves was all the more striking inasmuch as the individual members of the whorls were very uniform in number and size. This particular plant was considerably smaller than normal specimens.

Some other specimens of Trillium sessile and recurvatum showed a sepal and petal either partly, or in some instances wholly, grown together. In these cases the sepal half, which could be distinguished by its position, was much greener than the other or petal part, which was partly white.

*See also Bott. Gaz., vol. 16. pp. 163 and 231, and vol. 19, pp. 137 and 460.

Trillium erectum also deviated somewhat from the usual appearance, without a multiplication of parts but apparently merely a partial substitution. For example, one specimen had the usual floral leaves, three sepals, five petals, four stamens and two styles. In all other respects these plants were normal. Some flowers of the other species have shown a tendency to unite two or more of the parts. Some slight deviations in Trillium nivale have been observed in the way of a union of the floral parts.

It would be an interesting point to determine whether or not the plant arising from a rhizome showing such changes as here mentioned would appear afterward. Accordingly experiments of this nature are in progress.

A Natural Proof That the Root Tip Alone is Sensitive to the Gravitation Stimulus.

By Frank Marion Andrews.

Pfeffer* and Czapek* have demonstrated that it is the root tip only that is sensitive to the stimulus of gravitation. In order to accomplish this end they resorted to the following method. Glass tubes of such a diameter as would just fit over the end of the root tip were made by drawing out thick-walled glass tubes. The tubes thus obtained were bent into an L shape, had a total length of about three (3) mm., and weighed about thirty (30) milligrams. They were closed at one end and left open at the other; each limb of the L-shaped tube made in this way had a length of 1.5 mm. The inside diameter of the tube depended on the size of the root for which it was intended. It was necessary in all cases to have this glass tube fit the root loosely. It was connected to a piece of cork and the germinated seedling also fastened to the same cork in such a way that the root tip projected into the glass cap about to the bend. The whole being rotated in a klinostat for some hours the root, freed of the stimulus of gravity, grew into the above mentioned glass cap and finally assumed its L-shaped form. When removed from the klinostat and placed with the curved tip of the root vertical and the rest of the root horizontal no geotropic curvature took place, which shows that since the tip of the root was constrained from bending, the sensitiveness of geotropic stimulus must be located there, else it would have bent at a point outside the glass tube. I have accidentally found a natural proof of this admirable and conclusive discovery of Pfeffer and Czapek. In some germinating corn I observed one instance in which the root of the embryo had not freed itself in the usual way, but instead, the scutellum was broken about midway and carried down by the root on its tip as a mass of tissue. The outer coats were not broken, and these adhering about the scutellum on one side in the usual way made the mass so strong that the root could not grow out of it—at least it did not do so. This mass of tissue when removed weighed fifteen (15) milligrams. The root had turned and grown

*Jahr f. wiss. Bot., 1895, Bd. 27, p. 243, and 1900, Bd. 35, p. 313.

in this mass toward the back of the scutellum at a right angle a short distance from the tip; upon removing all the mass from the root tip, which could be done quite easily, this curving was plainly evident. The root was fixed in a moist atmosphere on a sheet of cork, with the curved part in a vertical position and the rest of the root in a horizontal position, but no geotropic curvature took place. During the time the root was kept in this position it grew almost as rapidly as the control specimens which were used to estimate the growth. While this accidental occurrence of a cap-like mass of tissue on the root-tip showed and verified the same effect on geotropic curvature, as was proved by using the glass caps, nevertheless it eliminated all the dangers of traumatic effects, to which the glass-cap method might render these parts liable in the absence of skillful manipulation, upon which experimentation is being conducted.

Plasmodesmen.

By Frank Marion Andrews.

It has been shown by W. Gardiner,[1] Strasburger,[3] Kohl,[2] and others that plasmodesmen are not confined to the pits in the cell walls but that they may also penetrate the cell walls themselves at other places. Excellent names for the plasmodesmen penetrating the cell wall in the places above mentioned have been chosen by Kohl.[4] Those which pass through the pit membrane he calls aggregated and these which pass through the unpitted membrane solitary. Strasburger[5] has recommended for all these protoplasmic connections the term plasmodesmen. It has also been shown that the plasmodesmen arise independently of cell division, for in the dermatogen of a phanerogam, in which only anticlinal and radial walls are formed these plasmodesmen are present in the walls between the dermatogen and the next inner layer of cells.

The plasmodesmen arise, according to Strasburger, secondarily in a very early stage in the formation of the membranes, before the beginning of their secondary thickening. Pfeffer[6] states—according to reports—that a subsequent formation of very thin plama connections is just as possible, as the larger fusion of protoplasts, which is made possible by dissolution of adequate parts of the cell wall.

I have investigated the occurrence of plasmodesmen to some extent in the endosperm of Phoenix dactylifera, and find both the solitary and aggregate forms present in large numbers.

Fig. 1 represents a cross-section of a cell of the endosperm of this plant before treating with any reagent. The pits are large and numerous and are generally somewhat enlarged where the ends come together with the corresponding ones of contiguous cells. The walls are rather thick and hard. Fig. 2 is a longitudinal section of the endosperm of Phoenix

[1]Gardiner W. Arbeiten des Botanischen Institutes in Wurzburg 1888, Bd. 3, p. 52.
[3]Strasburger Ueber Plasmaverbindungen pflanzlicher Zellen Jahr für wis. Bot. 1901, Band 36, p. 493.
[2]Kohl-Ber. d. Deutsch botan. Gesellsch. 1900, p. 364.
[4]Kohl-Ber. d. Deutsch botan. Gesellsch. 1900, p. 364.
[5]Strasburger-Ueber Plasmaverbindungen pflanzlicher Zellen Jahr für wis. Bot. 1901, Band 36, p. 503.
[6]Pfeffer-Pflanzenphysiologie zweite Auf. 1904, Bd. II, p. 219.

dactylifera in which the wall has been greatly swollen and the plasmodesmen stained to make them more plainly visible. In this case I treated the specimens according to Gardiner's method first by allowing them to lie for a while in iodine and potassium iodide and then adding chloriodide of

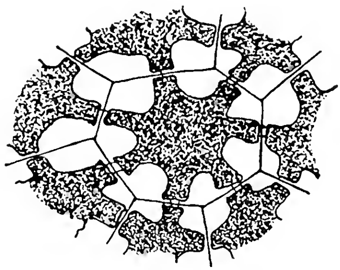

Fig. 1.

zinc and allowing it to act for twelve hours. The sections were then carefully washed in water. The walls were found to be strongly swollen to at least twenty-five times their original thickness where the pits occurred. In only a few instances were any of the aggregate plasmodesmen

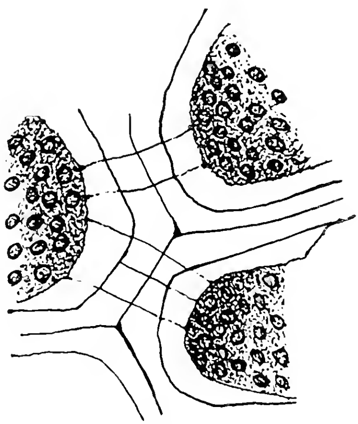

Fig. 2.

found broken where they entered the pit of the cell. Sometimes this occurred, especially in the solitary plasmodesmen, and a small filament could be seen as in Fig. 2. Attempts were made to bring these plasmodesmen more plainly to view by the use of Hoffman's blue, but this did not succeed very well. I found after considerable experimentation that a solution of clove oil eosin stained them densely and then made them plainly visible. The solution I used was made by adding a small quantity of eosin to the pure clove oil. This stains very quickly and must therefore only be allowed to act a few seconds. The aggregate plasmodesmen did not show themselves in this specimen to be perfectly smooth threads of protoplasm but were coarsely granular or appeared considerably thickened at irregular intervals. (Fig. 2.) The solitary plasmodesmen, however, were more uniform. This appearance of the plasmodesmen was only to be seen to good advantage under very high magnification. The plasmodes-

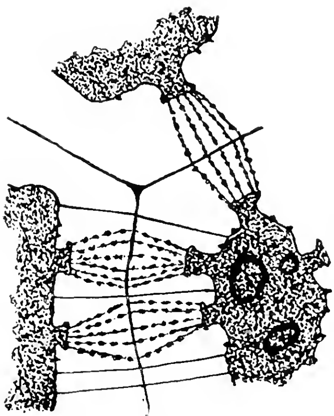

Fig. 3.

men shown in Fig. 2, for example, were magnified 2,250 times. The enlarged ends of the pits above referred to are better shown here than in Fig. 1.

