PROCEEDINGS

of the

Indiana Academy of Science

1906

PROCEEDINGS

OF THE

Indiana Academy of Science

1906

EDITOR, ... ARTHUR L. FOLEY

INDIANAPOLIS, IND.
1907

INDIANAPOLIS
Wm. B. Burford, Printer
1907

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
May 7, 1907.

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

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, May 18, 1907.

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

J. C. BILLHEIMER,
Auditor of State.

May 18, 1907.

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,
Secretary to the Governor.

Filed in the office of the Secretary of State of the State of Indiana, May 18, 1907.

FRED A. SIMS,
Secretary of State.

Received the within report and delivered to the printer May 18, 1907.

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 of said

Number of printed Reports.

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 Board 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.

Indiana Academy of Science.

OFFICERS, 1906–1907.

PRESIDENT
DAVID M. MOTTIER.

VICE-PRESIDENT
GLENN CULBERTSON.

SECRETARY
LYNN B. MCMULLEN.

ASSISTANT SECRETARY
J. H. RANSOM.

PRESS SECRETARY
G. A. ABBOTT.

TREASURER
WILLIAM A. MCBETH.

EXECUTIVE COMMITTEE

D. M. MOTTIER,
GLENN CULBERTSON,
LYNN B. MCMULLEN,
J. H. RANSOM,
G. A. ABBOTT,
WILLIAM A. MCBETH,
ROBERT HESSLER,
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,
O. P. HAY,
JOHN M. COULTER.

CURATORS

BOTANY	J. C. ARTHUR.
ICHTHYOLOGY	C. H. EIGENMANN.
HERPETOLOGY	AMOS W. BUTLER.
MAMMALOGY	
ORNITHOLOGY	
ENTOMOLOGY	W. S. BLATCHLEY.

COMMITTEES, 1906-1907.

Program,

R. F. Lyons, Donaldson Bodine, A. J. Bigney.

Membership,

R. B. Moore, O. L. Kelso.

Nominations,

J. W. Beede, W. A. McBeth, W. F. M. Goss.

Auditing,

D. A. Rothrock, J. P. Naylor.

State Library,

W. S. Blatchley, A. W. Butler, G. W. Benton,
J. S. Wright, L. B. McMullen.

Restriction of Weeds and Diseases,

D. M Mottier, W. S. Blatchley, M. B. Thomas,
G. E. Hoffman, W. H. Manwaring.

Editor,

Arthur L. Foley, Indiana University, Bloomington.

Directors of Biological Survey,

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

Relations of the Academy to the State,

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

Distribution of the Proceedings,

L. B. McMullen, L. J. Rettger, John S. Wright,
A. L. Foley, J. P. Naylor.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885–1886	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886–1887	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887–1888	J. P. D. John	Amos W. Butler			O. P. Jenkins.
1888–1889	John C. Branner	Amos W. Butler			O. P. Jenkins.
1889–1890	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890–1891	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891–1892	J. L. Campbell	Amos W. Butler			C. A. Waldo.
1892–1893	J. C. Arthur	Amos W. Butler	Stanley Coulter W. W. Norman		C. A. Waldo.
1893–1894	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894–1895	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895–1896	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896–1897	Thomas Gray	John S. Wright	A. J. Bigney		W. P. Shannon.
1897–1898	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.
1898–1899	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899–1900	D. W. Dennis	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900–1901	M. B. Thomas	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901–1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine	Geo. W. Benton	J. T. Scovell.
1902–1903	W. S. Blatchley	John S. Wright	Donaldson Bodine	G. A. Abbott	W. A. McBeth.
1903–1904	C. L. Mees	John S. Wright	J. H. Ransom	G. A. Abbott	W. A. McBeth.
1904–1905	John S. Wright	Lynn B. 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.
1906–1907	D. M. Mottier	Lynn B. M'Mullen.	J. H. Ransom	G. A. Abbott	W. A. McBeth.

CONSTITUTION.

ARTICLE I.

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

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

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

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

ARTICLE II.

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

SEC. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

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

ARTICLE III.

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

Sec. 2. The annual meeting of this Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past Presidents, together with the officers and Executive Committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not 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
J. C. Arthur	1893	Lafayette.
J. W. Beede	1906	Bloomington
George W. Benton	1896	Indianapolis.
A. J. Bigney	1897	Moore's Hill.
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.
W. A. Cogshall	1906	Bloomington.
Mel. T. Cook	1902	Santiago, Cuba.
John M. Coulter	1893	Chicago, Ill.
Stanley Coulter	1893	Lafayette.
Glenn Culbertson	1899	Hanover.
E. R. Cumings	1906	Bloomington.
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	Urbana, Ill.
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.
Robert E. Lyons	1896	Bloomington.
W. A. McBeth	1904	Terre Haute.

---

*Date of election.

V. F. Marsters	*1893	Bloomington.
C. L. Mees	1894	Terre Haute.
J. A. Miller	1904	Bloomington.
W. J. Moenkhaus	1901	Bloomington.
D. M. Mottier	1893	Bloomington.
J. P. Naylor	1903	Greencastle.
W. A. Noyes	1893	Washington, D. C.
Rolla R. Ramsey	1906	Bloomington.
J. H. Ransom	1902	Lafayette.
L. J. Rettger	1896	Terre Haute.
David Rothrock	1906	Bloomington.
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.

---

*Date of election.

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.
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.
Edward Hugh Bangs	Indianapolis.
Walter D. Baker	Indianapolis.
Harry Eldridge Bishop	Indianapolis.
William N. Blanchard	Greencastle.
Lester Black	
Lee F. Bennett	Valparaiso.
Charles S. Bond	Richmond.
Fred J. Breeze	Remington.
E. M. Bruce	Terre Haute.
Lewis Clinton Carson	Detroit, Mich.
Herman S. Chamberlain	Indianapolis.
E. J. Chansler	Bicknell.
Otto O. Clayton	Geneva.
Howard W. Clark	Chicago, Ill.
H. M. Clem	Monroeville.
Charles Clickener	Silverwood, R. D. No. 1
Charles A. Coffey	Petersburg.
Ulysses O. Cox	Terre Haute.
William Clifford Cox	Columbus.
J. A. Cragwall	Crawfordsville
M. E. Crowell	Franklin.
Lorenzo E. Daniels	Laporte.
S. C. Davisson	Bloomington.
Charles C. Deam	Bluffton.
Martha Doan	Westfield.
J. P. Dolan	Syracuse.

Herman B. Dorner	Lafayette.
Hans Duden	Indianapolis.
Arthur E. Dunn	Logansport.
Herbert A. Dunn	Logansport.
Max Mapes Ellis	Vincennes.
M. N. Elrod	Columbus.
Samuel G. Evans	Evansville.
William P. Felver	Logansport.
Wilbur A. Fiske	Richmond.
W. B. Fletcher	Indianapolis.
Austin Funk	Jeffersonville.
John D. Gabel	Montpelier.
Andrew W. Gamble	Logansport.
H. O. Garman	Lafayette.
Charles W. Garrett	Pittsburg, Pa.
Robert G. Gillum	Terre Haute.
Vernon Gould	Rochester.
Frank Cook Greene	New Albany
Walter L. Hahn	Mitchell.
Mary T. Harman	Odon.
Victor Hendricks	St. Louis.
John P. Hetherington	Logansport.
C. E. Hiatt	Bloomington.
John E. Higdon	Indianapolis.
Frank R. Higgins	Terre Haute.
S. Bella Hilands	Madison.
John J. Hildebrandt	Logansport.
G. E. Hoffman	Logansport.
Allen D. Hole	Richmond.
Lucius M. Hubbard	South Bend.
John N. Hurty	Indianapolis.
C. F. Jackson	Greencastle.
Wm. J. Jones, Jr.	West Lafayette.
O. L. Kelso	Terre Haute.
Frank D. Kern	Lafayette.
Charles T. Knipp	Urbana, Ill.
R. W. McBride	Indianapolis.
Richard C. McClaskey	Terre Haute.

N. E. McIndoo	Lyons.
Lynn B. McMullen	Indianapolis.
Edward G. Mahin	West Lafayette.
James E. Manchester	Vincennes.
Wilfred H. Manwaring	Bloomington.
William Edgar Mason	Borden.
Clark Mick	Berkley, Cal.
G. Rudolph Miller	Indianapolis.
Richard Bishop Moore	Indianapolis.
Fred Mutchler	Terre Haute.
Charles E. Newlin	Irvington.
John F. Newsom	Stanford University, Cal.
D. A. Owen	Franklin.
Rollo J. Peirce	Indianapolis.
Ralph B. Polk	Greenwood.
James A. Price	Ft. Wayne.
A. H. Purdue	Fayetteville, Ark.
Albert B. Reagan	Mora, Wash.
Allen J. Reynolds	Emporia, Kansas.
Giles E. Ripley	Decorah, Iowa.
George L. Roberts	Muncie.
E. A. Schultze	Ft. Wayne.
Will Scott	Bloomington.
Charles Wm. Shannon	Bloomington.
Fred Sillery	Indianapolis.
J. R. Slonaker	Madison, Wis.
Albert Smith	Lafayette.
Essie Alma Smith	Bloomington.
C. Piper Smith	Pacific Grove, Cal.
J. M. Stoddard	Indianapolis.
Albert W. Thompson	Owensville.
W. B. Van Gorder	Worthington.
H. S. Voorhees	Ft. Wayne.
Frank B. Wade	Indianapolis
Daniel T. Weir	Indianapolis.
Guy West Wilson	Bronx Park, N. Y.
William Watson Woollen	Indianapolis.
Herbert Milton Woolen	Indianapolis.

J. F. Woolsey	Indianapolis.
Wm. J. Young	Hyattsville, Md.
Lucy Youse	Terre Haute.
Charles Zeleny	Bloomington.

Fellows	53
Non-resident members	20
Active members	107
Total	180

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

PROGRAM

OF THE

TWENTY-SECOND ANNUAL MEETING,

INDIANAPOLIS, INDIANA.

Held in Shortridge High School Building, November 30 and December 1, 1906.

*President's Address—The Evolution of Medicine in Indiana	Robert Hessler

GENERAL.

*1.	A State Natural Park, 5m	Fred J. Breeze
*2.	Some Results from the Study of Life Insurance Problems, 10m	C. H. Beckett
3.	The Sex Ratio in the Fruit Fly and its Control by Selection, 10m	W. J. Moenkhaus
4	An Outline of the Course in the Experimental Engineering Laboratory of Purdue University, 10m	W. O. Teague
*5.	The United States Geological Survey	H. M. Wilson, Chief Geographer
*6.	Drainage Area of the East Fork of White River, 10m	G. W. Shannon
*7.	Steps in the Development of a Smokeless City	W. F. M. Goss
*8.	Experimental Studies of Reinforced Concrete, 7m	W. K. Latt
*9.	Reclamation Possibilities of the Great Plains, 30m	J. W. Beede
*10.	How the Body Fights Disease, 15m	W. H. Manwaring
11.	The State Production and Control of Vaccines and Antitoxines, 15m	L. W. Famulener
*12.	Recurrence of Uroglena in the Lafayette City Water Supply, 5m	Severance Burrage
*13.	Laboratory Tests on certain Liquid Dentifrices and Mouth-washes, 15m	Severance Burrage
*14.	A Critical Study of Methods of Sweeping Rooms and Wards in Hospitals, 10m	Severance Burrage

*The program committee suggests that papers 6 to 9 inclusive be heard at the Friday evening meeting and that the Academy invite its friends.

MATHEMATICS.

*15.	On the Reduction of Partial Differential Equattons of the Fourth Order, 10m	Charles Haseman
16.	The Determination of a Certain Family of Surfaces, 10m	Wm. H. Bates
*17.	Concerning Differential Invariants, 10m	D. A. Rothrock
*18.	Conjugate Functions and Canonical Transformations, 10m	D. A. Rothrock
19.	On the Formula for the Area of a Curve in Polar Coordinantes, 10m	Jacob Westlund
20.	A Group of Scrolls Connected with a Steam Locomotive, 10m	C. A. Waldo

CHEMISTRY.

*21.	Notes on Salt Lime, 10m	F. B. Wade
*22.	Sugar and Sourness, 10m	P. N. Evans
*23.	A Simple Method of Measuring Hydrolysis, 10m	G. A. Abbott
*24.	The Ionization of the Successive Hydrogens of Orthophosphoric Acid, 10m	G. A. Abbott
25.	Thiocarbonylsalicylamide and Derivatives, 5m	R. E. Lyons and Elizabeth Shirley
26.	Some Complex Ureids, 5m	R. E. Lyons and James Currie
27.	A Volumetic Method for the Estimation of Selenic Acid, 5m	R. E. Lyons and C. G. Carpenter
*28.	The Solubility of Uranium X in Ammonium Carbonate and the Variations in the Activity of Some Uranium Compounds, 10m	R. B. Moore and Herman Schlundt
*29.	The Separation of Iron and Manganese by means of Pyridine, 5m	R. B. Moore and Ivy Miller

PHYSICS

30. The Hall Effect in "Hensler" Alloy, 10m. .... D. H. Weir
*31. The Distribution of Stress in a Riveted Joint, 15m.. .... Albert Smith
32. Coefficient of Expansion of Brick, 10m... ....C. V. Seastone
33. Measurement of Water by Means of a Vertical Jet, 5m.. ....C. V. Seastone
*34. Mathematical Principles Applied in Earthwork Construction, 10m...... ......J. Garman
35. Strength of Materials Under Combined Stresses, 5m.................. E. L. Hancock
36. Lines on a Pseudosphere and Syntractrix of Revolution, 5m .... E. L. Hancock
37. Elastic Changes in Steel due to Overstrain, 10m........................ ....E. L. Hancock
38. Waterproofing Mixtures for Concrete, 5m.............................. .....W. K. Hatt
*39. Contributions to Knowledge of Vehicle Woods, 10m.................. ......W. K. Hatt
39a. The X Ray, 10m . . . . G. P. Hetherington
*39b. On Certain Demonstration Apparatus for Alternating Currents, 10m ....C. P. Mathews

BOTANY.

*40. Notes upon the Rate of Tree Growth in Glacial Soils of Northern Indiana, 15m. ... ..Stanley Coulter
41. The Michillinda (Michigan) Sand Dunes and their Flora, 10m..... ....Stanley Coulter
*42. A List of Algae, 10m.. Frank M. Andrews
*43. Some Monstrosities in Plants, 10m.. .Frank M. Andrews
44. How Plant Rusts Live over Winter, 10m. ... . .J. C. Arthur
*45. Parasitic Plant Diseases Reported for Indiana, 10m....... . ... Frank D. Kern
*46. Notes on Occurrence of Sclerotinia fructigena, 10m... ....Frank D. Kern
47. Additions to the Indiana Flora No. 3, 3m..... ... . Chas. C. Deam
48. The Hymenomycetes of Indiana, 10m. ....Donald Reddick
49. Comparison of Primary and Secondary Structures of Some Woods, 15m..... Katherine Golden Bitting

ZOOLOGY.

50. The Lummi Indians, 10m..................................... ... Albert B. Reagan
51. The Mammals and Reptiles of the Rosebud Indian Agency, 10m .... .Albert B. Reagan
*52. A Crow Roost near Remington, Indiana, 5m.................................. ....Fred J. Breeze
53. Fauna of the Grand Summit Section of Kansas and Remarks on the Development of Derbya
Multistriata, Meek and Hayden, 15m...................................... .....F. C. Greene
54. The Mammalian Remains of the Donaldson Cave, 10m.................... ...Walter L. Hahn
55. Birds of Northwestern Indiana, 10m...................................... .Henry Link
*56. Notes on Indiana Birds, 10m... ....A. W. Butler
57. Some Internal Factors Controlling the Rate of Regeneration, 10m............ ...Charles Zeleny
*58. The Reactions of the Blind Fish, Amblyopsis spelaens, to Light, 10m.......... .... Ferd Payne
*59. Observations on the Formation and Enlargement of the Tube of the Marine Annelid, Chaetopterus variopedatus, 10m...H. E. Enders
*60. Notes on the Artificial Fertilization of the Eggs of the common Clam, Venus mercenaria, 5m..H. E. Enders
*61. Some Observations on Ferment-activity in Unfertilized and Fertilized Eggs of Sea Urchins
and Star Fish, 15m... .... O. P. Terry
62. Blood Pressure in Man, 10m...G. E. Hoffman
*62a. The Sense of Sight in Spiders, 15m..Alexander Petrunkevitch

GEOLOGY.

*63. Evidence of a Local Unconformity of Considerable Extent in the Pennsylvanian Rocks of
Southern Indiana, 15m.............. .... .A. W. Thompson
64. Summary of Glacial Literature Relating to Glacial Deposit, 10m... ..... .Albert B. Reagan

---

*Papers marked with a star were read.

THE TWENTY-SECOND ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The twenty-second annual meeting of the Indiana Academy of Science was held in Indianapolis, Thursday, Friday and Saturday, November 29, 30, and December 1, 1906.

Thursday, at 6 p. m., twenty members of the Academy dined together at the Claypool Hotel. Following the dinner the Executive Committee met in regular session at the hotel headquarters.

President Robert Hessler called the Academy to order at 9:30 Friday morning, in the teachers' assembly room at Shortridge High School. The transaction of business and the reading of papers occupied the attention of the Academy until 11 a. m., when Dr. Hessler read his paper entitled: "The Evolution of Medicine in Indiana."

Following this address came an adjournment until 2 p. m., when other papers came up for reading and discussion. At night papers of general interest were read and the friends of the Academy were invited to be present. On Saturday morning all unsettled business was cared for and the remainder of the papers were heard, when the Academy adjourned.

THE SPRING MEETING OF 1906.

The spring meeting of 1906 was held in New Harmony, Indiana, May 25 and 26.

The party reached New Harmony Friday afternoon, and in the evening was entertained at a meeting planned by the residents. Frank Owen Fitton presided at this meeting, and talks were made by Miss Carrie Pelham, on "The Community Life of New Harmony," and the Rev. William DuHamel on "The Scientific History of New Harmony."

Saturday was spent in exploring the town and its surroundings.

PRESIDENT'S ADDRESS.

THE EVOLUTION OF MEDICINE IN INDIANA.

ROBERT HESSLER, A. M., M. D.

On looking over the addresses of our past Presidents, I observe that they have usually dwelt upon subjects in which they were especially interested, and I feel it but natural that I should do likewise.

In addressing you I am not unmindful of the fact that the people as a whole are behind you, are in a measure represented by you as leaders in scientific thought, and that a discourse should be shaped accordingly. All that I should like to say would require much time; what I can say in the brief time allotted must be suggestive rather than a full and exact statement of scientific facts and deductions.

The subject is a vast one, but I shall consider it briefly from three standpoints: First, the evolution of the medical student and the coming of the medical man into our State; second, the evolution of diseases and the coming in of new diseases, or, rather, the introduction of old diseases into a new locality; and lastly, the changes in methods of the treatment of diseases.

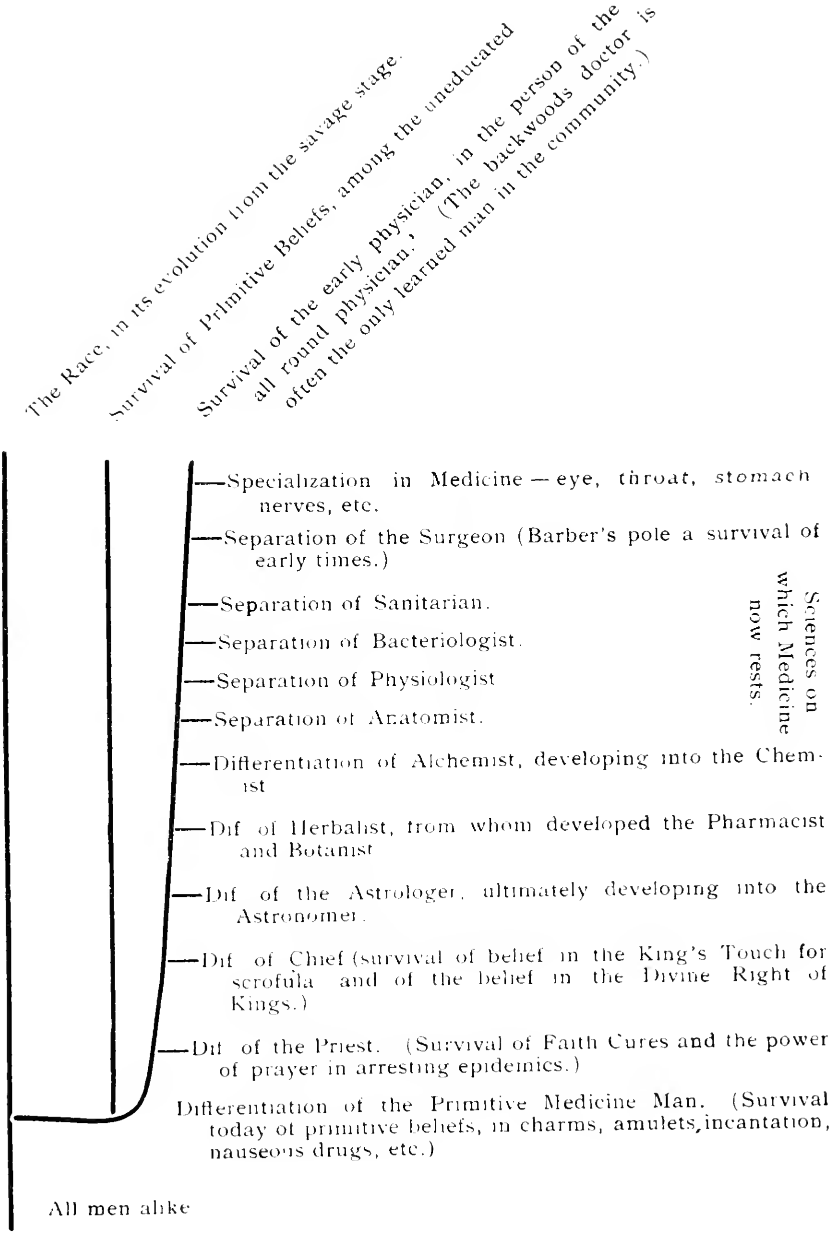
Art precedes science everywhere. Plants were used and cultivated before there was a science of botany; many of the processes underlying chemistry were known before there was a science of chemistry. Likewise the sick were treated before there was a science of medicine. There are not wanting those who deny that there is a science of medicine and who assert that it is simply an art based on many sciences—on anatomy, bacteriology, chemistry, and so on through the alphabet, but the prevailing view is that there is a science of medicine. Whichever view we adopt must lead to the conclusion that the greater a man's knowledge of science, the better a practitioner he will likely be, other things being equal.

What is the reason, I have been asked, so few of the Indiana physicians are members of the Indiana Academy of Science? If physicians are scientific men, why are so few members of the Academy? My usual reply is that our physicians are so busy fighting disease and giving relief to the sick that they have no time—such a reply satisfies many and places the doctors in a good light. But such a reply does not quite fit in case of the question: Why are so many doctors not members of a progressive medical society? Or, Why do so few contribute to the scientific medical literature of the State? Perhaps a brief review of the evolution of medicine in Indiana will enable us to draw some just conclusions.

As sciences do not spring up suddenly, but are a matter of slow growth, so likewise the accumulated stock of knowledge is not suddenly transferred to a new country; it takes a long time to bring it in, and our State is no exception.

THE PRIMITIVE MEDICINE MAN: The primitive medicine man was the first to differentiate from the race; when all hunted and fished, he alone stood apart and in the course of time separated more and more. As knowledge was brought together, there was a further differentiation, sciences crystallized out and pursued independent courses—but in their application are always of benefit to man. Where the early medicine man held all the knowledge of his race or tribe, in the course of time there arose a number of learned men. The man who studied the stars in time developed into an astrologer and later on into an astronomer, just as the herbalist developed in time into a pharmacist or botanist. (The diagram is intended to show this relationship in a general way. The survival of old time beliefs and methods of treating diseases being represented by a line parallel to the development of the race, we need only think of the use of charms and amulets, of faith-cures, the administration of nauseous drugs, and so on, to gain an idea of how much still survives.)

INDIAN MEDICINE MAN: The native Indian medicine man belonged to a race still in the childhood of civilization, a race in the hunting and fishing stage, and his beliefs and methods of treating disease were on a level with such a stage; moreover at the time the white man first came in, the Indians had few diseases to contend with. Contrary to the popular belief, the modern physician can learn nothing from the Indian medicine man, though the life of the Indian can teach him many things pertaining to the value of simple food, pure water and air, with out-of-door exercise.



The Race, in its evolution from the savage stage.

Survival of Primitive Beliefs, among the uneducated

Survival of the early physician, in the person of the all round physician. (The backwoods doctor is often the only learned man in the community.)

—Specialization in Medicine — eye, throat, stomach nerves, etc.

—Separation of the Surgeon (Barber's pole a survival of early times.)

—Separation of Sanitarian.

—Separation of Bacteriologist.

—Separation of Physiologist

—Separation of Anatomist.

Sciences on which Medicine now rests.

—Differentiation of Alchemist, developing into the Chemist

—Dif of Herbalist, from whom developed the Pharmacist and Botanist

—Dif of the Astrologer, ultimately developing into the Astronomer.

—Dif of Chief (survival of belief in the King's Touch for scrofula and of the belief in the Divine Right of Kings.)

—Dif of the Priest. (Survival of Faith Cures and the power of prayer in arresting epidemics.)

Differentiation of the Primitive Medicine Man. (Survival today of primitive beliefs, in charms, amulets, incantation, nauseous drugs, etc.)

All men alike

EARLY INDIANA PHYSICIANS: When the pioneer came to our territory he left his old diseases behind, but in the course of time they followed him, and he had to make the best of it. Until a country is sufficiently settled to support an educated physician, none comes in. Men were influenced then by the same motives that influence them today. No well educated physician today thinks of settling in the backwoods; but as soon as a settlement is made and a village arises, some venturesome spirit is apt to come in. As a matter of fact the first Indiana physicians were men connected with the United States army posts along the Wabash river, little over a century ago; unfortunately they left no records of their observations.

Physicians proper began to come in during the first decade of the past century, but there are scarcely any medical records prior to the year 1820. The early physicians led a strenuous life; there were no roads and the sick were scattered over a large area; it was a horseback and saddlebag life. Few had time or inclination to write—to the few who did write we owe all our knowledge of those days. Medical books then were few and costly; a man with one book in each branch of medicine was indeed a rarity. Medical journals were equally rare, and the fact that some of the early Indiana physicians took the London Lancet speaks volumes for their learning and ambition.

The educated physician soon had apprentices; that is, farmers' sons, who learned the rudiments of the profession and then began their own work; few went to a medical school. For a long time there were only two medical schools this side of the Alleghanies—at Lexington, Ky., and at Cincinnati—and to attend these meant a long trip over roads at times almost impassable. At first there were simple medical laws, but these were abolished, and after 1843 the field was open to all. Just as bad money drives out the good, so bad physicians drove out the good, or prevented good ones from coming in, and for a long time medical affairs went backward. But we must not forget that Indiana retrograded generally during this time. In 1850 Indiana was the eighth State in point of number of inhabitants, but ranked twenty-third in illiteracy—lower than all the slave states but three. The term "Hoosier" was a term of reproach, from which our physicians did not escape, and sharp criticism was passed on some of our civil war surgeons.

The early Indiana physicians had few kinds of diseases to contend with, but these few made up in number of cases for the lack of kind. Malaria ravaged frightfully and dominated all diseases. The standard treatment for malaria, as for most other diseases, was bleeding, purging and vomiting, and the use of calomel, whisky and bark, the latter in time displaced by quinine.

In the course of time the pains and aches of civilization came in. I have heard old settlers speak of them as "new-fangled diseases," and there came also a revulsion against old methods of treatment. In the absence of restraining medical laws, a host of practitioners soon appeared; some of these became quite skillful, but one is reminded of the story of the man who expressed his admiration at the skill of the oculist who had just operated on him; the oculist admitted that he was skilled, adding, "But I spoiled half a bushel of eyes in learning to perform that operation."

Gradually the "isms" and "pathies" of medicine appeared, most of them a protest against some of the absurdities of the old practitioners. There are no "isms" nor "pathies" among the sciences on which medicine rests—anatomy, bacteriology, chemistry, and so on, are free from them; but when it comes to therapeutics or treatment, one-half of the doctors think the other half wrong. However a number of established facts are gradually accumulating and in the course of time there will be a science of therapeutics, in which serum therapy will, no doubt, hold a prominent place, and many of the drugs of today only a minor one.

