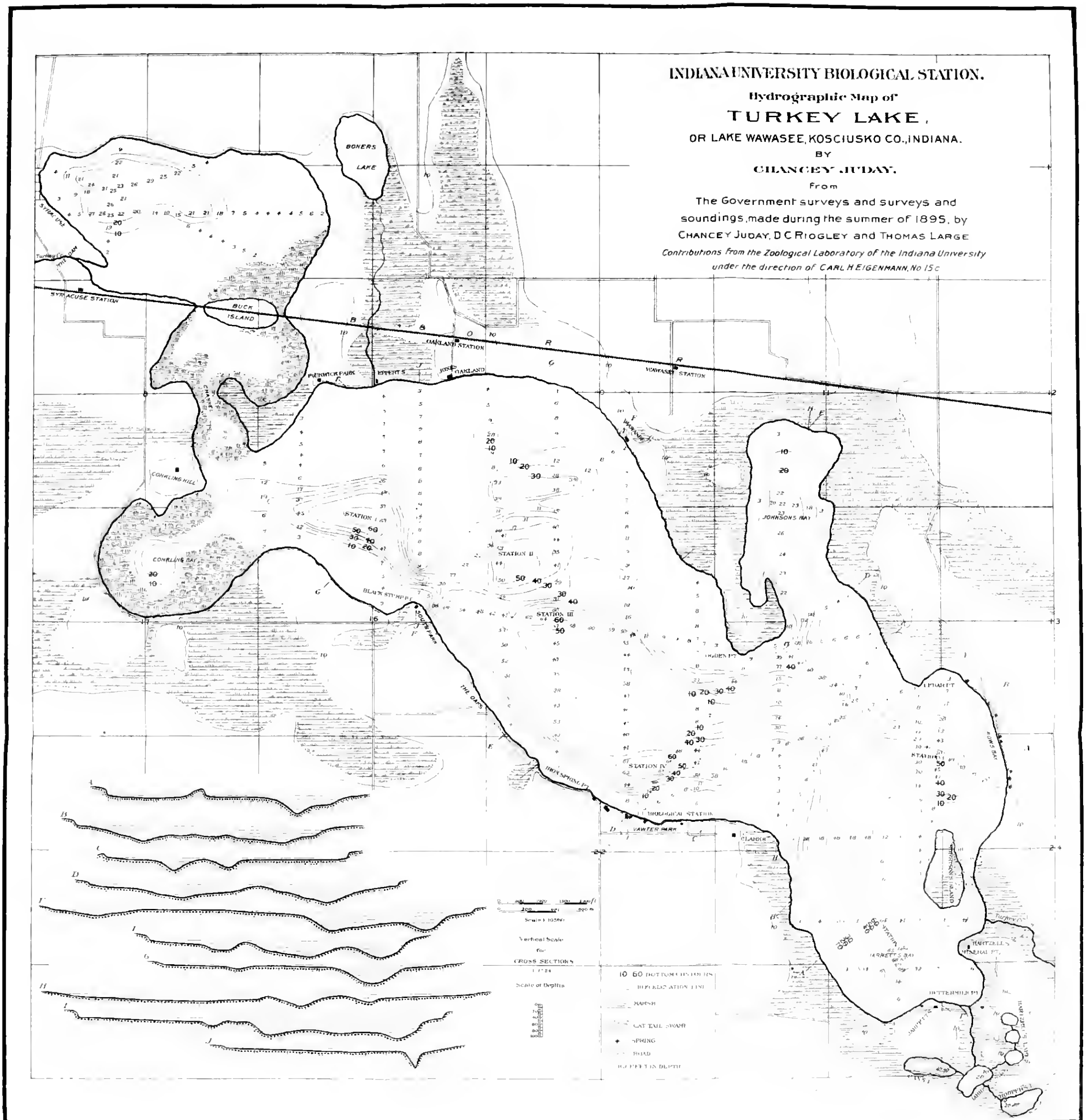
PROCEEDINGS

OF THE

Indiana Academy of Science

1895.


INDIANA UNIVERSITY BIOLOGICAL STATION.
Hydrographic Map of
TURKEY LAKE,
OR LAKE WAWASEE, KOSCIUSKO CO., INDIANA.
BY
CHANCEY JUDAY.
From
The Government surveys and surveys and
soundings, made during the summer of 1895, by
CHANCEY JUDAY, D C RIDGLEY and THOMAS LARGE
Contributions from the Zoological Laboratory of the Indiana University
under the direction of CARL H EIGENMANN, No 15c
BONERS LAKE
SYRACUSE STATION
BUCK ISLAND
OAKLAND STATION
OAKLAND
PICKWICK PARK
WAWASEE STATION
CONKLING HILL
CONKLING BAY
JOHNSONS BAY
STATION I
STATION II
STATION III
STATION IV
BLACK STUMPS
THE OAKS
IRON SPRING PT
VAWTER PARK
ROWS BAY
JARRETTS BAY
CROSS SECTIONS
Scale of Depths
SPRING
ROAD

PROCEEDINGS

OF TH

Indiana Academy of Science

1895.

EDITOR, - - C. A. WALDO.

ASSOCIATE EDITORS:

J. C. ARTHUR, W. A. NOYES, C. H. EIGENMANN, A. W. DUFF,
V. F. MARSTERS, A. W. BUTLER, W. S. BLATCHLEY.

INDIANAPOLIS, IND.,
FEBRUARY, 1896.

INDIANAPOLIS:
WM. B. BURFORD, PRINTER,
1896.

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 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

Number of printed reports.

Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894. Proviso.

Sec. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture. Disposition of reports.

Sec. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage. Emergency.

An Act for the protection of birds, their nests and eggs.

[Approved March 5, 1891.]

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

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

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

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

Permits to Science. Sec. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science to any properly accredited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to said Board written testimonials from two well known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege, and pay to said Board one dollar to defray the necessary expenses attending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of such permit has killed any bird or taken the nests or eggs of any bird for any other purpose than that named in this section, and shall further be subject for each offense to the penalties provided in this act.

Bond.

Bond forfeited.

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

Birds of prey. Sec. 7. The English or European house sparrow (passer domesticus), crows, hawks, and other birds of prey are not included among the birds protected by this act.

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

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

INDIANA ACADEMY OF SCIENCE.

(A Statement Made to the General Assembly, in 1895, of Its Work and Purposes.)

The Indiana Academy of Science has published during the last three years three volumes of proceedings. The first volume appeared in '92. It included many of the papers in full or in abstract that were presented at the previous Christmas meeting of the Society, together with titles and authors of all other papers presented before the Academy since its organization in 1885. Of all the titles appearing in this volume, many of them upon topics of vital importance, not over five per cent. were discussed in full in the publication. All the rest of this valuable literature has been scattered and lost or rendered practicably inaccessible.

The volumes appearing in '93 and '94 give in full or in abstract most of the important papers presented in each case at the previous holiday meeting, while the volume appearing in the summer of '94 is enriched by the reports of a large corps of voluntary and unpaid but thoroughly trained workers, who have undertaken and are energetically pushing a systematic biological survey of the State. But the expense attending these publications has been too great for private enterprise and the treasury of the Academy. Unless the State now takes hold of the matter they must cease for a time, at least, and a serious break in the proceedings must occur. This would be a lamentable check upon the progress of science in the State. At this crisis the State is asked to join hands with the Academy only in so far as to establish and preserve the work to which the latter is dedicated. It is our purpose here to set forth in detail, but briefly, some of the reasons why the State should make this compact. These reasons fall under two general heads: The Workers and Their Work.

By publishing the proceedings of the Academy the State secures, without further compensation, the services of over a hundred trained experts working in fields specially chosen and agreeable, spending a large portion of their time upon new problems whose solution is of vital importance to the development of our Commonwealth. These workers have been trained in the best schools, home and foreign, and bring to their investigations zeal, enthusiasm, skill, patience and common sense. For the results of their work they seek no other remuneration than the honor that comes from the willing and loving recognition of their labors by their friends, neighbors and fellow-citizens, to whose highest and best interests their lives are consecrated. These trained experts, who constitute the best authority in the State upon their several subjects, will act without compensation with the legislative body of Indiana just as the National Academy acts in conjunction with Congress; will freely advise with the legislators when asked upon scientific subjects, and give proper direction to scientific investigations undertaken by the Legislature as a basis for wholesome and logical laws.

To the work already done the publications of the Academy give but an imperfect witness. Certain it is that interest in these proceedings, incomplete as they are, has gone out far beyond the confines of our own States and has been extensively awakened even in transatlantic countries. The Academy has helped to train some of the foremost scientists of our day. When it expresses an opinion upon a scientific subject it is listened to with respect, even by such distinguished scientists as have been drawn in large numbers to our nation's capital.

It will be here attempted to set forth the scope and aims of the Indiana Academy in the barest outlines. The outline itself must be imperfect at best, but we hope this synopsis will show how closely it is identified in all of its ramifications with public progress. Without pretending to exhaust the subject, we will arrange under six heads what we have to say upon the character of the work undertaken by the Academy and the reasons why this work should be fostered by the State to the extent of proper publication and dissemination of its results. The six heads are: Educational Services, Development of Natural Resources, Industrial Assistance, Economical Effects, Contributions to the Reputation of the State and Recognition Accorded to This Kind of Work in Other States.

We may mention six ways in which the work of the Academy strengthens the educational forces of the State: 1. Through its meetings and publications the Academy gives direction and enthusiasm to the study of the sciences throughout Indiana. Scientific instruction is no longer taken up in a half-hearted, perfunctory way, but is instinct with life and energy. 2. It transforms teachers into life-long investigators. The best science teachers are those most under its influence. 3. It fosters and develops workers apart from and outside of the schools. All have observed the tonic effects on a community of a single bright, active mind. With every person thus endowed the Academy joins hands and helps him make a general uplift of his own locality in just such a way as university extension operates. 4. It brings together for conference teachers who are opening up lines of work in their several localities and enables them to plan and distribute original work in the wisest manner. 5. It fosters a spirit of home effort which makes the student of science everywhere practically familiar with home surroundings and alive to the possibilities of home fields and forests. 6. It classifies and arranges in a systematic way the whole plant and animal life of the State, making accessible at small expense to everybody the most important information otherwise scattered through an expensive library.

Without going into details, it is only necessary to call attention to the fact that everywhere the Academy is a powerful auxillary in developing the mineral, vegetable and animal resources of the State.

We may consider the industrial activity of the Academy under three heads: Its efforts in behalf of agriculture, of mines and minerals, of manufactures. It aids agriculture by studying and eradicating injurious weeds; by investigating insect life and showing what insects are beneficial, which injurious, and devising means for fostering the former and exterminating the latter; by studying parasitic fungi, their habits, effects, control; by the investigation and adaptation of soils; by studying birds and animals in their relation to agriculture.

It aids mines and mineral industries—by the study of coal, gas, oil, clays, sands, road materials, gravels, building stones, etc.; by application of physics, chemistry and mechanics to mine work; by the application of scientific knowledge of existing conditions, to the end that money should not be wasted in wild-catting and other useless operations.

It aids manufacturing industries—by investigating the physical and chemical properties of wood and iron, by perfecting accurate and economical methods of manufacture and testing; by stimulating and laying the foundations for the development of inventions which shall convert a given amount of power into the maximum amount of useful product; by investigating and devising economical methods of developing and distributing power; by preventing the expenditure of money upon unscientific and useless inventions.