The plasmodesmen in the cortex of Aesculus flava were also examined. To do this I removed the outer layers down to the green tissue, and the thin sections obtained there were treated in the same way as those of the endosperm of Phoenix dactylifera, except that instead of using chloriodide of zinc, sulphuric acid was employed for swelling. Clove oil eosin was also used here with good results. Hoffman's blue was also more effective than in the first case mentioned. The plasmodesmen of both kinds were made visible here, although the solitary ones were, as usual, more difficult to distinguish than the aggregate ones. Some experiments in demonstrating the plasmodesmen in moss leaves were also performed. This was done by plasmolysis. The leaves of Funaria hygrometrica, and often whole plantlets as well, were placed in a 17 per cent. solution of cane sugar and left for a few minutes. This was sufficient to bring about a plasmolysis in all the cells and make the plasmodesmen evident when stained. This is shown in Fig. 3. The fine strands of protoplasm ran from the protoplasts to pits in the wall and from there through the wall to the opposite protoplasts. If the protoplasts were contracted too much by plasmolysis they were broken and the fragments could often be seen (Fig. 3).

When moss-cells were plasmolized in the way above mentioned they were fixed in a 1 per cent. solution of chromic-acetic acid, then washed in water and the walls swollen in the usual way.

The walls must be swollen considerably in Funaria hygrometrica to locate exactly the passage of the plasmodesmen. Although the protoplasmic fibers running from the contracted protoplasts were visible even directly after plasmolyzing they were made much more evident by staining with clove oil or Hoffman's blue.

The importance of plasmodesmen uniting the various protoplasts of a plant is evident in several ways. Experiments have been made to show[1] that stimuli may be transmitted through them. Even certain nutrient substances[2] may pass through them in mass or by diffusion, and Miehe[3] has even observed that nuclei may under certain conditions pass from one cell to another by means of the pores of the plasmodesmen.

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[1]Townsend, Jahr. f. wiss. Bot. 1897, Bd. 30, p. 484.
[2]Pfeffer, Pflanzenphysiologie zweite Auf. Bd. II, p. 225.
[3]Miehe, Flora, p. 115.

The Effect of Alkaloids and Other Vegetable Poisons on Protoplasm.

By Frank Marion Andrews.

It has not yet been satisfactorily determined whether the protoplasm of plants is affected by alkaloids and other vegetable poisons,* and accordingly I have begun an investigation of this subject. I was enabled to begin this work at the Marine Biological Station at Wood's Hole, Mass., during a part of the summer of 1905, through the courtesy of the Carnegie Institution of Washington, D. C., which kindly placed at my disposal one of the rooms which it controls at that place. Naturally only a beginning could be made in this work which I am pursuing further now, but the results thus far obtained are not without interest.

Many alkaloids are only slightly soluble in cold water, as for example, strychnine, of which only about one part in seven thousand (7,000) is soluble in water. The salts of the alkaloids are, however, much more soluble in cold water, both fresh and sea water.

My first experiments were carried out with strychnine sulphate on volvox. This was found in great abundance in a pond some distance from the station. When the volvox was put in a solution of strychnine sulphate containing .125 gr. in 875 cc. of fresh water the movement of the plant was at first accelerated, but it was killed by this solution in one hour. The color of the vegetative cells became lighter and when colonies were present these were a little darkened. I then placed a drop of water on the slide and to this I added some crystals of the strychnine sulphate. The volvox individuals at first swam to these dissolving crystals, but coming too near entered a place where the concentration was fatal in five minutes. When put in a solution containing .01 gr. of strychnine sulphate in 100 cc. of water volvox was killed in one hour and thirty minutes. When placed in a solution containing .01 gr. of strychnine sulphate in 1,000 cc. of water volvox was killed in one hour and forty-five minutes. At the expiration of twenty-four hours the volvox individuals were perfectly discolored and disorganized. Distilled water does not affect volvox outside of the effects of nutrition, if properly prepared.

*Pfeffer Pflanzenphysiologie zweite Auf. 1904, Bd. II, p. 333.

Other fresh-water forms such as Oscillaria, Chrococcus, Cosmarium, Closterium, Desmids and Diatoms were not killed in a solution of strychnine sulphate containing one gr. in 1,000,000 cc. of water. The movement of the protoplasm even did not stop. I have not yet determined the exact lethal concentration of strychnine sulphate for these forms.

Marine forms of the Cyanophyceae (as Oscillaria and Rivularia); also Diatomes; Chlorophyceae, as Cladophora and Enteromorpha; Brown Algae, as Ectocarpus; and Red sea weeds, as Polysiphonia and others were not killed in a solution of strychnine sulphate having one part in 100,000 of water. Nor was the movement of the protoplasm stopped by this concentration. A solution of the same having one part in 10,000 also had no effect.

A solution of the same having one part in 1,000 also had no effect. A solution of the same having one part in 250 killed all the plants in twenty-four hours, but the animals which happened to be present were killed in seven hours.

There are only a few animals that can bear transferring from salt to fresh water and vice versa. One of these is the form Artemia salina, which may bear such treatment, but in so doing it assumes a somewhat different size and shape. As a rule animals that are transferred from salt to fresh water or vice versa, show at first accelerated movements, but these become rapidly slower and slower, death ensuing in most instances in a few seconds.

All the marine forms experimented with were killed in two hours by a solution of strychnine sulphate containing .5 of a grain in 100 cc. of water.

The above mentioned marine forms were killed in a solution of cocaine containing .5 of a gram in 25 cc. of water, in two and one-fourth hours.

A Specimen of Kirtland's Warbler, Secured May 13, 1905.

By D. W. Dennis and Loren C. Petry.

This specimen was secured May 13, 1905, rather late in the afternoon, probably 5:30 p. m. The place was the northern end of a thicket on the farm of W. W. Kirkpatrick, about five miles east of New Paris, Ohio.

This part of the thicket is composed principally of second growth, with no trees more than 25 or 30 feet in height. The particular place where the specimen was secured is near the edge of the thicket within a few feet of an open field.

At no time while the bird was seen did it go more than from eight to ten feet from the ground. It flitted about the branches of the bushes in the usual manner of warblers, and after going over one, would fly directly to the next, and in a similar manner, go over it.

A teetering motion of the tail was constantly kept up, and was very noticeable. In fact, it was this that first attracted our attention. While moving about the branches, the tail was almost constantly moving up and down. This motion was not a motion of the body, as in the sandpipers, but of the tail alone.

The bird was not shy, and permitted us to approach within 20 or 25 feet, without flying or showing any alarm. At this distance it was easily possible to see the black spots upon the yellow underparts, without a glass.

The specimen taken was a female, and is preserved in the private collection of D. W. Dennis. Not more than 25 specimens of this bird have been seen; its biography is nearly a blank.

Nitrifying Bacteria.

By A. J. Bigney.

Everybody is searching for the wealth of the world. The scientist, however, is the one who usually makes the actual discoveries. He may not reap much of the result himself, but the world is richer and better for his having lived in it.

The past few years has seen much wealth added to Indiana through the labors of her scientific men. New sources of income will be found and new applications made as time passes on.

To the most casual observer it is certainly true that southern Indiana, in particular, has too much abandoned land. Waste fields are to be seen on every hand in many communities, and in some localities most of the land has been turned over to the free action of the elements and to the rabbits. As the population increases this land will be needed. The people are not much concerned now, because there is an abundance of land in the country. If their farms become too poor they will sell out and move into other localities or into other States. The time is coming when there will not be the inducements in other places, so the farmers will be compelled to earn a livelihood on the old farm. Even now it would be less expensive and much more satisfactory, especially to their good ladies, to remain on the old farm and transform their worn-out land into a veritable garden. The Germans are doing this very thing now on the hill lands about some of our rivers. This shows that it can be done when our people are willing to devote themselves to the task and not be too anxious to become rich too quickly and with as little labor as possible. When this waste land is put under a high state of cultivation, it will make the country more beautiful and will thus be an incentive to the agricultural classes. Who does not feel encouraged when travelers compliment a people on their beautiful country?