With the advance of civilization a number of well defined diseases tend to diminish, but with a massing of humanity a host of ills tend to increase. There are any number of affections that scarcely rise to the dignity of a disease. Prescribing becomes largely a prescribing for symptoms, and many of the sick do their own prescribing; some go to a physician only as a last resort. Many are unwilling to pay the physician for the time it takes to investigate, and so the physician himself simply prescribes for the symptoms. Some physicians are so busy doing this that they have no time for study or to attend the meetings of their medical society, much less attend and take part in the deliberations of any scientific society. The bane of the scientific physician is the busy practitioner who flits from one patient to another, never studying any case in detail nor taking time for study, or manifesting any interest in the progress of medicine. The number of men who have contributed to the annual Transactions of the Indiana State Medical Society is remarkably small; where a few make frequent contributions, many make none at all.

MEDICAL SCHOOLS: For a long time our State had no school for the education of physicians and the more ambitious students of medicine had to go elsewhere. More than fifty years ago the doctors of Indiana were discussing the advisability of establishing a medical college; there were arguments pro and con. Some believed that if we could not have a good school, we had best have none. Since then many medical colleges have come into existence and continued for variable periods of time. Some "went under" early, others experienced the hardships of existence as private institutions. The struggle is still going on. Indiana is behind the times; she is still without a medical school controlled by the State. Every civilized country sooner or later is compelled to assume control of medical education.

The art of medicine has made progress in Indiana, but the science lags behind; so far, our State has made little real addition to the science of medicine.

Although at the time of the passage of the common school law, only about fifty years ago, the term Hoosier was one of reproach, the advent of the schoolmaster and State education soon changed that, and today we take pride in being called Hoosiers—it is becoming a term of honor rather than of reproach. We have wholly outgrown our former reputation, and Indiana literary productions are known the world over.

The old medical schools did their work well; it was a practical work; but until the State takes charge of medical education and sets a good standard, little advance in medical science is to be expected.

Art precedes science everywhere. Our own physicians have been so busy applying the knowledge already extant that they have not had time to make original observations, and few have published their observations. But the time will come when our physicians will add to the scientific literature of medicine—the rise of general education and of literature in our State foreshadows it.

THE ADVENT OF DISEASES.

The coming in of new diseases can perhaps be best understood in the light of the analogy of the coming in of new weeds. Weeds and diseases can be compared in many ways, but after a time analogies fail and each must be studied separately. Pointing out analogies often leads men to think, and in this light they are justifiable.

Early Botanists and Early Weeds—Early Physicians and Early Diseases: Of the prevalence of the early weeds of our State we know but little; there were no competent observers. A farmer might fight weeds all his life and yet know but little about them, about their characteristics and properties, or their classification, and he is very apt to confound species. A farmer usually simply learns to do certain things, only a few inquire into the reason why or into the nature of the thing itself; we call these few progressive farmers.

The erratic Rafinesque was perhaps the first botanist who visited our State, but he left no records of Indiana plants. The first botanist to make a local list was Dr. A. Clapp, of New Albany, in the early thirties; at that time many European weeds had already wandered in. Since then a number of local lists have been made, some of them by physicians who botanized as a recreation. The first State Catalogue was that of Coulter, Barnes and Arthur, published in 1881. The complete State Catalogue of Stanley Coulter did not appear until 1900; since then a number of additional lists have appeared in the Proceedings of our Academy. New plants are constantly arriving, brought in from other States and countries; of these new arrivals many are weeds and of these some remain and become common. Where at first there were but few observers of new arrivals, now there are many, and new weeds are soon recognized and reported.

If it requires a botanist (even though only an amateur who submits to the superior knowledge of the expert) to distinguish between weeds, it must be evident that an educated physician is required to distinguish between diseases and to record the arrival of new ones. A man may fight disease or diseases all his life without knowing anything about Das Wesen der Krankheit; indeed, it is painful to admit that the best physicians have to fight diseases about whose real nature they know but little; like the farmer and his weeds, they can simply fight them in the way they have been taught or have learned how. Unfortunately the routinism of some physicians is on a plane little above that of the farmer's method; they are satisfied to live on without making any effort to find out and we do not look for any advance in learning from them.

The advent of the educated physician has already been referred to, so I shall proceed to give a few analogies between weeds and diseases. My remarks, as already mentioned, will be suggestive rather than exact scientific statements, mere outlines without dates. Of the many introduced diseases I can mention but a few. Animals and plants also have diseases but I shall refer only to disease in human beings.

ANALOGIES OF WEEDS AND DISEASES.

THE DAYS OF FEW WEEDS AND OF LITTLE DISEASE: The first settlers cultivated only small patches of ground, often only a "truck patch"; there were few kinds of weeds and these were natives and easily destroyed. The Ragweed (Ambrosia artemisiaefolia) was probably the chief among them.

Of the diseases of the native Indians at the time the white man first came among them, we know nothing, but we do know that their life was not conducive to the evolution and propagation and dissemination of diseases, and we can assume that, in all probability, they were practically free from disease. Men who live in isolation, and in proportion as they do live in isolation, are almost free from the common pus formers, the Staphylococci and Streptococci, with an absence of many of the common ailments of life dependent more or less on them.

The early settlers were a hardy set of men and women; they had left their weak and feeble behind, and they led a happy life, especially in the northern part of the State where the Indians were not savage or warlike, owing mainly to the influence of the French pioneers. There were few weeds and likewise few diseases; they had left both behind. But they found at least one native disease, namely milk sickness, or in other words, they found the cause of it, and when this got into the body, through the use of infected milk or the flesh of cattle with the trembles, a reaction came on, and this reaction was called Milk Sickness—a disease about which there has been much discussion.

THE DAYS OF DOG FENNEL AND JIMSON WEED—OF MALARIA AND TYPHOID FEVER: The Dog fennel came in early, from Europe. Jimson is a corruption of Jamestown, the early colonial settlement in Virginia. Both weeds flourish in neglected places, on farms, in villages and in towns; they disappear with the advance of progress and civilization. On clean farms and in clean villages and towns we see no Dog fennel today—but there are still Dog fennel towns in Indiana.

Malaria and Typhoid fever may appropriately be compared and contrasted with these two weeds; both were brought in by the white man. Malaria came first and was known as "The Fever." When typhoid fever came in it was called "Continued Fever," to distinguish it from malaria also known as "Periodical Fever." Until the decade 1840-1850, physicians the world over were not able to clearly differentiate typhoid fever, it was long confused with typhus fever; very recently another disease has been differentiated, known as paratyphoid. Thus finer and finer distinctions are being made. In this connection I might refer to the analogous case of the plants Scrophularia nodosa, Scrophularia Marylandica, and Scrophularia leporella, and how the latter, a native Indiana plant, was for a long time confounded with the other, just as that in turn had been confused with the European form—a botanist will readily understand this simple allusion.

Malaria and typhoid fever both flourish under simple and primitive conditions, that is, under a neglect of sanitation. Malaria flourishes where the Anopheles mosquito breeds and is transferred from one individual to another by its bite. The drainage of wet places and the use of quinine are the chief factors that account for the subsidence of malaria and its present rarity. Typhoid fever differs markedly from malarial fever in that one attack protects the individual. The weak are killed off and those who survive are immune (second attacks of the disease being rare) and this fact has an important bearing. Typhoid fever is chiefly a water-borne disease, especially well water. Where wells and closets are close together or where the subsoil is porous, diffusion takes place. In a family where typhoid fever occurred there may be no further difficulty from the use of the well water, but any stranger or visitor using it may fall a victim. In cities dependent on wells there may be much typhoid fever, while on the other hand a city with a good municipal water supply, especially where the water is properly filtered, may have little of it. Cities dependent on a river supply without previous filtration may fare very well so long as the water is clear, but with the muddying of the river after a rain and with a resort of the citizens to the old wells, there may be a constant recurrence of the disease. In this connection we must not forget that many of our rivers are today nothing but open sewers full of infectious germs.

Malaria has disappeared from the cities (the Anopheles mosquito does not live in cities) but it still flourishes in backward, undrained, communities—communities that are still in the Dog fennel days. On the other hand, typhoid fever is all too common in some of our cities and towns—another indication of the survival of Dog fennel days.

Not so very long ago the chief diagnostic character for distinguishing between the two diseases was the fever, that is the elevation of temperature, but every now and then so-called atypical cases occurred which left the diagnosis a matter of doubt. Today the scientific physician takes a few drops of blood from the finger of the patient, one drop he examines for the malarial parasite, the other is used for making the serum test for typhoid fever. In the one disease a few large doses of quinine usually cures outright; in the case of typhoid fever little medicine is given, little being required; with good nursing, proper diet, and an abundance of pure water and pure air, the patient is apt to recover. Although formerly no exact diagnosis was possible, yet the treatment of cases was simple; quinine, whisky, calomel and opium were standard remedies. Little attention was given to hygienic measures, the sickroom was often tightly closed, with the exclusion of fresh air, and as a consequence there was bronchial irritation, often bronchitis. Typhoid fever is not the fatal disease it was considered to be in the early days, and the nurse has largely taken the place of the doctor in the treatment.

In the early days of Indiana, bleeding was in order in the treatment of malaria, but this practice soon declined. Although the proper remedy is quinine, yet for a long time it was given in insufficient dosage. Just as too little water can be put on a fire, and fail to put it out, so too little quinine can be given to cure a patient—and if you wait too long the fire (or the disease) may become very destructive. It was customary to "prepare the patient for the quinine." Some died before the preparation was completed. The discovery of the Plasmodium malaria, the active cause of the disease, was a great advance in medicine. But to look for the parasite is not universal today; some physicians find it easier to prescribe before they are sure of the diagnosis—Dog fennel days still survive.

THE DAYS OF COMMON EUROPEAN WEEDS: The white man in his wanderings over the world has brought together a miscellaneous collection of weeds, and these follow him wherever he goes. Today most of our common Indiana weeds are immigrants from Europe, where they have resisted destruction for ages. The Amaranths and Chenopodiums when cut down will sprout anew; pulled up by the roots they take fresh hold while lying prostrate on the ground; if but a single plant ripen seed, the surrounding country will soon be restocked.

The white man in his wanderings has likewise collected a miscellaneous lot of diseases, and these, like his weeds, follow him wherever he goes. A list of their names may be found in the daily mortality statistics in the newspapers or in the advertisements of patent medicines.

Man fights his common diseases by resorting to the use of medicines, especially patent medicines; he has not yet learned that diseases, like weeds, may be eradicated, or that prevention is easier than cure. An intelligent farming community is apt to make a combined attack on weeds, and the less seed scattered about the fewer weeds there will be. Perhaps after a time we will go after diseases as the good farmer goes after his weeds; indeed, we have already reached the stage where we keep a lookout for such formidable diseases as the plague, cholera, typhus fever and several others; we do not allow them to land. But we are so accustomed to some diseases that have already landed and that have gotten a foothold among us, that we seem to have forgotten that we could get rid of them if we only tried.

Among the diseases once common in civilized Europe but now becoming more and more rare, may be mentioned leprosy, cholera, plague, typhus fever, miliary fever, scurvy, smallpox, malaria, typhoid fever, and others. Some countries are even beginning to show a reduction in the number of deaths from tuberculosis, and some cities regard the presence of much typhoid fever as a municipal disgrace. Man's control over the spread of diseases is becoming more and more marked.

THE ANALOGY OF WEEDS AND DISEASES CARRIED FURTHER: A botanist can take his manual and check off plants, especially weeds, that are spreading or migrating, and confidently look forward to the time when they will appear in his own locality. Those who are on the lookout for new weeds are rewarded every now and then by finding new arrivals. The date of many arrivals is known. New weeds are introduced in impure garden seed, or in the packing of crates or boxes; some travel by rail, others by water. Some come to stay for but a single season; they may find the environment unfavorable, early or late frosts may be detrimental; some live for a few years and then die out; a few, however, may find conditions favorable and flourish to such an extent that they may be seen everywhere, and a man who did not know of their introduction might be led to conclude that they always grew in the locality. The list of naturalized weeds in our State is today quite large.

The date of the first appearance of some of our diseases is likewise known, but unless a disease has some marked or striking characteristic, it is apt to be overlooked. Influenza and cholera were readily identified when they arrived in our State and the date of their arrival is duly recorded, but tuberculosis and typhoid fever came in so quietly and unobtrusively that no notice was at first taken of them, at least we have no records of their first appearance. People ordinarily do not reason about these things, but the early Indiana doctors realized that a change was going on and long ago the Indiana State Medical Society had appointed a committee to look into the matter. (In this connection I may say that only last week I reported to the Cass County Medical Society a case of tropical sprue, or psilosis, brought into the State by a missionary returned from Korea. New cases are, however, not apt to arise from it.)

Although there is an analogy between weeds and diseases, the former growing in the earth, the latter on or in the body, yet diseases are not entities that can be handled and examined. But in the childhood of the race disease was held to be a thing that had gotten into the body, had taken possession of it, and the early medicine man tried to drive it out by the use of all sorts of noises and nauseous drugs, even by torture. The Chinese and Korean medicine men of today are quite expert in thrusting long needles into the body of the sick; it is really wonderful how little damage they do—they have learned how to avoid the vital spots or organs. In some other countries the sick are filled up with all sorts of nauseous drugs, and the physicians are quite skilled in knowing what to give so that the patient may not die from the effect of the supposed remedy.

A specific disease is now regarded in the light of a reaction of the organism, of the body, toward some foreign cause, the reaction depending on the kind of cause. The reaction may be so definite that the disease may be diagnosed from the symptoms alone, without examining into the nature of the cause, though diagnoses based on a recognition of the cause are of course more exact than when based on symptoms.

The classification of diseases a hundred years ago, at the time when our State was first being settled, was by classes, orders, genera and species, just as in the case of botany and zoology. Many systems of classification have appeared, each one supposed to be an improvement over preceding ones, and physicians are just now working upon a new system which they believe will stand the test of time. Old systems were based on symptoms, the new is based on the recognition of the cause of the disease. Thus Osler's recent treatise takes up first the diseases due to animal parasites—those due, in order, to protozoa, parasitic infusoria, to flukes, cestodes, nematodes, and so on—followed by the specific infectious diseases, from typhoid and typhus fever running down to tuberculosis and leprosy, including some whose causes have not been definitely identified, analogy admitting their inclusion. The reactions or intoxications due to the ingestion of chemical substances, such as alcohol, morphia and lead, follow, with a mention of sunstroke—and then all at once there is a classification riot. For want of something better, a number of diseases are described under the head of "Constitutional Diseases." Then follow a host of affections and diseases that for convenience are grouped under their respective organs, beginning with the diseases of the mouth and running down the alimentary tract, followed by the affections of the other organic systems—the respiratory, the nervous, etc. One-third of the book is thus definite, based on a scientific system, the rest is simply based on convenience of reference. Although we have here real progress, yet how much still remains to be done.

Some of you may recall the story of the amateur botanist who complained to Linneus of the poverty of Sweden in material for study, and how Linneus placed his hand over a tuft of moss and said, "Here is study for a life-time." To study diseases we need not go to unexplored Africa, where so many new and strange diseases are being found; our common every-day ailments and affections and diseases are worthy of the deepest study, much is still to be learned about them. Not all is known about common everyday coughs and colds, about rheumatic and neuralgic aches and pains, about anemia and fever, dyspepsia and nervousness.

The old physicians diagnosed diseases almost wholly from or by their symptoms, and they were close observers, with sharpened senses like those of the Indian. The modern physician relies to a great extent on so-called laboratory methods, and the influence of the college and university laboratories is being felt. Rough and ready methods are more and more being replaced by refined ones. But we must not undervalue the importance of simple observations, without the use of instruments, nor should we neglect the training of the sense organs.

Scientific classifications are for scientific minds, but we must not forget that "Nature makes transitions and naturalists make divisions." Hair splitting in medical classifications, or nosology, is not unknown. As a matter of fact each group of specialists has its own system and nomenclature, and when the average all-round physician takes up one of the special treatises he requires the aid of a medical dictionary.

Popularly we can classify the diseases of our State, including those we have had in the past and not excluding those still to come, according to the way in which they are transmitted from one individual to another. It is perhaps needless to say that diseases are carried from one individual to another, from host to host, much after the fashion of weeds carried from one field to another. The seed of a weed may gain access to a field by being blown in by the wind, or it may have been brought in by an animal, especially by birds; many weeds have been brought in by impure garden seeds. Cheat or chess among wheat means that the seed was present; it does not mean the transformation of one species into another, nor does it mean a spontaneous generation.

The railways are important factors in the distribution of weeds, as they are of diseases. Before the days of railways new diseases traveled slowly, cholera and influenza required a long time to encircle the globe in their early migrations; today diseases may spread rapidly. In a thinly settled country, weeds and diseases spread slowly, while the massing of people in cities, especially in the absence of sanitation, favors dissemination.

Diseases due to specific causes can be grouped in various ways, like weeds; whether native or foreign; whether coming to stay, or to disappear after a short time; whether spreading rapidly and then dying out, or spreading slowly but surely and permanently, etc. Looked at in this light we might regard Milk Sickness as a native disease which is disappearing; Cholera as a disease which has come in repeatedly but on account of unfavorable conditions never gained a permanent foothold; Malaria as spreading rapidly and lasting for a long time and then declining; Tuberculosis as coming in and spreading slowly but surely and not yet having reached its maximum among us. Measles, scarlet fever, smallpox, whooping cough, etc., need only be referred to.

CLASSIFICATION OF DISEASES ACCORDING TO THEIR MODES OF TRANSMISSION: In a general way we may classify diseases according to how they are carried from one individual to another thus:

1. By direct contact—from one host to another.
2. Transmited through insects. (Notably malaria.)
3. Diseases conveyed by or through food.
4. Water-borne diseases.
5. Air and dust-borne diseases and affections (notably tuberculosis and pneumonia, with a host of other respiratory affections and a variety of aches and pains and functional disturbances.)

Out of the many diseases and affections that come under one or the other of the above groups, I desire to make mention of only two, namely, malaria, already referred to, and tuberculosis—one a decreasing, the other an increasing disease.

MALARIA: Malaria was the Grendel of the early Indianians. Today we can scarcely realize what the disease meant to the early settlers; in some localities it ravaged frightfully. Thus in the early history of our capital city we read that the forest was cleared in 1820 and lots laid out and in the spring of 1821 the immigrants rushed in to the number of six hundred or more. In the latter part of July malaria appeared, and, I quote from Drake, "Before the epidemic closed in October, nearly every person had been more or less indisposed, and seventy-two, or about an eighth of the population, had died." In some localities the disease was so severe that farming lands could not be sold, and for a long time immigration to our State was retarded; people went through to Illinois, to the prairies.

In an account of the diseases prevailing in Indiana in 1872, by Dr. Sutton, it was noted that the summer was dry, and in comparing reports from different counties of the State it was found that malaria had been more prevalent than usual in some of the rolling southern counties and in places along streams and rocky creeks, while, on the other hand, it was less common than usual in the northern counties where before it had been very common (but where drainage had made some of the worst places salubrious). At that time the view that decaying vegetation and moisture had a causative influence was universally believed, yet that theory did not explain the conditions. Today, in the light of the role the mosquito plays in the transmission of malaria, we can readily account for the facts.

In the rolling southern counties many of the small streams are fed by springs which flow a small volume at all times, but in dry seasons not sufficiently to create a current in the rocky creeks; hence many pools formed, and these pools served for breeding places for mosquitoes. Ordinarily even a small continuous current of water will prevent the development of mosquito eggs, and we must keep in mind the presence of fish and insects which feed on the mosquito larva, but which die off in times of low water, on account of its stagnacy. In the wet northern counties the drought meant a drying out of the breeding places of the mosquitoes, with a consequent reduction of the number of insects and of cases of malaria. The same reasoning holds for the increase of malaria along the larger streams; in ordinary stages of water there may be no stagnant pools or isolated bayous, but such form in time of drought, resulting in a destruction of the minnows and the development of countless numbers of mosquitoes.

MOSQUITOES: Mosquitoes occurred in immense numbers in the early days, when breeding places were plentiful. They were common along the canals, and an English traveler on the Wabash canal, in 1851, writes of them: "After tea, we all began a most murderous attack upon the mosquitoes that swarmed on the windows and inside our berths, in expectation of feasting upon us as soon as we should go to bed. But those on which we made war, were soon replaced by others; and the more we killed, the more they seemed to come to be killed, like Mrs. Bond's ducks; it was as though they would defy us to exterminate the race. At last, we gave up the task as hopeless, and resigned ourselves, as well as we could, to pass a sleepless night." He adds: "What with turning about on account of the heat and trying to catch the mosquitoes, who bit us dreadfully, we did not get much rest; and we rose the next morning unrefreshed."

Canals were a factor in the mosquito-malaria problem. In some of the older States it was noticed that malaria followed the canals, that the disease appeared where it had formerly been unknown; in other places it markedly increased its prevalence; some towns were almost depopulated. When Indiana undertook to build canals the malaria question was not overlooked; there was opposition. The reservoirs were considered especially obnoxious, and in places, notably in Clay County, the people began to destroy them; State troops had to be called out to protect the embankments; the Legislature even appointed a committee to inquire into the matter and report. This commission, and medical men generally, tried to minimize the supposed evil influence; in the light of the then prevalent decaying-vegetation theory they could not see how canals or reservoirs could increase the disease. Today we can readily see that the popular belief rested on good foundation; the reservoirs and the small ponds made on account of the embankments at gulleys or ravines, formed breeding places for mosquitoes. The larger ponds in the course of time became inhabited by fish and thereby lost their mosquitoes, but in the smaller ponds with a periodical drying out, fish could not live.

It was noticed that canal-boat men suffered less from the disease than the people along the banks, and this at first sight seems difficult to explain. But the explanation is simple; it is analogous to the explanation of why railway conductors and porters seem healthy in spite of their exposure to infective dust from the coaches, especially the smoking cars. On our railways today, men who are constantly suffering from the evil effects of inhaling a polluted atmosphere, manifested by colds and coughs, and catarrhs, by weeping eyes and noses, and are inclined to be sickly and demand frequent vacations, such men are not long retained in these positions by the railway managers—the weeding out process goes on all the time. Similarly a canal-boat man who was readily attacked by malaria and who lost much time on account of it, was not long retained in the position; those who retained their positions were the more resistent ones.

Facts are sometimes explainable by different theories. In the following story, taken from Drake, the substitution of "mosquitoes" for "whisky," as the apparent cause, more satisfactorily accounts for the facts or conditions. It should be remembered that the Anopheles mosquitoes are night-biters, that ordinarily they fly low, and do not frequent rooms or houses in which tobacco is smoked.

A few miles to the east of Fort Wayne there was a densely wooded swamp, known as the Maumee or Black Swamp, which extended on into Ohio. This swamp seems to have been salubrious; it was free from malaria, and families who settled in it "enjoyed uninterrupted autumnal health for three or four years," until malaria was brought in by other settlers. In 1838 excavations were made in the eastern end of this wet section for a canal. "The laborers, four or five hundred in number, were chiefly Irish, who generally lodged in temporary shanties, while some occupied bowers formed out of the green limbs of trees. * * * One contractor kept a liquor store, and sold whisky to all whom he employed, which was drank freely * * * the mortality (from malaria) among them was very great. Another lodged his operatives on straw beds, in the upper room of a large frame house, made them retire early, kept them from the use of whisky, and nearly all escaped the disease."

In this connection it may be said that in the malaria prophylaxis of Italy, screens on houses, and an avoidance of the mosquitoes outside of the houses, are of the greatest importance. In our own country the use of screens in windows and doors is a most important factor in the diminution of many ailments and diseases that formerly prevailed during the time of mosquitoes and flies, cholera infantum not the least among them.

The belief in the injuriousness of night air, still so prevalent among us, is readily traced to the days of the night-biting Anopheles mosquitoes filled with the germs of malaria. These mosquitoes do not live in cities, or at most only in the outskirts, and city night air is really better than that of the day time, because there is less dust in it.

The widespread use of quinine today is also traceable to the days of much malaria. Then it was given in almost every case of sickness, a sort of panacea, and this practice is simply kept up, not only by the people but by many doctors. Today quinine really has a very limited use. The so-called "False malaria" of our cities has no relationship to malaria proper; it is simply a reaction due to bad air, and not to the plasmodium malaria.

In the early days, when there was but little quinine, and that high priced, many of the native barks and herbs were used, notably the Dogwood, Yellow Poplar, Wild Cherry, Thoroughwort and American Centaury. They were steeped in whisky and formed "bitters;" bitters still survive and some are widely advertised in the newspapers; as a rule their value is nil. A number of other things concerning malaria might be mentioned, but I must desist and will close this account with a few remarks on Adaptation and Immunity.

We know that plants and animals are adapted to their surroundings and that few can bear any marked change of environment; wet soil and dry soil plants can not exchange places, nor can tropical animals exchange places with those of the frigid zones. But many of our cultivated plants and animals have been shifted about so much that they are able to flourish under a variety of surroundings, just as the white man flourishes because he has had such a varied experience in the past. Now there is also an adaptation in the case of diseases. Where a disease has long been in a country or locality, there is a mutual adaptation between the disease and the people, or in other words, between the parasite and the host. If a disease is so virulent that it kills off all the people, then the disease in turn is killed off, or dies out, for want of material. If on the other hand, a disease is not strong enough to attack at least some members of a community, then it is apt to be mild and to pick out and live only on the weak and feeble or aged or the very young, the robust adults escaping. But where a disease gets among a people who have never had it then it may be very destructive, many may perish and few survive, but the survivors may repeople the territory with a stock less susceptible, and we can see how, in the course of ages, with a killing off or weeding out of the susceptible, a strain may be produced that is able to live in the presence of the disease.

Examined in this light we get some clew to the original home of malaria. The negro of Africa is quite immune against malaria; there is an

MALARIA IN INDIANA.

Primeval conditions.

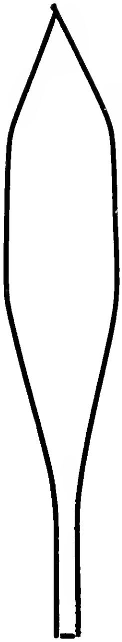
Ground covered by forest or herbage, retention of moisture or rain.

Streams running, clear, full of fish.

Coming in of the settlers.

Destruction of the forest, periodical drying up of the small streams.

Destruction of fish, increase of mosquitoes.



Advent of malaria.

Absence of physicians and remedies—antiperiodics.

Settling up of the country, malarial parasite more readily transferred.

Canal reservoirs and railway embankment ponds as factors.

Drainage of wet places, fewer mosquitoes.

Free use of quinine.

Isolation of the sick and use of screens.

Subsidence of malaria.

No malaria in large cities, little in suburbs.

Continuance of malaria in backward communities.

adaptation. The disease producing agent, the plasmodium, is there, and has been found in the blood of the people without apparently doing much harm, but when a white man gets into the country he may succumb very quickly. There may be even a marked difference in white men in their susceptibility to malaria, or other diseases, doubtless depending on the exposure of the ancestors in former times. The susceptibility of our native Indians is one of the chief arguments against the indigenous origin of malaria.

Malaria in Indiana has about run its course, as it has in older civilized countries; its mortality today is slight—our dog fennel days of malaria are about over.

TUBERCULOSIS: If malaria was the Grendel of early Indiana, tuberculsis occupies that position in our State today. While there has been a steady decrease in mortality from malaria, there has been a steady increase in mortality from tuberculosis, and we have not yet reached the maximum. Tuberculosis is an air-borne disease, or, more strictly speaking, a dust-borne disease, and conditions in our State were never so bad as today. Although the mortality statistics of tuberculosis are a fair index of bad air conditions, they do not tell the whole truth; the deaths from a number of other affections must be included, notably those from pneumonia.

Tuberculosis is the slow protest of nature against bad air conditions, pneumonia is the sudden outcry. The approach of tuberculosis is heralded by many and repeated warnings—clinicians speak of a pre-tubercular stage, a stage of coughs and colds, of pains and aches. Pneumonia strikes suddenly, without warning. The stranger within the gates of the city has no time to flee; and to remain in the crowded city is too often synonymous with death. In the country where air conditions are good, pneumonia is neither frequent nor very fatal, and under good air conditions tuberculosis does not thrive at all; indeed, the city victim on going out into good air is apt to recover, if he goes in time. The ancient Greeks knew the value of good air, the ponderous volumes of the physicians of a hundred years ago testify to its value, a value which we are now but rediscovering—we do not yet fully appreciate it.