We may group the general economical services of the Academy under three heads:

1. It strives to increase the possibilities of existing properties—by improving the soils; by the study and culture of fish; by developing new soil products, such as the sugar beet, or by investigating the conditions under which they flourish; by utilizing neglected food materials, such as mushrooms, etc.; by discovering practical and beneficial uses for waste products; by studying the uses of woods, clays, etc. in the arts and manufactures; by studying the medicinal properties of

plants; by studying the properties of plants injurious or fatal to man or beast, as the stagger-weed.

2. It strives to increase the happiness, safety and productive capacity of society by investigating food adulteration, drainage, water supply, sanitary questions; by investigating the effects of mineral and vegetable poisons upon man and animals; by studying the diseases of animals; by investigating general economical and social problems.

3. It studies the question of the protection of forms of life beneficial to man, such as forests, native birds, game and fishes.

In general, we may remark, the reputation of a State is a matter of pecuniary as well as sentimental importance. While it is true that the work of the Academy is widely known and its worth acknowledged, while the same is true for other educational forces in the State, yet when all is said, we must confess that we occupy too low a position in the estimation of the scientific world, lower we believe, than our merit as a State deserves. On the other hand, if the State Legislature should cordially recognize the work being done, should encourage investigation along all lines by the method here suggested, as it can at so slight an expense, that act alone of enlightened and far-seeing policy would greatly improve our reputation; it would tend to give tone and character to the State; it would make the strong workers within its borders more patriotic; they would not be so ready when opportunity offers to change their residence to some more appreciative community; it would do much to attract from without first-class ability to assist in making Indiana in every respect what her fertility and natural resources intended she should be—a leader among the States of the Union.

New York, Connecticut, Wisconsin, Illinois, Minnesota, Iowa, Kansas and the National Government, together with the foremost foreign States and nations, are more or less committed to the policy advocated. Its results in Indiana can not be different from those achieved elsewhere. Its adoption can only inure to the great and lasting benefit of Indiana and all her people.

The amount annually needed to publish in a proper manner, illustrate and distribute the proceedings of the Society will not exceed $2,000. The Academy does not ask a direct appropriation of money, but an annual publication of its proceedings.

As shown by its constitution, the objects of the Academy "shall be scientific research and the diffusion of knowledge concerning the various departments of science."

The membership is limited only by the following clause:

"Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership." The membership now numbers 146, of whom 25, known as Fellows, are supposed in a special manner to represent the Academy in its relations to the general public.

In order that the general character of the Academy may be clearly understood, the list of Fellows with their addresses is appended:

Daniel Kirkwood, Riverside, Cal.; J. C. Arthur, Lafayette; P. S. Baker, Greencastle; W. S. Blatchley, Indianapolis; J. C. Branner, Palo Alto, Cal.; A. W. Butler, Brookville; J. L. Campbell, Crawfordsville; John M. Coulter, Lake Forest, Ill.; Stanley Coulter, Lafayette; H. T. Eddy, Minneapolis, Minn.; C. H. Eigenmann, Bloomington; W. F. M. Goss, Lafayette; Thomas Gray, Terre Haute; O. P. Hay, Chicago, Ill.; H. A. Huston, Lafayette; J. P. D. John, Greencastle; D. S. Jordon, Palo Alto, Cal.; V. F. Marsters, Bloomington; T. C. Mendenhall, Worcester, Mass.; D. M. Mottier, Bloomington; W. W. Norman, Austin, Texas; W. A. Noyes, Terre Haute; W. P. Shannon, Greensburg; Alex. Smith, Chicago, Ill.; W. E. Stone, Lafayette; M. B. Thomas, Crawfordsville; L. M. Underwood, Greencastle; T. C. Van Nuys, Bloomington; C. A. Waldo, Greencastle.

OFFICERS, 1895-96.

President,
STANLEY COULTER.

Vice-President,
THOMAS GRAY.

Secretary,
JOHN S. WRIGHT.

Assistant Secretary,
A. J. BIGNEY.

Treasurer,
W. P. SHANNON.

EXECUTIVE COMMITTEE.

Stanley Coulter,
Thomas Gray,
John S. Wright,
A. J. Bigney,
W. P. Shannon,
Amos W. Butler,
W. A. Noyes,
J. C. Arthur,
J. L. Campbell,
O. P. Hay,
T. C. Mendenhall,
John C. Branner,
J. P. D. John,
John M. Coulter,
David S. Jordan.

CURATORS.

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

COMMITTEES, 1895-96.

PROGRAM.

C. A. Waldo, A. J. Bigney.

MEMBERSHIP.

C. H. Eigenmann, George A. Talbert, G. W. Benton.

NOMINATIONS.

W. A. Noyes, W. E. Stone, W. S. Blatchley.

AUDITING.

W. E. Stone.

STATE LIBRARY.

C. A. Waldo, W. A. Noyes, A. W. Butler, A. W. Duff, J. S. Wright.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

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

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, Ph. Kirsch.

EDITOR.

C. A. Waldo.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, V. F. Marsters. J. C. Arthur.

RELATIONS OF THE ACADEMY TO THE STATE.

C. A. Waldo, A. W. Butler, C. H. Eigenmann.

GRANTING PERMITS FOR COLLECTING BIRDS.

A. W. Butler, C. H. Eigenmann, W. P. Shannon.

DISTRIBUTION OF THE PROCEEDINGS.

A. W. Butler, W. A. Noyes, C. A. Waldo.
C. H. Eigenmann, V. F. Marsters, J. S. Wright.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

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

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, 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 programmes and have charge of the arrangements for all meetings for one year.

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

SEC. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of 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 evening of one of the days of the meeting at the expiration of his term of office.

3. 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.

4. No bill against the Academy shall be paid without an order signed by the president and countersigned by the secretary.

5. 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.

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

MEMBERS.

FELLOWS.

J. C. Arthur .... Lafayette.
P. S. Baker .... Greencastle.
W. S. Blatchley .... Indianapolis.
J. C. Branner .... Palo Alto, Cal.
Wm. Lowe Bryan .... Bloomington.
A. W. Butler .... Brookville.
R. E. Call .... Cincinnati, O.
J. L. Campbell .... Crawfordsville.
John M. Coulter .... Lake Forest, Ill.
Stanley Coulter .... Lafayette.
D. W. Dennis .... Richmond.
C. H. Eigenmann .... Bloomington.
Katherine E. Golden .... Lafayette.
W. F. M. Goss .... Lafayette.
Thos. Gray .... Terre Haute.
A. S. Hathaway .... Terre Haute.
O. P. Hay .... Chicago, Ill.
H. A. Huston .... Lafayette.
J. P. D. John .... Greencastle.
D. S. Jordan .... Stanford University, Cal.
V. F. Marsters .... Bloomington.
C. L. Mees .... Terre Haute.
T. C. Mendenhall .... Hoboken, N. J.
D. M. Mottier .... Bloomington.
W. A. Noyes .... Terre Haute.
J. T. Scovell .... Terre Haute.
W. P. Shannon .... Greensburg.
Alex. Smith .... Chicago, Ill.

W. E. Stone . . . . Lafayette.
M. B. Thomas . . . . Crawfordsville.
L. M. Underwood . . . . Auburn, Ala.
T. C. Van Nuys . . . . Bloomington.
C. A. Waldo . . . . Lafayette.
F. M. Webster . . . . Wooster, O.
H. W. Wiley . . . . Washington, D. C.
J. S. Wright . . . . Indianapolis.

NON-RESIDENT MEMBERS.

D. H. Campbell . . . . Stanford University, Cal.
B. W. Evermann . . . . Washington, D. C.
Charles H. Gilbert . . . . Stanford University, Cal.
C. W. Green . . . . Stanford University, Cal.
C. W. Hargitt . . . . Syracuse, N. Y.
Edward Hughes . . . . Stockton, Cal.
O. P. Jenkins . . . . Stanford University, Cal.
J. S. Kingsley . . . . Tufts College, Mass.
Alfred Springer . . . . Cincinnati, O.
Robert B. Warder . . . . Washington, D. C.

ACTIVE MEMBERS.

R. J. Aley . . . . Bloomington
Timothy H. Ball . . . . Crown Point.
H. H. Ballard . . . . Terre Haute.
C. L. Barnes . . . . Indianapolis.
George W. Benton . . . . Indianapolis.
Andrew J. Bigney . . . . Moore's Hill.
J. A. Bergstrom . . . . Bloomington.
A. W. Bitting . . . . Lafayette
Alexander Black . . . . Greencastle.
M. A. Brannon . . . . Ft. Wayne.
Charles C. Brown . . . . Indianapolis.
H. L. Bruner . . . . Irvington.
Severance Burrage . . . . Lafayette.

J. B. Burris .... Cloverdale.
Noble C. Butler .... Indianapolis.
J. T. Campbell .... Rockville.
E. J. Chansler .... Bicknell.
Fred. M. Chamberlain .... Bloomington.
J. Fred. Clearwaters .... Indianola, Ill.
H. J. Clements .... Washington.
U. O. Cox ....•.................... Mankato, Min.
M. E. Crowell .... Indianapolis.
Glenn Culbertson .... Hanover.
Will Cumback .... Greensburg.
Alida M. Cunningham .... Kirkpatrick.
H. S. Cunningham .... Indianapolis.
George L. Curtiss .... Columbus.
B. M. Davis .... Irvington.
J. P. Dolan .... Syracuse.
Chas. R. Dryer .... Terre Haute.
A. Wilmer Duff .... Lafayette.
Joseph Eastman .... Indianapolis.
E. G. Eberhardt .... Indianapolis.
M. N. Elrod .... Hartsville.
F. L. Emory .... Ithaca, N. Y.
Percy Norton Evans .... Lafayette.
Samuel G. Evans .... Evansville.
E. M. Fisher .... Lake Forrest, Ill.
J. J. Flather .... Lafayette.
A. L. Foley .... Bloomington.
Robert G. Gillum .... Terre Haute.
J. R. Francis .... Indianapolis.
Austin Funk .... Bloomington.
J. B. Garner .... Crawfordsville.
U. F. Glick .... Newbern.
Michael J. Golden .... Lafayette.
W. E. Goldsborough .... Lafayette.
C. F. Goodwin .... Brookville.
S. S. Gorby .... Indianapolis.
Vernon Gould .... Rochester.

Deceased.

J. C. Gregg.......................................Brazil.
E. H. Heacock.....................................Leadville, Colo.
Chas. A. Helvie...................................Chicago.
Wm. Perry Hay.....................................Irvington.
Franklin W. Hays..................................Indianapolis.
Flora Herr..Bloomington.
Robert Hessler....................................Logansport.
T. E. Hibben......................................Indianapolis.
J. W. Hubbard.....................................Bloomington.
Thomas M. Iden....................................Irvington.
Alex. Jameson.....................................Indianapolis.
A. E. Jessup......................................Carmel.
Sylvester Johnson.................................Irvington.
W. B. Johnson.....................................Franklin.
Chancey Juday.....................................Bloomington.
E. M. Kindle......................................Bloomington.
J. G. Kingsbury...................................Irvington.
Ph. Kirsch..Columbia City.
Charles T. Knipp..................................Bloomington.
Thomas Large......................................Rensselaer.
Daniel Layman.....................................Indianapolis.
V. H. Lockwood....................................Indianapolis.
Robert E. Lyons...................................Bloomington.
Herbert W. McBride................................Indianapolis.
Robert Wesley McBride.............................Indianapolis.
Kate McCarthy.....................................Wabash.
Rousseau McClellan................................Indianapolis.
D. T. McDougal....................................Minneapolis, Minn.
J. W. Marsee......................................Indianapolis.
G. W. Martin......................................Indianapolis.
Franklin S. Miller................................Brookville.
W. J. Moenkhaus...................................Bloomington.
G. T. Moore.......................................Crawfordsville.
Joseph Moore......................................Richmond.
J. P. Naylor......................................Greencastle.
Charles E. Newlin.................................Indianapolis.
John F. Newsom....................................Elizabethtown.
E. W. Olive.......................................Frankfort.