The Department of Agriculture of our Government is accomplishing wonders in developing new plans for work through their laboratories at Washington and in the experiment stations. The farmers are being stimulated to take an interest in scientific farming and the work is being made more practical and more interesting and also more popular. When they see that no line of work really needs more knowledge and skill it will be a strong inducement to our young people to think of spending their time in developing our country along agricultural lines.

The great need that may be seen in many parts of southern Indiana is the formation of a proper vegetable mould. This means that there must be a greater amount of proteid substance in it. This further means that nitrogen is the element most needed and the one most difficult to secure. Since about four-fifths of the air is composed of nitrogen it would seem that we should not lack for this substance. This source of wealth had remained hidden for centuries. Not until recently did we learn of the part that the leguminous plants play in this problem. Now we know that this class of plants is the one that can make use of the nitrogen of the air for the manufacture of proteid substances of plants.

Fewer than ten years have elapsed since the noted German scientists Nobbe and Hiltner suggested that pure cultures of soil bacteria might be used to inoculate new soils. German experiments continued to be made, but they were quite unsatisfactory.

In 1901 the Department of Agriculture of the United States began investigations in its laboratory of plant physiology to find an artificial medium in which bacteria would grow and still preserve its power or even to intensify its qualities. Furthermore the bacteria must have the power to penetrate the roots of the plants, because it is impossible to fix nitrogen unless they are stimulated by the activities of the plant itself. The result of this investigation was a liquid culture. This culture is put up in three packages, Nos. 1, 2, and 3. No. 1 consists chiefly of sugar with a little potassium phosphate and magnesium sulphate. No. 2 consists of cotton laden with bacteria. No. 3 contains ammonium phosphate. No. 1 is dissolved in one gallon of water and the bacteria placed in it. This must be kept in a warm place, the temperature of which is between 70 and 80 degrees. At the end of twenty-four hours No. 3 is added and kept twenty-four hours more under similar conditions. The water by this time will be quite milky. Examination with the microscope reveals myriads of bacteria in active state.

The seed is now thoroughly moistened with the water and spread out to dry as quickly as possible. This liquid culture will retain its qualities for about forty-eight hours. The inoculated seed may be kept however for several weeks, or even for months, before sowing and still retain all its power of growth.

It has been demonstrated that each legume has its own particular kind of bacteria, hence the Department of Agriculture always desires to know what seed is intended to be used.

These cultures were completed by the spring of 1904 and sent out to 12,000 farmers in every State in the Union and in many of the foreign countries including New Zealand, South Africa and Australia. This gave every variety of climate and soil for making the test and also all classes of farmers for trying the experiment, whether particularly adapted to such work or not. Of course all did not report the result, but the reports that were sent in showed an increase of 79 per cent. in the production. The rate of increase for the different legumes was as follows: Alfalfa, 73 per cent.; red clover, 92 per cent.; garden peas, 87 per cent.; common bean, 80 per cent.; cow pea, 85 per cent.; soy bean, 51 per cent.; hairy vetch, 75 per cent., and crimson clover, 88 per cent. This certainly indicates a remarkable result and plainly shows that there is something in this method of increasing the fertility of the soil.

My own experiments extend over only the past season. I ordered my supplies in November, 1904, and they were sent to me February 1, 1905. I inoculated four and one-fourth bushels of red clover seed with two supplies of bacteria. I sowed the seed on 25 acres of land, most of which was in wheat. For comparison I sowed a strip that was not inoculated. The sowing occurred between April 4 and 10. Anxiously I watched the growing seed. As soon as the nodules began to form I could notice more nodules on the inoculated plants than on the uninoculated ones. This increase has continued throughout the season. In comparing the stand of clover with neighboring fields it is plainly seen that it is better, the plants more vigorous and healthful.

My experiments have not been as successful as I anticipated, yet I feel that it has been very encouraging and that it can be of service to the farmers in southeast Indiana. Many farmers already in various parts of the country have succeeded in getting a stand of clover or alfalfa where it had previously been impossible to get it to grow.

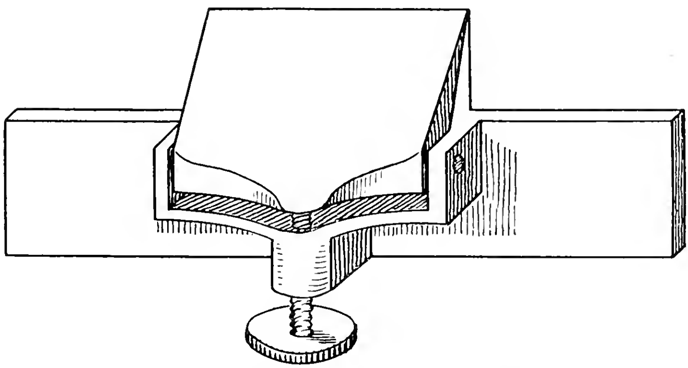
It might also be stated in this connection that soil which has been growing clover becomes inoculated, and this soil can be sprinkled over another field and it will become inoculated. When the soil is once inoculated it remains rich in these germs and thus insures the perpetuity of the power of gathering nitrogen from the air. It may take a number of years to make the people see the advantage of this inoculation, but when it is shown that there is an actual increase in the production, the farmers will not be slow to take up with the method. I expect to continue my experiments, and already have supplies engaged for another season.

November 29, 1905.

A New Form of Microtome Knife.

By E. G. Martin.

The writer has been much impressed, both as student and teacher, with the great waste of energy and time involved in keeping microtome knives in satisfactory condition for use. In every biological laboratory the care of these knives is recognized as constituting a serious drain upon the student's time. In most undergraduate laboratories there is also apt to be more or less disposition to use poorly sharpened knives, rather than take the trouble to put them in satisfactory condition, with the inevitable



Microtome Knife.—In this drawing the two blades are shown clamped together in position for use, but without the cutting blade inserted. When the set-screw is loosened the front blade falls forward far enough to allow of the insertion of the cutting blade.

consequence of inferior sections. In order to insure that the student shall always be provided with a satisfactory cutting edge, and at the same time to avoid the expenditure of time necessary when the usual form of knife is used, the writer devised the instrument herein described for use in the biological laboratories of Purdue University.

The apparatus makes use of the patent safety razor blades which are now on the market at a moderate price. The form for which this instrument is adapted is the one which first appeared on the market. The device consists essentially of a stout blade split lengthwise in a plane passing through the cutting edge, and having the two parts hinged together at the side away fram the cutting edge. By means of a setscrew the two parts of the blade may be firmly pressed together and held so. The thin blade, which is to be used as the actual cutting edge, is placed in position between the two parts of the supporting blade with its edge slightly projecting, and is firmly clamped there by tightening the setscrew. The instrument is then ready for use. For the details of structure the reader is referred to the accompanying drawing.

The device is adapted for microtomes, either of the Minot form or the Bausch & Lomb sliding form. In the author's hands it has cut as good sections with either instrument as he has ever gotten with the best knives of the old form. The capacity of the knife is limited by the shortness of the blade, but for practically all student work it will be found ample. The instrument possesses the great advantage that each student can provide his own cutting edge, the cost being trifling, and thus the confusion of having a number using the same knife is avoided.

The Present Status of the Chromosome Controversy.

By D. M. Mottier.

(Abstract.)

Cytologists are now agreed that the first mitosis in the spore mother-cells of higher plants is a "reducing" or qualitative division, the chromosomes being bivalent, and that the second mitosis is equational. Two views, however, are held concerning the manner in which the bivalent chromosomes are formed. Gregoire and his associates; Allen, and Strasburger and his students, maintain that the double chromatin thread appearing after synapsis is not the result of a longitudinal splitting of a single spirem, but the approximation of two spirems, one presumably paternal and the other maternal. On the other hand, Farmer and Moore and others, among whom is the writer, assert that the double spirem is due to a longitudinal splitting, which, as the spirem shortens and thickens, becomes indistinguishable except in certain cases. Parallel portions of the spirem, or a part of the same, now approximate, forming loops, the parallel sides of which are twisted upon each other. This looping or approximation of parallel portions of the spirem is accompanied by a second contraction resembling a partial synapsis. The result is that near the center of the nucleus there is formed a closely entangled or balled up mass of the spirem from which extend somewhat radially the loops or approximated parts of the spirem having a straighter course. Each parallel part of a loop is, for example, a chromosome, the two forming a bivalent chromosome. The spirem now segments transversely, and in case the parallel sides of the loops or the otherwise approximated parts of the spirem adhere at one end, as is very frequently true, the spirem may be said to segment into pieces equal to the length of two chromosomes. These two chromosomes, each of which is split lengthwise, now come to lie side by side, or to form rings, loops, X's, Y's, etc. (Lilium, Podophyllum.) The longitudinal splitting of the daughter segments observed during the meta, or anaphase, is, according to this view, the original longitudinal fission of the early prophase.