We as a matter of course look upon tuberculosis as the great enemy of the human race—but after all it may be a friend in disguise! Few may be able to look at it in that light, but some arguments may be made in support of such a statement.

The old herbalists believed that the Creator made no plant in vain; they believed that every plant had its uses, if we could only find it out. Looked at in this light the lowly plants that produce disease may have some use; the cholera bacillus teaches our cities to clean up, and in proportion as they clean up they escape the ravages of the disease. The typhoid bacillus teaches us to look after the purity of our water supply, and cities and individuals who heed the lesson escape the disease. Perhaps the tubercle bacillus may teach us to clean up our cities and our homes and meeting places; it may teach us the use of pure air. But if tuberculosis is a friend of the race, it needs watching as fire needs watching; like it, it may be an exceedingly bad master.

We must look at the pre-tubercular stage in the light of a warning to get out of the dusty and smoky city; the aches and pains and the coughs and colds may subside very promptly in good air. If the individual remains in the city the disease sets in in earnest, to attack the lungs, and then it generates hope, and the victim wants to be up and about. And he should heed the additional warning before it is too late; he should not lie about the house or the dusty city; he should go out into "God's green country" and into the sunshine and pure air.

When a man has an acute alimentary tract affection, not to say disease, nature takes away his appetite and makes him gloomy; he lies about and refuses food, thus imitating the lower animals; if he persists in eating she sends a violent pain and he will probably desist. Nature wants no food and no work to do with an impaired alimentary tract; she wants rest, just as a broken bone wants rest to repair the damage. Men who heed the warnings of nature, the little aches and pains that tell them to do this and avoid that, are apt to live longest; the chronic invalid who takes care of himself may live on to old age, while the so-called strong or robust man who never has an ache or a pain, no warnings from nature, may go to pieces all at once and prematurely.

The aches and pains of the pre-tubercular stage of consumption should be heeded, and the hope generated by the disease itself should be acted upon; nature is showing the way. The elimination of the imprudent, and of those not adapted to their surroundings, has been going on for countless ages. Diseases have killed off our weak, and the process still continues. Our Indians scarcely came within the range of disease elimination; their life was not conducive to the propagation of diseases, certainly not of tuberculosis. When the white man brought in tuberculosis the Indian was scarcely attacked so long as he lived under old time conditions, an active out-door life; but when he tried to live under white man's conditions, in a fixed home, he promptly began to fail and is still failing—just as the negro fails when he crowds into the cities, and as the Italian fails who comes to our cities from the pure air of his mountain home. We may say the Italian is degenerate, that he has no stamina, but that does not explain his susceptibility, no more than to say the Chinaman is degenerate because he can live under filth conditions that the white man can not bear. The Jews coming from the old European cities, where their ancestors have for a long time lived in the ghettos and under extremely unsanitary conditions, are quite resistent to attacks of tuberculosis; they are simply the survival of the fittest; the Jew whose ancestry goes back to the open country, to a pure air life, can not hold up alongside the other, for his ancestors have not undergone the elimination process.

Tuberculosis is a protest against bad air conditions. We ought to be the healthiest and strongest people on the face of the earth; land is abundant and fertile, we have no years of famine, men are not tied down as in the old world; the poor food of Europe and the long hours of toil are unknown among us; at least there is no valid reason why long hours should be required. In spite of these conditions tuberculosis is on the increase among us, whereas in some European cities there is a decrease. Why should this be so?

If we write out statements of conditions, one line for clean European cities and another line for American city conditions, and make an equation by canceling conditions that equal each other, we have left the polluted air condition or factor: it offsets all our advantages.

Many individuals can thrive in the air of our cities today, others fail; thousands fail every year. Many contract the disease in the city and go to the country to die: many die from city diseases, other than tuberculosis and pneumonia, traceable to bad air conditions.

Shall we let bad air conditions go on, or even get worse, as they seem to be doing, and shall we let countless thousands die in the unceasing process of adaptation to environment, or shall we attempt to modify the abnormal environment and allow these thousands to live? We are told that tuberculosis is a curable disease, and that it is a preventable disease. It is an introduced disease which we have allowed to flourish unhindered. It is a disease that flourishes only under certain surroundings. We can make

TUBERCULOSIS IN INDIANA.

Primeval conditions.

Ground covered by vegetation—no dust. Indian had no name for dust.

Outdoor life not conducive to the propagation of tuberculosis.

Coming in of the white man, minus his weak, feeble and sick.

Clearing of the ground, formation of dust; Indian applied name of ashes to it.

Building of cabins and houses, formation of house dust.

Coming in of the feeble and sick; cared for in houses.

Advent of tuberculosis.—Tubercle bacillus.

Tuberculosis picking out the weak and those living indoors.

Settling up of the country, building of roads—formation of road dust.

Villages as factors, increased facilities for distributing the disease.

The village store, farmers crowded about the stove in winter, a factor.

Schools, churches, meeting halls, factors in polluted air.

Development of the tobacco chewing habit, an important factor—spitting.

Development of town conditions, shops and trades, confinement of men indoors.

Coming of the railroads and filthy cars and plush seats.

Development of city conditions—city dust.

Smoke from coal; paved streets and sidewalk dust.

Street cars as factors, crowding and bad air.

Tenements and flats, poor ventilation and little sunlight.

The trailing dress an important factor, filth dragged into the home.

Advent of the city slums, increase of poverty and neglect.

Blunting of sensibilities by the use of alcohol, opiates and anodynes.

Continued increase of tuberculosis.

these surroundings unfavorable for the disease; but it takes a combined effort, the individual is powerless.

Malaria is disappearing because the conditions favorable for its existence are disappearing; the opposite is true of tuberculosis. Moreover, quinine both prevents and cures malaria, and pure air prevents and cures tuberculosis. Whisky and calomel were popular prescriptions for malaria, neither cured; whisky and cod liver oil are popular prescriptions for tuberculosis today, yet neither cure, neither singly nor combined.

The administration of whisky, or of alcohol in any form, may be followed by a sense of well-being in tuberculosis, and in dust infection generally, and that is the reason why alcoholic preparations are so popular and so widely advertised as cures. But the sense of well-being is a false sense of security; to benumb the body and reduce the pain, the pain by which nature warns us, is poor treatment. As a matter of fact, alcohol is still one of the great eliminators of the human race; if we are wise we will avoid using it.

Over fifty years ago one of the pioneer physicians of Eastern Indiana wrote of the changes he had observed in his community and in the State; he said: "Phthisis, pneumonia and bronchitis are believed to be on the increase. Whether this is due, in any degree, to improved modes of living, such as tight houses, the general use of stoves, a less constant exercise in the open air, etc., it would be interesting to know." Today we know. Fifty years ago conditions in Indiana were quite primitive compared with conditions seen in our cities today, and yet the gradual increase of dust diseases was being noticed. (Tuberculosis in Indiana, page 45.)

(The chart of the evolution of different kinds of dust will explain itself.) (Dust chart, page 47.)

Tuberculosis, known also as phthisis and consumption, is among us; it came in with other diseases; it came in like some of the weeds of the fields. How soon will we make any attempt to get rid of it?

Our State Board of Health has been and is an important agent in diffusing a knowledge of diseases and of disease prevention among our people, and the recent establishment of laboratories for identifying diseases and for testing the purity of foods and drinks is of the greatest importance.

Physicians have been the prime movers in the establishment of these evidences of civilization, but it has been a long fight.

I am glad to see several papers on the program of our Academy this year that bear on the subject of sanitation; there have been some in the

THE EVOLUTION OF DUST.

	Cosmic Dust.	
	Volcanic Dust.	
Absence of Man.	Desert Dust.	
	Plant Pollen Dust.	
	Wild Animal Trail Dust.	
Hunting and Fishing Stage. (All men alike)	Traces of Dust due to Man.	Age of neglect of the Feeble, Aged and Sick.
Pastoral Stage.	Domestic Animal Dust.	
	Dust in Tents.	
Agricultural Stage.	House Dust.	Origin of House Diseases. Care taken of the weak, aged and sick; Greater development of Parasitism.
	Country Path or Road Dust.	
	Village Street Dust.	
Handicraft Stage.	Shop Dust.	Employment of the feeble in shops. Rapid development of air-borne diseases. Homes for the aged and feeble. Free use of alcohol.
	Shop Dust with Spittle.	
	Paved Street Dust.	
Industrial Stage.	Factory Dust in variety.	Large factories; crowded tenements; dusty and smoky air.
	Sidewalk Dust mixed with Spittle.	The age of hospitals and dispensaries, of throat and chest disease specialists.
	Tobacco Juice Dust.	
	Trailing Dress Dust.	No pure air in large cities.

past, and I hope to see more in the future; perhaps they could be grouped under a separate head, that of Sanitary Science.

Our Academy has a committee on "Legislation for the Restriction of Weeds." The popular conception of a weed is, a plant growing in the garden or field or meadow, of a plant out of place and more or less resisting destruction at the hands of man. That some plants grow on and in the human body, and in animals as well, is not so well known. The thought has suggested itself: Perhaps the scope of this committee could be enlarged by taking account of the minute weeds of the body. I would like to see the title of this committee read "Legislation for the Restriction of Weeds and Diseases."*

STATE HOSPITAL FOR TUBERCULOSIS.

In conclusion I desire to make a few remarks concerning the establishment of a State institution for the treatment of tuberculosis.

Modern medicine concerns itself more and more with disease prevention, in the individual and in the community. To give relief from disease and affliction has always been the aim and the practice of the physician, but so long as the active causes of diseases and the modes of their transmission were unknown, little could be done in disease prevention. The good Samaritan still has a place, but the physician who today is only a Samaritan in binding up wounds and who makes no effort to prevent the infliction of wounds, or who treats diseases and makes no effort to prevent the propagation of diseases,—such a physician does not fully represent modern medicine.

Modern medicine knows much about disease prevention, if the knowledge were only applied. Intelligence counts for much. The intelligent of a community often avoid much sickness, whereas the ignorant suffer; some of the latter are kept in a state of poverty on account of their lack of knowledge of diseases and disease prevention. As people become better educated in sanitary science and in hygiene, they will require more of their physicians. The high school graduate who has studied the human body in health and in disease is not apt to be a purchaser of quack medicines, or to consult an ignorant physician, much less one who has to herald his ac-

---

*On the day following this suggestion, the chairman of the above committee made a motion to enlarge this committee by adding two men who are physicians and changing the title as suggested; the motion was carried without a dissenting voice.

complishments in advertisements in the newspapers. Much is to be expected from the teaching of sanitary science in our schools.

Since it was discovered that tuberculosis is a curable disease, a number of countries and States have established institutions where such sick can be treated. Germany leads in this work. Some of the institutions are tent colonies in the forests. Out-of-door life, plain food and drink, pure air, little or no medicine, that is all that is required. The nostrums advertised in the newspapers are of no value. Nature simply needs a chance to correct the difficulty. When the disease has once fully taken hold, little is to be expected from any form of treatment, and only too often the real nature of the disease is not recognized until it is too late. It is possible to recognize the early stages of tuberculosis, and that is the time for beginning treatment; beginning in the pre-tubercular stage is still better. With flames bursting from every window, we do not look for the firemen to save the building, but we rather expect it of them when they arrive at the stage of much smoke and a tiny flame.

There are at least 25,000 individuals afflicted with tuberculosis in our State today, and 5,000 die annually in Indiana from this disease; in addition many die from pneumonia and other respiratory diseases, and of affections dependent on a polluted atmosphere. Shall we imitate Germany and a number of our sister States and attempt to save these lives, or shall we let disease elimination go on unhindered? Sooner or later the process of elimination will reach our own families, it may reach us individually.

But, you may say, it will require an immense institution to take care of so many sick. So it would if all were to be admitted, but we can at once exclude those who are mortally ill and who can not recover, and if we also exclude those who are able to pay for treatment at a private institution, the number would be considerably reduced. We need scarcely consider the argument that if the State allows its citizens to get sick from preventable disease, it should also take care of those sick.

As a matter of fact many institutions, even State institutions, can not take care of more than a hundred, or at most a few hundred of the acutely sick. What then, you say, is the use of attempting to save the few and let the many perish? That is one way of looking at it. But if we look at a State Hospital as being a school for missionaries in the cause of pure air and right living, we get a different conception of the problem. It is not a question of saving a few out of the many lives now going to waste and leaving behind a trial of desolution, but it is a question of trying to bring about a change, in arresting the increase of the disease in our State. Every man and every woman who returns from such an institution would be a missionary in the cause of pure air and right living—and we need such missionaries more than do the heathen.

A STATE NATURAL PARK.

FRED J. BREEZE.

Primeval Indiana has passed away. The great forest-covered plains are now bare, and divided into cultivated fields. The wild animals, like the bison, bear and deer, have gone with the forests; while numerous species of birds and other small animals have also disappeared. Our streams have lost their purity and wild beauty; some have been fouled with sewage, while others have been dredged and straightened into artificial drainage channels. Thousands of marshes and hundreds of lakes have been drained, and cultivation of the soil has destroyed thousands of the smaller forms of plant life.

Not all of these changes are desirable, neither are they all necessary, yet the destruction of natural features will continue; and it seems that the time is not far away when Indiana will be nothing but a vast expanse of farms and cities, and man, having humanized everything, will be surrounded by a surfeit of artificial features, the only fauna and flora being the domestic animals and plants.

Some intelligent work ought to be done to stop the useless destruction of the wild forms of nature. Many natural conditions still existing ought to be preserved, and others now gone but still redeemable ought to be restored before it is too late. Every farm has some little corner of ground which is not tillable and this should be given over to nature. Here, trees, shrubs and flowers may grow in freedom, and birds and small ground animals find safe retreat. Every county should have a small reserve or natural park. Such an area could well serve as a small forest reservation, as well as a place where a rich plant and animal life could safely exist.

But to maintain an area in which natural or primitive conditions could exist on a sufficiently large scale we need a natural park under the control of the State. It should be several square miles in area, and should be in the northern part of the State, so that it might include a lake within its limits. Its size and shape should make it possible not only to have a lake, but a stream basin drained by the lake. Into this park should be placed the wild animals that formerly lived in this State. Here animals and plants could live under perfectly natural conditions. The park could serve for many scientific purposes. In it the Department of Fisheries and Game could carry on experiments in fish and game culture. After a few years it would be the best possible place for a Biological Station. It would also be just the place for the field meetings of the Academy of Science. It is not necessary at this time to go into details concerning its character management, and purposes, but only to suggest a few of these things.

Such a reserve would be a little part of the "Indiana of Nature" preserved for the pleasure and profit of the people for all time to come. If the members of the Academy become convinced of its value and will co-operate to educate public opinion toward this end, a State Natural Park can be secured within the next decade.

The Drainage Area of the East Fork of White River.

Charles W. Shannon.

"Every river appears to consist of a main trunk, fed from a variety of branches, each running in a valley proportioned to its size, and all of them together forming a system of valleys, communicating with one another, and having such a nice adjustment to their declivities that none of them join the principal valley either at too high or too low a level, a circumstance which would be infinitely improbable if each of these valleys were not the work of the streams flowing through them."*

Streams are among the most important agencies which give form and expression to the surface of the land. The study of streams, therefore, involves to a great extent the consideration of the nature and origin of many topographic forms—hills and mountains, plains and valleys—and the changes they pass through.

Every person is familiar with the manner in which the rainwater that falls is gathered into rills, rivulets and brooks, which unite to form larger rivers. Every one is aware, also, that streams are turbid after heavy rain. Yet comparatively few people have thought of the work and change upon the surface of the land which is done by even the smallest of the rills and all along the course of the river; nor have they thought that the smallest rill down the hill slope or along the roadside is adding to the work of the large streams, or adding to the extent of the drainage area of the stream.

The drainage area of a stream is the land area which is drained by the main stream and all its tributaries—and the tributaries of the tributaries.

The drainage area of the East Fork of White River is composed of the western central and southern part of Indiana, including the greater part of twenty-five of the ninety-two counties of the State, and a total of about 7,000 square miles, or a little less than one-fifth of the total area of Indiana. This area is mapped out in full on the accompanying map, with the exception of a few counties lying to the north of the area shown.

---

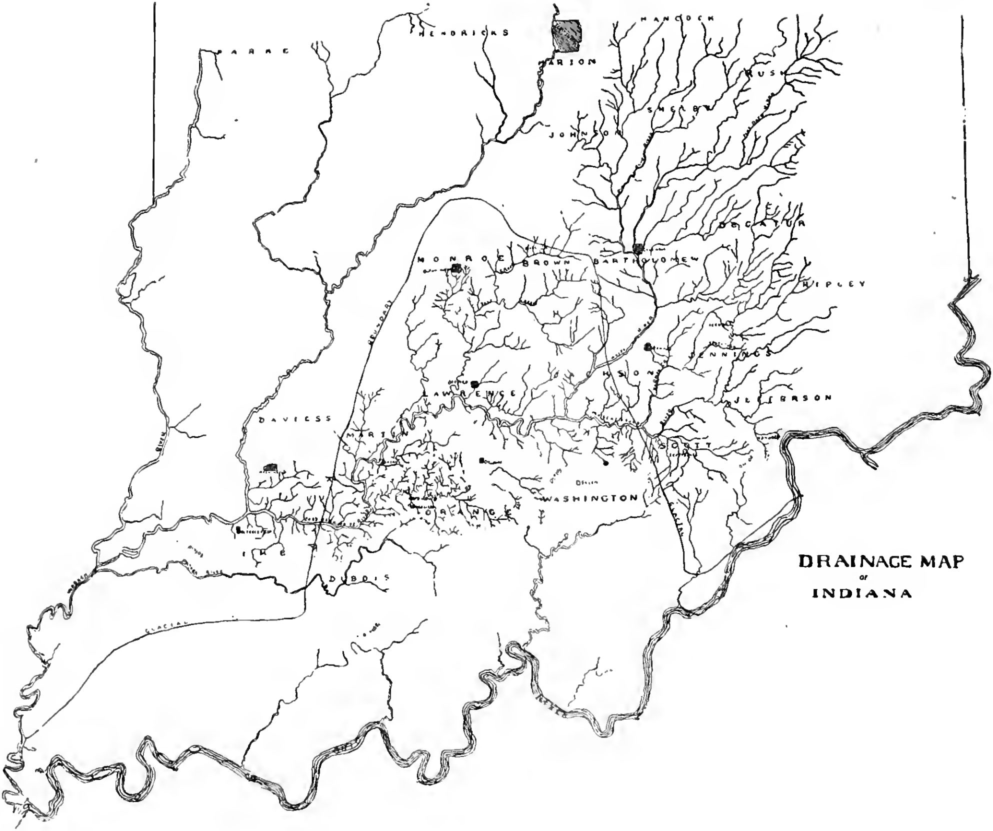
*Illustrations of the Huttionian Theory of the Earth; by John Playfair.

The geological conditions of the country greatly influence the course and action of streams. The heavy curved line across the map represents the southern limit of the ice sheet. Thus this drainage area is partly in the glaciated and partly in the unglaciated portion of the State. It is in the unglaciated region that we have the most picturesque scenery. The entire area, subjected to the processes of weathering and stream erosion for millions of years, was maturely dissected into a complex network of valleys, ridges and isolated hills. Over this surface the ice-sheet passed several times, extending as far as the boundary shown. Its effect was to smooth off the hills, fill up the valleys and to leave the surface covered over with a great mass of loose, foreign material from the northern regions. Since glacial times the streams have to some extent removed the loose material from some of the old valleys and are forming a system of new drainage in the surface of the drift. Geologically speaking, this glacial accumulation is of very recent origin and the streams seem to have made only a small beginning in the work they will be able to perform.

An accurate topographic map of the drainage area would show the contrast in the physical features of the glaciated and unglaciated portions better than any other description or illustration that could be given to a person who had not been over the area to investigate the contrast. In the glaciated area the contour lines would run in large regular curves and far apart, showing the smoothness and regularity of the surface. South of the drift limit the lines would be very close together, with a very winding course and sharp curves, showing a region of deep, narrow valleys, irregular divides and abrupt cliffs.

In attempting to work out the geographic history of an area whose drainage has been arrested by the invasion of an ice-sheet, we find that the story of the life resolves itself into four fundamental parts. First: What are the topographic characteristics of the area during the preglacial history. Second: What changes took place during the glacial history. Third: What has happened since the disappearance of the ice-sheet; its post-glacial history. Fourth: What was the effect produced by the above events on the unglaciated parts of the area.

It is doubtful if the entire glacial area in Indiana was covered by the ice-sheet at any one time. At its extreme limit the ice deposited but little drift; and as a rule there is not a well-defined ridge of drift along the glacial boundary, though some drift is to be seen—as in Chestnut Ridge, in Jackson County, and a similar ridge in southern Morgan County.



DRAINAGE MAP
OF
INDIANA

From the east border of the river, a few miles below Columbus, northeastward to Whitewater valley, in southern Fayette County, there is a well-defined ridging of drift standing twenty to forty feet above the border tracts. Upon crossing Whitewater, the border leads southeastward and is not so well defined as west of the river, though there is usually a ridge about twenty feet high.

From the north line of Jackson County, following the boundary around to the west and south, it is in many places hard to trace as a well-defined line. The ice-sheet must have been very thin, since the topography shows little, if any, modification. In many places, however, heavy beds of gravel and till lie against the hill slopes to the north and east. Many large granite bowlders are also piled up along the hillsides and scattered along the streams. In this area in the counties of Hendricks, Rush, Johnson, Shelby, Henry, Decatur and Randolph, there is a form of moraine known as "bowlder belts," long, narrow, curving strips of country, thickly covered with large bowlders. Low, winding ridges of sand and gravel parallel to the ice movement mark the course of a sub-glacial drainage through Madison, Hancock, Shelby and Bartholomew counties. The longest glacial drainage channel in the State extends from Grant County to White River, in Bartholomew, but it is not now occupied by any one continuous stream. Most of the streams in the glacial area are known as sand and gravel streams and afford great quantities of sand of economic importance and an abundance of gravel suitable for road material and ballast. In several of the counties are overwash aprons in which the sand and gravel are spread out over broad areas.

The thickness of the drift over the State varies greatly, the greatest thickness in the State being about 500 feet. While in this area the drift would be from 50 to 100 feet, there is on the higher points but a thin coating, but the filled valleys make a higher average. It is the glaciated part of the area that is of importance from an agricultural standpoint. The glacial drift is a very productive and permanent soil, and can not be surpassed in the production of the cereals, while the bluffs, knobs and hills of the driftless area are proving to be favorable for the growing of fruits.

The rocks of the State are all sedimentary, and in the area here discussed were laid down upon the bed of a shallow sea receding to the southwest. Thus the strata dip gently to the southwest, at the rate of about 20 to 40 feet to the mile.

In the State there are six different geological periods represented—the

Pleistocene (no rock outcrop), the Coal Measures, the lower Carboniferous or Mississippian, the Devonian, the Silurian, and the Ordivician or lower Silurian. All of these are found in the territory of this drainage area; and of the twenty-five or more formations as subdivisions of the above-named periods there are at least eighteen of these found as surface outcrops in this area. These formations may be listed as follows: *Merom Sandstone.*—A massive coarse-grained sandstone lying unconformably on the coal measures. It furnishes glass-sand and some building stone. *Mansfield Sandstone*, the basal member of the coal measures, is a medium to coarse-grained stone. It is quarried for building purposes and for whetstones and grindstones. *Coal.*—This area is just in the edge of the Indiana coal field. The coal is, therefore, very thin-bedded and is mined only by drifting. *Shales.*—The shales of the coal measures are in many places from 25 to 40 feet in thickness, and are of value in the manufacture of cement, paving brick and sewer tile. Associated with these shales in Martin, Greene, Lawrence and Orange counties are considerable deposits or iron ore; there are also beds of fireclay underlying the coal. *Huron.*—This consists of a series of thin bedded limestones separated from each other by shales and sandstones. *Mitchell Limestone* consists of massive compact layers of dark blue and gray limestone with interbedded impure fossiliferous limestone, shales and chert. *Salem Oolitic Limestone.*—The massive fine-grained stone so well known as a building and ornamental stone. *Harrodsburg Limestone.*—A very fossiliferous limestone, and also contains great numbers of geodes and chert in the lower members. *Knobstone.*—A series of shales and sandstones reaching a thickness of more than 500 feet. This formation has its western outcrop in the eastern half of Monroe and Lawrence and extends to the east as the surface stone for many miles. To the present time but little use has been made of this group, but it is growing to be of economic importance. *New Albany Shale.*—A persistent underlying brown to black shale at the top of the Devonian System. It is rich in bitumen and when kindled will burn. The laminated structure and joints are shown in the illustration. *Hamilton Group.*—The Sellersburg and Silver Creek limestones. The former is a white to gray limestone, rather thin bedded but persistent, stretching from the Falls of the Ohio, north through Clark, Scott, Jefferson, Jennings and Decatur counties. The Silver Creek lies beneath the Sellersburg. It ranges in thickness from 15 to 16 feet in the Silver Creek region to 5 or 6 feet in the vicinity of Lexington, in Scott County, and disappears altogether as a persistent formation in the northern part of the same county. *Niagara Group.*—The member of the group found in this region, is a soft, massive, buff, sub-crystalline to a bluish-green, shaly, limestone, with a characteristic bed of bluish-green shale several feet thick at the base of the formation. *Pleistocene.*—The area deeply covered with glacial drift and having no rock outcrop.

Triassic to Tertiary, Inclusive.—"The only deposits of these ages known (with the possible exception of the Merom Sandstone) are some gravels found on certain high ridges in Martin and Perry counties, and possibly elsewhere. These are outside the drift area, and above any known stream deposits of gravel. Taken in connection with the uniformity of elevation reached by the highest hills, in the Mansfield sandstone area, the Knobstone area and the Silurian area in the southern part of the State, it has been suggested by Mr. Frank Leverett of the United States Geological Survey, that at least southern Indiana was reduced to base level in Tertiary times. In that case the present and pre-glacial topography of Indiana would date from some time in the Tertiary. This Tertiary erosion might also account for the absence of cretaceous deposits, if any such were ever laid down in the State. Until more study shall have been given these gravels and their interpretation, the matter of this paragraph must be considered more as a suggestion than as a demonstrated fact."* (See Report State Geologist 1872, p. 138; 1897, p. 22.)

The highest point in the State is in the southern part of Randolph County, which at the highest level is about 1,285 feet above sea level. It is on this height of land that both the East and West forks of White River have their source. The C., C., C. & St. L. R. R. (Peoria Div.) passes along this divide between the head waters of these streams. The West Fork increases in volume and velocity more rapidly than the East Fork, which reaches its destination by a very winding course. Its length is greatly increased and its slope decreased by its numerous meanders, but it is still a moderately swift stream. After reaching the unglaciated area the direction of the stream is greatly influenced by the joint planes in the geological formations. The main streams of these forks grow farther apart until they reach Shelby and Marion counties, where they approach each other,

---

NOTE.—For description, composition, structure, extent, uses, etc., of the various formations named above, see Thompson, 17th Ann. Rep., pp. 30-40; Hopkins, 20th Ann. Rep., 1895, pp. 188-323; Kindle, 29th Ann. Rep., pp. 329-368; Hopkins and Siebenthal 21st Ann. Rep., 1896, pp. 291-427; Blatchley 22d Ann. Rep., 1897, pp. 1-23; Ashley 23d Ann. Rep., 1898; Siebenthal 25th Ann. Rept., 1900, pp. 330-39; 30th Ann. Rep., 1905; E. R. Cumings, in Pro. Ind. Academy of Science, 1905, pp. 85-100.

then again turn from one another until, in the western part of Lawrence and Martin counties, they come nearer and at the southwestern corner of Daviess County are united in one stream at an elevation of about 425 feet. Both forks are fed by numerous tributaries, which produce an intricate drainage system. In many places the heads of these tributaries approach each other very closely and have in some cases resorted to piracy. It is obvious from the varying character of the valleys and the terraces which border them, that both forks suffered many disturbances during the glacial period. As has been stated, we know that valleys have been excavated by the streams flowing through them, and it is also true that the terraces beautifying their sides are in most cases due to the same agencies—that is, terraces owe their origin to the processes of corrosion, or of deposition, or to both. Many of the terraces are due principally to the re-excavation of preglacial valleys. In much of the unglaciated area there are marks of several well-defined drainage levels. The region ranges in elevation from 150 to 300 feet; the streams cut down rapidly from the upland, then run off with a slight gradient through deep valleys with rather flat and comparatively wide bottoms and very steep sides, with stepped and sloping terraces with gracefully bending curves which add much to the attractiveness of the valleys. The upper terraces are formed by the streams cutting down through the formations of the original table-lands. The lower terraces are composed of mixed materials of the higher levels. The best examples of these terraces are in the Salt Creek and Clear Creek valleys, and in the principal valley of the main East Fork and its adjacent side valleys. Some of these terraces are shown in the illustrations.