J. H. Oliver .... Indianapolis.
D. A. Owen .... Franklin.
George J. Peirce .... Bloomington.
W. H. Peirce .... Indianapolis.
Elwood Pleas .... Dunrieth.
A. H. Purdue .... Chicago, Ill.
Ryland Ratliff .... Fairmount.
H. G. Reddick .... Bloomington.
Bessie C. Ridgley .... South Bend.
D. C. Ridgley .... Delphi.
Curtis A. Rinson .... Bloomington.
George L. Roberts .... Greensburg
L. J. Rettger .... Terre Haute.
Adolph Rodgers .... Newcastle.
John F. Schmaible .... Lafayette.
C. E. Schafer .... Huntington.
Claude Siebenthal .... Bloomington.
G. W. Sloan .... Indianapolis.
Richard A Smart .... Lafayette.
Harold B. Smith .... Lafayette.
Theo. W. Smith .... Indianapolis.
F. P. Stauffer .... Logansport.
M. C. Stevens .... Lafayette.
H. M. Stoops .... Brookville.
Joseph Swain .... Bloomington.
William Stewart .... Lafayette.
Geo. A. Talbert .... Laporte.
Frank B. Taylor .... Fort Wayne.
Erastus Test .... Lafayette.
F. C. Test .... Washington, D. C.
Wm. M. Thrasher .... Irvington.
A. L. Treadwell .... Oxford, Ohio.
A. B. Ulrey .... Bloomington.
W. B. Van Gorder .... Knightstown.
J. H. Voris .... Bloomington.
Ernest Walker .... New Albany.
F. A. Walker .... Anderson.
W. P. Wallheiser .... Bedford.

W. O. Wallace .... Wabash.
Wm. M. Whitten .... South Bend.
J. R. Wiest .... Richmond.
W. L. Wood .... Covington.
A. J. Woolman .... Duluth, Minn.
P. A. Yoder .... Bloomington.
A. C. Yoder .... Bloomington.
O. B. Zell .... Clinton.

Fellows	36
Non-resident members	10
Active members	134
Total	180

PROGRAM

OF THE

ELEVENTH ANNUAL MEETING

OF THE

Indiana Academy of Science,

STATE HOUSE, INDIANAPOLIS.

December 27 and 28, 1895.

OFFICERS AND EX-OFFICIO EXECUTIVE COMMITTEE.

A. W. BUTLER .... President
STANLEY COULTER .... Vice-President
JOHN S. WRIGHT .... Secretary
A. J. BIGNEY .... Assistant Secretary
W. P. SHANNON .... Treasurer

D. S. JORDAN,
J. M. COULTER,
J. P. D. JOHN,
J. C. BRANNER,
W. A. NOYES,
T. C. MENDENHALL,
O. P. HAY,
J. L. CAMPBELL,
J. C. ARTHUR,
Ex-Presidents.

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

PROGRAM COMMITTEE.

P. S. BAKER .... Greencastle | GEO. W. BENTON .... Indianapolis

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GENERAL PROGRAM.

Thursday, December 26.

Meeting of Executive Committee at Denison House .... 8 p. m.

Friday, December 27.

General Session .... 9 a. m. to 12 m.
Sectional Meetings .... 2 p. m. to 5 p. m.
Address by President A. W. Butler .... 7 p. m.

Saturday, December 28.

General Session, followed by Sectional Meetings .... 9 a. m. to 12 m.
General Session .... 2 p. m. to 4 p. m.

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

MR. A. W. BUTLER,

At 7 o'clock Friday evening.

Subject—"Indiana: A Century of Changes in the Aspects of Nature."

AT THE SAME HOUR, BY REQUEST,

MR. W. W. PFRIMMER

Will read a new poem. Subject—"The Naturalist."

The address has been placed at this early hour in order that other engagements for the usual hours of evening entertainment may not keep the members of the Academy and their friends from being present.

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

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

GENERAL SUBJECTS.

1. Unconscious mental cerebration, 5 m. . . . . C. E. Newlin
2. Human physiology in its relation to biology, 15 m. . . . . Guido Bell
3. A means of preventing hog cholera, 5 m . . . . D. W. Dennis
4. The Hopkins Seaside Laboratory at Pacific Grove, Cal., 10 m. . B. M. Davis
5. Infection by bread, 10 m. . . . . Katherine E. Golden
6. Simple apparatus for photo-micrography, 5 m. . . . . M. J. Golden
7. Sanitary science in the modern college, 10 m. . . . . Severance Burrage

GEOLOGICAL SUBJECTS.

8. Glacial and Eolian Sands of the Iroquois and Tippecanoe River valleys, 10 m. . . . . A. H. Purdue
9. [1]The recent earthquakes east of the Rocky Mountains, 10 m. . A. H. Purdue
10. [2]Some minor processes of erosion, 10 m. . . . . J. T. Scoville
11. [3]Kettle holes at Maxinkuckee, 5 m. . . . . J. T. Scoville
12. Fossils from sewer trenches in the glacial drift, 15 m. . . . . Wm. M. Whitten
13. Relief map of Arkansas, 10 m. . . . . John F. Newsom

MATHEMATICAL SUBJECTS.

14. Some skew surfaces of the 3d and 4th degree, 15 m. . . . . C. A. Waldo
15. [4]A problem in gravitational attraction, 5 m. . . . . A. W. Duff
16. Note relative to Peirce's "Linear Associative Algebra". . James Byrnie Shaw

PHYSICAL SUBJECTS.

[*]17. Some old and new experiments in sound, 10 m. . . . . M. N. Elrod
18. Variation of a standard thermometer, 10 m. . . . . Chas. T. Knipp
19. [5]A method of graphically representing the laws of falling bodies, 5 m. . . . . F. P. Stauffer
20. Rates of combustion in locomotive furnaces, 10 m. . . . . R. A. Smart
21. The influence of heat, the electric current, and magnetism upon Young's Modulus, 15 m. . . . . Mary C. Noyes
22. [6]The temperature coefficient of the surface tension of liquids, 15 m. . . . . Arthur L. Foley
23. Strains in steam machinery, 5 m. . . . . W. F. M. Goss
24. The viscosity of a polarized dielectric, 12 m. . . . . A. W. Duff
25. [7]A modification of the ring method for permeability, 10 m. . . . . . A. W. Duff
[*]26. Some peculiarities in the formation and descent of drops, 5 m. . A. W. Duff
27. [8]The effects of changes of temperature and pressure on viscosity, 5 m. . . . . A. W. Duff
28. On the alternating-current dynamo, 15 m. . . . . W. E. Goldsborough

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[*]Neither paper nor abstract furnished the Academy for publication; no further mention made in the proceedings.

NOTE: The titles set off by small numerals are discussed in the body of the proceedings under corresponding heads given in the foot notes.

1. The Charleston (Missouri) earthquake.
2. Some minor eroding agencies.
3. Kettle holes near Lake Maxinkuckee.
4. The gravitational attraction of a homogenous ellipsoid of revolution.
5. Graphic representation of the law of falling bodies.
6. The surface tension of liquids.
7. A method of measuring permeability.
8. Empirical formula for the temperature variation of viscosity.

CHEMICAL SUBJECTS.

29. [1]The influence of grape sugar upon the composition of certain fat-producing bacteria, 5 m. . . . . .Robert E. Lyons
30. A new method for the preparation of phenyl compounds with sulphur, selenium and tellurium, 5 m . . . . .Robert E. Lyons
31. Camphoric acid, 15 m. . . . . .W. A. Noyes
32. Note on milk inspection, 5 m. . . . . .Geo. W. Benton
33. Ratio of alcohol to yeast in fermentation, 10 m. . . . . . .Katherine E. Golden
*34. Note on crystallized silicon, 1 m. . . . . .W. B. Johnson

BOTANICAL SUBJECTS.

35. The circulation of protoplasm in the manubrium of *Chara fragilis*, 5 m. . . . . .D. W. Dennis
36. [2]Some beneficial results from the use of fungicides as a preventive of corn smut, 5 m. . . . . .Wm. Stuart
37. A new station for *Pleodorina*, 5 m . . . . .Severance Burrage
*38. Certain plants as an index of soil character, 5 m. . . . . .Stanley Coulter
39. Forms of *Xanthium Canadense* and *X. strumarium*, 15 m. . . . . . .J. C. Arthur
*40. An interchangeable clinostat of new design, 15 m. . . . . .J. C. Arthur
41. Some notes on wood shrinkage, 10 m . . . . .M. J. Golden
42. Botanical literature of the State Library, 5 m. . . . . .John S. Wright
43. Microscope slides of vegetable material for use in determinative work, 8 m . . . . .John S. Wright
*44. Embryology of *Hydrastis Canadensis*, 10 m. . . . . .Geo. W. Martin
*45. Some determinative factors underlying plant variation, 10 m. Geo. W. Martin

ZOÖLOGICAL SUBJECTS.

46. Haemoglobin and its derivatives, 10 m. . . . . .A. J. Bigney
47. Effects of heat upon the irritability of muscle, 10 m. . . . . .A. J. Bigney
48. The evolution of sex in *Cymatogaster*, 20 m. . . . . .C. H. Eigenmann
*49. Variations in the cleavage of the *Fundulus* egg, 10 m. . . . . .Geo. W. Martin

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*Neither paper nor abstract furnished the Academy for publication; no further mention made in the proceedings.

1. The effect of grape sugar upon the composition of certain fat-producing bacteria.
2. Fungicides for the prevention of corn smut.

THE STATE BIOLOGICAL SURVEY.

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[1] Neither paper nor abstract furnished the Academy for publication; no further mention made in the proceedings.

TURKEY LAKE AS A LIMIT OF ENVIRONMENT AND THE VARIATION OF ITS INHABITANTS. BIOLOGICAL SURVEY REPORTS.