Assuming the individuality of the chromosomes, and that one-half is paternal and one-half maternal, Gregoire, Allen, Strasburger and others claim that the double spirem, developing in the prophase of the first mitosis, consists of the paternal and maternal spirems which have been brought together side by side during synapsis. But according to the view of Farmer and Moore and the writer, the double spirem is produced by a longitudinal splitting, and that it is composed of paternal and maternal chromosomes united end to end.

The Blooming of Cercis Canadensis in September.

By D. M. Mottier.

(Abstract.)

A small tree of Cercis Canadensis, or common red bud, growing on the campus of Indiana University was observed bearing many perfect blossoms upon three or four of its larger branches, September 20. The flowers were perfectly normal both as to structure and color. They remained on the tree for about the same length of time as in the spring. No fruits were formed however.

A Peculiar Monstrosity in the Seedling of Zea Mays.

By D. M. Mottier.

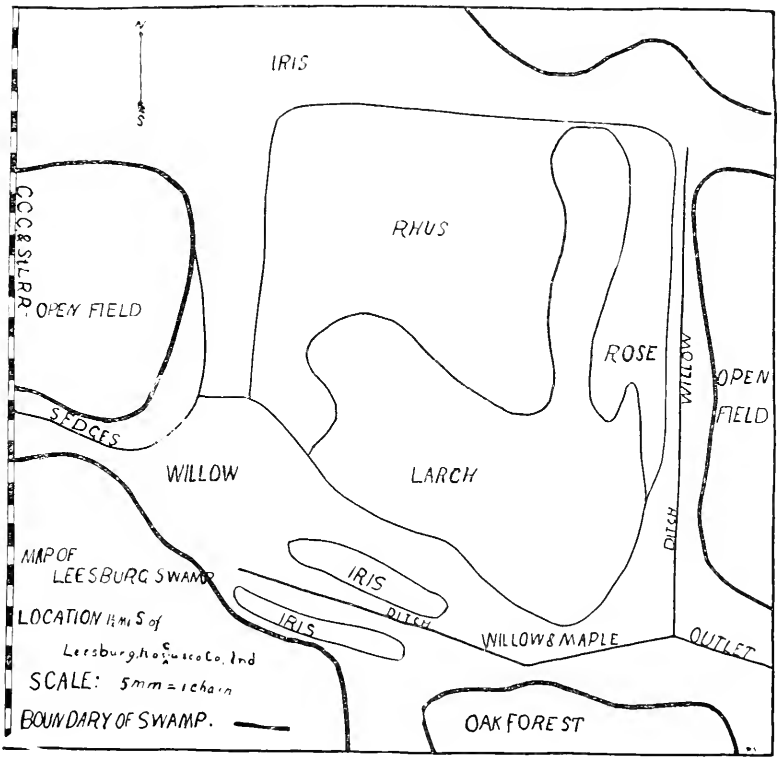
(Abstract.)

A seedling of Zea Mays was exhibited, which consisted of two perfectly developed shoots about eight centimeters long and two primary roots. Each primary root bore several secondary roots, and secondary roots had also put in an appearance at the lower nodes of each shoot. The double members arose just above and below the first node of the embryo, and apparently by the respective bifurcation of the shoot and primary root.

B. The Leesburg Swamp.*

By Will Scott.

Northern Indiana is dotted with lakes and swamps. This land surface is the result of the uneven deposits of the ice sheet and the modification of these by the processes of erosion, sedimentation and plant deposition.



Since the swamp illustrates so well the process through which present conditions came to exist, it was thought worth while to select a typical one, study its flora, physiography and plant depositions, and from these

*Trees of northern United States, by Apgar, was used for the identification of trees. Gray's Manual of Botany (sixth edition) was used for the identification of flowering plants other than trees.

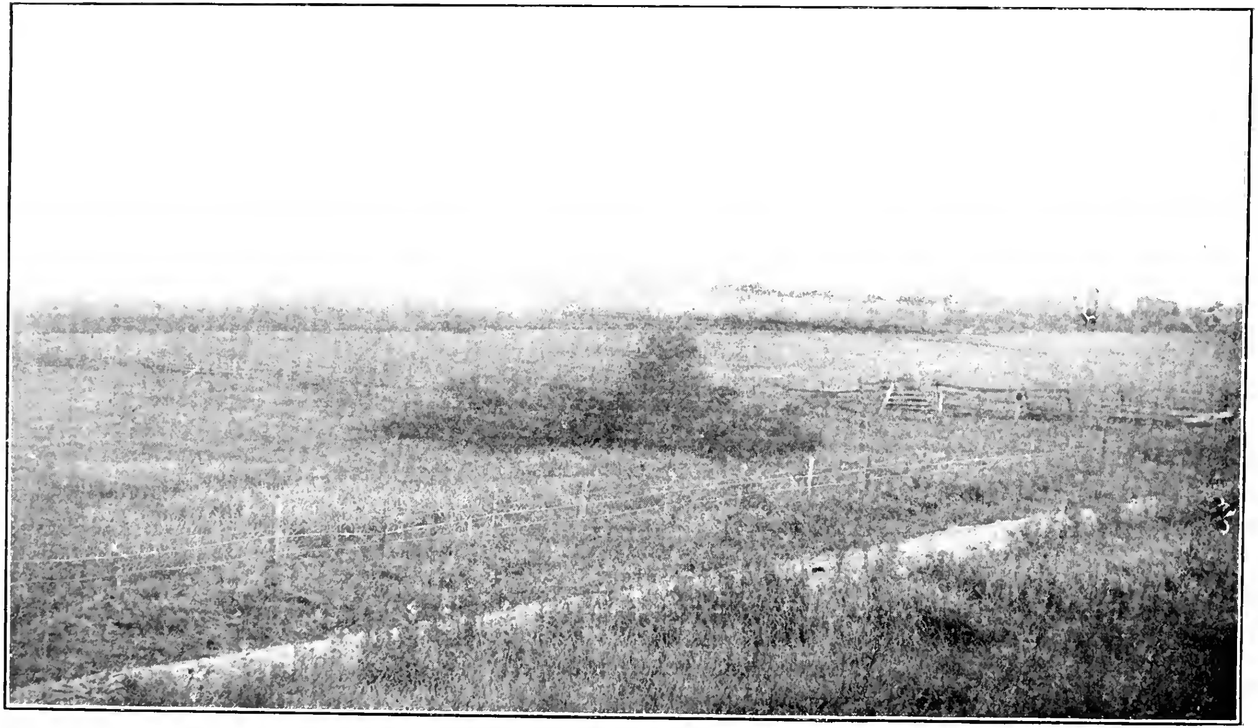


Fig. 1. General view of the swamp (looking southeast). The open cultivated field is a portion of the bottom of the first lake which was exposed by the destruction of the first moraines. The foreground is a sort of bay to the present swamps and was a part of the second lake. The left center is the third lake area and may be distinguished by tamaracks and an intervening belt of Rhus.

things, if possible, determine former conditions and project those yet to be introduced.

The Leesburg swamp was selected. It is located in Kosciusko County, Indiana, one and one-fourth miles south of Leesburg on the east side of the C., C., C. & St. L. R. R. It has an area of 62 acres.

The work was carried on under the general direction of Dr. C. H. Eigenmann, director of the Indiana University Biological Station, and under the immediate direction of Dr. O. W. Caldwell. I wish also to acknowledge the assistance rendered by Mr. W. D. Curtis in collecting, and Mr. A. M. Mahaffey for most of the accompanying photographs.