This entire drainage area affords much for interesting study and exploration, but, as stated above, it is in the unglaciated portion that is found the most picturesque scenery. The diversified physical features produced by the processes of erosion and the weathering of the various geological formations give a region of rugged and beautiful scenery. Some of the characteristic and marked scenic points are described below.

"Weed Patch Hill," in Brown County, is a high ridge in the Knobstone, forming the divide between two of the main branches of Salt Creek. At its highest point it is a little more than 1,000 feet in elevation. One of the illustrations gives a view looking northwest from this elevation and gives an idea of the Knob topography. "Guinea Hills" is a ridge rising to a considerable elevation, extending in a northeast and southwest direction through the southwest part of Scott and the northwest part of Clark counties. These hills form the divide between the tributaries of the Muscatatuck, one of the chief branches of the East Fork, and the headwaters of Silver Creek, which flows south into the Ohio. It is interesting here to note that water falling on the high bluffs of the Ohio near Hanover, and to the north within one mile of the river, does not there flow into the Ohio, but finds its way into the Muscatatuck and the East Fork, and after covering a distance of more than 300 miles flows into the Ohio at the southwestern corner of Indiana. The "Haystacks" are conical shaped hills which, seen from a distance, have the appearance of haystacks; these are plentiful in the central part of Lawrence County. "Rock Houses" are large openings between and under large rock masses due to undercutting and the breaking off and tilting of the rocks. "Honeycombs" are rock surfaces in which the softer parts have been weathered out, giving a porous, honeycombed appearance. These are found in the region of the Oolitic Limestone and the Mansfield Sandstone. One of the most interesting spots to visit is the "Pinnacle," near the town of Shoals, the county seat of Martin County. Here a high ridge of Mansfield Sandstone, one hundred ninety-six feet above the level of the stream, terminates abruptly within a few yards of White River. Large masses of rock that have broken off, lie around the foot of the ridge in every position. From this point one obtains a good view of the character of the topography of this region. To the northwest of this ridge the formations have been cut through by disintegrating forces, and there has been left standing at some distance from the head of the ravine a tall mass of sandstone, which has received the name of "Jug Rock," from the fancied resemblance to an old-fashioned jug. On the upper side it is forty-five feet high and on the down-hill side, seventy feet high; it is capped with a flat projected layer of harder sandstone. At the south of the deep-wooded ravine is the "Glen," an under-cut sandstone cliff with an intermittent cascade. Across a valley to the north is "House Rock," a large sandstone cave, the entrance to which is about thirty-five feet high, and the main room, with an opening in the top, is very much higher. It is formed principally by the tilting of large rock masses. The sandstone in front of the cave is weathered into an elaborate fretwork. Other points of interest as one goes down along the river are the "Acoustic Rock," "Buzzard's Roost," "Hanging Rock," "Kitchen-middings," "Shell-bank," and the "Hindostan Falls."

In Washington, Lawrence, Orange and Monroe counties the subterranean drainage has an important place. The ground water working along the point planes and on the more soluble parts of the limestones has produced a great variety of sink-holes, caves and "lost rivers." The sink-holes are basin shaped depressions many feet deep, and often hundreds of feet in diameter, with an opening at the bottom which leads into some underground channel; in some cases the openings have become filled and the water is held in the basin. In many places a stream runs into these holes, then by underground passages for a great distance, and again comes to the surface in the form of springs. Valleys, sometimes two to four miles in length, are drained through underground channels. This gives rise to a confusing system of hills and valleys, though a well-defined drainage may be worked out which in itself is usually made up of sink-holes. There are many pure water springs in this region and also many springs of mineral waters. The best known of these are the French Lick and West Baden Springs, Trinity and Indian Springs. Lost River, a main branch of the East Fork, through Orange and Martin counties, has many "lost" tributaries in Orange County. The numerous caves and the mineral springs are described in the State Geologist's Reports for the years 1896 and 1901-02.

The greater or less degree of uniformity in the volume of the river in the course of a year is one of its chief physical features and depends very much on the manner in which the water supply is obtained. The streams of this area depend for their increase wholly upon the rains, which, occurring frequently and at no fixed periods, and discharging only comparatively small amounts of water at a time, except in periods of the heavy rainfall of several days' duration, preserve a moderate degree of uniformity in the volume of the streams. This uniformity is aided by the fact that under normal conditions only about one-third of the rainfall finds its way directly over the surface to the streams, the remaining two-thirds sinking into the ground and finding its way to springs, reservoirs, or gradually oozing through at a lower level until the soil becomes drained of its surplus moisture, a process which continues for weeks and helps to keep up the volume of the stream. But, on the other hand, man has done a great deal to destroy the uniformity of the volume. By the removal of the forests, the cultivation of the soil, and the use of ditches for drainage, a greater part of the water is at once thrown into the stream and greater fluctuations occur. Owing to the streams being hemmed in by lofty, abrupt cliffs, which resist the free passage of the swollen streams, and the velocity being checked by winding courses, greater floods occur from the same amount of rainfall than formerly.

View upper half of the Pinnacle, Shoals, Ind. Distance from top to water level 196 feet.

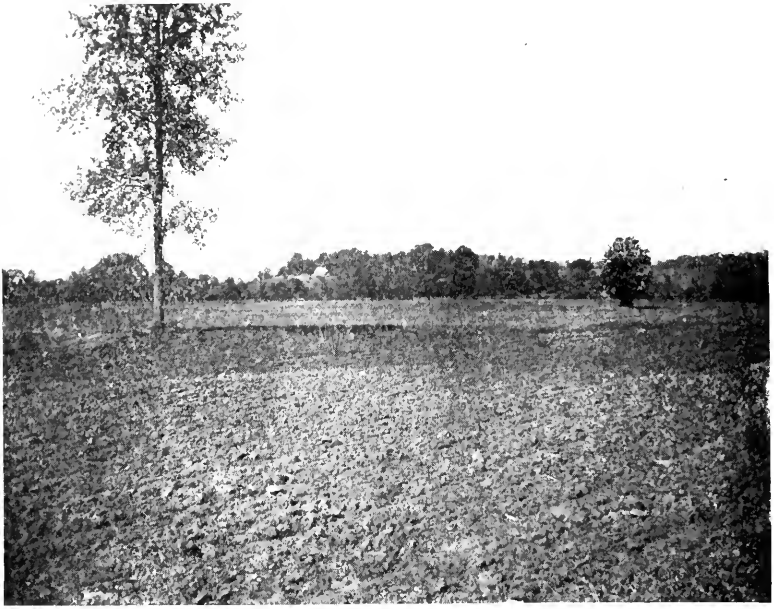
Hanging Rock, an undercut sandstone cliff, southwest Lacy, Martin County.

Showing laminated structure and joints in the New Albany Black Shale. Scott County.

Rectangular Blocking in the Huron Limestone. Greene County.

Jug Rock, a column of sandstone capped with a harder layer of sandstone. (See description.)

House Rock, a cave formed by the tilting of large blocks of sandstone, north of Shoals, Martin County.



View in Salt Creek Valley, showing high terraces in background, southeast Stobo, Monroe County.

Recent terraces in Salt Creek Valley southeast of Stobo, Monroe County.

Salt Creek Valley near Harrodsburg, Monroe County.

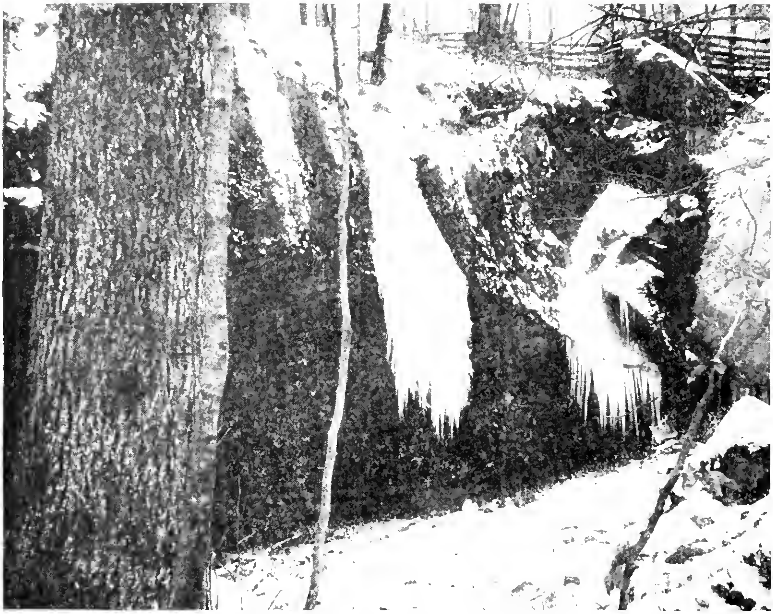
White River Valley, looking north from the Pinnacle. Shoals, Ind.

Gullies in the clay and shale of the Knobstone, eastern Monroe County.

Recent gullies in clay and shale, eastern Monroe County.

Showing east side of City Waterworks Reservoir, Bloomington. The water is supplied by springs from the underground drainage of sinkhole region in Mitchell limestone.

Boating along Public Highways during Spring Flood, 1906, in River Valley near Shoals.

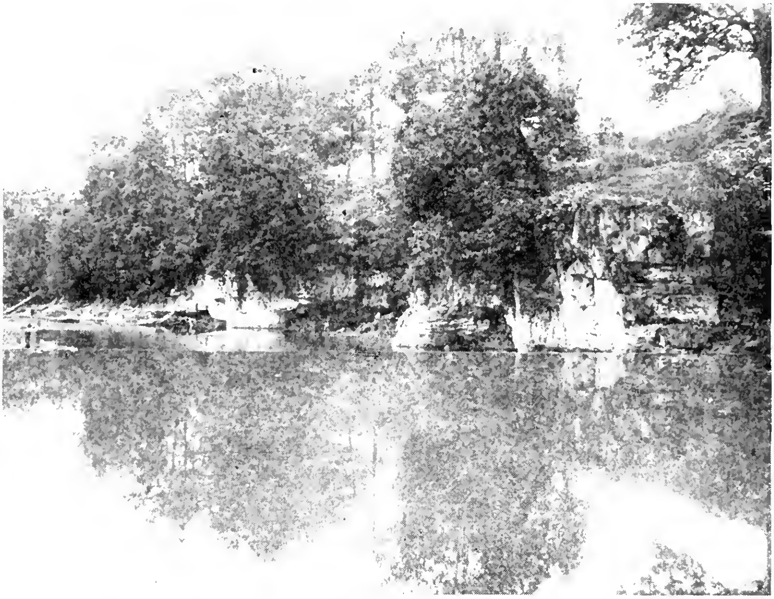


Undercut Sandstone Cliff with overhanging Icicles, southern Martin County.

The Glen, an undercut sandstone cliff with an intermittent cascade, Shoals, Martin County.

View looking northeast from Weedpatch Hill, showing Knobstone topography.

Many gravelly and rock bottom streams are used as public roads. This view in southern Martin County.



Silurian exposure on the Muscatatuck directly south of Vernon.

View on Clear Creek along Monon Railroad between Bloomington and Harrodsburg.

STEPS IN THE DEVELOPMENT OF A SMOKELESS CITY.

W. F. M. GOSS.

1. *The Presence of Smoke* in those cities of our country which are within easy reach of its soft coal mines is becoming more serious every year. People are beginning to understand that this smoke which, in earlier days, was welcomed as evidence of a city's growth, and of its industrial prosperity, is, in fact, a source of heavy expense to all of its citizens. The annual smoke bill of such a city as Indianapolis is, in fact, enormous! This arises, not from the loss of fuel or heat in the form of smoke, for that is so small as to be almost negligible, but in the damage which is wrought by its presence, upon the architectural embellishment of the city, upon the fixtures and furnishings of its homes, and upon the apparel of its citizens. Loss also occurs through the extensive use of artificial light which the presence of smoke enforces, and because of its effect upon the welfare of those from whom it shuts out the sunlight and takes away the purity of the atmosphere.

Thus far urban communities have sought to protect themselves through prohibitive legislation, with the result that while flagrant abuses have sometimes been abated, the atmosphere of the city as a whole has not materially improved. It is doubtful if such legislation, unsupported by corrective measures which are broadly co-operative, can ever be made an effective instrument in the abolition of smoke. The problem is one of many complications and its solution can only be reached through action based upon a full understanding of difficulties to be overcome.

2. *The Sources of Smoke* in cities may be separated into five different groups, each of which will require different treatment. They are as follows:

1. Large furnace fires such as are employed in metallurgical processes.
2. Large boiler plants, by which is meant all plants in excess of 500 horse-power.
3. Small boiler plants and small industrial fires.
4. Domestic fires.
5. Locomotive fires.

Accepting this classification as a convenient one for the purpose in hand, we may inquire as to the process by which the smoke now being delivered by each of the several groups is to be eliminated.

3. *Large Fires Such as Are Employed in Metallurgical Processes.* Except in a few cities, of which Pittsburg is the best type, the proportion of the total smoke delivered from such fires is small. In the city of Indianapolis, for example, it is exceedingly small. Moreover, the managements of industries using such fires are, in many cases, finding increased efficiency in operation by the installation of gas producers which receive the coal and deliver highly heated gas for use in the furnaces. The gas producer makes smokeless the process of converting coal into heat. As its use under a wide range of conditions will result in economy in operation, no injury would be done by the prohibition of smoke from all fires which might properly be served by producer gas, provided a reasonable period is allowed between the passage of the prohibitive ordinance and its going into effect. Fires of this group which can not be thus treated in such cities as Indianapolis will be so few that their effect will be negligible.

4. *Large Boiler Plants.* The suppression of smoke from fires of this class by the adoption of a suitable automatic stoker, will effect an economy in operation, hence owners will not seriously object if they are required, after suitable notice, to so equip their plants. An ordinance requiring all boiler plants of more than 500 horse-power to be thus equipped within three years of the date of its passage would not be unreasonable.

5. *Small Boiler Plants and Small Industrial Fires.* Referring first to boiler plants, it should be noted that the fires of this group are ordinarily prolific sources of smoke. Boilers of 100 horse-power or less are all over the modern city. Generally speaking, no economy can result from the application of automatic stokers to these small boiler plants and hence owners can not be influenced to add to their fixed charges in the expectation of securing a money return. The requirement that such furnaces employ anthracite coal, coke, or other smokeless fuel, would in all cases work serious hardship and in many cases it would be prohibitive. The wisest and most effective course to follow with reference to such fires is to provide a satisfactory substitute, then abolish them. So far as such plants are now employed in the production of power, they can be rendered unnecessary through the cheaper and more effective distribution of electrical power. So far as steam from such boilers may at present be used for heating they can be rendered of no effect through the supply of heat from a

central station. There are, however, in every large city many minor industrial establishments, such as dye works, bleacheries and laundries, requiring steam at high pressure, and for these a general system of supply from a central plant must be provided. That this may be the more readily accomplished, such industries should be encouraged to group themselves within a prescribed area to better accommodate themselves to some reasonable plan of steam distribution. To properly supplant the fires of numerous small boilers now in service, it will be required, therefore, that stations be established throughout the business portion of the city, capable of delivering electric current for power and lights, steam or hot water for heating, and a limited amount of high pressure steam for industrial uses; these central plants to be of sufficient size to justify the use of stokers which will make them smokeless. When by municipal co-operation these shall have been provided, under conditions which will safeguard the interests of all consumers with reference to costs, then it will be in order to prohibit, after a series of years, the use of soft coal under all boilers of the city, except in connection with automatic stokers.

Small industrial fires other than those under boilers should be sustained by gas drawn from sources hereinafter referred to.

6. *Domestic Fires.* While individual domestic fires are not the source of heavy volumes of smoke, their number in any city is large, and their effect in the aggregate as a source of smoke is as pronounced as that of any other single group of fires. So long as soft coal can be had more cheaply than anthracite coal, just so long will there be a desire on the part of the consumers to employ it in domestic service. Domestic fires being small, it is impracticable to apply to them effectively the principles of smokeless firing. A necessary step, therefore, in the development of a smokeless city is a complete prohibition of the use of soft coal for domestic purposes. As a preliminary step, two things are essential. First, a supply of low-priced gas for use in cooking; and second, the distribution from a central station of large capacity of steam or hot water for domestic heating.

There are no real problems in the supply of gas for cooking except such as may grow out of existing franchises. At prices now prevailing, this form of fuel is much used in cooking and generally is less expensive for that purpose than solid fuels. Add to this the fact that the cost of gas to the producer is reduced as the quantity sold is increased, and an abundant supply at a cost sufficiently low to permit all people in a city to use it for cooking, becomes not only possible, but attractive as a means of economy.

The establishment of centralized heating plants of sufficient size to justify the maintenance of smokeless fires therein, and in such number as to serve an entire city, constitutes a problem presenting no serious engineering difficulties. Such a system would need to be developed under sufficient municipal control to insure satisfactory service to all portions of the city and to guarantee to the consumers of heat a cost not greater than is required to insure a fair return upon the investment made. Enough has already been accomplished in heating from central stations to insure the practicability of such a scheme. While the loss of heat in transmission is necessarily large, this loss is more than neutralized by the use of low grade coal in the central station, in the place of high grade fuel now employed in domestic heating, so that, basing an estimate on the heat delivered, the cost should not be greater than under present conditions of domestic heating. Attention should be called to the fact, however, that such a system would be easily practicable even at some advance in cost, for freedom from smoke and the convenience of a supply of heat from outside sources are matters for which people will be willing to pay.

7. *Locomotive Fires.* These, in railroad centers such as Indianapolis, are prolific sources of smoke. Moreover, if soft coal is permitted to be used in fire-boxes the delivery of smoke from locomotive stacks can not be prevented. As a consequence, prohibitive legislation in various American cities has thus far had but little effect in reducing the amount of smoke delivered from locomotive fires. It is not the fault of the railway management; it is due to the difficulties which are inherent in the case. There are, in fact, but two ways out of the difficulty, and the acceptance of either solution will involve railway companies in heavy expenditures and will entitle them to concessions or direct aid from municipalities. The first and simplest is to be found in the requirement of all steam locomotives operating within the smoke limits of a city, to be supplied with smokeless fuel, that is, with anthracite coal or with coke; the second solution is to be found in the prohibition of the use of steam locomotives and in the substitution of electric locomotives within the smoke limits of the city.

The development of either of these plans will involve the establishment of locomotive terminals upon every road outside of the smoke limits of the city. By the use of such terminals the road locomotive of an approaching train can be stopped before reaching the city, its place being taken either by a steam locomotive using coke or anthracite coal for its fuel, or by an electric locomotive which will serve to carry the train on to the city, and afterward out of the station and across the city to another terminal where it will stop, its place at the head of the train being taken by another road locomotive having its usual supply of soft coal. Such a plan has been put into effect in New York City, and has been settled upon for Washington, D. C., where the commissioners of the District of Columbia, on November 17th, took final action on an order to prohibit the use of any except electric locomotives in drawing trains into the new Union Station. Excepting in very large cities, however, the cost of electric transmission will be prohibitive. It will be far cheaper for railway companies, and quite as satisfactory to the urban communities, to admit steam locomotives, provided they are supplied with a fuel which prevents smoke.

It is evident that procedure under this outline with reference to locomotive fires must necessarily involve plans extending through a series of years. An equitable scheme of co-operation between the railroads and the city must be devised, plans must be made and adopted, and time must be given for financing and executing them.

In the working out of the general plan described by this brief outline for the elimination of smoke, many difficulties are to be met and antagonistic interests to be harmonized, but there is nothing which, from an engineering point of view, is impracticable, or which can not, as a business matter, be reduced to a satisfactory procedure. A city, to be made smokeless by the measures suggested, would first seek to fix limits defining the area to be controlled. Within this area would be developed a series of power and heating plants which would be spaced upon a system of squares in the business portions, at intervals of a mile or a mile and a half, and in the residence portion at intervals of two miles. From these several stations would go out currents of electricity for all power and light needed by the city. From certain of them steam at high pressure for industrial purposes would be distributed over the limited areas and from all of them would go out steam or hot water for heating. By a suitable grouping of equipment within these stations, those in the residence portions would be made to serve as heating plants alone and hence would be out of service during a considerable portion of the year. Because of their size and the perfection of equipment, all would be operated by smokeless fires. All small fires, which at the present time serve for heating and power in individual buildings, would cease to exist, and large fires under boilers of great industries and in furnaces of metallurgical establishments, would be made smokeless by means which would enhance their economy in operation. Railroad trains passing through the controlled area would be drawn by smokeless locomotives, and above and around the city a clear atmosphere would contribute to the cleanliness of ali things and to the comfort and peace of mind of all its people.

EXPERIMENTAL STUDIES IN REINFORCED CONCRETE.

W. K. HATT.

It was the comfortable assurance of that urbane Roman poet, Horace, that he had built himself a monument more lasting than brass in the intellectual life of mankind. At the time that he was writing these lines the Roman engineers were constructing those concrete aqueducts and domes that have served mankind on the physical side during the time that Horace had been a source of perpetual delight to the students of classical writings. Which product will endure the longer is an open question. One thing is certain, while many persons of exquisite taste may prefer Horace to our modern writers, all well-informed persons conclude that the engineer of today has surpassed the Roman engineer in the quality and use of concrete.

The number of recent failures of reinforced concrete buildings, attended with the loss of life of workmen, does not constitute an argument against the advance of the practice of this new art, but calls attention to the need of correct theory in design and expert supervision in construction. Steel for buildings is made under highly technical methods, and a searching inspection by trained men, whereas concrete for buildings may be formed by ignorant and unskilled workmen, and may be supervised by foremen who are mostly inexperienced in the art of proportioning and mixing the ingredients. Defective material, either of cement, sand or stone, dishonest skimping of cement and poor inspection, incorrect proportioning, and a too early removal of the wooden forms from the floors molded in cold weather, or heavily laden with stored cement and other materials, are sufficient causes to explain these failures. An increasing number of these may be expected as time goes on and untrained men who have learned their business in other lines of construction, take up the work of building reinforced concrete structures. The resulting loss of life will no doubt call attention to the necessity of regulating by proper building laws this new construction, which has spread so rapidly over the country from sea to sea. In 1902, when the first published results of experimentations appeared in this country from the Laboratory for Testing Materials of Purdue University, one had to go far to observe instances of reinforced concrete. Last summer in Seattle the writer saw no other type of building in process of construction. At Atlantic City in 1902, when the experiments referred to were placed before the American Society for Testing Materials, there was no instance of the use of reinforced concrete in sight. Last summer, at the meeting of the Society, one viewed the stately and beautiful Marlborough-Blenheim hotel entirely constructed of reinforced concrete; the replacement of the steel pier by reinforced concrete piles and girders; and the construction of a new recreation pier of this type of construction. The growth has been truly marvelous. Not only has the extent of its use in bridges and buildings increased, but the variety of its application is extraordinary. In a list of constructions in which it is successfully and economically used may be included: Retaining walls, dams, tanks, conduits, chimneys, arches, culverts, foundations, floors for buildings, railroad girders, highway bridges, pipes, railway ties, piles, stairs and roofs.

At the present time the underlying mechanical principles and the constants of design are fairly well determined, and we wait upon the architects to express the truth of these principles in a beautiful structure. While this type of construction associates itself with the broad and simple wall spaces and low buildings of the Spanish Mission style, with surface ornaments of tiling and Mosaic, it also lends itself to important modern civic buildings. The stateliness of beauty of the Marlborough-Blenheim Hotel at Atlantic City has been mentioned. The Ingalls Building, Cincinnati, and the new Terminal Station at Atlanta, Ga., are other examples.

Without stopping to discuss the properties of waterproofness, fireproofness, durability, etc., or the multitude of topics of interest and importance that crowd one's mind in connection with reinforced concrete, attention will be simply called to the mechanical principles underlying the construction.

Concrete, like stone, is weak in tension, but strong in compression at a ratio of 1 to 10. Consequently when under flexure, as in a beam, the concrete is not used economically; for it breaks on the lower side in tension before the compressional strength is utilized. A beam may be, however, strengthened, or *reinforced*, by the insertion of a steel rod in the lower side of the beam. These rods are usually bent up near the ends of the beam so as to also reinforce the beam against the diagonal tensional stresses that occur at the ends, due to the combination of shear and direct stress.

Before the rod can come into operation during a flexure of the beam, there must be the necessary adhesion between the concrete and the rod to transfer the stress to the rod, and bring the latter into action. This adhesion varies from 300 pounds to 500 pounds per square inch of the surface of the rod, and under favorable conditions is sufficient to develop the strength of the steel in the concrete. The adhesion seems to be more of a mechanical action than chemical, and is due to the entrance of the fine cement into the microscopic pits on the surface of the smooth rods. Many designers use artificially deformed bars, such as corrugated bars and twisted steel bars, to increase this adhesion.

In this way a beam is reinforced so that both the concrete in compression and the steel in tension may be worked to their full value. Any one who has seen a plain concrete beam broken in a testing machine, and then has witnessed a test of a reinforced concrete beam, will be first of all struck by the apparently greatly increased flexibility of the reinforced concrete beam, which deflects ten times as much as the plain beam before showing any visible cracks, and when the load is removed the elasticity of the steel draws the beam back nearly to its original shape. It is probable, however, that this process of bending the reinforced concrete beam early develops very minute flaws in the concrete which are invisible to the naked eye, so that it is not safe to count upon a tensile strength of the concrete in computing the total resisting strength of the beam. Designers compute the resisting moment of the beam as based upon the compressional stresses in the concrete and the tensional stress in the steel alone.

The original tests at Purdue University were arranged to determine:

1. The increased strength added by a given amount of steel inserted in a plain concrete beam.

2. The law connecting the strength of the beam with the amount of steel.

3. The law connecting the strength of the beam with the position of the rods in the beam.

4. The value of gravel in reinforced concrete.

To determine these relations a series of concrete beams was made of first-class materials with rich mortar. In other words, the beams were carefully made with a combination of one part cement to two parts of sand and four parts of broken stone. The concrete was probably superior to that made in the ordinary process of construction. This was proper because the theoretical laws were being verified, and for that purpose it was necessary to have uniform materials of good quality. The elements of the strength of the materials entering into the beams were determined first of all; namely, the compressive and tensional strength of the concrete, together with the modulus of elasticity of the concrete, both in tension and compression; the adhesion between the cement and the steel; the elastic limit of the steel; a mechanical analysis made of the materials. Since the beams were long in span compared to their height, and, therefore, the shearing stresses were not important, rods of smooth steel were used. Having determined all the elements entering into the strength of the beam, and then the tested strength of the beam itself, it next became necessary to formulate a mechanical analysis of the combination of steel and concrete in flexure, and, with the experience of the tests of the beams in hand, to derive equations for design and calculation. The truth of these equations and the validity of the process of the analysis could then be checked by reference to the tested strength of the beams. These equations were derived and have been used very largely by engineers throughout the country in designing reinforced concrete structures.

Engineers as a rule have found it necessary to review their knowledge of mechanics in dealing with reinforced concrete, not that there is any new principle involved, but the number of factors in the equations of flexure is greater, and an account must be taken of the relative moduli of elasticity of the two materials, steel and concrete. Furthermore, the lack of perfect elasticity of the concrete leads to an assumption of some other than a rectilinear relation between stress and strain.

Again the neutral axis of the cross section must be determined. Its location is not simply fixed by the center of gravity of the cross section, but is controlled by the amount of steel present, the relative moduli of elasticity of the steel and concrete, and by the position of the steel. The writer's equations have followed the usual assumptions of flexure, with the following special assumptions:

1. That the modulus of elasticity of concrete in tension and compression is the same.

2. That there is a parabolic relation between stress and strain in the concrete.

3. That in the earlier stages of the loading of the beam the concrete carries stress in tension, but later, at higher loads, this tensile strength may be disregarded.

The equations are somewhat cumbersome, but have been reduced to diagrammatic form in the Transactions of The American Railway Engineering and Maintenance of Way Association, Vol. V, 1894, pages 626 and 627. Empirical equations of simple form are presented in The Engineering Review of Purdue University, Vol. I, 1905.