69. I. First report of Biological Station, 10 m. .... C. H. Eigenmann
70. II. [2]Some of the physical features of Turkey Lake, 10 m. . D. C. Ridgley
71. III. Hydrographic map of Turkey Lake, 2 m. .... C. Juday
72. IV. Temperatures of Turkey Lake, 5 m .... J. P. Dolan
73. V. [3]Inhabitants of Turkey Lake in general, 3 m .... C. H. Eigenmann
74. VI. *Hirudinea* of Turkey Lake, 1 m .... Bessie C. Ridgley
75. VII. [4]*Rotifera* of Turkey Lake, 5 m. .... D. S. Kellicott
76. VIII. *Cladocera* of Turkey Lake, 5 m .... E. S. Birge
77. IX. [5]*Mollusca* of Turkey Lake, 5 m. .... R. Ellsworth Call
78. X. [6]*Odonata* of Turkey Lake, 1 m .... D. S. Kellicott
79. XI. [7]Fishes and tailed batrachians of Turkey Lake, 5 m. C. H. Eigenmann
80. XII. [8]Tailless batrachians of Turkey Lake, 1 m .... C. Atkinson
81. XIII. Snakes of Turkey Lake, 5 m .... H. G. Reddick
82. XIV. [9]Turtles of Turkey Lake, 5 m. .... C. H. Eigenmann
83. XV. Water birds of Turkey Lake, 2 m .... N. M. Chamberlain
84. XVI. Flora of Turkey Lake, 10 m. .... O. H. Meyncke
*85. XVII. [10]Methods of determining variations, 5 m .... C. H. Eigenmann
86. XVIII. Variation of *Etheostoma* of Turkey and Tippecanoe Lakes, 10 m. .... W. J. Moenkhaus

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*Neither paper nor abstract furnished the Academy for publication. No further mention made in the proceedings.

1. A report upon certain collections of phanerogams presented to the State Biological Survey.
2. A preliminary report on the physical features of Turkey Lake.
3. The inhabitants of Turkey Lake.
4. *Rotifera.*
5. On a small collection of mollusks from Northern Indiana.
6. The *Odonata.*
7. Fishes.
8. Batrachia.
9. *Testudinata.*
10. The study of vari tion.

ELEVENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The eleventh annual meeting of the Indiana Academy of Science was held in Indianapolis Friday and Saturday, December 27 and 28, 1894, preceded by a session of the executive committee of the Academy, 8 P. M. Thursday, December 26.

At 9 A. M., December 27, President Amos W. Butler called the Academy to order in general session, at which committees were appointed, other routine business transacted. After the disposition of the morning's business, papers of the printed program, under the title of "General Subjects," were read and discussed until adjournment at 12 M.

The Academy met at 2 P. M. in two sections—biological and physico-chemical—for the reading and discussion of papers. President Butler presided over the biological section and Prof. W. A. Noyes acted as chairman of the physico-chemical section. After the adjournment of the sectional meetings at 5 P. M. the Academy again met in general session at 7 P. M. After the disposition of some committee reports and other business, by request of the Academy, Mr. W. W. Pfrimmer read a new poem, subject: "The Naturalist," following which was the address of the retiring President, Mr. A. W. Butler, subject: "Indiana; A Century of Changes in the Aspects of Nature."

Following this evening session of the Academy was a meeting of the executive committee.

Saturday, December 28, 9 A. M., the Academy met in general session for the transaction of business, after which followed the reading and discussion of papers until adjournment, 12:15 P. M.

PRESIDENT'S ADDRESS.

INDIANA: A CENTURY OF CHANGES IN THE ASPECTS OF NATURE. BY A. W. BUTLER.

Out of the wilderness of the past has come our present civilization. From the fauna and flora of the wilderness-time proceeded the forms of life about us. The progress of this century is the marvel of history. Co-extensive with this progress are the changes in nature wrought by human agency. The story told by the witnesses of these things is incomprehensible. To the earliest pioneer a day spent in the present time would paralyze his faculties. To the student of to-day placed in the wilds of a century past would his wonder be any less? We can not comprehend what man hath wrought. Within our memories, a few there have been—here and there one—whose lives included the beginning of the white man's activity and who, much out of place in every feeling have seen the progress of the ages move by. We listen to their tales of the past, but who is there who can picture in his mind the natural conditions of those early days and the subsequent changings? Vague and imperfect are our impressions if, indeed, we have any conception of them

It is probable that the first white man within the boundaries of Indiana was the explorer LaSalle. His voyage was made about 1669. The earliest settlements were established within the first quarter of the last century at Ouiatanon and Vincennes. Authorities do not agree as to which was settled first or the date of settlement. These were only trading posts. Their effect upon existing conditions was but small. Nor was it until the Americans began to occupy this region at the opening of this century that the old began to fade before the new.

Over the greater part of this State were spread dense forests of tall trees—heavy timber—whose limbs met and branches were so interwoven that but occasionally could the sunlight find entrance. There was little or no undergrowth in the heaviest woods, and the gloom of those dense shades and its accompanying silence were terribly oppressive. Mile upon mile, day's journey upon day's journey stretched those gloomy shades amid giant columns and green arches reared by nature through centuries of time. The only interruptions were the beds of water-courses; the poorer hillsides covered with underbrush; the smaller growth of the less productive uplands; the site of an extensive windfall—the record of a tornado's passage; the small area of second growth timber marking the former clearing for some Indian camp; the more or less extensive patches of meadow, occupying ground on which the forest had been destroyed by Indian fires. To the west, in the valley of the Wabash, were wide meadows covered with long grass. In the northern third of our territory were prairies and sloughs alternating with wooded sand hills and reedy swamps, imperfectly drained by a network of sluggish streams, which in turn gave place to extensive marshes toward Lake Michigan.

The southern portion of the State was more heavily timbered. Perhaps nowhere could America show more magnificent forests of deciduous trees, or more noble specimens of the characteristic forms than existed in the valleys of the Wabash and Whitewater. The trees decreased in size to the northward, those along the great lakes being noticeably inferior. The number of coniferous trees was small and was confined to restricted areas. Those found were poor representatives of their species.

The forests were made up of many kinds of trees growing together indiscriminately. Here and there certain groups and occasionally a species were found predominating. In various localities the character of the forest was different. Oak, ash, hickory, maple, beech and elm were prevailing trees, varying much in number and proportion. In some places the Tulip Poplar (*Liriodendron tulipifera* L.) was very numerous, often attaining great size—the largest tree of the primitive forests.

Forty-two kinds of trees in the Wabash valley attained a height above 100 feet.[1] The tallest recorded being a Tulip Poplar, 190 feet in height. It was twenty-five feet in circumference and ninety-one feet to the first limb.[2] Many thousands grew over the State measuring from three feet six inches to ten feet in diameter. Numbers of Sweet Gum (*Liquidamber styraciflua* L.) in the more fertile ground in the southern part of the State, contended with the tulip poplar in height, and in beauty and symmetry exceeded it. They attained a height of 130 to 150 feet and were three to four feet in diameter at the base, often preserving almost the same size to the first limb.[3] In the oak woods there were giants too. The Red Oak (*Quercus rubra* L.), Scarlet Oak (*Quercus coccinea* Wangheim), Burr Oak (*Quercus microcarpa* Michaux), and White Oak (*Quercus alba* L.) reaching a girth of ten to twenty feet, and often a height of 125 to 150 feet. One instance is reported of a Scarlet Oak 181 feet high.[4]

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1. Prof. Stanley Coulter: The Forest Trees of Indiana. Trans. Ind. Hort. Soc., 1891, p. 8.
2. Dr. J. Schneck: Rept. Ind. Geological Survey, 1875, p. 512.
3. R. Ridgway: Proc. U. S. National Museum, Vol. V, 1882, p. 67.
4. R. Ridgway: *Ibid*, p. 80.

In the southern part of the State, too, the Sweet Buckeye (*Æsculus glabra* Willdenow) attained great size, often being three feet six inches and four feet in diameter with trunks as straight as columns, the trees reaching a total height of over 100 feet. One example of this species is unique. It is the tree from which was made the celebrated buckeye canoe of the Harrison presidential campaign of 1840. The tree grew in the southeast corner of Rush county and is said to have been, when standing, twenty-seven feet nine inches in circumference and ninety feet from the ground to the first limb.[1] Here and there, quite thickly scattered, would be found groves of the finest Black Walnut (*Juglans nigra* L.) trees the world has ever known. Some of these groves were quite extensive, containing hundreds of trees, individuals of which were four to six feet in diameter and 100 to 150 feet high.[2]

In the river valleys, along the streams, the great size of the Sycamore (*Platanus occidentalis* L) was noticeable. This was the largest of the hardwood trees, reaching a maxium height of 140 to 165 feet and often measuring five to ten feet in diameter.[3] Keeping those company were the Cottonwoods (*Populus monilifera* Aiton), the larger of which measured five and even eight feet through and 130 to 165 feet high. The beauty of all the trees of this region was the White Elm (*Ulmus americana* L.). Its diameter sometimes reached five feet, and its height 120 feet or more, the ambitus often spreading over 100 feet.

At the time of its settlement the southeastern third of our territory, including all the Whitewater Valley, contained no Indian towns and was unoccupied by them save as occasionally a hunting or a war party passed through it. In the valley of the Wabash and in the northeastern part of the State were Indian villages, located because of natural advantages. These have been apparent to the whites, who in several instances established upon their sites settlements which have since become prominent as towns or cities. Among these Kekionga (Ft. Wayne), Chip-kaw-kay (Vincennes) and Ouiatanon (on the west side of the Wabash River, four miles below Lafayette[4]) were selected as trading posts by the whites, being centers of the finest game regions occupied by man within the limits of the present State. The peltry from the last-mentioned post, in one year, in those early times amounted to about eight thousand pounds sterling.[5]

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1. W. P. Shannon: Proc. Ind. Acad. Science, 1894, p. 130.
2. R. Ridgway: Proc. U. S. National Museum, Vol. V, 1882, p. 76.
3. R. Ridgway: *Ibid*, p. 73-75.
4. Prof. Oscar J. Craig: Ouiatanon, a Study in Indiana History. Ind. Hist. Soc., pubs. Vol. II, No. 8, p. 3.
5. Prof. Oscar J. Craig: *Ibid.*, p. 22.

In different localities under different conditions were different forms of life. We have noted this regarding plants. It was so concerning animals.

American Bisons (*Bison americanus* Gmelin), generally known as Buffaloes, ranged in countless numbers over the meadows and prairies at the time we first learn of them. The Whitewater and Miami valleys formed routes to the Ohio River and the Big Bone Lick in Kentucky. The Wabash Valley became another avenue for their journeys, and the old trail from the prairies to the Kentucky barrens crossed the Wabash River below Vincennes. Over this wide, well-marked road, evidences of which still remain, countless thousands of Bisons passed annually. From the Ohio River to Big Bone Lick was a wide road which these animals had beaten "spacious enough for two waggons to go abreast."[1] Evidence of their former abundance is preserved in the swamps about this lick. In places their bones are massed to the depth of two feet or more, as close as the stones of a pavement, and so beaten down by succeeding herds as to make it difficult to lift them from their beds.[2] At the Blue Licks in Kentucky we are told in 1784: "The amazing herds of buffaloes which resort thither, by their size and number, fill the traveler with amazement and terror, especially when he beholds the prodigious roads they have made from all quarters, as if leading to some populous city; the vast space of land around these springs desolated as if by a ravaging enemy, and hills reduced to plains, for the land near these springs is chiefly hilly."[3] In the region that was densely wooded the Bisons were only seen as transients, but in the meadows and prairies they abounded. From the summit of the hill at Ouiatanon we are told, in 1718: "Nothing is visible to the eye but prairies full of buffaloes."[4]

Elk (*Cervus canadensis* Erxleben) were common, and Deer (*Cariacus virginianus* Gray) still more so. Bear and wolves were quite abundant. In one favorite locality, it is reported, a good hunter, without much fatigue to himself, could supply daily one hundred men with meat. Beaver (*Castor fiber* L.) were found in many localities. Especially favorable to them were the more level regions to the northward. Otter (*Lutra canadensis* Sabine) were quite common, while the Wild Cat (*Lynx rufus* Raf.), Canada Porcupine (*Erethizon dorsatus* F. Cuvier) and Panther (*Felis concolor* L.) were numerous.