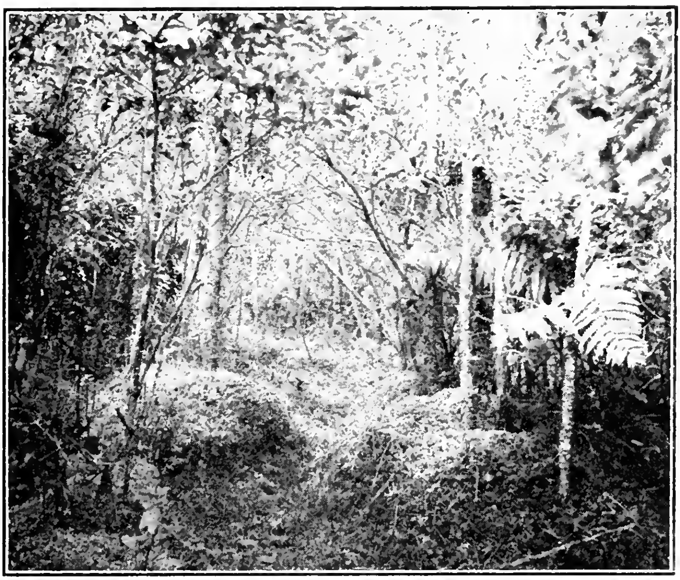


Fig. 2. Sphagnum.

In this investigation Schimper's[1] division of ecological into climatic factors and edaphic factors was assumed and the edaphic factors only considered.

One of the main purposes has been to test the theories and factors proposed by Warming[2] and Cowles.[3]

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[1]Schimper, A. F. W.: Pflanzengeographie auf physiologischer. Grundlage, Jena 1898.

[2]Warming, E.: Plantsamfund. Copenhagen, 1895

[3]Cowles, H. C.: The Physiographic Ecology of Chicago and Vicinity. Bot. Gaz., 1901.

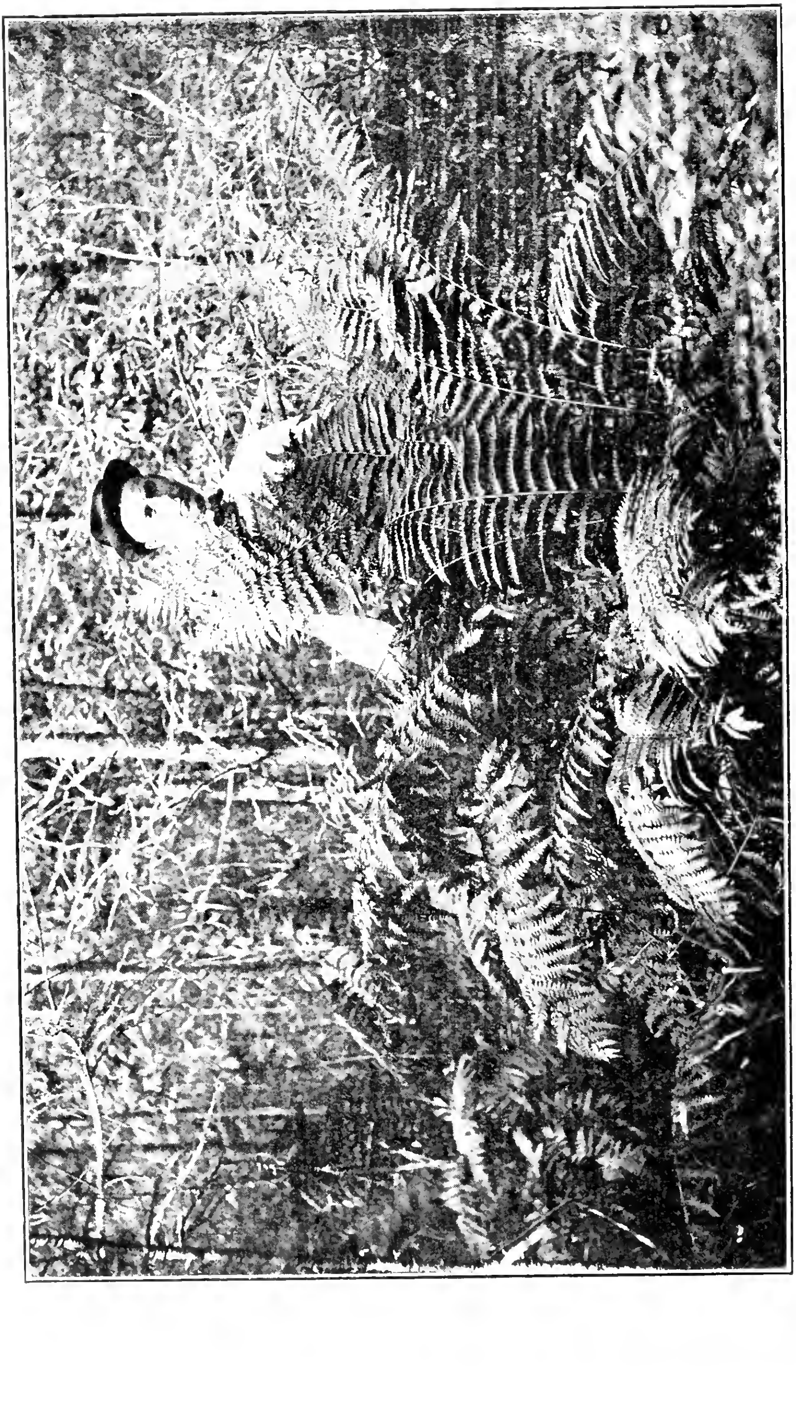

Fig. 3. Cinnamon fern. (*Osmunda cinnamomea.*)

The theory of Warming is that all plant societies are determined primarily by the water content of the soil. Cowles accepts the proposition of Warming, but thinks it insufficient because of the fact that there is a wide variation in plant societies which grow in soils having the same water content. His most important conclusion is that plant societies are intimately associated with the physiography of a region and as the topographic forms change from one form to another the plant societies are also modified.

Physiography.

The evidence indicates that this swamp has been a lake or a part of a lake which at consecutive periods has occupied three distinct levels.

The First Lake.—A level plain whose elevation is about eight feet above the level of the swamp extends around the swamp and along its marshy outlet to the Tippecanoe River. Below the outlet two moraines approach the river from each side and show indications of being cut by water at their ends. It seems probable that these and possibly other moraines were continuous immediately after the glacial recession, while the Tippecanoe drainage basin was being established. This would have caused a large irregular area, including the area described, to be under water.

The Second Lake.—When these larger moraines were cut in two this lake was lowered to the level of a moraine, extending across its outlet and nearly parallel to the Tippecanoe River. The outline of this lake can be pretty accurately traced by the dark peaty soil and the sedges which still grow in what was the shallower part of it.

The Third Lake.—The erosion of the outlet tended to lower the water-level of the lake while constant deposition of plants that grew and died around the margin tended to bring the lake floor nearer the surface. These processes eventually resulted in limiting the lake to the much deeper "kettlehole" in the northern part of the area described. The kettlehole is the region occupied by the present swamp.

The outlet of this lake was not through a narrow moraine, as had been the outlet of the lake at higher levels, but through a channel one mile in length, whose slope was very slight.

By a series of excavations on the west side of the swamp it was determined that the slope of the sand under the peat for the first eighty-two feet, beginning at the peat margin was one in ten; that is, for every

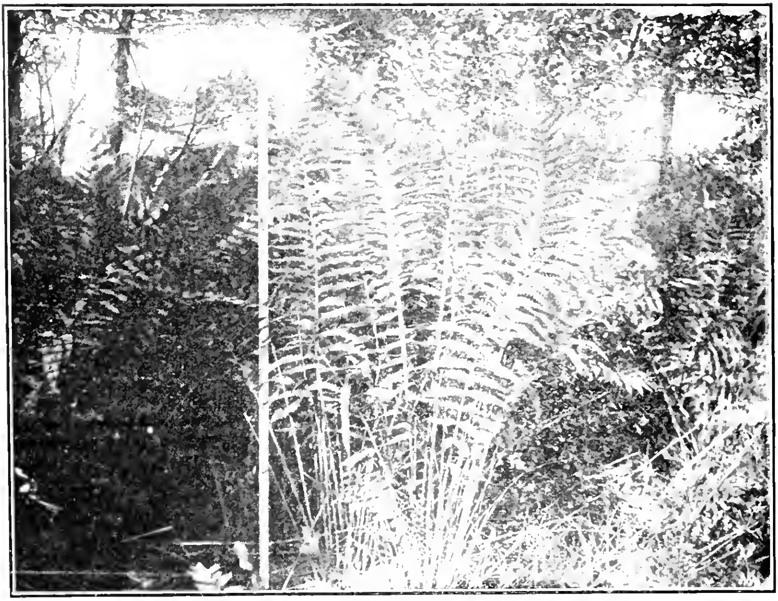

Fig. 4. Cinnamon ferns with scale. Spaces = 1 foot.