In calculating the strength of the reinforced concrete beam sufficiently approximate results can be obtained by omitting consideration of the tensile stresses in the concrete, and supposing a rectilinear relation between stress and strain. The moment of flexure is then most simply expressed as the total force in the steel multiplied by the distance to the centroid of the compressive stresses. This latter distance is expressed with sufficient accuracy as a fraction of the depth of the beam, this fraction having been determined by experimental measurement on the tested beams.

Care in all cases must be taken to compute the maximum compressive stress arising in the concrete under the conditions of the problem, and also the amount of diagonal tension at the ends of the beams must be computed and provided for by stirrups, or by bending up some of the rods at the ends.

To conclude this brief consideration of reinforced concrete, a conservative estimate would include the following principles:

1. Concrete is durable and fireproof when made of the proper aggregate.

2. The strength of combination of steel and concrete may be calculated with a sufficiently close degree of accuracy.

3. Shapely and beautiful structures may be built of this material. It is particularly adapted for mill buildings because of the absence of vibrations which are induced in the ordinary type of mill buildings by the rapidly revolving machinery.

4. The cost of a properly designed reinforced concrete building, where wooden forms are used to advantage, need not exceed more than 5 or 10 per cent. of the cost of mill buildings of the ordinary type with brick walls and wooden beams of the so-called slow-burning construction, provided that the concrete may be laid as at present by unskilled labor.

THE NEWER HYGIENE.

WILFRED H. MANWARING.

Instruction in the nature of infectious diseases, especially in the means of transmitting these diseases from one person to another, is required by law in all our public schools. This law is of great value; for it is only through the intelligent co-operation of a well-informed public that hygienic and sanitary measures designed to control and stamp out infectious diseases can be successful. A wide diffusion of this knowledge will go far to make tuberculosis a thing of the past, and diphtheria and smallpox unknown.

In obedience to the legal requirement, there are taught, in our public schools, certain elementary facts regarding the nature of pathogenic bacteria, and certain facts regarding the ways in which these bacteria are transmitted from one person to another. These facts in themselves are of inestimable value, but they are insufficient.

The presence of bacteria within or upon the human body, the transmission of disease-germs from the sick to the well, is but one of the factors tending to cause disease. To acquire a disease it is usually necessary, not only to acquire the germs of that disease, but there must be a lowering of bodily resistance as well.

Every fourth person in this room is carrying daily in his throat or mouth virulent pneumococci. Yet he does not acquire pneumonia. And why? Because there is an efficient defense against this disease in the healthy human body. Some day this defense will be lowered and pneumonia develop. Most soldiers in the Philippines carry in their intestinal canals virulent germs of dysentery; and with no ill effects, till intoxication or dietary excesses lower the intestinal resistance. We daily inhale germs of tuberculosis. Some day, when our resistance is low, we will acquire the disease.

A knowledge of the body's fighting power against bacteria, a knowledge of the ways in which that power can be increased or decreased by hereditary influences and by modes of life, is therefore of hygienic importance. It should form part of the curriculum of every public school.

The body fights disease in many ways. It will be sufficient for hygienic purposes to teach but three of these ways: (i) the method of antitoxines; (ii) the method of antiseptics and (iii) the method of phagocytosis.

There ar many diseases in which the symptoms are caused, not by the bacteria themselves, but by the poisons the bacteria manufacture. Thus, in tetanus, or lockjaw, the bacteria grow, perhaps unnoticed, at the bottom of the Fourth-of-July wound on the hand or foot; but the chemical poisons they manufacture, carried by the blood to the brain and spinal cord, cause the spasms and convulsions that characterize the disease. In diphtheria the bacteria rarely enter the body, but grow in grayish-white masses on the moist surfaces of the mouth and throat. The chemical poisons they manufacture, absorbed by the tissues, cause the paralysis and heart failure that characterize the disease.

The body has the power of forming substances that neutralize these poisons. To these neutralizing substances the name antitoxine has been given.

This fact is of hygienic importance for two reasons: First, because it is sometimes possible to assist the body in its efforts to form antitoxines, by introducing into it antitoxines artificially prepared; and, second, because the body's power to form these substances is modified by mode of life.

A horse that has been repeatedly injected with the poisons manufactured by the germs of diphtheria, grown on artificial culture media, develops enormous amounts of diphtheria antitoxine. A few drops of the serum of this horse renders harmless large quantities of diphtheria poison. Through the use of diphtheria antitoxine in practical medicine, the mortality from diphtheria has been reduced from the 24 per cent. to 40 per cent. it was, twenty years ago, to the less than 1 per cent. it now is, in well-treated cases. Overwork, insufficient clothing, improper food, alcoholic excesses, lack of sleep, and other factors, so lower the antitoxine-forming power of the body as to greatly increase the dangers from infection.

The second way of hygienic significance in which the body fights disease, is by the formation of chemical substances that, although they have no influence on the chemical poisons manufactured by bacteria, have an even more important property, that of killing the bacteria themselves.

The presence of antiseptic, or bacteria-killing substances in the blood and tissue juices is easily shown. One has but to mix bacteria with serum and test from time to time, by simply cultural methods,* whether or not the bacteria are alive. Thus, in one experiment, there were mixed with human serum typhoid fever germs in such numbers, that every drop of the serum contained 50,000 bacteria. Two minutes later but 20,000 of these were alive; at the end of ten minutes, but 800; and in twenty-five minutes, they were all dead.

Not only can serum kill bacteria, but most of the secretions of the healthy human body are bacteria-killing as well. Gastric juice, vaginal secretion and nasal secretion, kill bacteria in enormous numbers. The hygienic significance of this is evident from the fact that these bacteria-killing substances, also, are modified by modes of life. Dietary excesses may so lower the bacteria-killing properties of gastric juice, and unsanitary conditions so lessen that of the tissue juices that susceptibility to infectious diseases is greatly increased.

The third way of hygienic importance in which the body fights disease, is by phagocytosis. In the body there are millions of white blood corpuscles, each having the power of independent motion and as one of its functions the faculty of eating and destroying disease germs.

It is found that the bacteria-eating power of white corpuscles is largely dependent upon certain chemical substances† present in the blood and tissue juices. Without these chemical substances the eating of certain pathogenic bacteria does not take place. With them, it is very active. It is further found that these chemical substances are influenced by modes of life. That they may be increased or decreased under different hygienic conditions. Phagocytosis, therefore, has also a place in popular hygienic knowledge.

One of the unfortunate results of the spread of knowledge of pathogenic micro-organisms is the formation of an unreasoning popular fear of disease germs. It is thought that a wide understanding of facts regarding bodily resistance will tend to replace this unfortunate germ-fear by a rational faith in the body's marveloas powers. That it may turn the tide of hygienic endeavor, from an exclusive fight against bacteria to a combined fight *against* bacteria and *for* bodily resistance.

---

*See Popular Science Monthly, Vol. 66, pp. 474–477.

†Opsonins.

CONCERNING DIFFERENTIAL INVARIANTS.

DAVID A. ROTHROCK.

During the last forty years wonderful progress has been made in many fields of higher mathematics. One distinct line of investigation has had to do with a *microscopic* examination of the fundamental axioms of the elementary mathematics, of conditions of convergence, of the sufficient conditions in the calculus of variations, and so on. Another essential advance has been made by unifying many separate and apparently distinct fields of mathematics under one common law. Among many advances in this latter line of work, none are more important than the work of Sophus Lie, a Norwegian, who lived from 1842 to 1899.

Lie received his doctorate from the University of Christiania in 1865, caring no more for mathematical work than for literary or philological work. In fact, he had thought of becoming an engineer; but receiving an appointment to a docentship in the university, he turned his attention to the study of advanced mathematics. The real mathematical genius of Lie was aroused by a course of lectures on substitutions by Professor Sylow. Lie's creative period seems to have extended from 1868 to about 1874, during which time he came into possession of the essential features of his epoch-making Theory of Continuous Groups. The remainder of his life was devoted to the elaboration of his early conceptions, and to the applications of his theories. A general development of the higher number systems, a classification of ordinary and partial differential equations, with methods of their solutions, invariants and covariants, many problems of physics and astronomy, are all treated from the standpoint of the continuous group. Below is sketched a brief outline of the continuous group theory of Lie, as applied to differential invariants, and the calculation of an important differential invariant is indicated.

1. *Point Transformation.* Let x, y be the Cartesian coördinates of any point in the plane, and let x_1, y_1 be any point other than x, y. Then

$$x_1 = \Phi\ (x, y),\ y_1 = \Psi\ (x, y)$$

is said to be a point transformation, carrying point x, y into point x_1, y_1. Here it is assumed that inversely

$$x = \Phi_1 (x_1, y_1), \; y = \Psi_1 (x_1, y_1)$$

carries the point from x_1, y_1 back to x, y. A point transformation may be looked upon either as a transference of axes from one system to another, not necessarlly the same kind of system, or it may be considered as an actual transference of one point into another position in the plane, the axes of reference remaining unchanged.

2. *Group of Transformations.* A point transformation containing one or more parameters

$$x_1 = \Phi (x, y, a, b, c, \dots k),$$
$$y_1 = \Psi (x, y, a, b, c, \dots k),$$

such that for a_0, b_0, c_0, ...k_0, the point x, y transforms into itself, is said to constitute a group of transformations when a succession of two such operations may be replaced by one of the same species. That is, if

$$x_2 = \Phi (x_1, y_1, a_1, b_1, c_1 \dots) = \Phi \left\{ \Phi (x, y, a, \dots k), \Psi (x, y, a, \dots k), a_1 \dots k_1 \right\}$$

$$= \Phi (x, y, a_2, b_2, c_2, \dots k_2),$$

$$y_2 = \Psi (x, y, a_2, b_2, c_2, \dots k_2),$$

where $a_2 = f_1 (a, b, \dots k, a_1, b_1, c, \dots k_1)$, $b_2 = f_2 (a, b, \dots k_1)$ ...., then

$$x_1 = \Phi (x, y, a, b, \dots k), \; y_1 = \Psi (x, y, a, b, \dots k)$$

are the transformations of an r-parameter group, the parameters a, b, c, ... k being r in number and independent. A similar definition may be given to a group in one, three, four, or n variables*.

3. *The Infinitesimal Transformations.* An infinitesimal transformation is defined analytically by

$$\delta x = \xi (x, y) \delta t, \; \delta y = \eta (x, y) \delta t.$$

Such a transformation attaches to any point x, y an infinitesimal motion whose projections on the x —, and y — axes are respectively, $\xi \delta t$ and $\eta \delta t$, and whose distance is $\sqrt{\xi^2 + \eta^2} \, \delta t$. Lie shows such infinitesimal transformations to belong to a single-parameter group.

$$x_1 = \Phi (x, y, a), \; y_1 = \Psi (x, y, a).$$

This may be easily seen by letting a_0 be the value of a which leaves x, y fixed; then

$$x_1 = \Phi (x, y, a_0 + \delta a), \; y_1 = \Psi (x, y, a_0 + \delta a)$$

---

*See Lie—Scheffers, Differential-gleichungen, pp. 24-25.

give to the point x, y an infinitesimal motion. Expanding in powers of δa, we have*

$$x_1 = \Phi(x, y, a_0) + \left\{\frac{d\,\Phi(x, y, a_0)}{d\,a_0}\right\}\delta a + \dots,$$

$$y_1 = \Psi(x, y, a_0) + \left\{\frac{d\,\Psi(x, y, a_0)}{d\,a_0}\right\}\delta a + \dots.$$

But $\Phi(x, y, a_0) = x$, $\Psi(x, y, a_0) = y$, hence

$$x_1 = x + \left\{\frac{d\,\Phi}{d\,a_0}\right\}\delta a + \dots,$$

$$y_1 = y + \left\{\frac{d\,\Psi}{d\,a_0}\right\}\delta a + \dots,$$

$$\delta x = \left\{\frac{d\,\phi}{d\,a_0}\right\}\delta a + \dots = \xi(x, y)\,\delta t + \dots,$$

$$\delta y = \left\{\frac{d\,\psi}{d\,a_0}\right\}\delta a + \dots = \eta(x, y)\,\delta t + \dots.$$

Omitting infinitesimals of higher order we have the relations

$$\delta x = \xi(x, y)\,\delta t, \quad \delta y = \eta(x, y)\,\delta t$$

as the infinitesimal transformations of a one-parameter group.

In the notation of Lie the symbol

$$U f = \xi(x, y)\left\{\frac{d\,f}{d\,x}\right\} + \eta(x, y)\left\{\frac{d\,f}{d\,y}\right\},$$

denoting the variation which a function $f(x, y)$ undergoes when x, y receive the increments δx, δy, is employed as the symbol of an infinitesimal transformation. Writing p, q instead of the partial derivative of $f(x, y)$ with respect to x and y, respectively, we have

$$U f = \xi(x, y)\,p + \eta(x, y)\,q.$$

The infinitesinal transformations of an r-parameter group would be given by the symbol

$$U_k f = \xi_k(x, y)\,p + \eta_k(x, y)\,q, \quad k = 1, 2, 3, \dots r.$$

4. *The Group Criterion.* One of Lie's fundamental theorems furnishes a test whether or not any given set of infinitesimal transformations, $U_k f$, $k = 1, 2, \dots r$, actually forms a group. This test is the application of Jacobi's *bracket expression*

$$U_i(U_j f) - U_j(U_i f), \quad (i, j = 1, 2, \dots r, \text{ in all combinations}).$$

---

*In this article the symbol $\left\{\frac{d\ f}{d\ x}\right\}$ will be used to denote the partial derivative of f with regard to x, instead of the round d usually employed.

If the Jacobi bracket-expression, constructed for all combinations of i, j, is equivalent to a linear function of the symbols $U_k f$ with constant coefficients, then are the symbols

$$U_k f = \xi_k (x, y)\, p + \eta_k (x, y)\, q,\quad k = 1, 2, \ldots r,$$

the infinitesimal transformations of an *r*-parameter group.*

5. *The Extended Group.* An infinitesimal transformation

$$U f = \xi (x, y) \left(\frac{d f}{d x} \right) + \eta (x, y) \left(\frac{d f}{d y} \right)$$

may be *extended* in two ways. In the first place, the variation of the coördinates of *n* points is simply the sum of the variations of the coördinates of the separate points; hence, $U f$ extended in this manner becomes

$$(A).\quad U f_n = \sum_{k = 1}^{k = n} \left\{ \xi_k (x_k, y_k) \left(\frac{d f}{d x_k} \right) + \eta (x_k, y_k) \left(\frac{d f}{d y_k} \right) \right\}.$$

The symbol $U f$ may also be extended so as to include the variation of $y' = \frac{d y}{d x}$, $y'' = \frac{d^2 y}{d x^2}$, $\ldots$, $y^{(n)} = \frac{d^n y}{d x^n}$. We have

$$\delta x = \xi (x, y)\, \delta t,\quad \delta y = \eta (x, y)\, \delta t.$$

$$\delta y' = \delta \frac{dy}{dx} = \frac{dx\, \delta\, dy - dy\, \delta\, dx}{dx^2} = \frac{d\, \delta\, y - y' d \delta\, x}{dx}$$

$$= \left\{ \frac{d \eta}{dx} - y' \frac{d \xi}{dx} \right\} \delta t = \left\{ \eta_x + y' (\eta_y - \xi_x) - y'^2\, \xi_y \right\} \delta t$$

$$= \eta' (x, y, y')\, \delta t.$$

In a similar manner,

$$\delta y'' = \left\{ \frac{d \eta'}{dx} - y'' \frac{d \xi}{dx} \right\} \delta t = \eta'' (x, y, y', y'')\, \delta t,$$

and so on for higher variations.

The infinitesimal transformation $U f$ extended to include these higher variations becomes

$$(B).\quad U f_n = \xi \left(\frac{df}{dx} \right) + \eta \left(\frac{df}{dy} \right) + \eta' \left(\frac{df}{dy'} \right) + \eta'' \left(\frac{df}{dy''} \right) + \ldots + \eta^{(n)} \left(\frac{df}{dy_n} \right).$$

Each of the members of an *r*-parameter group $U_k f$, $k = 1, 2, \ldots r$, may be extended, giving the infinitesimal transformations of the coördinates of *n* points as indicated by equation (A); or each may be extended as in (B) to include the variations of $x, y, y', y'', y''', \ldots y^{(n)}$. A group of transformations extended in style of (A) or (B) is called an extended group.

---

*Lie—Scheffers, Continuierliche Gruppen, p. 390.

6. *Invariant Functions.* The variation of any function $\Phi(x, y)$ when operated upon by an infinitesimal transformation.

$$U f = \xi p + \eta q$$

is given by

$$U \Phi = \xi \left\{ \frac{d \Phi}{dx} \right\} + \eta \left\{ \frac{d \Phi}{dy} \right\}.$$

If $\Phi(x, y)$ is to remain unchanged, then $U \Phi = o$, and $\Phi(x, y)$ is a solution of the homogeneous linear partial differential equation

$$U f = \xi p + \eta q = o,$$

that is, $\Phi(x, y)$ is an integral of Lagrange's equation

$$\frac{dx}{\xi} = \frac{dy}{\eta}.$$

$\Phi(x, y)$ so determined is called an invariant for the transformation

$$U f = \xi p + \eta q.$$

A group of two or more independent transformations will not in general have an invariant function. But when extended to include the coördinates of n points, as in (A) above, an r-parameter group

$$U_k f_{(n)} = \sum_{i=1}^{n} \left\{ \xi_k (x_i, y_i) \left\{ \frac{df}{dx_i} \right\} + \eta_k (x_i, y_i) \left\{ \frac{df}{dy_i} \right\} \right\}, \; k = 1, 2, \ldots r,$$

gives rise to $2n - r$ independent functions

$$\phi_1 (x_1, y_1, \ldots x_n, y_n), \phi_2, \phi_3, \ldots \phi_{2n-r},$$

which are *point-invariants* of the group $U_k f$, and which are derived by integrating the r partial differential equations $U_1 f_n = o$, $U_2 f_n = o$, $\ldots U_r f_n = o$.

After the manner here indicated the writer has calculated all the point-invariants for the twenty-seven finite continuous groups of the plane as classified by Lie.* The results appear in the Proceedings of the Indiana Academy of Science, 1898, pp. 119-135.

7. *Differential Invariants.* An infinitesimal transformation extended to include the increment of y' leaves invariant two functions $\phi_1 (x, y, y')$, $\phi_2 (x, y, y')$, the solutions of

$$U' f = \xi p + \eta q + \eta' \left\{ \frac{df}{dy'} \right\} = o.$$

The functions ϕ_1, ϕ_2 are called differential invariants of the infinitesimal transformation $U' f$. Lie shows that when two independent differential

---

*See Lie-Scheffers, Contin. Gruppen, pp. 360-362.

invariants of a given transformation are known, then all others may be found by differentiation.*

$$\varphi_3 = \frac{d\varphi_2}{d\varphi_1},\ \varphi_4 = \frac{d\varphi_3}{d\varphi_1},\ \ldots .$$

An r-parameter group $U_k f$ extended to include the increments of $y', y'', \ldots y^{(r)}$, when equated to zero, gives r partial differential equations in $r + 2$ variables. These r equations have two independent solutions, $\varphi_1 (x, y, y', \ldots y^{(r)})$, $\varphi_2 (x, y, y', \ldots y^{(r)})$, which are differential invariants of the r-parameter group. After the plan here indicated Lie has calculated the differential invariants for the twenty-seven groups of the plane.

The calculation of differential invariants may be made by an entirely different method than that used by Lie, and indeed without any knowledge of the group extended as indicated above. A knowledge of the form of a point invariant for the group is necessary.

Let a point invariant $\varphi (x_1, y_1, x_2, y_2, \ldots)$ be given, and suppose the points $x_1, y_1; x_2, y_2; \ \ldots ; x_n, y_n$, to be located upon a plane curve

$$x = f_1 (t),\ y = f_2 (t)$$

Then we would have

$$x_1 = f_1 (t_1),\ y_1 = f_2 (t_1),\ \ldots\ x_n = f_1 (t_n,\ y_n = f_2 (t_n),$$

Allowing $x_2, y_2; x_3, y_3; \ldots ; x_n, y_n$ to coalesce toward $x_1\, y_1$, we may then expand $x_2, y_2, \ldots .$ in power-series

$$\text{(I)} \left\{ \begin{array}{ll} x_2 = x_1 + x' dt_2 + x'' \frac{dt_2^2}{2} + \ldots, & y_2 = y_1 + (y' dt_2 + (y'') \frac{dt_2^2}{2} + \ldots, \\ x_3 = x_1 + x' dt_3 + x'' \frac{dt_3^2}{2} + \ldots, & y_3 = y_1 + (y') dt_3 + (y'') \frac{dt_3^2}{2} + \ldots, \end{array} \right.$$

and so on for $x_4, y_1, \ldots x_n, y_n$, where

$$\text{(1)} \qquad x' = \frac{dx_1}{dt_1},\quad x'' = \frac{d^2 x_1}{dt_1{}^2},\quad x''' = \frac{d^3 x_1}{dt_1{}^3},\ \ldots ,$$

$$\text{(2)} \qquad (y') = \frac{dy_1}{dt_1},\quad (y'') = \frac{d^2 y_1}{dt_1^2},\quad (y''') = \frac{d^3 y_1}{dt_1^3},\ \ldots . .$$

The notation of (1), (2) should be changed from parameter notation to the ordinary $y' = \frac{dy}{dx}$, $y'' = \frac{d^2 y}{dx^2}$, ...

$$\text{(3)} \left\{ \begin{array}{l} y' = \frac{dy}{dx} = \frac{(y')}{x'}, \text{ hence } (y') = y' x', \text{ similarly,} \\ (y'') = y'' (x')^2 + y' x''; \ (y''') = y''' (x')^3 + 3y'' x' x'' + y' x'''; \\ (y^{iv}) = y^{iv} (x')^4 + 6y''' (x')^2 x'' + 3y'' (x'')^2 + 4y'' x' x''' + y' x^{iv}; \\ (y^{v}) = y^{v} (x')^5 + 10 y^{iv} (x')^3 x'' + y'' \left(15 x' (x'')^2 + 10 (x')^2 x'''\right) + \\ \qquad\qquad y'' \left(10 x'' x''' + 5 x' x^{iv}\right) + y' x^{v}, \end{array} \right.$$

and so on for higher derivatives.

---

*Lie, Math. Annalen, Bd. XXXII.

If in any point invariant ϕ, the values of $x_2, y_2; x_3, y_3 \ldots$, taken from (I) be substituted, and then the result developed into in infinite power-series in the ascending powers of $dt_2, dt_3, dt_4, \ldots dt_n$, the successive coefficients of the separate powers of $dt_2, dt_3, \ldots$, and of the products $dt_2, dt_3, \ldots$ are all invariant functions of $x', x'', x''', \ldots, (y'), (y''), (y'''), \ldots$. These separate invariant functions may then be changed by means of equations (3) above so that only $x', x'', x''', x^{v}, \ldots$ and $y' = \frac{dy}{dx}$, $y'' = \frac{d^2y}{dx^2}, \ldots$, occur. Then by algebraic manipulation the parameters $x', x'', x''', \ldots$ may be eliminated, leaving a differential invariant for the continuous group from which the point invariant ϕ had been derived.

8. *The Differential Invariants for the General Projective Group.*

The general projective group: $p, q, xq, xp - yq, yp, xp + yq, x^2p + xyq, xyp + y^2q$, when extended leaves invariant the point-function.

$$Q = \left\{ \begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_5 & y_5 & 1 \end{vmatrix} \div \begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_4 & y_4 & 1 \end{vmatrix} \right\} \div \left\{ \begin{vmatrix} x_1 & y_1 & 1 \\ x_3 & y_3 & 1 \\ x_5 & y_5 & 1 \end{vmatrix} \div \begin{vmatrix} x_1 & y_1 & 1 \\ x_3 & y_3 & 1 \\ x_4 & y_4 & 1 \end{vmatrix} \right\}.$$ [*]

Substituting in Q the series expansions of $x_2, y_2, x_3, y_3, \ldots x_5, y_5$ from equations (I), and developing the determinants, we have the ratio of infinite series which may be further developed into a single power series of the form

$$Q^1 = a_0 + a_1, \left\{ \frac{I_2}{I_1} \right\} + a_2 \left\{ \frac{I_3}{I_1} \right\} + a_3 \left\{ \frac{I_4}{I_1} \right\} + \ldots,$$

where a_i is an expression containing a function of dt_2, dt_3, dt_4, dt_5 to degree i, and where

$$\begin{aligned} &I_1 = x' \; y'' - x''(y' = y'' x'^3, \\ &I_2 = x'(y''') - x'''(y') = y'''(x')^4 + 3y''(x')^2x'', \\ (K) \quad &I_3 = x'(y^{iv}) - x^{iv}(y') = y^{iv}(x')^5 + 6y'''(x')^3x'' + 3y''x'(x'')^2 \\ &\qquad + 4y''(x')^2x''', \\ &I_4 = x''(y''') - x'''(y'') = y'''(x')^3x'' - y''(x')^2x''' + 3y''x'(x'')^2 \end{aligned}$$

and so on until all orders of differentials $y', y'', y''', \ldots, y^{viii}$ have been included. Now the separate ratios $I_2 : I_1, I_3 : I_1, I_4 : I_1, \ldots$, are separately invariant, and when reduced as in equations (K) contain the arbitary parameters $x', x'', x''', \ldots x^{viii}$. The elimination of these parameters is

---

[*] See Pro. Ind. Acad., 1898, p. 135.

a tedious process, and will not be indicated here. When performed, however, there results the two differential invariants

$$\phi_1 = \left[2\,A_3\,A_5 - 35\,A_2\,A_3^2 - 7\left\{ A_4 - \frac{5}{3}A_2^2 \right\}^2 \right] \div (A_3)^{\frac{5}{3}},$$

$$\varphi_2 = \left[A_3 \left\{ A_6 - 84\,A_3\,A_4 + \frac{245}{3}\,A_2^3 \right\} - 12\left\{ A_5 - \frac{35}{2}A_2\,A_3 \right\}\left\{ A_4 - \frac{5}{3}A_2^2 \right\} \right.$$
$$\left. + \frac{28}{3}\left\{ A_4 - \frac{5}{3}\,A_2^2 \right\}^2 \right] \div A_3^3,$$

where
$$A_2 = 3y^{\prime v}\,y'' - 4\,(y''')^2,$$
$$A^3 = y^{v}\,(y'')^2 - 15y^{\prime v}\,y'''\,y'' + \frac{40}{3}(y''')^3,$$
$$A_4 = 3y^{v\prime}\,(y'')^3 - 24y^{v}\,y'''\,(y'')^2 + 60y^{\prime v}\,(y''')^2\,y'' - 40\;y''')^4,$$
$$A_5 = 9y^{v''}\,(y'')^4 - 105y^{v\prime}\,(y'')^3\,y''' + 420\,y^{v}\,(y''')^2\,(y'')^2 -$$
$$700y^{\prime v}\,(y''')^3\,y'' + \frac{1120}{3}(y''')^5,$$
$$A_6 = 27y^{v'''}\,(y'')^5 - 48\,A_5\,y''' - 840\,A_4\,(y''')^2 - 2240\,A_3\,(y''')^3$$
$$- 2800\,A_2\,(y''')^4 - \frac{2240}{3}(y''')^6.$$

Conjugate Functions and Canonical Transformations.

By David A. Rothrock.

(Abstract.)

It is known that any function, ϕ (Z), of a complex variable, Z $=$ x $+$ i y, may be separated into a real part ϕ_1 (x, y an imaginary part, $i\phi_2$ (x, y), and that φ_1, φ_2 each satisfy Laplace's equation $\frac{\delta^2\phi}{\delta x_2} + \frac{\delta^2\phi}{\delta y_2} = o$ * A very elegant geometric interpretation of these two functions φ_1, ϕ_2 may be had by equating each to a third variable ζ : ϕ_1 (x, y) $= \zeta$, ϕ_2 (x, y) $= \zeta$. Each equation then represents a surface for any point of which Laplace's equation is true. By developing $\zeta = \phi_1$ (x, y) into a power series in the vicinity of any point x_o, y_o, and using the Laplace equation, we have the theorem: the projection of the section of a tangent plane to the surface $\zeta = \phi_1$ (x, y) upon the x, y-plane is a curve having a double point at x_o, y_o with real, orthogonal tangents, and hence the surface is hyperbolic at every point.