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1. Journal of Colonel Croghan: Butler's History of Kentucky, 1834, p. 368.
2. Dr. A. W. Brayton: Rept. of Geological Survey of Ohio, Vol. IV, Pt. I, Mammals, pp. 75-77.
3. W. T. Hornaday: Rept. U. S. National Museum, 1887, pp. 387, 388.
4. Paris Documents, 1718: Colonial Hist. N. Y., Vol. IX, p. 891.

Of snakes especially noticeable for their abundance were Rattlesnakes (*Crotalus horridus* L., and *Sistrurus catenatus* Raf.) and Copperheads (*Agkistrodon contortrix* L.).

The ponds, sloughs and deeper swamps were the homes of many species of fishes, mollusks and crustaceans. The creeks, shaded by the closely crowding trees, contained water all the year round and in them smaller fishes reared their young. The rivers were clogged and dammed with fallen trees and driftwood and the water, when the streams were swollen by heavy rains, pouring over these obstructions, cut deep holes, which became the homes of great numbers of the larger fishes.

Wild Turkeys (*Meleagris gallopavo* L.) were found in large flocks. Bobwhites (*Colinus virginianus* L.) were so numerous that when they collected in the fall as many as a hundred were taken in a day with a single net. Ruffed Grouse (*Bonasa umbellus* L.) were abundant. Ducks and geese, snipe and plover were found in inestimable numbers where favorable conditions existed. Paroquets (*Conurus carolinensis* L.) were more or less numerous over the entire region and in the lower Wabash and Whitewater valleys were as abundant as blackbirds now are in spring and fall. Passenger Pigeons (*Ectopistes migratorius* L.) bred and roosted in many localities. During the migrations they appeared in such numbers that they obscured the sun and hid the sky for hours; sometimes for days in succession. The strange appearance was made more wonderful by the continuous rumble of the thunders of the oncoming clouds—the noise of the strokes of millions upon millions of wings.

Besides these, more rarely, Swallow-tailed Kites (*Elanoides forficatus* L.) and Ivory-billed Woodpeckers (*Campephilus principalis* L.) added their characteristic forms to the wild scenery. The Osprey (*Pandion haliaëtus carolinensis* Gmel.) and the Bald Eagle (*Haliæetus leucocephalus* L.) built their nests beside the streams and while one fished the other plundered the fisher.

Within the dense shades of the deeper woodland there was but a small number of birds. There quiet reigned. Twilight by day and densest darkness by night. How oppressive the awful quiet amid those gloomy solitudes! Everywhere the smaller birds were few compared with their present numbers.

But men of our race came upon the scene. Indians there had been there before. As it always has been, and so will continue to be, when two races, one superior, the other inferior, come into competition, the superior will overcome. The contest was inequal. The barbarism of the Ohio Valley could not hold its own against the alert and thoroughly equipped pioneer. Soon the native began to part with his land. It was not long until many sought other homes. Others attempted to become permanent residents and to adopt, in some measure, the habits of the conquerors. The result is too well known. An ancestor of theirs gifted with the powers of a seer may have been the subject of these lines:

"There was once a neolithic man, an enterprising wight,
Who kept his simple instruments unusually bright:
Unusually clean he was, unusually brave,
And he sketched delightful mammoths on the borders of his cave.

To his neolithic neighbors, who were startled and surprised,
Said he, "My friends, in course of time we shall be civilized!
We are going to live in cities and build churches and make laws;
We are going to eat three times a day without the natural cause;
We are going to turn life upside down about a thing called gold:
We're going to want the earth and take as much as we can hold;
We're going to wear a pile of stuff outside our proper skins:
We're going to have diseases! and accomplishments!! and sins!!!"

One can not but be impressed with the significance of the design of "The Seal of the Territory of the U. S., N. W. of the River Ohio." Impressions of it are preserved in the Department of State, Washington, D. C. In the light of the development of the past century, of the changes that have been witnessed, it would be impossible standing here, at the other end of the century, to conceive a device more expressive or truer to facts. I quote from a work that has just appeared:

"A study of this historic seal will show that it is far from being destitute of appropriate and expressive meaning. The coiled snake in the foreground and the boats in the middle distance; the rising sun; the forest tree felled by the ax and cut into logs, succeeded by, apparently, an apple tree laden with fruit; the Latin inscription '*Meliorem lapsa locavit,*' all combine to forcibly express the idea that a wild and savage condition is to be superseded by a higher and better civilization. The wilderness and its dangerous denizens of reptiles, Indians and wild beasts, are to disappear before the ax and rifle of the ever-advancing western pioneer, with his fruits, his harvests, his boats, his commerce, and his restless and aggressive civilization." "*Meliorem lapsa locavit!*" "He has planted a better than the fallen!"[1]

The white man made the navigable water ways his routes and settled along them. At once, under his influence, the aspects of nature began to change. As in every other land the effects of man's settlement began to be seen. The need for food and clothing and the desire for tillable land were the great causes which impelled him to action. In every land, on every sea, the story has been the same. Before his aggression disappeared the most noticeable forms of life. The large or conspicuous species were those most easily affected—the ones which were

1. William Hayden English: Conquest of the Country Northwest of the River Ohio, Vol. II. 1896, p. 774.

first destroyed. The story of the disappearance of the great animals of Europe; of the Bison and the Urus; of the extinction of the giant birds of New Zealand; of Steller's Sea Cow and the Great Auk, one each upon our eastern and western coast; the most wonderful destruction of the great herds of the American Bison, and the threatened extinction of the Fur Seal in the North Pacific, and of the Zebra, Camelopard and other large animals in Africa, are notable illustrations of the greater changes that have been wrought. But there are smaller ones not so conspicuous but more potent in their influences upon human welfare.

The Bison, the most characteristic of all the animals of America, was the first to disappear from the region under consideration. Formerly it had ranged east, at least as far as western New York and Pennsylvania and in States farther south almost to tide water, but about 1808 it was exterminated east of the Wabash River. The Elk followed it closely, disappearing from the Whitewater Valley about 1810 and from the State in 1830. The Panther followed soon after. Virginia Deer, Bear, Otter, Beaver, Wolves and other forms were almost exterminated. Though of some, if not all, of these latter forms a remnant yet remains in some favored localities.

Turkeys and Bobwhites; Ivory-billed Woodpeckers and Wood Ibises (*Tantalus loculator* L.); Black Vultures (*Catharista atrata* Bartram) and Carolina Paroquets have been almost, or in a great measure, exterminated. The Paroquets which ranged to the great lakes and were so common a feature in the landscape of the pioneer times, have not only disappeared from Indiana, but from almost all the great range from Texas to New York over which they spread at the beginning of this century, and are, perhaps, now only found in a restricted area in Florida. The day of their extirpation is near at hand.

The Passenger Pigeon survived the beautiful little parrot until a later day. But nets and guns, a short-sighted people and inefficient laws have all but swept out of existence this graceful bird. It is now on the verge of extinction. We can no more appreciate the accounts given of the innumerable hosts of these birds of passage than we can of the incalculable multitudes of the Bisons three score years ago. The words of those who saw them, we are assured, do not in any way convey an adequate idea of the wonderful sights and sounds during a flight of Pigeons. Some of their roosts covered many miles of forest. There, as they settled at evening, the gunners from near and far began to collect for the slaughter. The loaded trees upon the borders of the wood were first fired upon. Then the shooters passed into the denser forest. Three or four guns fired among the branches of a tree would bring down as many two-bushel sacks of dead birds, while numbers of cripples fluttered beyond reach. After a number of shots over a considerable area—several acres perhaps—the whole roost would rise with a deafening thundering which no one has attempted to describe and soar out of sight in the dusk of the early evening, while from the rising cloud came a noise as of a mighty tornado. As the darkness settled the birds descended and alighted many deep upon the branches of the trees, the weight being sufficient to break off many of the large limbs. Then the scene changed. The slaughter began in earnest. The rapid firing of guns; the squawking of the Pigeons; the breaking of the limbs of giant trees beneath the living weight; the continuous rumble arising from the whirr of countless wings; all illumined by the lurid lights of numerous torches and many fires produced an effect of which no words can convey a conception to one who has not experienced a night at a pigeon roost. Each year such scenes were re-enacted. Each year the slaughter went on. Less and less the numbers grew. Trapping and netting, supplemented by repeating guns, added to the power of destruction, and the Pigeons, whose numbers were once so great that no one could conceive the thought of their extinction, have dwindled until they are rarely found. One Pigeon in a year! Soon they will be but a memory.

The pioneers' first work was to cut away the trees and build a cabin. As each cabin was built, it foreshadowed a clearing extending more and more each year. The line of the Ohio and of the Wabash formed the basis for the advance of settlement. The ax and fire performed their work. Great deadenings gave promise of a lively time log-rolling next season. Giant Tulip Poplars; monster Black Walnuts; and Oaks, Ash, Wild Cherry (*Prunus serotina* Ehrhart) and Sweet Gums, the largest of their fellows, were rolled into heaps and burned. To this, in time, was added the necessity for fuel, for lumber and for timber to supply all the demands which human minds could make upon the forest, not only for our own population, but also for other States and other lands. Thus were our forests destroyed. Now, except in a few localities, there remains no virgin forest.

The destruction of the primitive woods cost much besides the trees that were sacrificed. Each tree was the host or resting place of other forms of life. Of the blight upon its leaves; of the fungus upon its limbs; of the lichen and moss upon its bark; of the birds among its branches; the insects on its foliage and about its blossoms; the borers within its body. And it sheltered other lowly, ground inhabiting forms beneath its spreading shades. Who can tell what the destrnction of a tree signifies? How far-reaching are its effects! After the axe came fire, carrying destruction to the more inconspicuous animals and plants. Fire, too, swept the standing woods and in its blighting effects extended far beyond the immediate necessities of the pioneer. With the cutting away of the larger trees, in many localities, sprang up thickets and therewith came thicket-inhabiting animals. As the clearings were extended, meadow lands and pasture lands were reserved.

To the meadows came such forms as the Bay-winged Sparrow (*Pooecetes gramineus* Gmelin), Field Sparrow (*Spizella pusilla* Wilson), Grasshopper Sparrow (*Ammodramus savannarum passerinus* Wilson), Meadow Lark (*Sturnella magna* L.), meadow mice, garter snakes, green snakes, bumble bees and grasshoppers—species peculiar to such surroundings. Some parts of this land were wet and where the drainage was poorest, became swamps and sloughs. There, forms which love such places, came. Among them Marsh Wrens, Swamp Sparrows (*Melospiza georgiana* Lath.), and Red-winged Blackbirds (*Agelaius phœniceus* L.), salamanders, frogs, water snakes, aquatic insects and marsh plants. As the orchard and garden developed, birds well known to us and greatly beloved for their cheery social ways, there made their home and lived upon food brought to the locality by the changing conditions. The number of settlers increased, causing a steady diminution in the numbers of all the larger mammals, especially those used for food or valuable for fur; of geese, ducks and other water loving birds. The early settlers had brought with them the Black Rat (*Mus rattus* L.). Later another form, the Brown Rat (*Mus decumanus* Pallas), which, like the first, was a native of the old world, appeared, following the routes of civilization. It drove out the other rat and has since occupied its place. The shy Gray Fox (*Urocyon cinereo-argentatus* Schreber), disappeared in advance of the incoming pioneer and the Red Fox (*Vulpes vulpes* L.) occupied the field left vacant. The hog, a most valuable factor in the development of the West, proved equally valuable as an ally in the warfare against snakes. Largely through its efforts were the rattlesnakes and copperheads destroyed.