Fig. 5. Pitcher plants (*Sarracenia purpurea*).

advance of ten feet toward the center of the swamp there was an increase of one foot in the depth of the peat. If this slope continues to the center, a depth of 117 feet would be attained. The evidence cited does not prove that the slope is so uniform nor that the depth mentioned did exist, but approximately such a depth is probable.

Here was a lake of considerable depth surrounded by a very level plain (the older lake bottom), with an outlet over a mile in length, and with shores of slight slope. What was the cause of its extinction?

Fig. 6. Drosera intermedia.

Description of the Swamp Proper (Fig. 1).—The drainage lines of the swamp begin at the northwest corner and extend around near the margins to the southeast corner. The central part is slightly elevated above the remainder.

These facts indicate that the plants are more vigorous in the center than near the margins. This elevated portion has in its center a U-shaped area of tamaracks (Larix Americana), with the open end of the U pointing northward. Most of this northern opening has been due to artificial disturbance. The primary drainage-lines are on the east and

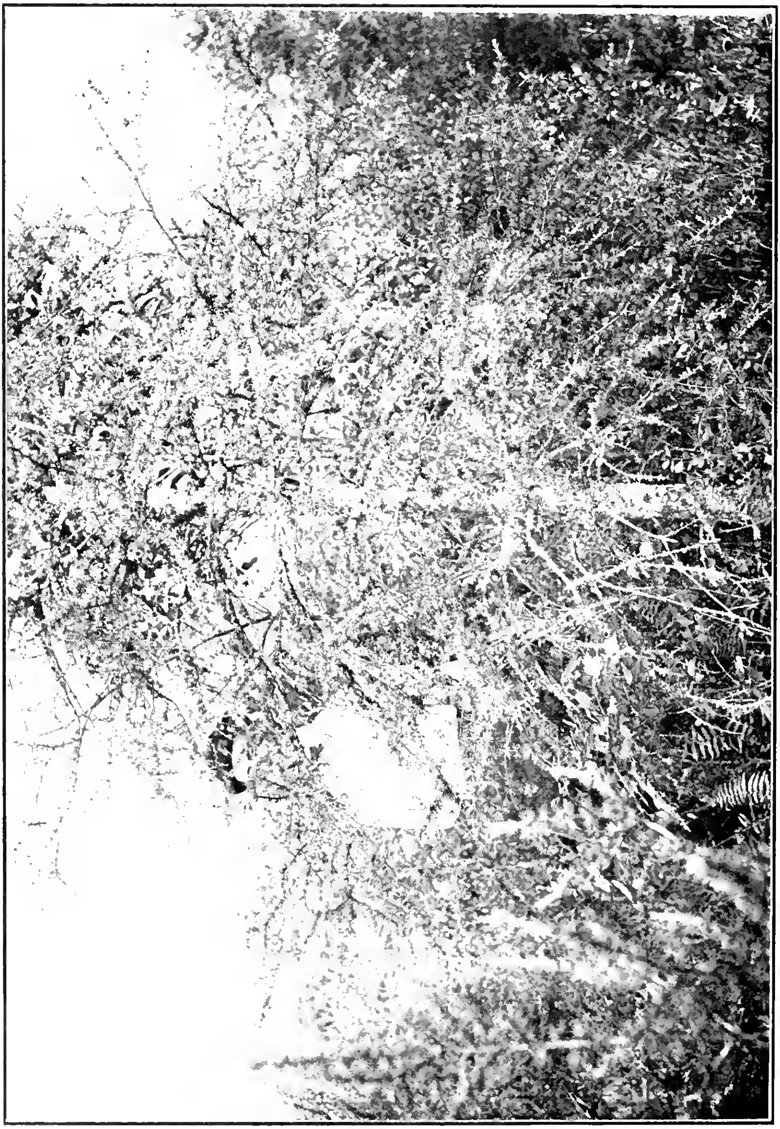

Fig. 7. A lichen-covered tamarack.

south. On these sides the slopes are more abrupt. This has a very marked effect upon the flora.

The flora may be divided into four regions: (1) The tamarack area, (2) the west and north slope, (3) the south slope, (4) the east slope.

The tamarack area has many individual plants but few species. The tamaracks are very dense except in the southwest part. Mingled with these are poison sumachs (Rhus venenata), dwarf birch (Betula Americana) and huckleberry (Gaylussacia resinosa). The ground is covered with sphagnum, much of which is arranged in its characteristic hassocks. (Fig. 2.) Growing from among these hassocks and probably assisting in forming them are ferns (Osmunda cinnamomea), Figs. 3 and 4. Near the margin this fern is replaced by the Royal fern (O. regalis). Mingled with the sphagnum are pitcher plants (Sarracenia purpurea) (Fig. 5) and Drosera (Fig. 6). D. intermedia being the most abundant in the southern partion and D. rotundifolia in the northern part. As the dryer marginal regions are approached sphagnum is replaced by such mosses as Polytrichium, Leucobryum and Dicranum. In the slightly shaded portion two species of orchids were found (Calapogon pulchilla, and Cypripedium spectabile).

In the eastern part the boles of the tamaracks were covered with Parmelia, but in the southern and western part these were replaced with Cetraria aleurites and Usnea barbata of such vigorous growth that they often cover the branches to their tips and envelope the chlorophyl tissue (Fig. 7). Coincident with this is the death of the tamarack, but whether there is a cause and effect relation between these phenomena and, if such a relation exists, which is cause and which effect has not been determined.

Under this growth excavations showed that there was a great depth of pure peat. Many of the plants composing this peat were well preserved. It was possible to identify some of them as being of the same species as some of the living forms now growing above this accumulated debris.

The West Side.—At the south end of the west side, is a rail fence. Along this fence has crept in maples (Aces rubrum), poplars (Populus tremuloides), and a few elms (Ulmus Americana). This fence, as all artificial things seem to do, disturbed the natural sequence of plants. As a result of this disturbance, just north of it occurs a great variety of plant life, which, as one passes to the north, is differentiated into three well defined zones (Fig. 8). The inner is dominated by the poison sumach

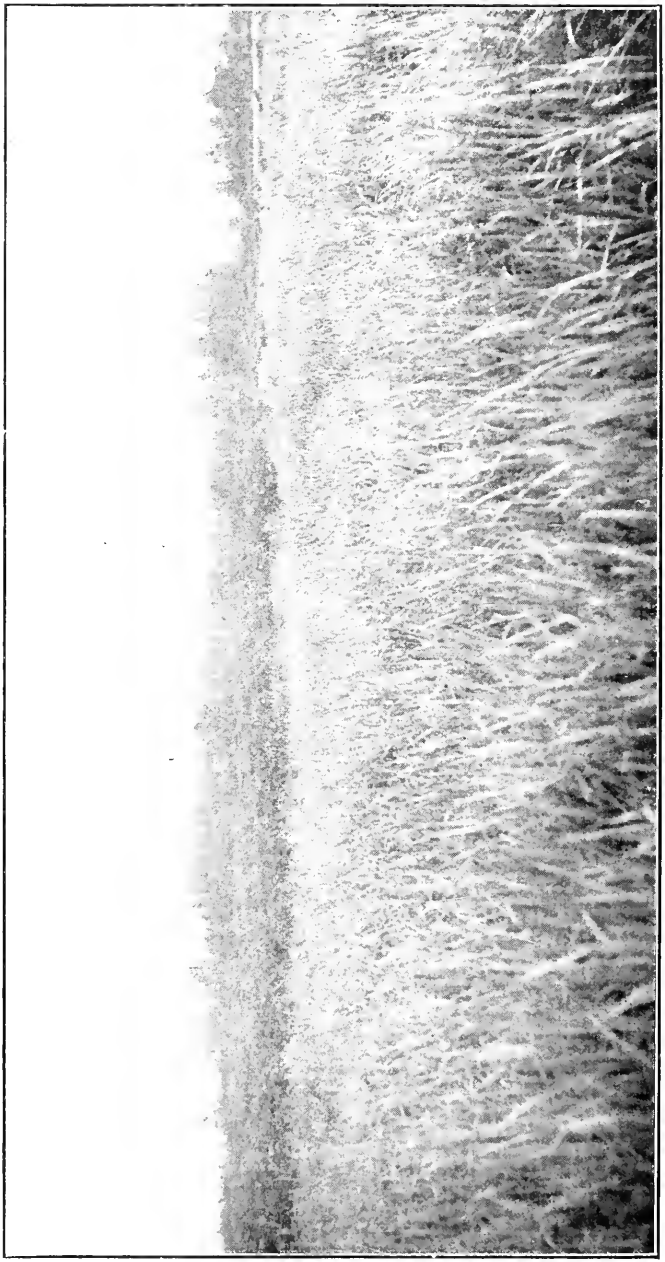

Fig. 8. The three zones on the west side.