$\zeta = k$ gives lines of level on $\zeta = \phi_1$ (x, y), while $\zeta = k_2$ in $\zeta = \phi_2$ (x, y) gives cylinders which intersect $\zeta = \phi_1$ (x, y) in *curves of quickest descent.*

The second part of the paper deals with the linear fractional function $Z_1 = \frac{a\zeta + \beta}{\gamma\zeta + \delta}$ which has the fundamental invariant points f_1, f_2 about which a canonical transformation may be constructed so that Z $=$ o, when $Z^1 = f_1$; $Z = \infty$, Z $= f_2$. This function is $Z = \frac{Z^1 - f_1}{Z^1 - f_2} = \frac{a - \gamma f_1}{a - \gamma f_2}\left(\frac{Z - f_1}{Z - f_2}\right)$. The modulus of $\frac{Z - f_1}{Z - f_2}$, and amplitude of $\frac{Z - f_1}{Z - f_2}$, set, respectively, equal to constants give an elliptic system and an hyperbolic system of circles about and through the two points f_1, f_2. Now the transformation

$$Z = \frac{Z^1 - f_1}{Z_2 - f_2} = \frac{a - \gamma f_1}{a - \gamma f_2}\left(\frac{Z - f_1}{Z - f_2}\right),$$

sets up a motion about f_1, f_2 which is determined by the modulus and the amplitude of $\frac{a - \gamma f_1}{a - \gamma f_2}$. If mod. $\mp$ 1 and amp $=$ o, motion

---

*Where $\frac{\delta^2\Phi}{\delta x^2}$ denotes the second partial of Φ with regard to x, and so for $\frac{\delta^2\Phi}{\delta y^2}$.

goes along the hyperbolic circles, the elliptic circles interchanging. If mod. $= 1$, amp. ∓ 0, motion goes along elliptic circles, the hyperbolic system being invariant. If mod. ± 1, amp. ∓ 0, motion is along neither family but passes diagonally from curvilinear rectangle to curvilinear rectangle. These respective transformations may be named *hyperbolic*, *elliptic*, *loxodromic*. The circles about and through the fundamental points are potential lines and lines of flow in the well known problem of electricity of equal source and sink.

BLOOMINGTON, IND., NOV. 28, 1906

NOTES ON "SALT LIME."

FRANK B. WADE.

"Ye are the salt of the earth: but if the salt have lost his savour, wherewith shall it be salted? it is thenceforth good for nothing but to be cast out and trodden under foot of men."—Matthew, v, 13.

This passage from "the Sermon on the Mount" has doubtless puzzled many a chemist, for salt without savour is as much an anomaly as a smile without a face.

Last summer, while spending my vacation at the seashore, I came across an old-fashioned "salt works," where common salt is prepared by evaporation of sea water, partly by means of trickling it over masses of brush and further by solar evaporation in shallow vats.

It was while investigating the process that I came upon what seems to me to be a plausible explanation of the scriptural passage, and at the same time I secured a quantity of the material called by the salt makers "salt lime," which is the subject of this paper.

It seems that the first solid product to separate from the sea water upon concentration by evaporation is a very slightly soluble, white, crystalline substance, which gathers in the first four or five shallow vats. These are provided, so that the tasteless, gritty substance may not come down along with the salt and constitute an undesirable impurity in it. This tasteless substance is "salt lime."

As to the connection between this substance and the salt which had lost its savour, I think it very probable that the ancient salt makers omitted to provide separate vats for the first, very slightly soluble product, and that as a result it got mixed up with their salt. Then, possibly, owing to exposure to moisture, the real salt may have become dissolved away from this less soluble part in certain instances, and the residue, being tasteless, would naturally be supposed to have "lost its savour," by the unscientific mind of that time.

Having secured eight or ten pounds of salt lime, I made an examination of the substance to determine its nature.

In physical appearance it is grayish white in color, crystalline in structure and it forms a layer about one-quarter inch thick as scraped from the evaporators. I was told by the owner of the salt works that not over thirty or forty bushels were obtained from the evaporation of an amount of sea water that would yield 5,000 bushels of salt; so it will be seen that the substance represents a high degree of concentration as the average per cent. of common salt in sea water is only 2.61 per cent.* and the amount of "salt lime" obtained is only about 1 per cent. of that of the common salt.

This high degree of concentration has led me to investigate the substance to see if it possesses any radio-activity, as, owing to the wide distribution of radio-active material more or less of it must find its way into the ocean, and, judging from the position of radium in the periodic system, the salts of radium ought to be found as sulphates among the less soluble constituents of the ocean water.

Experiments are now under way with a view to still further concentrate the material and to find whether it contains any trace of radio-active material.

Upon consulting the literature to which I have had access, I find that mention is made in nearly all cases of the separation of gypsum ($CaSO_4$, $2H_2O$) prior to the separation of common salt in the evaporation of both sea water and natural brines from wells.

I have conducted a qualitative analysis of the salt lime in the regular way and find that it does consist mainly of gypsum. It has the water of crystallization and gives the reactions of Ca and SO_4. It gives, moreover, evidence of the presence of a small amount of carbonate of calcium. I have seen no mention of this last fact in the literature to which I have had access. In order to determine the proportion of carbonate in the mixture I pulverized about 20g. in an agate mortar until it had all passed through a 100-mesh sieve; then taking a "fair sample," as in assaying, I weighed out 5.6623 grams into a Schrötter apparatus and determined the weight of CO_2 lost, in the usual manner.

The weight of CO_2 lost was .0156g. indicating a weight of .4354g of $CaCO_3$ (calculated) or .62 per cent. $CaCO_3$. A second determination gave .71 per cent.

I have tested carefully for Ba and Sr, using the ordinary form of chemical spectroscope as well as the regular analytical tests, and have

---

* New International Encyclopoedia, p. 723. 3.5 parts solid in 100. 77.76 per cent of solid is salt.

found no trace of either. I have also tested for PO_4 and fluorine with negative results.

On heating a sample of the salt lime in a dry test tube, there was a slight charring, possibly due to a slight amount of material from the wooden vats or perhaps from sea algae. There was also a slight smell of NH_3 on boiling a large mass of the finely-powdered substance with excess of NaOH in an attempt to remove $CaSO_4$ to secure concentration of the less soluble constituents. This was probably also due to small amounts of remains of sea algae.

From my study of the substance I would conclude that it consists mainly of gypsum, but that it contains an appreciable amount of $CaCO_3$ (.65 per cent.) and that it is remarkably free from other constituents, due probably to the sharp distinctions in solubility between the less soluble and the more soluble constituents of sea water. I hope to concentrate further a considerable amount of the substance and examine it for traces of radioactive material or other constituents.

THE EFFECT OF SUGAR ON SOURNESS.

P. N. EVANS.

It is common experience that some foods and beverages taste less sour when sugar is added, and it seems worth while to seek an explanation of the fact.

In books of popular science the statement is sometimes made that the sugar "neutralizes" the acid—in some such way, presumably, as a base might. This explanation is untenable from the chemist's standpoint, inasmuch as sugar enters into no such reaction with acids.

Better informed writers sometimes aver that since sugar can not neutralize acids its value in such cases is only imaginary and not real. Since, however, in matters of taste, if the imagination is satisfied the problem is practically solved, it becomes of interest to know *how* the imagination is satisfied in this instance.

Sourness is now known to be a property of the hydrogen ion; for all acids, and acids only, are sour, and all have this constituent, and this only, in common, when dissolved in water. A diminution in intensity of sourness must therefore be due either to a reduction in the number of hydrogen ions in a given volume of the solution, or to a lessened sensitiveness to sourness on the part of the nerves of taste.

An investigation was made by the writer as to whether the introduction of sugar diminished the degree of ionization of hydrochloric acid in a given solution, using the freezing point method, and it was found that there was no effect, the degree of ionization of the acid being the same in the presence and in the absence of sugar.

The value of sugar, then, must depend on its physiological effect on the nerves of taste, not on any chemical action by which the concentration of hydrogen ions is reduced.

Some years ago Professor T. W. Richards of Harvard University (Am. Chem. Jour. *1898*, 121), called attention to the delicacy of the sense of taste in detecting sourness and in comparing it in different intensities. With the assistance of Miss Carrie Richardson (now Mrs. C. E. Roth) the writer made a series of over four hundred experiments in detecting acid in the presence and in the absence of sugar.

The experiments were conducted as follows: Solutions of hydrochloric acid of known strength were prepared, and equivalent solutions of sodium hydroxide were added gradually, the solution being tasted after each addition until sourness disappeared. In other experiments the acid was added to the alkali until sourness was noticeable. Both methods proved about equally delicate. As long as the solution was strongly acid or alkaline, only a drop or two was introduced into the mouth, but when the neutral point was almost reached a cubic centimeter of liquid was used and held in the mouth for a few seconds. The graduations of the burettes were hidden during every titration, that the judgment might not be prejudiced.

Experiments were made with solutions of acid varying from 0.715 normal to 0.0143 normal, or solutions containing 0.715 to 0.0143 milligrams of hydrogen ions per cubic centimeter. Sugar was added in quantities ranging from 0.04 to 0.8 grams per cubic centimeter.

With the experience gained in about twenty titrations considerable accuracy of taste had been acquired, so that consistent results were then obtained differing only about 1 part in 70 in a 15 cubic centimeter titration with the stronger solutions and in the absence of sugar, from those obtained with chemical indicators, the error being in almost all cases in the same direction, as might be expected—sourness disappeared with the addition of *less alkali* than the acidity as determined by phenolphthalein, or sourness appeared only on adding slightly *more acid* than required by the indicator. With the more dilute solutions, however, the *absolute* results were more exact. This is accounted for by the presence at the end point of less salt (due to the neutralized acid and alkali) in the more dilute solutions, the presence of salt reducing the delicacy of the sense of taste for sourness. With the most dilute solutions it was found possible to recognize with certainty the presence of 0.007 milligrams of hydrogen ions in the mouth, in 1 cubic centimeter of liquid, although 4 milligrams of salt were also present. In the most concentrated solution 0.01 milligrams of hydrogen ions was recognizable in the presence of 34 milligrams of salt.

The presence of sugar had the same effect as that of salt—the more sugar present in the solution the larger was the quantity of acid necessary for detection by taste; even the largest quantities of sugar used (0.8 grams per cubic centimeter) increased the necessary quantity of acid less than 1.5

times compared with that needed in the absence of sugar; 4.034 grams of salt was about as effective as 0.8 grams of sugar. In other words, if the mind is intent on noticing sourness, even large quantities of sugar do not seriously interfere. In the usual eating of sweet and sour food, however, the mind is, as it were, engrossed with the sensation of sweetness and rendered correspondingly less sensitive to other tastes.

In all probability any other powerful taste would be as effective in hiding sourness as sweetness is, but no other taste in concentrated form is so generally agreeable as sweetness. The sourness of lemonade would certainly be as thoroughly masked by highly salting it as by the addition of sugar; the result would not, however, be as agreeable to the majority of lemonade drinkers, probably.

In conclusion, brief reference might be made to a few experiments on the effect of sugar on bitterness, as sweetness and bitterness are commonly considered to be mutually exclusive terms—a thing can not be both sweet and bitter, though it can be at once sweet and sour. The experiments were made by the writer with mixtures of solutions of sugar and of quinine, but it was found impossible to obtain any numerical results, for, no matter what the proportion within very wide limits, the sensation of sweetness *preceded* that of bitterness, the mixture tasting sweet at the first moment and then bitter, the latter sensation being very lasting.

The use of sugar, then, to render sourness less intense, is based on a physiological, not on any chemical effect; the nerves of taste are less sensitive to one kind of taste in the presence of another, though the mind by concentration can largely overcome this obscuring effect.

A Simple Method of Measuring Hydrolysis.

George A. Abbott.

Several methods of measuring the degree of hydrolysis of dissolved salts have been proposed from time to time; e. g., the measurement of the rate at which the solution saponifies an ester, such as ethyl acetate; the rate of hydration of milk sugar; and the measurement of the partial pressure of ammonia gas over solutions of its hydrolysed salts; but none of these methods is precise, and even under the most favorable conditions, they are far from satisfactory. The first is based upon the bold assumption that the rate of saponification is proportional to the concentration of the hydroxyl ions, and that it is unaffeced by the presence of other molecular aggregates; the second method involves a similar assumption; while the last is of little if any practical value, owing to experimental difficulties.

The method about to be described was developed in the course of an extended research on the dissociation relations of Ortho and Pyro Phosphoric Acids and their salts, which will be published in detail elsewhere. It is simple and convenient, and should be capable of a fairly wide application to the ammonium salts of other weak acids; therefore it has seemed sufficiently interesting to justify a brief description at this time.

When an aqueous solution of ammonia is shaken up with chloroform, the ammonia distributes itself between the two non-miscible solvents, and the distribution ratio is constant at a given temperature. Fortunately this ratio is of a magnitude which makes it possible to determine the concentration of the ammonia in the aqueous solution by simply titrating a measured volume of the chloroform with which the solution is in equilibrium. It is obvious that we may take advantage of this fact to determine the concentration of the free ammonia in a solution of its hydrolysed salt, and thus determine the degree of hydrolysis. It is free from assumptions and is as direct as a chemical analysis itself.

But, simple in principle as the method appears, its successful application requires attention to certain experimental details. The chief difficulty arises from the fact that the ammoniacal solutions form emulsions with the chloroform layer which remain turbid even after standing several hours in the thermostat. Drops of the aqueous solution of variable size thus remain suspended in the chloroform layer, making it impossible to obtain concordant results when different samples are titrated. Fortunately this difficulty may be easily overcome by merely rotating the solutions in glass-stoppered bottles in the thermostat. For this purpose the bottles are fastented to the axle of the rotary stirrer of the thermostat after the familiar method of making solubility measurements, and allowed to rotate several hours (one to three), when the two phases invariably separate perfectly clear, with a sharply defined bounding surface. In order to establish the equilibrium between the solution of the hydrolysed salt and the chloroform, the latter is vigorously shaken with the aqueous solution in a stoppered separatory funnel. The phases are allowed to separate, after which the water layer is removed as completely as practicable, and another portion of the solution is added. This process is repeated until three portions have been shaken up with the chloroform; a fourth portion is then rotated with the chloroform, at a constant temperature, as described above. It is important to remove the sample of chloroform for titration without contamination by any of the aqueous solution. This may be easily done by means of a syphon. The short limb of the glass tube is sealed in the flame, and a small thin bulb blown on the end. It may then be passed, closed, through the aqueous layer, and opened by breaking against the bottom of the bottle. The chloroform is syphoned into a clean, dry, vessel, measured, and titrated with 0.02 Normal hydrochloric, or nitric, acid, using methyl orange as indicator. Enough pure water should be added to make a layer of convenient depth to view the color of the indicator; since the latter does not enter the chloroform, and the stoppered vessel should be vigorously shaken at intervals during the titration.

The distribution coefficient of ammonia between chloroform and water was measured, at 18°, at concentrations 0.1, 0.05, and 0.02 Normal, and the mean of eight measurements gave 27.36. This is the ratio of the concentration of the undissociated ammonia in the aqueous solution to the concentration of the ammonia in the chloroform.

The method was applied to the measurement of the degree of hydrolysis of $Na_2NH_4PO_4$, at 18°, and concentrations 0.1, 0.05, and 0.02 molal, with the following results:

Conc. Mols. per Litre.	*Per Cent. Hydrolysis.*
0.1	95.39
0.05	95.44
0.02	95.65

That is, in a solution of $Na_2NH_4PO_4$, at the above concentration, only 5 per cent. of the ammonia is chemically combined. When the hydrolysis is large the method is accurate, and even when it is small the results are good, as shown by the following values for the salt $NaNH_4HPO_4$:

Conc. Mols. per Litre.	*Per Cent. Hydrolysis.*
0.1	2.98
	2.92
	2.98
0.05	3.02
	3.13
	3.02
	2.90
	Mean, 3.0

These values are corrected for the ionization of the ammonia at the different concentrations.

THE IONIZATION OF THE SUCCESSIVE HYDROGENS OF ORTHOPHOSPHORIC ACID.

GEORGE A. ABBOTT.

The dissociation relations of polybasic acids are at present imperfectly understood. Owing to the natural complexity of the compounds and the experimental difficulties due to hyrolysis, hydration, and possibly association in solution, few investigators have attempted to determine the dissociation constants of the different hydrogens of these acids; but the recent development of physico-chemical methods of investigating the nature of dissolved substances has made the solution of such problems appear entirely practicable. Therefore an extended investigation was undertaken, at the suggestion of Prof. A. A. Noyes, in the hope that an exhaustive study of the dissociation relations of the phosphoric acids might contribute toward a better understanding of their chemical behavior in inorganic reactions. This investigation was conducted in the Research Laboratory of Physical Chemistry of the Mass. Inst. of Technology.

In this paper I shall attempt to present briefly only a few results, in the hope that they may prove sufficiently interesting to justify their presentation. The method of measuring hydrolysis described in the previous paper gives us at once a reliable means of determining the dissociation constants of weak acids. When both acid and base are weak (slightly dissociated), the following relation holds:

$$\frac{h^2}{(1-h)^2} = \frac{Kw}{K_A\,K_B}$$

in which *h* denotes the degree of hydrolysis of the salt, and Kw, K_A and K_B *are* the dissociation constants of water, the acid and the base, respectively. They are defined by the following expressions of the Mass Action Law:

$$\mathbf{Kw} = C_H \times C_{\bar{OH}}$$

$$K_A = \frac{C_H \times C_{A.}}{C_{HA}}$$

$$K_B = \frac{C_B \times C_{OH}}{C_{BOH}}$$

The dissociation constants of the successive hydrogens of Orthophosphoric Acid will be designated K_1, K_2 and K_3. They are defined by the Mass Action equations:

$$K_1 = \frac{H \times H_2PO_4}{H_3PO_4}$$

$$K_2 = \frac{H \times HPO_4}{H_2PO_4}$$

$$K_3 = \frac{H \times PO_4}{HPO_4}$$

They will be considered in inverse order.

K_3 may be determined by substituting the value of *h*, obtained by the partition method, in the hydrolysis equation.

$h = .95.$
$Kw = 8 \times 10^{15}$ (mols. per litre).
$K_B = 1.72 \times 10^{7}.$
$$\frac{(.95)^2}{(1. - .95)} 2 = \frac{50 \times 10^{16}}{(K_3)\ (1.72 \times 10^{7})}$$ whence,
$K_3 = 6.48 \times 10^{13}$ (mols. per litre).

K_3 was also determined by an utterly independent method based upon the measurement of the increase of electrical conductivity produced on adding to solutions of Na_2HPO_4, varying amounts of ammonia. Time will not permit a description of the method and calculations which are somewhat complicated, but the values obtained at different concentrations agreed remarkably well with the above value.

In like manner K_2 may be calculated from the hydrolysis of $NaNH_4HPO_4$. The value obtained by substitution in the above equation is $K_2 = 3.9 \times 10-^{7}$, but this calculation fails to take into account the influence of the unionized substances in the solution.

The correction involves merely the application of the Mass Action Law, and the principle that, in a mixture of salts with a common ion each salt has the same degree of ionization as if it were present alone at a concentration equal to the sum of the concentration of the two salts. However, the algebra involved is not particularly entertaining, and it will perhaps be sufficient to give the mean corrected value of $K_2 = 2.09 \times 10-^{7}$. It is then seen that the correction is large. The value of K_3, when corrected for the influence of unionized substances becomes $K_3 = 5.55 \times 10-^{13}$.

The hydrolysis of the salt $NH_4H_2PO_4$ is too small to be measured by the partition method, for the ionization of the first hydrogen of Orthophosphoric Acid is fairly large. It does not accurately obey the Mass Action Law: hence K_1 has no definite meaning. However, the degree of dissociation was determined from the values of the electrical conductivity of the acid and its salts, and other known data, and the following values were obtained, at 18°C:

Conc. Mols. per Litre.	*Degree of Ionization.*
0.1	0.286
0.05	.364
0.01	.602
0.002	.839
0.0002	.965

Ostwald's Dilution Law requires that

$$\frac{Cr2}{1-r} = K_1$$

wherein C represents the concentration and r the degree of ionization. Substituting the values of r we obtain, for the values of K_1 at the different concentrations:

Concentration.	*K.*
0.1	0.0114
.05	.0104
.01	.0091
.002	.0087
.0002	.0053

and it is seen that the deviation from the law is marked.

A comparison of the ionization constants of phosphoric acid with those of some other acids is interesting.

	$K \times 10^{10}$
Acetic Acid, $C_2H_3O_2 - H$	180,000.
Carbonic, $HCO_3 - H$	3,040.
Hydrosulphuric, $HS - H$	570.
Boric, $H_2BO_3 - H$	17.
*__Phenol, $C_6H_5O - H$__	1.3
Phosphoric Acid, $K_1 = H_2PO_4 - H$	100,000,000. (Approx.).
" " $K_2 = HPO''4 - H$	2,090.
" " $K_3 = PO''' \ 4 - H$	0.00555

---

*These values are taken from Walker, "Zeit Phys. Chem." *32*, 137, 1900.

The first hydrogen of ortho phosphoric acid behaves in a manner analogous to that of the strong acids; the second to that of a weak acid intermediate between carbonic and hydrosulphuric; while the third is even weaker than phenol. This accounts for the well-known behavior of the acid toward indicators.

COEFFICIENT OF EXPANSION OF BRICK.

C. V. SEASTONE.

Inasmuch as brick is used extensively as a building material in different ways and in different types of construction, and also beacuse it is used to a large extent as a paving material, a knowledge of its physical properties is of value. With a view to increasing this knowledge a series of experiments were made at Purdue University to determine the coefficient of expansion of different grades of brick. It is the purpose of this paper to give the results of these experiments.*

The method used to determine the coefficient was to subject a bar of steel whose coefficient of expansion was known, and the specimen of brick, to identical changes of temperature. The difference of expansion was measured by the principal of the optical lever. This difference reduced to unit length and unit temperature gave a correction to apply to the coefficient of the metal bar.

The apparatus used for these experiments was designed by Professor W. D. Pence, former Professor of Civil Engineering at Purdue University, and used by him to determine the coefficient of expansion of concrete. It consists of, first, the specimen to be tested; second, the bar of steel of known coefficient; third, a heating apparatus, consisting of a double-walled steam jacket through which the mirror of the optical lever could be seen; fourth, a rod in the opposite side of the room, whose image, reflected in the mirror, was read by means of an engineer's level. The thermometer is hung inside the heater and is read through the glass door by the aid of an incandescent lamp suspended alongside of it. The lamp is turned on only for an instant in order not to affect the reading of the thermometer. Both the level and the steam jacket were mounted upon a concrete foundation. The arrangement of the apparatus and the method of conducting the experiment will be easily understood from the figure.

---

*The experiments were conducted, under the writer's direction, by W. J. Burton and C. W. Wilson (1902-1903), and by G. W. Case and G. C. Curtiss (1904-1905), as thesis work in the School of Civil Engineering, Purdue University.

Three qualities of brick were used. First, a good quality of No. 1 paving brick; second, a medium quality of No. 2 paving brick; third, a soft quality of ordinary building brick. The brick were approximately 2"x4"x8" in dimension and were cemented together in order to obtain the specimen of desired length.

Following is the mean value obtained for each of the above qualities of brick:

No. 1 brick (hard) Coefficient of Expansion per degree F = .00000401.

No. 2 brick (medium). Coefficient of Expansion per degree F = .00000401.

No. 3 brick (soft). Coefficient of Expansion per degree F = .00000393.

It will be noted that the hardness of the brick has little to do with the amount of expansion, the three qualities giving essentially the same values.

CONTRIBUTIONS TO THE KNOWLEDGE OF VEHICLE WOODS.

W. K. HATT.

It is admitted by both the forester and the manufacturer of vehicles that the supplies of hickory and like woods used in vehicle construction are becoming scarce. The quality is poorer and the price is higher each succeeding year. Indeed, the condition with respect to the supply of vehicle woods may be said to have become acute, and the various trade organizations have become aroused to such an extent that meetings have been held to discuss means of increasing the sources of supply and economizing on the construction.

Three ways in general are open:

First, an endeavor may be made to determine the availability of new species as substitutes for such woods as hickory and white oak.

Second, planting operations might be made a success.

Third, a more economical use may be made of the timber supplies now entering the mills for manufacture into wagon parts.

The present paper discusses lines of effort in the substitution of new and untried species, and in improving rules of grading in the mills so that excellent material, fully available for service, may not be thrown out, as is the case now, by incorrect rules of grading.

The Forest Service, United States Department of Agriculture, and the Purdue University Laboratory have for some years co-operated in the establishment of a timber testing station in the Laboratory for Testing Materials of Purdue University, at which studies have been made to determine the essential mechanical properties of various species of wood, and what effect various factors have upon these properties. Other studies to determine the correctness of the rules of grading for vehicle parts, and to examine into the merits of different designs of such parts as wagon axles, and to investigate the properties of possible substitutes, have a direct application to an important industry of the State. This Laboratory at Purdue University is one of a series of laboratories operated by the Forest

Service at such institutions as the Yale Forest School, and the Universities of California, Oregon and Washington. The writer of this paper has been in charge of this work since is inception in the year 1903.

SUBSTITUTION OF NEW SPECIES.

The practice of substituting cheaper and weaker species for others which have become scarce and high priced has been increasing for some time. For instance, longleaf pine harvester poles have come into use in place of oak poles, and those parts of vehicles not bearing a great strain are now made of weaker woods. The successful introduction of species which are quite proper for the service is generally retarded by prejudice. Consumers have demanded certain species regardless of their actual fitness, and irrespective of the fact that other and cheaper woods might answer the purpose equally well. For instance, both poplar and red gum, which are now held in such high estimation, have both had to fight their way for a place on the market for such parts as wagon box boards.

It may be stated at the outset that there is probably none of our eastern species that can replace hickory for strength and general shock-resisting properties and permanence of shape after it is bent. The lines of endeavor must be to use hickory in only such parts of the wagon where great shock-resisting properties are required, and to correct the rules of grading so that minor defects which do not affect the strength of the wagon are not allowed to operate to throw a suitable piece of hickory out of use. A recent study of the properties of the eucalypts in California by the Forest Service seems to point to the value of some of these species for use in wagon construction. The blue gum (Eucalyptus globulus) is the most common species in California, and has competed with black locust for insulator pins, and has given satisfactory service in chisel and hammer handles, and has been used locally for wagon tongues, axles, shafts, spokes, hubs and felloes in California. The wood is hard, strong and tough, and grows very fast. In bending the modulus of rupture is 23,000 pounds per square inch for seasoned lumber, about equivalent to second-growth hickory. This eucalypts seems to be the most promising species upon which to draw for products requiring great strength, toughness and hardness.

GRADING RULES.

An instance of the method of attack to determine the correctness of the grading is in the case of hickory wagon spokes, which are now graded into six divisions: A, B, C, D, E and Culls. Five hundred spokes were procured from the Bannister Wheel Company of Muncie, Ind., and were tested under a direct load as shown in the diagram, and the maximum load, together with the amount of bending sidewise before fracture was noted. This combination of maximum load and amount of side bending gives a factor which represents toughness and shock-resisting capacity. The results from the spoke tests show more than 50 per cent. error in the present grading system, which is largely due to the traditional prejudice and consequent discrimination against red hickory. No red spokes are now allowed in the A and B grades, yet these tests show that a large proportion of the red spokes now included in the lower grades should be, because of their strength and toughness, included in the highest grades. It appears, also, that weight for weight, the red spokes and the mixed red and white spokes, are fully as strong as the entirely white spokes. These tests will be supplemented by tests on various hickory buggy shafts containing typical defects. Such tests have an interest not only to the genral public, in that a drain on a limited class of material is somewhat decreased, but they have an interest also to the grower of timber, because they increase the market value of a considerable portion of the product of the forests.

Tests have also been made on a number of wagon axles. Various species of woods, not only from the western forests, but from eastern forests, have been made up into axles at a mill and have been submitted to the laboratory for test. At the present time the series is complete upon hickory and maple axles of three different designs, and the method of attacking the problem and of determining the qualities of the axles by actual test will be of interest from a scientific standpoint. (Referring to the photograph of an axle under test, the method of loading and measuring and the behavior of the axle is shown in detail, and the various quantities entering into an estimation of the value of the axle are explained.)

Another example is in a series of tests to determine the proper grading of pine harvester poles. A large part of this material is shipped up from the south to such markets as Chicago, and is there graded by the manufacturers, the defective material being thrown out at a loss to the shipper, not only of the cost of the material, but of the freight. It becomes important, therefore, to know whether the poles thrown out might be used. Poles containing different classes of defects were tested, and it was found that at the present time there is an unjustifiable prejudice against the use of poles containing a considerable per cent. of sapwood.