Removing the timber and breaking the ground began to show its effect upon springs and water courses. Many became dry during the warm season. All life, be it salamanders, fishes, mollusks, insects or plants, that found therein a home, died. As time went on drainage became a feature introduced into the new country. With the draining of our sloughs and swamps other changes came. The birds that lived among their reeds and flags, mingling their voices with those of the frogs, disappeared, and the land reclaimed tells, in its luxuriant growth of corn, no story to the casual passer-by of the former population which occupied it.

And so it was. Change succeeded change. Little by little, but still each cleared field, each drained swamp, each rotation of crops, each one of a thousand variations in cause had its effect upon the numbers and life histories of our plants and animals.

When the Indians left, the prairies were no longer annually burned over. Forest vegetation began to seize upon this open land, and in time much of it became reforested. Into it was brought life from the surrounding woods, and the former occupants were driven out.

With the thinning of the trees appeared an undergrowth. Where the undergrowth came, and where the second growth appeared in neglected clearings, the vegetation was often different from that of the original forest. This, too, was destined to go the way of passing things.

The Ginseng (*Panax quinquefolium* L.), Spikenard (*Aralia racemosa* L.), Bloodroot (*Sanguinaria canadensis* L.), and Yellowroot (*Hydrastis canadensis* L.), and many ferns are following the woody plants to extermination.

Milksickness, once so prevalent among the early settlers, with the peculiar fevers of the new country, are of the past. Staggers has disappeared from many places, yet the Wild Larkspur (*Delphinium tricorne* Michaux), which, traditionally, is its cause, has become more abundant in some congenial localities, and in such neighborhoods the disease is quite serious.

But there are other results of the introduction of civilization which have made themselves felt. The streams were dammed and the migratory fishes prevented from ascending them. The driftwood disappeared from the streams. In time the dams, too, were gone. The deep holes, where the fishes loved to hide, filled up. The streams carried less water through the summer. Dynamiting, netting, and other illegal means of fishing became prevalent. All these have combined to wage a war of extermination against the inhabitants of our streams and lakes which might, if properly protected, prove an exceedingly valuable factor alike in the enjoyment and in the food supply of our people.

The telegraph wire is very destructive to birds. Birds and insects have found a new instrument of destruction in the electric light. Railroad tracks have proved very deadly to many living things besides man. They, in turn, are highways along which the cars introduce new forms of plants and animals. The self-binder and the mower play havoc with the lives of many inhabitants of the meadows and grain fields.

Following in the civilizer's footsteps have come other changes. Man has not only made the wilderness to blossom as the rose and gathered fruits and grain from all lands for the necessity and enjoyment of our people, but with the grain has been sown tares and with the fruit has been planted blight. Teasles (*Dipsacus sylvestris* Hud.), Canada Thistles (*Cnicus arvensis* Hoffm.), Wiregrass, Platains and Prickly Lettuce (*Lactuca scariola* L.) are contending for the soil. Pear blight, smuts, rusts and Black-knot affect fruits and flowers. Chinchbugs (*Blissus leucopterus* Say), Hessian Flies (*Cecidomyia destructor* Say), Colorado Potato Beetles (*Doryphora decem-lineata* Say), Clover-root Borers (*Hylesinus trifolii* Mull.), Scale Insects and Cabbage Worms dispute with the farmer his right to the crops he has planted.

Some of the native forms of life have, in some respects, changed their habits. This is evidenced by the Rose-breasted Grosbeak (*Habia ludoviciana* L.) feeding upon the Colorado Potato Beetle. The destruction in the rice fields of South Carolina caused by the Rice birds—our Bobolink (*Dolichonyx oryzivorus* L.). The loss inflicted in the rice swamps of Louisiana by the Red-winged Blackbird. The damage done to the western corn grower by the Bronzed Grackle (*Quiscalus quiscula æneus* Ridg.)—our common Blackbird. By man's agency the European House Sparrow, or "English Sparrow" (*Passer domesticus* L.), was introduced, and, as its numbers increased, it began to assert itself in the struggle for existence. The Bluebird (*Sialia sialis* L.), which had come from the hole in the snag, was driven from her box. The Martin (*Progne subis* L.), which, like the Chimney Swift (*Chætura pelagica* L.), formerly nested in hollow trees, left its nesting sites about the house, and even the Eave Swallow (*Petrochelidon lunifrons* Say.), which, in olden times, fastened its nest to the cliffs, was, in some cases, driven away. The warfare with this aggressive little foreigner still continues, worse some places than others. But it has such surprising powers of reproduction and such unheard of audacity it seems they must soon cover our entire continent. The history of the German Carp (*Cyprinus carpio* L.) in this country illustrates the same persistent and successful struggle for the mastery in our water ways that has been noted of the House Sparrow on the land.

In time fashion demanded of that which neither man's appetite nor his need for protection had impelled him to take. Her altars were erected and upon them sacrifices of animals a host innumerable—were offered. Fur bearing animals and bright plumaged birds were most earnestly desired, but even the shells of turtles, the skins of snakes, the teeth of alligators and the pearls of fresh water muscles were acceptable offerings. The extent of the destruction of innocent bird lives alone is appalling. A few facts may convey some idea of this. Among the items of one auction sale in London were 6,000 Birds of Paradise; 5,000 Impeyan Pheasants; 360,000 assorted skins from India; 400,000 Humming birds. One dealer in 1887 sold no less than 2,000,000 bird skins.[1] It is probable not less than 5,000,000 birds were required a year to supply the demand in this country alone when the bird-wearing "craze" was at its height. From information obtainable it is certain that hundreds of thousands of birds must have been slain in the United States for the glory of fashion's devotees. To this great number of victims our own State has been, to a greater or less extent, a contributor. Many counties in Indiana were visited by bird hunters. It is said from Indianapolis alone 5,000 birds, prepared for millinery purposes, were shipped in one year.[2]

1. Lucas. Report U. S. National Museum, 1889, p. 611.

2. Science. Vol. VII, 1886, p. 240.

Under our present law, which seems to be well enforced, it is a pleasure to say our birds are apparently free from that danger.

Changes still continue. The future will record them as has the past. Those to come promise to be more fruitful of results, to be of greater moment to mankind, to bring more earnest messages for human weal or woe. But no time in the future will the changes in the aspects of nature here be so noticeable, so incomprehensible, because of their vastness, as have those of the century just closing.

Unconscious Mental Cerebration. By C. E. Newlin.

If it be true, as Dr. Kay says, that "our mental progress is in the direction of our becoming unconscious, or largely unconscious, of many of our ac ivities," and "the great object of education should be to transfer as much as possible of our actions from the conscious to the unconscious regions of the mind," it seems to me our efforts should be more largely directed to the training of the mind in its *method of acting*, and less to the accomplishing of definite tasks. It seems to me that much of our failure in accomplishing results is caused by the very *effort* to accomplish them. The worry over the effort and the intense desire to succeed incapacitates the mind for clear action. If we could only be oblivious to the effort to think out a problem in any phase of life we would more easily reach the desired end. As in riding on a smoothly moving train, we are unconscious of the motion until we look out on the passing objects, so we should be entirely unconscious of the vehicle of thought and the ends to be attained, and let the mind attend to its *thinking* unhindered.

Dr. Mandsly says: "The interference of consciousness is often an actual hindrance to the association of ideas."

Much of this desired condition is attained through cultivation of the faculties. When an action becomes a habit the reflex action is unconscious. Dr. Kay says: "The more we cultivate and train any faculty or power, the more easily and rapidly does it perform its work; the less consciousness concerned in it the more work does it accomplish and the less does it fatigue."

Dr. Morrell says: "A purely unconscious action is accompanied by no fatigue at all." In my investigation I am convinced he is very nearly, if not entirely, correct. For example, the receiving teller of a bank will run up the long columns of figures in adding with ease, and fatigue only to the extent of his consciousness of his acts.

But I am convinced this is not altogether a matter of practice. It is partly due to the *method* of thought. He reads the figures and their combinations much as one reads words, without thinking consciously of each letter in the words. A bill clerk will extend the totals of goods as quick as he can write them when the number of articles or yards and the price are given. Some accountants will add two or three columns at once almost as rapidly as he would read the same length of printed words.

When in school I was given the problem of running a railroad much in the shape of a letter S through three given towns. After working four days on it and late into the night I decided to give it up, and prepared to retire. My instruments and figures still lay spread out on the table, and as I passed the table to hang up my coat unconsciously my eyes fell on the figures, and the solution came to me instantly, and I solved it and drew the figures in less than a minute. I do not believe I would ever have solved it if I had not given it up and thus relieved my mind of the intense consciousness of the effort to solve it.

When my father was a young man teaching school he had given his class a long problem in partial payments. The class failed to solve it, and when he tried it he failed also. Being unwilling to let them know he had failed, he worked on it every spare moment for several days. One night he worked at it until late at night, failed again, decided to give it up, and retired. In the night his mother heard him marking on the slate in the dark room and asked him what he was doing. He told her in his sleep he was trying to solve the problem. She let him work on for some time, when he again retired. He did not waken until called to breakfast the next morning, and when questioned in regard to the problem said he had failed to solve it and had given it up for good. In the meantime his mother had turned the slate over. His father insisted he should not give it up, and induced him to try it again. He did so, working on the other side of the slate, but he again failed. On turning the slate over they found he had solved the problem correctly, covering the entire side of the slate with his work, in his sleep and in a dark room, and yet remembered nothing of it and could not solve it the next morning. This seems such a remarkable case that I thought it worthy of giving to you as an illustration.

My conclusions are that we are wasting much time in life with simple mental acts that should be done unconsciously, and our very consciousness often defeats the effort. It seems to me we should spend more time learning *how* to think, and in concentrating our mind on the matter in hand regardless entirely of all accompanying subjects or the result of our thought. If this be true the "To learn to do by doing" does not cover all, nor the most important, of the ground.

Means of Preventing Hog Cholera. By D. W. Dennis.

During the spring term of 1894 I gave twelve chapel lectures at Earlham College on the conquest of disease. In one of these lectures I discussed the late cholera pestilence in Hamburg and presented a bulletin like those posted up throughout the city, directing the sterilization by boiling of every article of food and drink and of all infected utensils and clothing. I called attention to the fact that science had not only kept the plague from crossing the ocean, but had limited it by a single street in the city of Hamburg itself.

Mr. Porter Cook, of Wilkinson, Hancock County, was a student with us at that time. His father, Mr. Lorenzo D. Cook, had lost by hog cholera what he supposed was at least 50 per cent. of his hogs for the ten previous years. The disease had been among his hogs every year, and he had lost some years as high as five out of every six. It was the habit of the disease to break out during the summer months among the hogs destined for the following November market. When Mr. Cook returned home at the end of the term he found the disease beginning among their hogs as usual. He at once determined to try the effect of sterilizing all the drinking water given to the hogs by boiling it with a little corn or wheat in it to give the hogs a relish for it. The two that were then sick of the cholera got well and there has been no cholera on his place since. He has never permitted his hogs to drink anything but boiled water since.