(Rhus venenata), the second by blue flag (Iris versicolor) and the third by sedges. The Rhus belt contains a very little sphagnum, a few pitcher plants, and some droseras. These are plainly remnants of a condition similar to that which maintains at present in the tamarack area. Besides these there are sedges (Eriophorum Virginianum), swamp bellflower (Campanula aparionoides), and a few mints (Mentha Canadensis, and Lycopus sinuatus).

The Iris Zone.—The blue flag (Iris versicolor) gives the color to this zone, but there are nearly as many individuals of marsh shield fern (Asplenium thelypteris) and bonset (Eupatorium perfoliatum) as of Iris. These were the predominant plants, but there appeared a smaller number of goldenrods (Solidago Canadensis), meadow sweet (Spirea salicifolia), trow-weed (Vernonia Noveboracenous), horse-mint (Monardo fistulosa) agrimony (Agrimonia pariflora), and vervain (Verbena hastata). The mints and composites seem to be the most prominent among the forerunners of mesophytic life. Outside this was a fragment of a sedge belt. This contained coarse sedges and grasses (Scirpus atrovirens S. microcarpus, S. cyperinus, Panicum Crus-galli) and a few composites.

The north side (Fig. 9) is like the west except that there is no sedge zone, the Iris of the east end is replaced by calamus (Acorus calamus), and the Rhus almost disappears as the eastern extremity is approached. Two species, however, should be noted. On the inside of the Rhus zone two individuals of thistle (Cnicus lanceolatus) were found. These are, as it were, the extreme advance guards of xerophytic conditions. About the center of this zone, several individuals of Sagittaria (Sagittaria variabilis) in a healthy condition were found. So far as I am able to discover, this plant is never introduced except in water. This means that this plant has been able to survive the changing conditions from lake margin to Rhus belt by gradual adaptations. These plants were much smaller and contained less chlorophyl than plants of the same species growing in water at the same latitude.

The South Side.—The south side contains one of the primary drainage lines. Along this an open ditch has been dug. The willows (Salix nigra, S. alba, S. discolor, S. tristis, S. lucida, S. cordata) follow the ditch throughout its entire length. Near the east end the roses (Rosa Carolina) form a belt reaching from the deciduous forest trees on the south to the tamaracks on the north. North of the ditch they follow the ditch to its western extremity, but the zone becomes narrower. Toward the west a

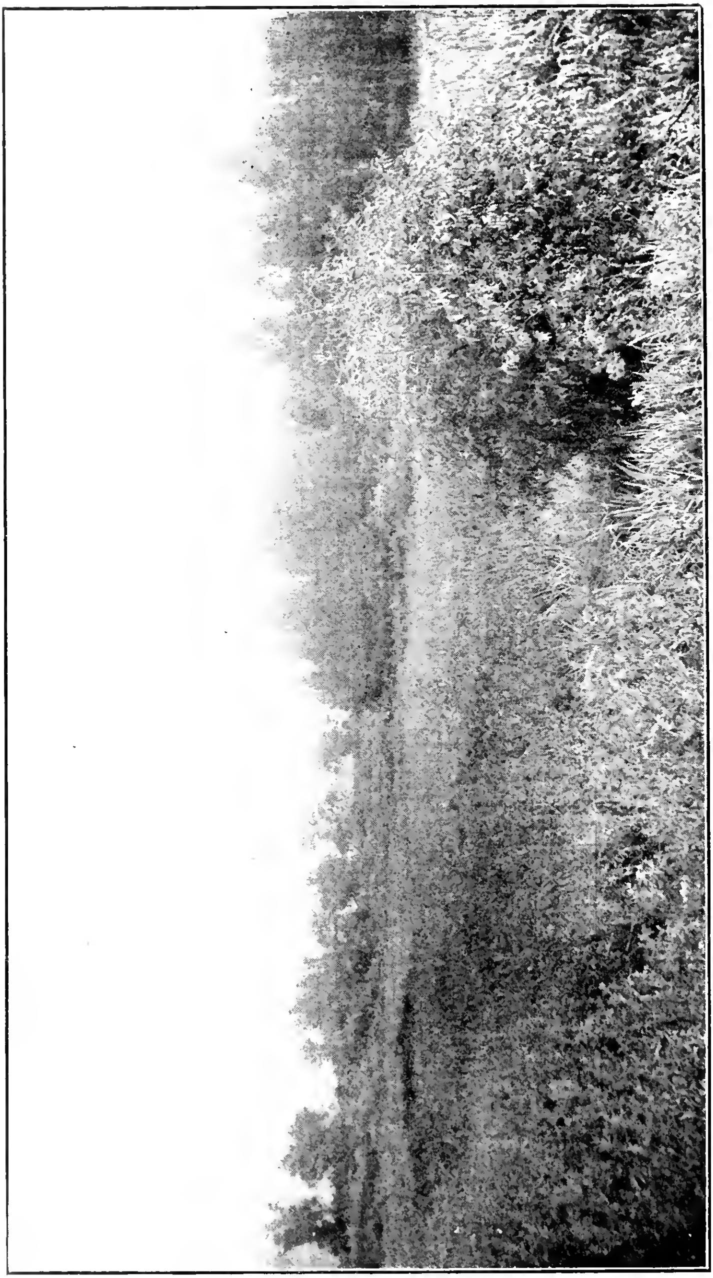

Fig. 9. The north side, look'ng sout'i.

zone of Iris occurs on each side of the willows. Wherever Rosa occurs Spirea abounds. Spirea tomentosa on the east side and Spirea salicifolia on the south side. Along the damper parts of this area grow Polygonum sagittatum, P. parvifolium, P. hydropiperoides, Epilobum strictum, Plantago pusilla, Galium trifida, Panthorum sedoides, and Alisma plantago. There is a fine carpet of false purslane (Ludwigia palustris) over the entire area.

The ditch itself contains water only in times of flood. Notwithstanding this it is almost covered with floating forms of liverworts (Riccia finitans, Ricciocarpus natans). Yellow wated lilies (Nuphur advena) grow in it for more than half its length.

At the west end, there is a sort of bay that has recently been fairly well drained. This has resulted in the introduction of a great variety of species. Most of those found further east along this side persist. In addition occur: Eupatorium perfoliatum, purpureum, Helianthus annuus, Solidago Canadensis, Bidens chrysanthenroides, Pycnantheum lanceolatum, Mentha Canadensis, Lycopus sinuatus, Virginicus, Potentilla argentea, P. parviflora, and Verbena hastata. It is a fine example of confusion of species during a change of conditions.

The East Slope (Fig. 10).—On the east side there is a row of willows near the margin. Inside this there is a broad zone of roses (Rosa Carolina), in which is mingled poplars (Populus tremuloides), swamp oaks (Quercus tinctoria), and elms (Ulmus Americana).

General Remarks and Conclusions.

First.—On account of the great depth of the peat and the slope of the underlying sand we may conclude that this swamp was a lake which has been filled with vegetation, and that the process still continues.

Second.—That in recent years the growth has been most rapid in the center of the swamp, thus elevating it and forcing the drainage lines to the margins. This was made possible through the inhibition of the processes of decay so often noted in sphagnum swamps.