Another series of tests on the relative strength of oak and yellow pine wagon poles is of interest, not only for the method of loading and measuring the quality of the pole, but from the light it throws on the essential difference between products from such woods as oak and such woods as yellow pine. (Referring to the diagram, the method of loading and measuring the various elements of the test were shown. The general results of the investigation are also shown by the diagram and table, from which it appears that while longleaf pine poles are as strong and elastic as the oak poles, yet they lack the toughness, and the effect of a cross grain is much more serious than in the case of oak.)

These various instances are brought forward to show the method of attack and scientific care in aiding the solution of a large commercial problem of this kind. The results of these tests will appear in a publication by the Forest Service.

NOTES UPON THE RATE OF TREE GROWTH IN GLACIAL SOILS IN NORTHERN INDIANA.

STANLEY COULTER.

The clearing of certain small timber areas near Lafayette in January and February, 1906, gave an exceptional opportunity for studying the rate of growth of certain native species of trees. The species occurring in sufficient number to warrant deductions were the white oak, red oak and black walnut. Of the red oak forty-nine trees were examined; of the white oak, sixty, and of the black walnut, thirty-two. It was assumed that the annual rings gave a fair indication of the age, despite the occasional formation of two rings in a single year, or the apparent suppression of an annual ring because of exceptionally unfavorable conditions, which were recognized as possible contingencies. In the forms examined neither of these conditions were indicated, the growth in each case having apparently proceeded in an orderly and orthodox fashion.

The measurements are the averages of the longest and shortest diameters and were taken inside of the bark. Both the measurements and the counting of the rings were made by four groups of students, insistence being placed upon accuracy. In cases of discrepancy a recount or remeasurement, or in some cases both, was directed. The tables, therefore, may be considered as exceptionally accurate, each specimen having been independently studied by four groups working on different days.

The oaks, with but few exceptions, occurred on the highest levels, just northwest of Purdue University. The general surface is rolling, with a southeastern exposure, more or less interrupted by ravines formed by small streams. Approximately the topographical conditions were the same.

The soil in the area under consideration is relatively thin. It consists of a few inches of humus made up of the usual forest material; a few inches (8-12) of a loam soil more or less alluvial in character, followed by perhaps a foot of fairly heavy clay. Underlying this is the glacial drift, extending downward from one hundred and ten to one hundred and twenty feet to the bed of the river. The drift in this region is mainly sand and gravel, with a few thin seams of light clay at various levels. Throughout the area from which the oaks were cut, the soil overlying the drift material ranges from eight to twenty-three inches in thickness. So far as the physical and chemical composition of the soil is concerned we have practically identical conditions over the entire area.

The black walnut was cut for the most part in an area lying in the second river terrace, where, in addition to the forest humus, there occurs from three to five feet of alluvial soil before the clay is struck. The clay also in this area is perhaps twice as thick as in the former case. The terrace has an eastern exposure, while the curves of the river protect the particular tract in question from the north winds, but leave it open to winds from the south. Upon the west it is protected by the escarpment of the upper terrace. The area covers but a few acres and evidently furnishes as uniform conditions as can be found in nature. The two tracts present, however, fairly distinct conditions, a fact which should be borne in mind in any comparison of the rate of growth.

The measurements of the different species are given in tabular form as furnishing in the main the data for the deductions drawn later in this paper. Possible occasional errors may occur in the computation of percentages in spite of the fact that the figures have been reviewed three times.

From the tables it is shown that in the area indicated and under the conditions outlined the average yearly increase in white oak, based upon sixty specimens, was .1995 of an inch; of red oak, based upon forty-nine specimens, was .22674 of an inch; of black walnut, based upon thirty-two specimens, was .27712 of an inch.

A number of interesting inferences seem plain.

1. There is a wide range in the growth rate in trees of the same species, even when growing under the same conditions. Thus the range in white oak is from .095 to .328 of an inch; in red oak, from .134 to .515 of an inch; in black walnut, from .195 to .358 of an inch. Such wide range under conditions so nearly identical must be referred to individual idiosyncracies, probably referable in most cases to the vigor of the acorn, to the character of the tree from which the acorn was derived, to inherited growth tendencies or similar causes. An examination of the table of trees of similar age in respect to their diameters will show clearly this "personal equation" of the tree. For example, in Table II, numbers 38 to 45, inclusive,

Table I. Quercus alba.

Serial Number.	Inches Diameter.	No. of An. Rings.	Average Yearly Increase.
1	32	200	.160
2	11	68	.162
3	11	74	.149
4	16	76	.210
5	22	78	.282
6	13	66	.196
7	19	60	.317
8	17	74	.230
9	15.5	74	.209
10	17	76	.223
11	17	79	.215
12	17	77	.220
13	16.5	74	.223
14	15	75	.200
15	13	77	.170
16	12.5	75	.166
17	15	77	.195
18	15.5	77	.201
19	13.5	78	.173
20	21.5	80	.269
21	16	79	.202
22	20	77	.260
23	13	77	.169
24	19	77	.247
25	19	75	.253
26	47	303	.155
27	9	63	.143
28	12	73	.164
29	16	78	.205
30	17	89	.191
31	15	78	.192
32	24	252	.095
33	12	75	.160
34	12	75	.160
35	50	243	.206
36	28	185	.151
37	28	180	.155
38	31	222	.140
39	26	232	.112
40	30	230	.130
41	18.5	72	.257
42	18.5	77	.240
43	25	76	.328
44	14	73	.191
45	13.5	77	.175
46	20	77	.261
47	16	79	.202
48	20.5	81	.253
49	13.5	76	.177
50	15.5	78	.200
51	14.5	73	.200
52	13	76	.171
53	13	76	.171
54	17	75	.226
55	41	208	.197
56	15.5	80	.194
57	17	76	.223
58	17	79	.215
59	17.5	78	.223
60	16.5	78	.211

TABLE 11. QUERCUS RUBRA.

Serial Number.	Inches Diameter.	No. of An. Rings.	Average Yearly Increase.
1	20	76	.263
2	15	78	.192
3	14	77	.182
4	15	77	.193
5	14.5	75	.193
6	24	77	.311
7	22	78	.282
8	22	83	.265
9	20	82	.244
10	19	82	.231
11	16.5	82	.201
12	15	82	.183
13	17	82	.207
14	15	82	.183
15	9.5	76	.125
16	15	80	.187
17	23	73	.315
18	14.5	77	188
19	12	87	.138
20	15.5	115	.134
21	14.5	76	.190
22	15.5	90	.172
23	13.5	78	.173
24	13	71	.183
25	11.5	74	.155
26	15	63	.238
27	14.5	76	190
28	16	73	.219
29	22.5	81	.277
30	16	70	.228
31	14.5	72	.201
32	24	88	.272
33	20	64	.312
34	22	79	.278
35	20	71	.281
36	22	71	.310
37	33	64	.515
38	22	82	.268
39	18.5	82	.225
40	20	82	.243
41	19	82	.231
42	15	82	.182
43	17	82	.207
44	15	82	.182
45	16.5	82	.201
46	13.5	61	.221
47	11	60	.183
48	23	73	.315
49	18.5	82	.225

TABLE III. JUGLANS NIGRA.

Serial Number.	Inches Diameter.	No. of An. Rings.	Average Yearly Increase.
1	25	82	.305
2	14	64	.219
3	15	77	.195
4	19	73	.260
5	18	67	.270
6	21	81	.260
7	19	58	.327
8	20	64	.312
9	18	76	.237
10	20	74	.270
11	14	52	.270
12	15.5	68	.228
13	21.5	64	.336
14	21	72	.291
15	22.5	71	.317
16	20	66	.303
17	24	67	.358
18	15	45	.333
19	22.5	88	.255
20	18	74	.243
21	19	76	.250
22	20	70	.285
23	20	78	.256
24	24	80	.300
25	17	63	.270
26	16	60	.266
27	23	74	.311
28	23	80	.287
29	22	77	.285
30	22	83	.265
31	19	79	.240
32	20	75	.266

are of the same age and grew on a gentle northward-facing slope in an area of less than an acre, yet the diameters range from 15 to 22 inches.

2. Conclusions as to the rate of growth of various species, which fail to take into account individual variations are manifestly misleading. This variation may reach as much as 25 to 30 per cent. above or below the average growth rate. Incidentally it gives strong emphasis to the necessity of great care in the selection of seeds for cultural work—since a careful selection may increase the wood crop to the extent of 25 per cent. beyond the average.

3. The growth rate in the area examined was exceedingly slow, especially in the case of the oaks. In a report of W. F. Fox, Superintendent of State Forests, New York, it is stated that a vigorous three-inch white oak sapling would, under favorable conditions, at the end of twenty years at-

tain a diameter of eleven inches, or make a net gain of eight inches. This would give an average yearly increase of .4 of an inch, which is considerably greater than the highest yearly increase in any of the sixty specimens examined, or .328 of an inch. Mr. Fox also states that a three-inch red oak sapling would, in twenty years, attain a diameter of thirteen inches, thus making a net gain of ten inches. This gives a yearly rate of .5 of an inch, or more than double the average yearly rate (.22674 of an inch) of the forty-nine specimens examined. It is true that specimen 37 shows an average yearly growth of .515 of an inch, but the next is .336 of an inch and only six out of the forty-nine show an average yearly growth in excess of .3 of an inch. An examination of a number of white and red oak logs at local mills confirms the conclusion that the growth rate in the area studied is exceedingly slow.

It is probable that the cause of this slow growth is to be found in relatively thin soil underlaid by the hundred or more feet of drift. The sand and gravel of the drift constitute a natural filter which rapidly carries the soil water to lower levels. The thin soil and the stratum of clay can not hold sufficient water to carry the trees through our long summer drought and at the same time furnish a large amount of material for growth. Observation of the trees of the Purdue campus furnishes confirmation of this view. The soil conditions of the campus are practically the same as in the area studied. The older trees of the campus were set out between 1875 and 1880, and were largely maples and elms along the driveways, other forms being scattered through the grounds. The maples and elms are in sufficient numbers to justify a few generalizations. The trees show an early period of rapid growth, a period of slow growth and finally a practical cessation of growth. During this latter period the trees begin to show all the signs of what might be called senility. In the early years, the roots not having penetrated deeply, find sufficient available moisture in the thin soil to provide for the maintenance of the tree and its normal growth. A little later, the deeper penetrating roots reaching the drift find but little water, so little, indeed, that under the most favorable conditions provision can be made for only a slight growth. Still later the increasing demands of the tree can not be satisfied and it begins to age, and we have the case of elms and maples completing their life cycle in twenty-five or thirty years, attaining in the meantime a diameter of from ten to fifteen inches. The duration of life upon the campus is much less that in forest conditions, because of the absence of the forest floor and of its work in the conservation of moisture and the enrichment of the soil.

4. It may be concluded that the most important factor in the growth of trees is *soil moisture*. A confirmation of this may be found in the conditions existing in areas of maximum development in number and size. According to Sargent, the hardwoods of the United States find their maximum development in numbers and size in the lower stretches of the Wabash Valley. In other words, in a region in which the soil possesses a rich water content.

In any forecasts as to the results of reforestation, or as to the rate of tree growth in any given locality the supreme factor to be considered is the constancy of the water content of the soil.

5. In the case of the oaks an examination of the table will show a period of rapid growth, a period of slower growth and finally a period of scarcely appreciable increase. In the case of the walnut the growth is much more uniform throughout the life of the tree. These are conditions that would be expected if conclusion three is at all correct.

6. It is probable that red and white oak in regions such as the one studied have reached their full size at from eighty to a hundred years, after which they begin to deteriorate. The few large forms introduced in the table are from the lowest river terrace and were introduced for purposes of comparison.

7. The growth habit of the tree seems to control more largely than external factors of growth. In a group of trees closely grouped the majority may show an exceptionally rapid growth in a given year, while one or two show but a small increase. That this might be due to insect defoliation or other causes is of course possible, but an examination of the growth through a series of years show a habit of slow growth as compared with other individuals, whatever may be the external conditions. On the other hand, individuals showing a habit of rapid growth are easily recognized. No observable differences in the proportion of spring and summer wood, in texture, in color or in any gross characters are to be observed in these differing forms. Some individuals of each species are rapid growers and some are slow growers, whatever may be the origin of the habit. It was impossible to determine whether or not this habit could be determined by external features, as the trunks had been sent to the saw mill before the area was found.

8. The conditions of the area described are fairly typical and apply

to a large part of the glaciated region of northern and northwestern Indiana. Of course the immediate valleys and terraces of rivers and streams furnish special conditions which must be considered as exceptional. It is probable that any extended study of the rate of growth of the species discussed in the region indicated will show results but slightly varying from those given above.

9. It is probable that under soil conditions such as those described, larger forms than those found today but rarely occurred. A careful examination over wide areas for old stumps of the virgin forest, showed that all of the large forms were found in alluvial soils and never by any chance in the thin-soiled uplands.

These studies are being extended to include many of our native species and arrangements have been made to increase the number of forms studied of the species discussed in this paper.

The exact knowledge of the rate of growth of various species under differing conditions is a matter of vital importance from the viewpoint of wood-lot forestry. It is scarcely less far reaching in its application and of scarcely less economic significance than a knowledge of forest utilization. If the conclusions here presented are warranted by the date very self-evident practical application necessarily follow. These, however, are not included in the scope of this paper, but will be presented later.

THE MICHILLINDA (MICHIGAN) SAND DUNES AND THEIR FLORA.

STANLEY COULTER.

Nowhere is the struggle for a place in nature by plants more spectacular or more severe than that with the sand dunes. The alignment of the opposing forces is so evident, their activity is so ceaseless, their modes of attack so varied that one wonders that the plants ever succeed in fixing these restless masses of sand. After the classic studies of Cowles upon the Dune flora it would seem that little remains to be said, but to the botanist accustomed to the placid plant life of mesophytic regions the struggle is irresistibly fascinating and, as a rule, he is unable to resist the temptation of a new consideration of some phases of the problem.

The region studied was a short stretch of beach dunes on the east shore of Lake Michigan at a summer resort known as Michillinda, about twenty-five miles north of Muskegon. That the region is exceptionally favorable for such studies is evidenced by the fact that it is the place chosen by Dr. Cowles for his classes when considering the problems presented by the dune flora. The study made was neither systematic nor exhaustive; it was merely a part of a rest of three weeks after a summer school session. No attempt was made to enumerate the constituent members of the flora or to work out all of the factors determining the success or failure of the plant invaders. The paper, therefore, touches only the more evident features of the problem and treats even these in the line of suggestion rather than explanation.

The plants begin their struggle on what Cowles calls the middle beach, a region beaten by the winter waves, but as a rule dry during the summer months. The struggle here is almost hopeless and on the open stretches of the beach the plants are extremely scattered. In the shelter of the drift logs and debris, however, they are more numerous and may maintain a precarious existence for some months. It is probably the area of greatest stress. The fierce winter storms compel an absolute renewal of the struggle each succeeding year, while the summer winds and sun make it possible for only such plants as possess the most marked xerophytic characters to maintain themselves. A severe summer storm may overwhelm the beach, killing all forms that have obtained a foothold, and the struggle must begin all over. Such a storm swept the Michillinda beach for almost a week during the past summer, blotting out absolutely the middle beach flora. In a week, however, the brave plants began to show themselves again and to renew the apparently hopeless struggle. The most notable member of this flora was the succulent leaved crucifer, *cakile edentula* (Bigel.) Hook. The adaptation in this case is plainly against the dessicating action of wind and sun. The plant also is able to withstand, to a certain extent at least, a sand covering of considerable thickness, forcing its way through it to the surface apparently but little injured by its temporary burial. Its stubborn erectness and unyielding rigidity are characters that at once serve to distinguish it from the other members of this flora.

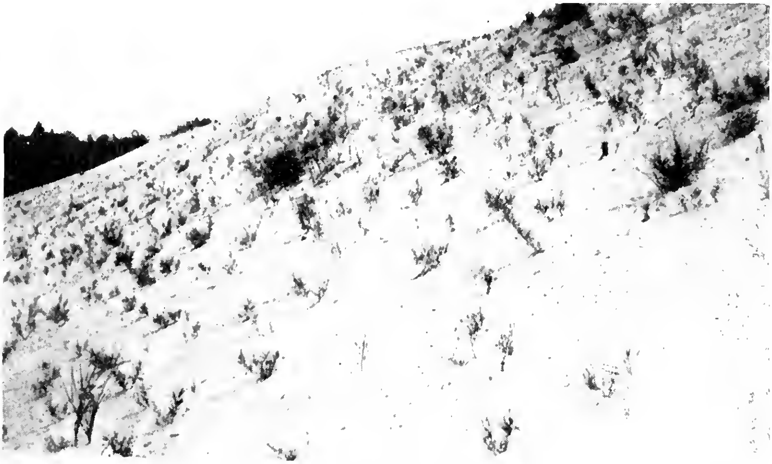
More numerous upon this stretch of beach is *Cuphorbia polygonifolia* L. This prostrate spurge finds its protection in its close hugging of the sands which are here always damp at a slight depth, whatever may be the sun's heat. A covering of sand does not seem to kill it, unless it is several inches thick, new shoots emerging from the crown, finding their way to the surface in a few days. In spite of these two species, the middle beach strikes one as practically destitute of plants—and the wonder grows as the conditions are studied that the few that do occur have found even a temporary lodgment.

The upper beach and the active dune region present a much more varied and consequently much more interesting flora. The opposing forces here are the fierce rays of the sun, the almost constant winds and the shifting sands. In high winds the mechanical action of the sands is very great, often completely destroying well-established plants. These factors have led to the development of the most pronounced xerophytic characters found in this latitude, and this in spite of the fact that there is no scarcity of water in the soil. Even after the long summer drought, the sand is moist at a slight distance below the surface. The most marked adaptations in this region are those against the covering of the plant with sand, exposure of roots by the shifting of the sand, excessive evaporation because of sun and wind, and the mechanical action of the sand driven by storms. Practically every device against these destructive agencies is here in evidence. They are so well known that they need not be recited in this connection.

Most interesting, perhaps, are the provisions against submergence by the sands. In the case of the poplars, willows and dogwoods, the sprouting habit in connection with the habit of sending out roots from any node in contact with the soil is sufficient protection, save in the most extreme cases. These plants, therefore, while not strongly developed in the upper beach, are rarely wanting on active dunes. The willows commonly found are *S. varialilis*, *gloucophylla* and *adenophylla*. The dogwoods are *C. stolonifera* and *Baileyi*. The poplar is the cottonwood, *P. deltoides*. To the botanist, the adaptation of these plants for such a position are self-evident, but individual cases present continual variations. Nothing could more clearly illustrate the extreme plasticity of these shrubby species than their quick and sure response to these constantly varying factors.

These grasses lead in the attack upon the dunes. These plants all arise from a single root stock.

In the case of the grasses, which are chiefly *Andropogon*, *scoparius*, *Ammophila arenaria*, *Calamorilfa longifolia*, and *Eleymus canadensis*, there is a quick setting of roots from the nodes when there is but a partial submergence, while the long, horizontal branching root stock is constantly sending up new stools during the continuance of favorable conditions. The first plants to obtain a foothold upon these shifting sands are usually the grasses. From a single stool through the agency of the root stock there is a rapid spread which covers a very considerable area. In various places upon the most active portion of the dunes some one or more of these grasses obtain a foothold and struggle fiercely to maintain the place they have seized. So far as my personal observations go, the invasion of the dune is made at its lower stretches, gradually creeping upward, until in a particularly favorable season the whole dune is fairly well covered with plants. The binding together of the soil by the grasses, even for a short time, is sufficient to permit the establishment of other forms, so that in places the flora of the upper beach and active dune may be quite varied. On the upper beach the most common of the plants are *Artemisia caudata* and *A. Canadensis*, while the attractive *Carduus Pitcheri* is scarcely less common. In these plants the strong and long tap-root and dissected leaves serve as an almost perfect protection against excessive evaporation and the mechanical action of the sand in the case of high winds. In the case of the Artemisias it was possible to observe in a considerable area, the perfection of the defense the finely dissected leaves afford against the sand blasts of a storm which lasted for nearly a week. Almost every other species in the area, which lay open to the direct action of the wind-driven sand was completely battered to pieces, while only about 15 per cent. of the Artemisias showed any sign of having been subject to a long continued action of a destructive force.



At the close of a favorable season the whole dune may be fairly well covered with plants.

Upon the upper beach, also, is to be found in favored situations the beach pea, *Lathyrus maritimus*, although in no instance was it at all a dominant form. Upon the active dune is often to be found the frost grape, *Vitis cordifolia.* Far more common, however, the common milk weed. *Asclepias Syriaca,* the bug-seed, *Corispermum hyssopifoliund* and *Puccoon, Lithospormum Gmelini.* This last is by far the most common of the groups, consisting in many instances a large proportion of the plants. A golden rod is not at all uncommon in such situations, but I am not certain what species it is. I am, however, confident it is not S. virgaurea gillmani, to which it is referred by Dr. Cowles in "The Ecological Relations of the Vegetation of the Sand Dunes of Lake Michigan." In no two cases are the conditions exactly similar, so that in spite of the paucity of species there is no monotony. Different dominant species, differing proportions of those occurring make each area a special study. If we add to these the varying adaptations of the same species and the fact that at best any victory of the plants is but apparent, we can understand something of the complexity of the problem. The illustration on page 127 shows a large pine dying because of an uncovering of its roots during the storm mentioned above.

At times the Artemisias are dominant plants over considerable areas.

The succulent type of annuals was not so strongly marked as I had expected, but dissected leaves, the profile position, inrolling of leaf blades, and coverings of hairs seemed the dominant adaptations against the excessive transpiration and doubtless also against the fierce heat of the sun. Against the wind action the prostrate or trailing habit and great rigidity were the prevailing adaptations among herbaceous plants. Against sand coverings, nodal rooting and branching root stocks are almost universal among the annuals. Where perennials have obtained a foothold, the long, thick tap-root is usually sufficient to give a new lease of life. Against the mechanical effects of the sand, the prostrate habit, the dissected leaves and at times

Any victory of the plants is but apparent. After years of possession of the soil they may be dislodged by the shifting of the soil under the action of the wind.

an extremely tough and resistant structure. The first two are by far the more common and apparently the more effective.

From the standpoint of the plant no situation can be more pitilessly cruel than the stretches of white, restlessly shifting sand making up the beaches and dunes. In a certain sense, no other situation furnishes ecological problems of such apparent simplicity, but even here, as I have tried to show, the problem is really one of extreme complexity. If in any measure this paper serves to indicate how utterly without significance much so-called ecological study really is, and to stimulate to work along these lines that is really analytic, that recognizes the fact that no ecological problem is in reality simple and needs long-continued, oft-repeated observation and reflection before generalizations are made, it will have a distinct value quite apart from the specific subject discussed.

PARASITIC PLANT DISEASES REPORTED FOR INDIANA.

FRANK D. KERN.

The following summary of plant diseases in Indiana has been made up from information which has been accumulating during the past few years at the Botanical Laboratory of the Indiana Experiment Station.

In this list only the more important diseases have been considered from the standpoint of the cultivator. The information at hand is far from complete, since the diseases are invariably reported by common names, and as it is impossible to investigate or verify each case there is a probability that disturbances in growth and health do not always have the proper causes assigned. An effort has been made to classify the diseases according to their pathological effects. fifty six in all being discussed. Such a grouping is difficult, owing to the lack of knowledge concerning the exact manner in which many of the parasites act.

Before taking up the detailed account it will be of interest from the point of view of the mycologist to consider the parasites which are held responsible for the various diseased conditions of root, stem, leaf and fruit. Out of fifty species under discussion forty-five are *fungi*, five *bacteria*, and one a *slime-mould*. Three species are causes for two separate diseases each, while three have no cause assigned, thus bringing the total up to fifty-six, the number selected for consideration by this paper. The fungus parasites are divided among thirty-two genera belonging to classes as follows: *Ascomycetes*, nine; *Basidiomycetes*, nine; *Phycomycetes*, one; *Fungi Imperfecti*, thirteen. Under the general term of *Fungi Imperfecti* are included a miscellaneous lot of forms whose life histories are imperfectly understood; some may have no other stages, while others may have connections not yet discovered. Comparatively recently three which were formerly classed here have had their perfect stages identified and have been transferred to the class *Ascomycetes*. These are the Bitter-rot fungus of the apple, the Scab-fungus of the apple and pear and the Brown-rot fungus of the peach and plum. The bacterial parasites are divided among two genera, both belonging to the same family, *Bacteriaceae*.

The enumeration of specific diseases is as follows:

I. Root diseases, affecting absorption of food materials—

Crown gall (cause uncertain). On fruit trees, small fruits, known to occur; extent of injury not reported.

Root-rot (Fungi not identified). On fruit trees; troublesome in orchards, principally in southern part.

Club-root (Myxomycetes, Plasmodiaphora Crassicae). On cabbages and other cruciferae. Distribution not known. Reported from market gardening regions about larger cities.

II. Stem diseases, affecting ascent of sap and transpiration—

Fire-blight (Bacillus amylovorous). On apples, pears and quinces in all parts of the State. Very destructive and difficult to control.

Black-knot (Plowrightia morbosa). On plums and cherries. Common all over State on plum trees. Cherries less injured by it.

Black-rust (Puccinia graminis). On wheat, chiefly, but attacking also other grains and grasses. Occurs everywhere. Extent of injury in any particular season usually dependent upon weather.

Black-rot (Pseudomonas compestris). On cabbage, cauliflower and related plants. Affects leaves also, and finally entire head. Very destructive in some localities.

III. Wood diseases, affecting absorption and transfer of water—

Wilt (Bacillus tracheiphilus). On melons and cucumbers. A common and injurious trouble affecting melons, especially in southern countries. Few reports concerning cucumbers; this crop of much less importance.

Blight (Bacillus salanacearum). On tomatoes. Few local reports of this. May be due to other causes than bacteria.

IV. Bark diseases, affecting transpiration chiefly—

Canker (Spaerapsis malorum, Bacillus amylovorus, Glomerella rufomaculans). On apple trees. Cankers may be due to the parasites mentioned or others. Occurrence of any except the first mentioned has not been verified.

Asparagus rust (Puccinia asparagi). On asparagus. Bad locally in northwestern portion of State.

Anthracnose (Gleosporium venetum). On blackberries and raspberries. Often very destructive.

V. Leaf diseases, affecting assimilation and transpiration—

Rusts, caused by uredineae (Gymnosporangium sup.). On apple, pear, quince and red cedar. Not reported as very destructive on cultivated apples: common on wild crabs or thorns.

(Puccinia rubigo-vera.) On wheat. This is the leaf rust and is usually common, but not especially injurious.

(Puccinia graminis.) On wheat and other cereals. This is the stem rust and only rarely occurs to any extent on the leaves.

(Puccinia caronata.) On oats. Occurs very commonly on leaves, but is not accountable for losses of any extent.

(Uromyces trifalii.) On clover. Not known to be of much economic importance, though quite common.

(Puccinia poarum.) On blue-grass, often in lawns.

(Puccinia sarghi.) On corn. Very widespread and common, but not especially injurious.

(Gymnoconia interstitialis.) On blackberry and raspberry, called the orange leaf rust. Has a perennial mycelium, but manifests itself only in the leaves. Common and distructive.

(Kuehneola albida.) On blackberry and raspberry. First noticed this season. Not of importance.

(Uromyces appendiculatus.) On beans. Extent and damage unknown.

(Uromyces caryaphyllacearum.) On carnations in greenhouses.

(Puccinia chrysanthemi.) On chrysanthemums in greenhouses.

Spots and Blights--

(Phylosticta spp.) On apple, often causing premature defatiation.

(Cylmdrosporium padi.) On cherry and plum. Not uncommon.

(Septoria ribes.) On gooseberry and currant. Extent unknown; crop of minor importance.

(Septoria lycospersici.) On tomato. Very injurious in some localities.

(Cercospora beticola.) On beets. Two reports have been received.

(Atternariae brassicae nigresscens.) On muskmellons. This is known as the leaf blight and is very injurious in some localities.

(Calletobuchum Lagenarium.) On melons. Known as anthraenace, and while affecting leaves, usually attacks stems and catyledons of young plants. Reported by several horticulturists.

Powdery mildew (Spaerothaera moro-uvae). On gooseberry. Extent of damage unkown.