During last month a neighbor on the west has lost seven out of eighteen; a neighbor on the north had a hundred head; the cholera broke out among them and he sold all but twenty-five, and of this number he thinks four will recover. A third neighbor has lost eight out of seventeen. There could not be a more satisfactory single experiment tried.

On a farm that had not for ten years escaped the disease, no case has occurred since the water has been boiled, *i. e.*, for two years, and during these two years every adjoining neighbor has been continuously troubled with the disease.

Mr. Cook says that his hogs have contracted a liking for boiled water and that they will not drink rain water when it gathers in pools in the fields, but wait for watering time instead. Two other facts which have come to my notice strengthen the view that boiling the water will entirely prevent the disease. A farmer in Wayne County never has had the cholera among his hogs. None of his neighbors' hogs have escaped the disease. Their hogs all drink from the neighborhood streams, his from a spring in his field. A farmer near Hillsboro, Ohio, when the disease was prevalent, divided a drove of 100 into two parts; half he watered from his well and the others at a stream. Of those watered at the well none died; of the others more than half. I have within the last week instituted a number of experiments, similar to the one Mr. Cook tried, in different parts of the State where the disease is now prevalent, and I submit that the splendid results above given demand that a fair and extensive trial be made. In a large part of Indiana, namely, where there is natural gas, the experiment will cost but little either in money or trouble, and if it is efficacious as it seems to have been in this one case, to arrest the progress of the disease after it breaks out in the drove, it will very richly repay the expense and trouble in every part of the country. The question does not alone concern the farmer whose hogs die; it is the policy of many raisers to sell fattening hogs as soon as the disease breaks out, and there can be no question that much diseased meat is every year on the general market.

Prof. Noyes, of the Hygienic Laboratory of Ann Arbor, writes me, under date of December 20th, that he does not know of any experimentation on a large scale along this line. He has, I know, given much attention to the diseases, and would be likely to know of such experiments if they had been made. Both the general government and the governments of several of the States are spending large sums of money at experiment stations for the arrest of this disease. The results so far reached, interesting from a scientific standpoint, are useless in the field because of the skill and expense which the application of the remedies requires. The purpose of presenting this paper here is to secure, if possible, the co-operation of a hundred stock-raisers in different parts of the State, and differently surrounded, that a demonstrative test of this simple remedy may, in the next twelve months, be had. The animals experimented upon must be isolated from all sources from which they can obtain drink, and given only water to drink which has just been boiled; it should be served as hot as the hogs will drink it in clean troughs. Can we secure these experiments tried in this way. Six dips in Jordan and one in Parphar will be no experiment at all. It would be worth while for us to show, if we can, that on the White River, also, the simple is the sublime.

THE "HOPKINS SEASIDE LABORATORY" AT PACIFIC GROVE, CAL. BY B. M. DAVIS.

[ABSTRACT.]

The great variety in fauna and flora, both in inland and marine forms, make the Pacific Slope and Coast, particularly that included in California, attractive to naturalists. As soon as Dr. Oliver P. Jenkins and Dr. Chas. H. Gilbert took their places in the Stanford faculty they recognized the resources of the coast from the standpoint of biologists. They immediately began to consider plans for establishing a biological station on the coast, and, after a careful survey of the whole coast, decided on Pacific Grove as the best location. The first substantial aid was $300 given by the town of Pacific Grove, and $500 given by the Pacific Improvement Company. With this a temporary establishment was maintained.

This beginning was put on a firmer basis by the generosity of Mr. Timothy Hopkins, a resident of San Francisco, and the present laboratory, known as the "Hopkins' Seaside Laboratory," is the result.

Pacific Grove is on Monterey Bay, two miles from the old California capital of Monterey, and is reached by a branch of the Southern Pacific Railway and by the Pacific Steamship Line. The coast is irregular and rocky, yielding great variety of forms. Working material may be gotten from the Chinese and Portugese fishermen, both of whom have villages there.

There are two buildings; the older one contains three general laboratories, a supply room and seven rooms for investigators; the other building has a general lecture room, library room, a general laboratory, ten rooms for investigators and a dark room for photographic work. The basement is designed for aquaria. The library and apparatus of Leland Stanford University is used. Each student is provided with a compound microscope, reagents and all accessary apparatus needful in his work. Salt and fresh water is in both buildings and so distributed that each student may preserve his collections. The investigators' rooms are similarly provided. The laboratory provides for three classes of students:

First. Investigators who are capable of carrying on independent researches in morphology or physiology.

Second. Students of Stanford University, who wish to pursue their work under more favorable circumstances and gain knowledge of practical methods of research.

Third. Students and teachers interested in biology, who wish to become acquainted with recent biological methods. For these courses of lectures are provided, supplemented by individual instruction at the work tables.

The spirit of the school is excellent. No hours are definitely appointed, but students may be found at work from early in the morning until late at night. Although the laboratory has been open practically only three years the advancement already made and the evidence of increasing interest assure its future prosperity and growth.

Infection by Bread. By Katherine E. Golden.

In recent years, since the subject of bacteriology has made such headway, there have been numerous scares among the people; sometimes it is tuberculosis in milk and meat, then the development of ptomaines in fish, clams, canned goods, etc., the list going on indefinitely. Among these the dangers from bread baked in basements, in "sweat shops," and by people who were not sufficiently clean, personally, have been dwelt upon in newspapers, and even in the Century Magazine an article appeared a year or so ago from a prominent member of the New York Board of Health, advocating certain methods of making bread in which baking powder should be used instead of yeast, so as to do away with the kneading and the consequent handling of the dough. Some of the cooking school teachers have advocated the same thing, claiming in addition that in bread not thoroughly cooked the yeast is not killed, and that on its introduction into the stomach a fermentation is set up.

To test the validity of these claims I made a number of experiments upon breads gotten from Lafayette bakers, the breads being obtained from the grocers, the object for which they were to be used not being stated. Specimens of the ordinary loaves, and also rolls that require a shorter time in baking, were obtained, an attempt being made also to select those specimens showing the least baking. In making the tests care was taken that outside germs should not be introduced. I first washed my hands with corrosive sublimate solution, then singed the outside of the loaf by means of a gas flame; the loaf was then broken open and a piece of about one gram weight taken from the center with sterilized forceps and placed in test tubes of sterilized beer wort. The specimens of bread were allowed to remain in this medium for about ten days, then plate cultures were made, the gelatine for the plate cultures being inoculated from the wort in the tubes. Duplicate experiments were made of each specimen of bread used.

Beer wort is one of the best media for the cultivation of yeast, as it contains an abundance of the food necessary for its growth. It is also valuable as a medium, as it becomes turbid by the growth and froths readily in the fermentation.

In the experiments in no case was there any apparent growth in the wort; it remained perfectly clear, and no gas was formed. In the plate cultures no growth took place, except in one case in which a mould grew. It is very probable this was introduced in the manipulation, as the duplicate showed no growth.

Duplicates of these experiments were made with bread obtained from Boston, with the same results. The Boston bread was bought in some of the large grocery stores and restaurants, which would, of course, insure the bread having come from reputable bakers. I was not successful in obtaining any basement made bread or that from so-called "sweat-shops" where the cleanliness is questionable.

Enough has been done, however, to demonstrate that yeast and the ordinary bacteria found in dough are killed in the baking, and that any germs introduced into the stomach by means of the bread have come from the outside of the loaf, and have been deposited upon it after the baking. If any doubt exists in one's mind in regard to the place from which he has obtained bread, it is very easy to render the bread safe from living germs by singeing the surface with a flame. As the interior of a loaf of bread is raised to nearly 100° C. in the baking, besides steam being generated, the conditions are such that yeast can not live, and most bacteria can not resist this prolonged steam heat. The danger in bread is not the introduction of living germs into the system, but the introduction of ptomaines formed by bacteria during the rising of the dough. As the rising is done inside of six or seven hours, the danger from this source is very slight, as it would take considerably longer than that time for sufficient ptomaine to be generated to be injurious; moreover, the yeast is there in sufficiently large quantities to check the growth of any foreign organism, that must of necessity be there in small quantities.

Simple Apparatus for Photo-Micography. By M. J. Golden.

This device enables one to secure a photograph of a section with little loss of time, and with little disturbance of the section.

The device consists of a piece of board, about an inch thick, forty inches long and about twelve inches wide, to which are attached a shelf to hold the microscope, and a sliding piece with a pair of brackets to carry the box of an ordinary hand camera. Under the shelf another piece of board is fastened to the first, at right angles, and this assists in supporting the shelf, and serves as a leg to help keep the apparatus in an upright position.

The back, leg, shelf and sliding piece may be constructed from a piece of smooth pine board; and the bolts and nut used with the sliding piece are ordinary machine ones, that may be gotten at a hardware store. One of the bolts must have the same pitch as the hole in the camera box, by which it is fastened to the tripod. One may easily make this stand for himself, or have it made by a carpenter at little cost.

The lens of the camera is removed, and a funnel made of heavy, black cloth, or some corresponding material having flexibility, put in place of it, so that light-tight connection may be made between the camera box and the eye-piece of the microscope. If this cloth funnel be terminated in a small cone, made of tin or paste-board, to fit over the eye-piece, the adjustment to the microscope can be more rapidly made.

By using a camera box, one can also use the ordinary plate holders for his negatives, and he can get his focus on the ground glass. Of course, the plates may be developed at one's leisure.

The advantage of the apparatus is that one can, with slight cost, have at hand in the laboratory, means for making a permanent record of any peculiarity in a section that he may find, with the expenditure of very little time.

It will be found that greater uniformity in the negatives from the sections can be gotten by using an artificial light rather than natural light; a Wellsbach incandescent gas lamp gives good results.

Sanitary Science in the Modern College. By Severance Burrage.

The modern college should reflect in its curriculum the best, the most advanced thought of the time on the physical as well as the mental and moral life of the people. Many old habits and customs which have been generally adopted into family life have been curtailed, leaving room for more modern ideas and discoveries.

One of the most profound changes in the latter part of this Nineteenth Century has been in our attitude toward the physical welfare of mankind, especially in regard to the causes and prevention of disease. This is no longer a matter of importance to the medical profession alone; in fact the physician deals mainly with the cure of disease, not its prevention; therefore, in order that the coming generation shall be prepared to meet and grapple with these vital problems, to apply the new ideas intelligently they must become familiar with the fundamental principles of sanitary science. This is particularly true in view of the extended growth of community life. The decline of individual responsibility, and the increase in one form or another of socialism, makes the necessity for public supervision doubly important. Public supplies are public dangers, and, therefore the supervision of them must be expert. The expert must be intelligent, and perhaps more important still, he must be backed by an intelligent public opinion. Here, then, are the two great vacancies to be filled—the expert sanitarian and the well informed citizen. No college should send out its students without some insight into this new science of the public health. Whether the course be compulsory or elective may be a matter of opinion, but the important bearing of such a training must be evident. This training should include a certain knowledge of sanitary chemistry, as applied to the analysis of air, water, milk, butter, cheese and other foods, as well as the principles of bacteriology, showing the importance of cleanliness in the home, in the public places of the community, and in the general habits of living. If the student is made to see, by actual laboratory experiment, that the air is full of dust, much of which is living matter in the form of mold and bacteria spores; if he examines a sample of milk and finds a million or more bacteria, and if he understands that wherever there is decaying animal or vegetable matter, there are myriads upon myriads of living microbes, then there is one more citizen, who, after he graduates, will insist on a neatly kept house in a clean, healthy neighborhood; who will, we hope, find out who his milkman is, and what kind of milk he and his family are drinking. Then, moreover, he will understand the importance of having, in the thickly settled communities, efficient men, free from politics, to look after the public supplies of water, ice, milk and meat; the removal of garbage and disposal of sewage; the ventilation of public buildings and the cleaning of the streets, the isolation of contagious diseases, etc.