Third.—The fact, that there are no peaty remains on the level plain surrounding the present swamp, indicates that the first lake was a very ephemeral one. When a topographic form exists for a short time its effect upon the flora is so slight that an interruption may be caused in the usual succession of plant life. An excellent illustration of this fact has been observed in connection with these studies in the case of Little Eagle

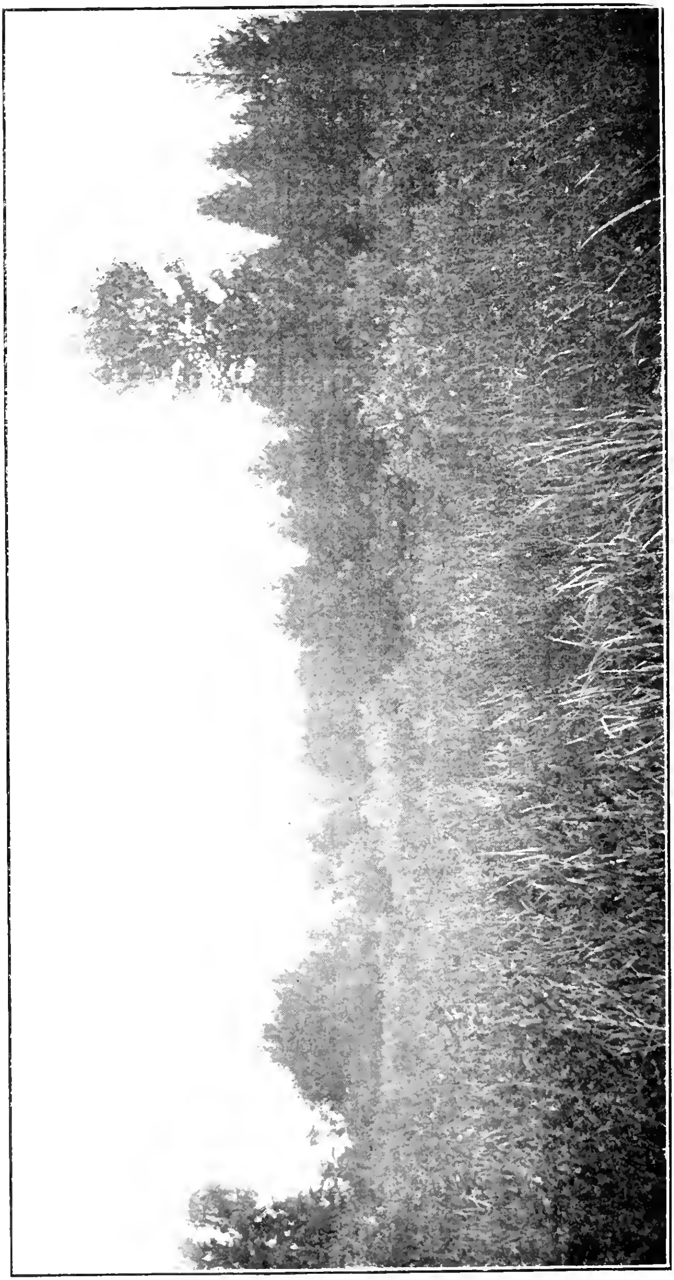

Fig. 10. The east side, looking south.

Lake, Kosciusko County, Indiana. Here the lake level has been lowered so rapidly that a meadow is developing without the usual intervening marginal swamp life.

Fourth.—Two additional comparative notes should be added. At the west end of Turkey Lake is a kettlehole which exhibits the early stages of the process. In parts the lake has been filled to the surface with plant remains. In some places the advance into deeper water is being made along the surface, so that a shelf of plant life exists with

Fig. 11. Kettlehole north of Eagle Lake.

very little beneath it except vegetable debris and water. The plant which contributes most to this is swamp loosestrife (Decodon verticillatus). It is soon assisted by sedges and willows, so that the zone which contains Decodon only is very narrow.

North of Eagle Lake is another kettlehole (Fig. 11), which exhibits the latter part of the process. The circular flat basin filled with peat and surrounded by moraines indicates clearly its origin. The water content of the soil would indicate mesophytic conditions. However the central part of this area is occupied by tamaracks. This affirms the proposition of Cowles that the change in topography may outstrip the co-ordinate modifications of plant societies.

Many more comparative studies will be required before each step in the process can be described in detail. All the conditions necessary for the formation of a tamarack swamp can not now be stated, although two are apparent (1) a relatively deep lake; (2) the destruction of this lake by plant deposition, for this alone can produce the proper substratum for the introduction of the tamarack.

A list of the orders of plants and the species in each found in the Leesburg Swamp:

1. NYMPHÆACEÆ.
   Nuphar advena.

2. SARRACENIACEÆ.
   Sarracenia purpurea.

3. GERANIACEÆ.
   Impatiens biflora.

4. ILICINEÆ.
   Ilex monticola.

5. SAPINDACEÆ.
   Acer rubrum.

6. ANACARDIACEÆ.
   Rhus venenata.

7. ROSACEÆ.
   Spirea salicifolia, S. tomentosa, Rosa Carolina, Potentilla Canadensis, P. argentea, Rubus hispidus, Agrimonia parviflora, Prunus Americana, Pyrus coronaria.

8. CRASSULACEÆ.
   Penthorum sedoides.

9. DROSERACEÆ.
   Drosera rotundifolia, D. intermedia.

10. ONAGRACEÆ.
    Epilobium strictum.

11. CORNACEÆ.
    Cornus Canadensis, C. florida, C. sericea, C. stolonifera, C. paniculata. Nyssa sylvatica.

12. CAPRIGOLIACEÆ.

Viburnum prunifolium, Sambucus Canadensis.

13. RUBIACEÆ.

Galium trifida, Cephalanthus occidentalis.

14. COMPOSITAE.

Vernonia noreboracensis, Helianthus annuus, Solidago Canadensis, Bidens chrysanthemoides, Eupatorium perfoliatum, E. purpuream, Cnicus lanceolatum.

15. LOBELIACEÆ.

Lobelia cardinalis.

16. CAMPANULACEÆ.

Campanula aparinoides.

17. ERICACEÆ.

Gaylussacia resinosa, Vaccinium macrocarpum.

18. VERBENACEÆ.

Verbena hastata.

19. LABIATÆ.

Scutellaria gulriculata, Monarda fistulosa, Pycnanthemum Virginiana, Mentha Canadensis, Lycopus Americana, L. virginicus.

20. PLANTAGINACEÆ.

Plantago elongata.

21. POLYGONACEÆ.

Polygonum sagittatum, P. hydropiperoides, P. arifolium

22. LAURACEÆ.

Sassafras officinale.

23. UTRICACEÆ.

Ulmus Americana.

24. JUGLANDACEÆ.

Carya alba, C. microcarpa

25. CULPULIFERÆ.

Quercus alba, Q. macrocarpa, Q. bicolor, Q. rubra, Q. tinctoria, Q. palustris, Q. imbricaria, Q. ilicifolia, Betula pumila, Corylus Americana.

26. SALICACEÆ.

Salix amygdaloides, S. alba, S. discolor, S. nigra, S. tristis, S. rostrata, S. lucida, S. cordata, S. humilis, S. longifolia, Populus tremuloides, P. grandidentata.

27. CONIFERÆ.

Larix americana.

28. IRIDACEÆ.

Iris versicolor.

29. ARACEÆ.

Acorus calamus.

30. ALISMACEÆ.

Alisma plantago, Sagittaria variabilis.

31. CYPERACEÆ.

Scirpus atrovirens, S. microcarpus, S. cyperinus, Eriophorum Virginianum.

32. GRAMINÆ.

Panicus Crus-Galli.

Note on the Recurrence of Brood V of Tibicen[1] Septendecim in Porter County, Indiana, During 1905.

By Walter L. Hahn.

In the Proceedings of this Academy for 1898 (p. 225-6), F. M. Webster, writing of the three broods of Cicada septendecim found in Indiana says: "Brood V covers only the area over which Brood XXII did not occur and does not, so far as I was able to learn, overlap that brood. It covers a small portion of Laporte County and the greater portion of Porter and Lake counties, and will reappear next in 1905." That his prediction was fulfilled the past summer, I am able to testify, for although I was not in this region during "cicada time" the evidences of their work were still abundant in the latter part of August, when I visited southern Porter County.

I am unable to define the limits of the brood, but saw the indications of its presence about Boone Grove and south of that village in the vicinity of Aylesworth switch, to within about a mile of the Kankakee River.

The effect of their work was most noticeable on the red oak trees, whose leaves were everywhere withered and brown to such a degree as to be easily seen at the distance of a mile or more. However, other trees had also been stung and were less noticeable only because their leaves had fallen and new ones had been put forth. The dried bodies and wings of the insects were everywhere abundant in the woods, so that there could be no doubt as to what had done this work, even had I not had the testimony of farmers living in the vicinity.

[1] Tibicen, Latreille, Fani. Nat., p. 426, 1825.

INDEX.

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