Powdery mildew (Podosphaera oxyacanthae). On cherry. Extent of damage unknown.

Leaf curl (Exoascus defarmaus). On peach. Usually quite prevalent.

Early blight (Alternaria solani). On potato. Usually prevalent, doing considerable damage.

Late blight (Phytophthora infestaus). On potato. Present to some extent; usually very destructive.

Black-rot (Pseudomonas compestrio). On cabbage and closely related crops.

VI. **Fruit**, Seed and Tuber diseases, affecting crop's economic value, directly—

Apple rots, ripe or bitter (Glomerella rufomaculaus); Apple rots, black (Sphaerapsis malorum). Usually common and causes of considerable losses.

Brown rot (Scleratinia fructigena). On peaches and plums chiefly, often causing a loss of half the crops.

Scab (Venturia inaequalis). On apple: very common and injurious. (Venturia pyrina). On pear; prevalent, but not especially prevalent. (Cladosperium carphyllum). On peach; bad on some varieties.

Black rot (Gnignardia bidwelli). On grape. Widespread and injurious.

Fruit rot (cause uncertain). On tomato. Very injurious in some localities.

Flyspeck and sooty blotch (Leptothyrum and Phyllachara spp.). On apple, often affecting a considerable per cent. of the crop.

Smuts (Ustilago leae). On corn; widespread, sometimes causing bad losses. (Ustilago avenae.) On oats; usually bad; losses underestimated. (Ustilago tritici.) On wheat; so-called loose smut; usually prevalent. (Tilletia foetaus.) On wheat; so-called stinking smut; usually prevalent.

Wheat scab (Fusarium culmorum). On wheat; usually more or less abundant; sometimes accountable for heavy losses.

White mold of corn (Fusarium sp.). Very abundant in some localities during present and past seasons.

Potato scab (Oospora scabies). Occurs quite generally over the State.

Brown rot of potato (Bacillus solanacearum). Often the cause of considerable losses in all parts of State.

Black rot of sweet potato (Ceratocyctis finbriata). Distribution and extent of injury unreported.

Selevotinia fructigena (ascus stage) showing apothecia about mummied peach.

NOTES ON THE OCCURRENCE OF SCLEROTINIA FRUCTIGENA.

FRANK D. KERN.

The rotting of the peach and plum fruit at the beginning of the ripening period is a rather familiar occurrence. Soft, brown spots appear, which usually grow until the whole fruit becomes rotten and finally shrivels up, becoming mummified. Twigs, leaves and flowers may also be attacked and exhibit discolored areas.

The rot is caused by a fungus, doubtless best known as *Monilia fructigene*, a name given it by Persoon[1] in 1801. That it was simply the conidial form of some ascomycetous species, was strongly suspected by several investigators and Schroeter[2] was even confident enough to transfer it to the genus Sclerotinia in 1893. This, however, remained a mere assumption until 1902, when Norton[3] collected the apothecia at several localities in Maryland, and established, by means of cultures, their relation to the conidial form.

Although the perfect stage had been diligently searched for before this was the first time it had ever been reported. Because this form has been so rarely seen, and because of the economic importance of the fungus in the other phase of its life history, it was with unusual delight and interest that the apothecia were discovered in the spring of 1906 in Indiana. Two collections were made, both at Lafayette, and by Prof. J. C. Arthur, on buried peaches, under trees in his garden, April 21; another by Dr. E. W. Olive and the writer, on buried plums, in a trash heap on a vacant lot, May 3. The earlier collection was in perfect condition, while the latter was somewhat dried. Both discharged clouds of spores when first disturbed, and when jarred even after partial drying made several subsequent discharges.

Only the mummied fruits which were buried or partially covered bore apothecia. On the plums one to three or four arose from a single fruit, while on the peaches as high as thirty or forty appeared about the sides of

---

[1] Persoon, Syn. Fung., 693, 1801.

[2] Schroeter, Krypt. Fl. Schles, 3^2:67, 1893.

[3] J. B. S. Norton, Irons. Acad. Sci., Sb. Louis, 12:91-97, pls. 18-21. 1902.

one fruit. (Illustration.) The disks are light brown, at first companulate, becoming cup-shaped, averaging about one-half to three-fourths of a centimeter broad when full grown. The stipes are comparatively slender and usually about one to two centimeters long, where that is sufficient to bring the disks above the surface.

In every case there was reason to suppose that the fruits bearing the ascus stage were not from the crop of the immediate preceding season, but that they were one year older. In a recent conversation, Prof. Norton confirmed this opinion. Schellenberg[4] has found this to be true, also, of two other species of Sclerotinia in Europe. The length of the period required for the development of the apothecia is doubtless the factor which is responsible for their scarcity, since it affords so much time and opportunity for the mummied fruits to be destroyed or removed from the vicinity of the trees. The above collection in a trash heap shows that development takes place wherever the dried rotted fruits are covered by soil or humus a sufficient length of time, but in such a location it is only by accident that they would be discovered.

While the ascoporic form is so excedingly rare, the conidial form is just the opposite. As the cause of the *brown rot* of peaches and plums, it is the most common and destructive enemy of these crops.

In 1905 it was estimated that *brown rot* caused a loss of one-fourth of the peach crop in the southern counties of the State. In 1906 the rot has been reported from twenty-six counties representing all parts of the State. Estimates as to the amount of damage vary from 10 to 50 per cent. of the entire crop. In the northern half of the State the early varieties seemed to sustain almost double the loss of the later ones. This is an illustration of the rapidity with which the rot spreads when the weather conditions are favorable. The fungus is dependent for a start at the beginning of a season chiefly upon conidiospores produced upon the mummied fruits lying on the ground or hanging in the trees. Warm, moist weather in August, at the ripening time, caused such a production of conidiospores from these mummy fruits that the fungus spread and caused more notable effects at that time than later, when the weather conditions were less favorable.

Plums in all parts of the State have been attacked during the present season, and a loss amounting in many instances to 75 per cent. of the crop has been suffered.

---

[4] H. C. Schellenberg, Ueber Scheratinia Mespili und S. Ariae, Centr. f. Bak. 17:188-202, pls. 1-4, 1906.

All of the facts thus far presented, which pertain to the life-history of the *brown rot* fungus and its methods of passing through unfavorable seasons, emphasize the importance of collecting and destroying the so-called mummied fruits as a means of control. If these infected fruits are allowed to remain hanging to the trees or upon the surface of the ground the conidial stage begins its destruction at once the following season, while if they are permitted to become buried beneath the trees, ascospores form the second season which are capable of producing in turn the conidial stage.

ADDITIONS TO INDIANA FLORA NO. 3.

CHAS. C. DEAM.

(The determinations have been made by competent authorities, and specimens are deposited in my herbarium.)

Paspalum Muhlenbergii Nash.

Crawford County, July 11, 1899. In waste place near Wyandotte cave.

Panicum praecosius Hitchcock No. 1270.

Steuben County, July 23, 1906. On top of dry wooded gravelly hill on east side of Hog-back Lake.

Festuca Shortii Kunth.

Allen County, June 3, 1906; Brown County, May 23, 1906; Fountain County, June 4, 1905; Posey County, May 25, 1906.

Carex stricta angustata (Boott.) Bailey.

Allen County, June 3, 1906. In slough along St. Joe river east of Robinson park.

Carex Haydeni Dewey.

Fountain County, June 5, 1905.

Carex pedicillata (Dewey) Britton.

Blackford County, April 29, 1906; Steuben County, May 28, 1905.

Carex rosea radiata Dewey.

Allen County, June 3, 1906.

Carex interior Bailey No. 980.

Porter County, June 16, 1900 (collected by L. M. Umbach); Wells County, June 1, 1906.

Carex canescens L.

Fountain County, June 4, 1905.

Carex canescens disjuncta Fern.

Steuben County, May 28, 1905.

Carex siccata Dewey.

Steuben County, May 28, 1905.

Carex mirabilis Dewey.

Fountain County, June 5, 1905.

Carex festucacea brevior Fernald No. 1046.

Allen County, June 5, 1906.

Carex Bicknellii Britton.

Steuben County, June 16, 1903.

Batrachium longirostris (Godr.) F. Schultz.

Allen County, June 3, 1906, Wells County, June 13, 1899. No doubt most of the plants named trichophyllum (Chaix.) Bosch. should be referred to this species.

Fragaria Virginiana Grayana (Vilm.) Rydb.

Blackford County, June 22, 1905; Franklin County, May 13, 1906; Marion County, April 30, 1905; Wells County, June 16, 1901.

Viola conspersa Reich.

Wells County, May 11, 1906; Steuben County, May 13, 1906. It is quite probable that what has been passing as Viola Labradonica Shrank should be referred to this species.

Viola pallens (Banks) Brainard.

Blackford County, April 29, 1906; Wells County, June 1, 1906. *Viola blanda* Willd. is often associated with this species and possibly mistaken for it.

Rhamnus alnifolia L'Her.

Steuben County, August 1, 1903.

Campanula uliginosa Rydberg.

Noble County, July 21, 1904; Steuben County, August 11, 1903; Wells County, July 6, 1902. All specimens of *Campanula aparinoides* Pursh I have examined should be referred to this species, although *aparinoides* Pursh may occur in Indiana also.

Lactuca Saligna L. No. 1389.

Blackford County, August 3, 1906. This species was taken just south of Hartford, along interurban right of way.

Bidens comosa (A. Gray) Wiegand.

Blackford County, September 3, 1905; Wells County, September 21, 1902.

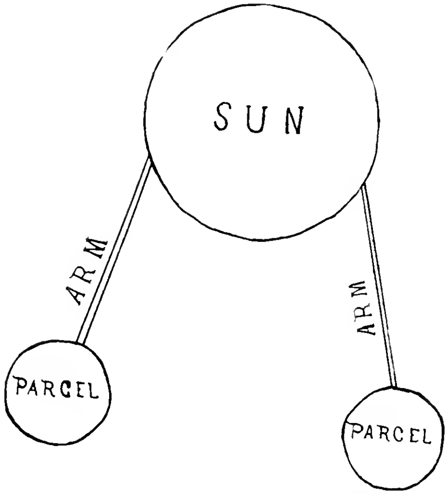
The Lummi Indians.

Albert B. Reagan.

The Lummi Indians occupy the Lummi Peninsula just across Bellingham Bay west from the City of Bellingham, Washington. The peninsula, containing about two townships, is their reservation. They number in all about three hundred and seventy-five, most of whom are half-breeds. These resemble the mulattoes of the south very much as to physical appearance and color; their hair, of course, is black and straight. The full-breeds are nearly all old Indians, most of whom are blind. They are all fishing Indians by nature. Formerly they lived almost wholly by fishing for salmon and trout; but since they took their allotments some years ago they live on their farms and till the ground most of the year, fishing only in August and September. At this time they sell fish to the canneries and also dry it for their own use. In old times they made flour from the fern root, but now the white-man's flour has taken its place. Their farming is very well done and their houses are often better than those of their white neighbors, though usually not kept so neat inside. The tribe as known to-day is made up of Nooksack, Lummi, Snowhommish and British Columbia Indians. They belong to the Salish linguistic stock, and now all talk the Lummi branch ot that language. When that fails they use the Chenook jargon as a means of communication. The young people all speak English. They are advanced in civilization almost to our standard; many of them even take daily newspapers.

In old times these Indians practiced all the ceremonies known to their linguistic group. They waged war for the sole purpose of capturing slaves. They flattened their babies' foreheads so that a modern hat fits them better cross-wise than the way we wear it. They had mortuary dance ceremonies. They believed in the superhuman power of medicine men. They slashed themselves with knives and thrust their arms through with arrows and elk bones in the medicine ceremonies. They had give-away dance feasts at which the man who gave away most was made chief. And they carved or painted their special dreams or visions (called in Chenook "tomanawis") in conspicuous places in their "plank" houses, usually on totem poles, as a mark of good luck or a guide to their lives. A carving of this sort is now to be found on each of the totem-posts of an old give-away, feast dance hall ("potlatch" house), now in ruins at the Portage on the reservation. An interpretation of this totem-tomanawis was given me as follows by Mr. McClusky (Indian), who also made me the copy of it given here:

"Chief Cha-we-tsot once owned the 'potlatch' house at the Portage. The drawings on the totem-posts are his 'tomanawis.' The sun, carrying a parcel of valuables in each hand, came to him in a dream and said: 'Your storehouses (or trunks) will always be full. You will therefore give two more feasts than the average chief; custom had established the rule that the ordinary chief should give three feasts in a lifetime. So Chief Cha-we-tsot built the 'potlatch' house and carved his 'tomanawis' on its totem-posts. He then gave five feasts, two more than the average, as the sun in the vision had commanded him."



To-ma-na-wis of Chief Cha-me-tsot.

These Indians are now Catholics and all attend church every Sunday. When the priest is present he gives his sermon first in English and then in Chenook. When the priest is not present, the Indians pass around within the church from left to right, while they sing and pray a few minutes in

Indian before each of the passion pictures, the altar, and the image of Christ and of the Virgin Mary. Then the quietly leave the church, and, after eating their picnic dinner. go to the Sunday ball game.

Their government school was abandoned this year and their reservation will propably be thrown open this winter.

THE MAMMALIAN REMAINS OF THE DONALDSON CAVE.

WALTER L. HAHN.

While occupying the Donaldson Farm Fellowship in Zoology in Indiana University, the writer has had occasion to make frequent trips into the Donaldson Cave, situated about three miles southeast of Mitchell, Indiana. On one of these trips bones of small mammals were noticed and diligent collecting on that and subsequent occasions has resulted in the finding of identifiable remains of 244 individuals, representing eleven species. The occurrence and relative abundance of some of these species is of considerable interest and this occasion is taken to place all on record.

The list follows

1. *Didelphis virginiana* Kerr. Opossum.
    A portion of one skull found on a gravel deposit in a side passage leading off from the "big room" of the cave.
2. *Odocoileus virginianus* (Boddaert). Virginia deer.
    A vertebra found not far from the preceding specimen has been identified for me by Mr. J. M. Gidley, Vertebrate Paleontologist of the National Museum, as the fourth cervical of this species. It was doubtless carried in, either by a flood or by some carniverous animal, in the days when deer were plentiful in Indiana, and since that time has lain undisturbed in the darkness of the cave.
3. *Sylvilagus floridanus* (Allen). Rabbit.
    Remains of three individuals found.
4. *Peromyscus leucopus* (Rafinesque). White-footed mouse.
    Mandibles of four individuals found.
5. *Microtus pinetorum* (Le Conte). Pine mouse.
    Four of this species also.
6. *Blarina brevicauda* (Say). Large shrew.
    One skull.

7. *Pipistrellus subflavus* (F. Cuvier). Georgian bat.

Partial skulls and mandibles representing eight individuals of this species were found at various points in or near the "big room."

8. *Lasiurus cinereus* (Beauvois). Hoary bat.

This species is widely distributed, but everywhere rare. The finding of two partial skulls and skeletons adds this locality to the two previously recorded for Indiana.

9. *Lasiurus borealis* (Müller). Red bat.

Remains of this species were far more abundant than of any other. More or less complete skulls and skeletons of 203 individuals were found. The abundance of the species will be discussed later.

10. *Myotis subulatus* (Say). Say bat.

One skull can be unquestionably referred to this species.

11. *Myotis lucifugus* (Le Conte). Little brown bat.

Nine skulls could be positively referred to this species. Eight others were probably *M. lucifugus*, but were too badly broken to determine with certainty whether they belonged to this or to the last preceding species.

It will be noted that the above list contains a large number (203) of specimens of the red bat and but few (17) of the little brown bat. If we turn to the living representatives of the two species this abundance is exactly reversed. Mr. W. S. Blatchley informs me that the proportion of the two species in Wyandotte Cave is about 1 to 1,000, the larger number being the brown. Mr. A. M. Banta, who has had a very extensive acquaintance with the cave fauna of Monroe and Lawrence counties, is of the opinion that the red bat never enters caves at all, and that, though common above ground, it is less abundant than the brown species. My own observations are in complete accord with those of Mr. Banta.

The period at which this change in relative abundance has taken place can not be determined accurately from the evidence now at hand. Evidently it has been within recent geological times, since many of the bones were found in places where they would have been destroyed by changes which must have taken place during some recent epoch. On the other hand many of them were found partially covered with fragments of stone which have gradually weathered away from the larger masses, and this would seem to indicate that at least a part of the bones are many years, possibly centuries, old. For the most part they seem to lie where they fell when the animals dropped dead from the places where they clung to the roof of the cave. This seems to indicate that they died, one at a time, from natural causes.

The above facts seem to warrant two conclusions: (1) The red bat is less abundant than formerly; (2) it has changed its habits and no longer frequents caves as it did formerly.

SOME NOTES ON INDIANA BIRDS.

AMOS W. BUTLER.

Nyctea nyctea (Snowy Owl).—One reported by Louis A. Test, upon authority of J. Keegan, as having been taken near Washington, Daviess County, Indiana, November 5, 1904.

I saw one in Deschler's cigar store, Lahr House, Lafayette, which was procured by Geo. M. Timberlake from a man who shot it about fifteen miles south of Lafayette in the winter of 1901-02. Beasley and Parr, taxidermists, Lebanon, report that they mounted this specimen in November or early in December of 1901. Snowy Owls have been more generally distributed over the State the present winter and more individuals have been reported than ever before since records have been kept.

November 25, 1905, while at Hammond, Lake County, Mr. LeGrand T. Meyer told me that two fine specimens of this bird had been taken near that place a few days before. One of these we saw afterwards in the possession of Mr. Schmid, who mounted it and who also had the other one at the same time in his work room. Mr. Meyer has kindly supplied me with the following data of these, and three other birds of the same species taken in that vicinity:

First.—A man by the name of Johnson killed one on November 12, 1905, about a mile and a half southeast of Tolleston, Indiana, in the gravel pits.

Second.—Fred Burg shot one on the lake front of Lake Michigan, near Indiana Harbor, on November 19, 1905, which is now in the possession of Mr. Louis Freeze of Hammond.

Third.—Wm. J. Thompson killed one near Wolf Lake ice houses in Hammond, on November 25, 1905. This one was on the top of a telegraph pole when killed.

Fourth.—One was killed on Wolf Lake, near Lake Michigan, in Hammond, by a person unknown to me, which is now in the possession of Louis Mankowski of this city, which was killed November 23, 1905.

Fifth.—At the time it was killed there was another one with it which the hunter was unable to secure.

The specimens Mr. Schmid had were numbers one and four, given above.

Beasley and Parr, Lebanon, Indiana, have mounted quite a number of these birds recently. From information kindly supplied by them regarding specimens in their hands I have been able, through extended correspondence, to collect some interesting facts regarding this dispersion of these owls over Indiana this winter. They have been reported from the following counties: Allen, Benton, Fountain, Hancock, Johnson, Lake, Marion, Miami, Montgomery, Noble, Shelby, Sullivan, Warren.

H. A. Dinius of Fort Wayne reports that two Snowy Owls were observed on the Godfrey, Indiana, Reservation, west of that city, December 22, 1905.

One was shot by Clem Woodhams in Bolivar township, Benton County, November 10, 1905. The same gentleman informs me that one was seen north of Otterbein in that county about December 24, 1905.

One of two owls seen was shot nine miles east of Fowler, in Benton County, November 4, 1905, by a corn husker working for Thomas Eastburn. It was wounded and brought alive to Fowler. The second one was taken afterwards. They are reported to be male and female. They were sent by J. F. Warner of Fowler to be mounted, who reports on January 4, 1906, another one observed some days before at Earl Park.

J. W. Crouch of Fowler has a Snowy Owl that was killed by Nelson Hendricks five miles west of that place about February 12, 1906.

J. R. Opp has a specimen taken four miles west of Otterbein December 21, 1905. Another was shot near there on December 4, 1905.

One shot November 29, 1905, two miles southeast of Mellott, in Fountain County, by John Whalen, just after dusk, after it had killed two old hens. Mounted for Red Men's Hall at Mellott.

One shot one mile northwest of Fortville, Hancock County, by Ottis Shepherd. Reported by David Fair of Fortville.

John Hammer took a Snowy Owl about six miles south of Franklin, Johnson County. It is now owned by S. B. Eccles.

Gus Habich, Indianapolis, received two of these owls recently. Both were killed about December 1, 1905. One was shot by William Stroble, near Shelby, Lake County; the other by Frank Hoffman, below Shelbyville, in Shelby County, Indiana.

One killed by Isom Kelsey, two and one-half miles southwest of Shelbyville, November 30, 1905.

One killed by John Tucker, four miles north of Fairland, Shelby County, about November 16, 1905. Owned by D. H. Tucker.

One owned by Fletcher M. Noe, Indianapolis, he informs me was taken near Southport, Marion County, Indiana, December 20, 1905. He reports that six or seven have been brought in to him the present fall and winter.

One, a male, killed by Frank Clark, in Erie Township, Miami County, December 17, 1905. The next day a female was killed in that vicinity by Rawley Runnell. The first one was mounted for the First National Bank of Peru. Reported by Joseph H. Shirk.

One shot three miles northwest of Linden, Montgomery County, by George Ciderdin, November 22, 1905. Owned by J. M. Hose of Linden.

One killed near Darlington, Montgomery County, November 21, 1905, by N. Royer. Reported by S. G. Kersey.

One reported by Henry A. Link to have been killed near Avilla, Noble County, Indiana, a few days prior to December 14, 1905.

W. S. Blatchley, State Geologist, has a photograph, taken the past fall, of a bird of this species, in the possession of J. W. Sampson, Farmersburg, Sullivan County, Indiana. Mr. Sampson writes that another was killed at Blackhawk, about six miles east of Farmersburg, about the same time.

John Morgan killed one in Warren County, December 21, 1905.

A fine specimen, seen in the window of the Starr Piano Co., Richmond, Indiana, was killed by Mr. Edgar Moon, near Bowersville, Greene County, Ohio, November 8, 1905. Reported by J. E. Perkins.

Mr. Louis A. Test of Lafayette reports, upon the authority of Mr. L. J. Owens of that city, the capture of one by Mr. Carl Townsley at Chalmers, Indiana, about November 25, 1906.

Mr. Joseph F. Honecker reports seeing six of these owls near Oak Forest, Franklin County, December 15, 1905.

Mr. J. W. Crouch informs me that a Snowy Owl, almost perfectly white, was killed November 11 or 12, 1906, at Fowler, Benton County, and brought to him. This is interesting as giving an early record for this year from the same county where a number were found in 1905.

Elanoides forficatus (Linn.) Swallow-tailed Kite.—On September 3, 1906, one was seen one mile south of Brookville, Ind.—(Jos. F. Honecker.)

Falco peregrinus anatum (Bonap.) Duck Hawk.—A pair were found nesting in an old stone quarry near Laurel, Ind., April 28, 1906. The two eggs were placed in a small cavity on the bare rock on a shelf ten or twelve feet from the ground. About them were bones and feathers of pigeons, chickens and ducks. The eggs are now in the collection of Jos. F. Honecker, Oak Forest, Ind., by whom they were found and reported.

Ectopistes migratorius Passenger Pigeon; Wild Pigeon.—Joseph F. Honecker reports seeing a Wild Pigeon, with young, near Haymond, in Franklin County, in the spring of 1905. The same person says: "On May 18, 1906, I had the good fortune to find three nests of the Wild Pigeon about one half mile east of Oak Forest, Franklin County, Indiana. The nests were about eight to fifteen feet from the ground in a small elm tree. Two of them contained two eggs each and one contained two young only a few days old. I saw the six adult birds at one time, and observed them until the young were grown. They were last seen together in a flock, July 13. There is another record of the capture of a specimen in Shelby County.

Meleagris galloparo. (Linn.) Wild Turkey.—According to Mr. E. J. Chansler, a few are still to be found in the southern part of Knox County, Ind.

Dendroica vigorsii. Pine Warbler.—C. P. Smith, during the summer of 1904, visited the sand dunes near Michigan City. There among the pine trees he found Pine Warblers. They were fairly common June 19-23. Though the birds were in full song, he did not find the nest. He describes the song as very similar to that of a Chipping Sparrow; in fact, so similar that he was deceived by it at first. The preceding summer (1903) the same observer, while studying the biology of the State Forest Reserve, at Henryville, saw Pine Warblers three or four times among the pine-covered "knobs." The last of July he found adults feeding young that were practically full grown. They doubtless nested there.

Pelidna alpina pacifica. Red-backed Sandpiper; Aremican Dunlin.—A specimen taken October 11, 1905, from a flock of shore birds at a pond in Marion County, north of Indianapolis, was presented to me by Philip Baker. This is the first fall record for this vicinity.

Aegialitis meloda circumcincta. Belted Piping Plover.—A fine group of these birds, with four eggs, in the collection of the Chicago Academy of Sciences, was taken at Millers, Indiana, June 13, 1905 (F. M. Woodruff).

Numenius borealis. Eskimo Curlew.—There are few recorded specimens of this rare migrant from Indiana. It, therefore, is of interest to learn from Mr. J. H. Fleming, Toronto, Ont., that he has one marked Chalmers, Ind., male, April 19, 1890(?).

Phalacrocorax dilophus. Double-crested Cormorant.—Mr. Roman

Eichstodt of Michigan City has a specimen taken by him inside the breakwater there, the last of November, 1903. No others of this species were seen.

Sula bassana. Gannet.—A few months ago I was taken to see a bird of this species in the store of Roman Eichstodt, Michigan City, Ind. It was in immature fall plumage, as determined by the U. S. Biological Survey, to which a photograph was sent. The bird was killed, according to the owner, on Lake Michigan, in November, 1904, about two miles from Michigan City. It was said to be unlike anything before seen in that vicinity.

Oceanodroma castro. (*Oceanodroma cryptoleucura* Ridgw.) Hawaiian Petrel.—A specimen of this rare species, whose distribution seems to be almost world wide, was given to me by Alden M. Hadley of Monrovia, Ind. He obtained it from Mr. N. H. Gano, who, on June 15, 1902, found it fluttering in a wheelbarrow in his yard at Martinsville, Ind. He picked up the bird, but it soon died. Its stomach was entirely empty and it had evidently died of hunger and exhaustion. The bird was sent to Mr. Hadley, who preserved the skin. It was recognized as a petrel, and the species was kindly determined by Dr. C. W. Richmond of the Smithsonian Institution. Five specimens of this bird, from its collection, were later sent me for examination. The following notes and measurements in inches are given:

Cat.No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Tarsus.	Tail.
132764	♂	Galapagos......	April 4, 1891	C H Townsend.	6.125	3.250	.937	Slightly forked.
189861	♀	Maderia........	Sept. 12, 1902	....	5.750	3.000	.937	Much worn.
189860		Maderia	Oct. 14, 1902	...	6.500	3.555	.937	Very slightly forked.
115461		Kauwai, H. I.	....	Knudsen. ...	5.750	3.968	.937	Nearly square.
154436	♂	Wash., D. C...	Aug. 29, 1893	W. Palmer.	6.250	3.125	.937	Nearly square.
....		Martinsville, Ind.	June 15, 1902	N. H. Gano	6.000	3.500	.937	

BLOOD PRESSURE IN MAN.

G. E. HOFFMAN.

(Abstract.)

The paper consists of a tabulation of the readings of blood pressure in 220 men with age, day and hour of day, mental condition, and the condition of arteries, heart and kidneys; with conclusions as to what factors influence and are influenced by the blood pressure in man.

As the subjects were unfamiliar with the procedure it itself increased the blood pressure in most cases so that the readings are high for them. The highest, taking the systolic as most reliable, was 270 in an old man with beady arteries; the lowest, 88; thirteen were above 200; six were below 100; the averages for the series was 134 mmg Hg by the Rivi-Rocci mercurial sphygmomanometer, Stanton's form.

Age, by the changes in the blood vessels, is the most constant factor in change of blood pressure, which increases with age; the condition of the arteries is a determining factor; the more rigid their walls the higher the blood pressure; all with high pressure have rigid arteries; coincidently, casts and albumen occurred in the urine, indicative of lesion in the kidneys. Valvular lesion of the heart lessening its efficiency raises the systolic pressure.

In stupor invariably the blood pressure was low, as in the cases of catalepsy, which gave the low records; likewise in dementia the blood pressure is relatively low; also in maniacal conditions it is decreased, approaching its normal with recovery; and contrawise the blood pressure is raised in melancholia and in states marked with delusions of persecution; in general paresis it varies according to the mental condition. This correspondence of mental condition to blood pressure is tolerably uniform.

INDEX.