Aside from the importance of this work as shown above, it is a most valuable training for the young man or woman as a laboratory course. Dr. George M. Sternberg, Surgeon-General of the United States Army, in his address given in September before the Georgetown Medical College, gives very much importance to bacteriological work as a most excellent exercise for teaching the student to observe. This was meant particularly for the preparation of men for the medical profession, but accurate observation is desirable for, and often woefully lacking in our modern citizens, both men and women. The many delicate tests, chemical and physical, that are essential in modern bacteriology give exceptional opportunities for a training of this kind. The careful manipulation necessary in making microscopical preparations of bacteria, diseased tissues, etc., gives ample chance for the training of the hand as well as the eye.

The study of vital statistics, which to a certain extent should enter into a course of this kind, would necessarily show the need of accurate systems of registering births, deaths and cases of infectious diseases.

Much has been done in the last ten years toward establishing such courses in sanitary chemistry and biology, and the recent gift of Miss Culver to Chicago University, providing especially for departments in sanitary science and hygiene, shows clearly that the subject is not only in the public eye, but that its importance is even beginning to be realized. Indianapolis is alive to the subject, having this month passed the ordinance providing for the supervision of the milk supply and inspection of the dairies.

We see, then, that the rapid developement of applied biology and hygiene is calling for and must have intelligent, well-trained men and women to lessen the dangers that arise from public supplies of various kinds; to teach the children as well as the public, their duty from the sanitary standpoint toward their neighbors, and to assist in the solution of problems that are today perplexing physicians and scientists. Many of these wants can be, and are being supplied by the colleges and scientific schools, and the periodicals and the public press are earnestly pushing on the good cause.

It can hardly be less than an educational and scientific duty for us to see to it that the young people who are graduated from our modern colleges shall have at least a realizing sense of this new scientific development, all of which has grown up within the last forty years.

The Charleston (Mo.) Earthquake. By A. H. Purdue.

The earthquake of October 31, 1895, is the greatest seismic disturbance that has occurred in the Mississippi Valley since the noted earthquake of 1811. Though nowhere intense enough to do great injury to buildings, it was perceptible over an area of more than 400,000 square miles.

A short time after the occurrence of the earthquake the writer communicated blanks to the teachers of science in seventy-five cities and towns in the States of Indiana, Illinois, Missouri, Arkansas, Alabama, Mississippi, Georgia, Kentucky and Tennessee, requesting information concerning the time, duration and intensity of the shock, together with the apparent course of wave movement, and subsequent phenomena. The major part of these blanks was sent to science teachers of Indiana with a view to determining, if possible, whether the great volume of gas removed in recent years has had any effect on the stability of the crust within the gas region. It seemed not unreasonable to suppose that the relief of pressure within the rocks from which gas has been removed has left them in a strain, in which case the earthquake waves might produce a collapse which would be indicated by their reinforced intensity.

Of the seventy-five blanks sent out, only thirty-nine were returned, consequently my information is not so complete as I had hoped to secure. Of the thirty-nine received, however, twenty-seven are from Indiana, so that the facts concerning that field are tolerably complete.

The reports sent in substantiate what the newspapers had already indicated viz., that the epicentrum was in the vicinity of Charleston, Missouri. The person[*] reporting from that place says that the force was "sufficient to break several plate-glass windows, crack brick walls, and throw down brick chimneys." He also reports: "About four miles southwest of this place the ground was cracked open in several places, and sand and water were forced from the fissures, causing what are commonly known in this section as sandblows. For a few minutes afterward water spurted from several pumps." There were at least two

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[*] A. R. Boon.

slight shocks immediately following the severe one, at intervals of ten or fifteen minutes. Subsequently earthquakes occurred on November 1 at 8:15 P. M.; November 2 at 9:50 A. M., and November 17 at 9:20 P. M.

A good deal of injury to buildings is reported from Cairo, Illinois. At that place there is reported to have been at least one shock each day during the first five days of November. During one day there were three shocks.

At Columbus, Kentucky, the shock was sufficient to crack brick walls and throw off plaster. As at Charleston the first shock was immediately followed by two others of less intensity. One subsequent earthquake is reported for November 1 at 8:00 P. M.

From nowhere else do the reports indicate such intense movement as at these three places, and from no other place is there an earthquake reported subsequent to the one of October 31st. As the three places are within a radius of twenty-five miles, the epicentrum can be considered fairly well located.

Reports from the Indiana gas field and vicinity indicate a movement slightly more intense than those from other parts of the State, but the increased force was not sufficient to justify the conclusion that it was due to the removal of gas. Three shocks in rapid succession are reported from Portland and Marion; two from Decatur, Goshen, Lafayette and Frankfort. From other places only one is mentioned. The average duration of the shock in six towns and cities within the gas region was 44.1 seconds. The average duration of the shock in sixteen towns and cities outside of the gas field was 43.2 seconds. That the apparent increase of intensity within the gas region and vicinity is not necessarily due to the removal of gas is shown in the reports from Bowling Green and Frankfort, Kentucky, each of which announces three shocks. Frankfort and Indianapolis are about an equal distance from the centre of disturbance. At Batesville, Arkansas; West Plains, Missouri, and Nashville, Tennessee, the shock is reported intense. At Wichita, Kansas, it was scarcely felt. At Atlanta, Georgia, it was slight.

Following the earthquake were increased flows of gas at Portland, Marion, and Bluffton. There were increased flows of water at Columbus, Shelbyville, Albion and Wabash. The water in Blue River rose several inches at Columbia City. The water in Pigeon Creek, Warrick County, rose one and a half feet the day following the earthquake, but soon subsided. Phenomena of this kind are a common result of earthquakes.

The average time of the shock as reported from Indiana was 5 o'clock, 10 minutes, and 30 seconds, A. M. There was no preceptible difference between the time the wave was felt in the southern part and in the northern part of the State.

This indicates either an extreme velocity of movement or great depth of disturbance, probably both. The large area affected and the comparative mildness of the shock at the epicentrum indicate that the disturbance was deep. A disturbance at a small depth might be felt over a large area, but if so, the force at the epicentrum would be great. According to the conclusions of Capt. Dutton from his studies of the Charleston (S. C.) earthquake,* the wave movement at that time had a velocity of about three miles per second. At this rate, it would require 1.38 minutes for a wave to travel from Charleston, Missouri, to Indianapolis. It will be seen that it would have required close observation to determine the difference in time at which the wave was felt at Evansville and at Indianapolis. The average time of the shock as reported from Charleston, Cairo, and Columbus was 5 o'clock 8 minutes and 20 seconds, or 2 minutes and 10 seconds earlier than the average time reported from Indiana.

An interesting feature of this earthquake is the fact that its epicentrum has approximately the same position as that of the earthquake of 1811 which resulted in the sinking of large areas about the mouth of the Ohio River for a distance of several feet.

There are newspaper reports of an earthquake at Cotapaxi, Colorado, November 18 at 4:10 P.M.; one at Greeley, Colorado, November 24th at 5 A. M.; and one at Clayton, Delaware, November 20, at 3 A. M. There was an earthquake of some severity reported from Rome and Naples, Italy, November 1. When we consider the great frequency of earthquakes in volcanic regions and in regions where there is great crustal disturbance, these closely simultaneous earthquakes in distant parts appear as probable coincidences hardly worthy of remark. It is reported† that in Japan there is an average of at least one earthquake a day. According to the records kept at Lick Observatory‡ there was an average of one earthquake for every 11.4 days in the State of California for the years 1890 and 1891.

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* Ninth An. Rep. U. S. Geolog. Survey.

† Rep. Brit. Association, 1884, p. 242.

‡ Bull. U. S. Geolog. Survey, No. 79.

Some Minor Eroding Agencies. By J. T. Scovell.

The major or more effective erosive agents are: Heat and cold, air and water, plants and animals, wind, flowing water and ice.

The roots of growing vegetation sometimes open fissures in soils and rocks so as to hasten erosion, but generally growing vegetation is conservative in is action, serving to hinder the work of erosion. But decaying vegetation, especially trees, often open the ground to the water, and frequently a gully has its beginning from rain-water entering the ground along the decomposing roots of some ancient forest tree.

Burrowing animals, as the ground hog and gopher, the badger and prairie-dog, rabbits, mice and crayfish, bring loose soil to the surface, where it can be scattered by the wind or washed away by the rain. Air and water, by means of these openings, penetrate the ground with their disintegrating powers, and the cause of erosion receives material aid. Again, the track of a mole breaks the surface, and is the beginning of a drainage channel whose extent is limited only by the amount of rainfall and the steepness of the slope. Smaller animals of lower groups are also important erosive agents.

Darwin mentions earth-worms, and calls attention to the immense amount of work they do in working over the soil, rendering it more porous and fertile, and opening it to the action of more active agents, as air and water.

Burrowing spiders do a similar work, they are not as numerous as the earth-worms, but their burrows are wider and generally deeper than those of the earth-worm, so that, with fewer numbers, they still do a great amount of erosive work. They are abundant everywhere, in yards and fields, between the bricks of walks and by the roadside. Frequently they build a little curb of sticks, bits of grass or other material, so that the burrow somewhat resembles a well.

Grasshoppers aid in erosion when they open the ground for their eggs. They do not form a very large or a very deep hole, but when their great numbers are considered, it soon appears that they are erosive agencies of no mean proportions.

The male cricket in some localities does a work that is quite similar to that of the garden mole, only on a smaller scale. An immense number of the cole-aptera spend a large portion of their larval stage underground. The entrance to their burrows and the opening for their escape stirs up the ground to the action of air and rain. Thus these humble workers contribute their mite toward keeping the land on the run toward the sea. The numerous family of burrowing beetles and many others as adult insects aid in this work.

The larva of the cycadia of different kinds, during their long period of life under ground, must do much toward pulverizing the soil. The larva of some of the tipulidæ, or crane flies, are among the most effective of these minor agencies. I found them last season working in shale and bowlder clay. These materials were honey-combed to a depth of about three inches below the level of the water, and so well was the work done that the mass broke down easily in the fingers. The materials removed in boring their tubes was quickly dissolved or washed away, and penetrating the holes the water rapidly dissolved the partitions or so weakened them that even a gentle current carried away the shale and clay in great quantities.

Many different kinds of ants burrow in the ground often ranging over large areas. The amount of soil worked over each year by these little laborers must be very great. Then there are several kinds of wasps which work more or less extensively in the soil. Some of the bees also work in the ground, or in banks much like cliff swallows. They deposit their eggs at the bottom of a hole or burrow some two or three inches deep. Often they build out an entrance or porch to the hole, possibly as a protection against intruders. Their work breaks up large areas of material each season for the rains of spring and autumn to dissolve and carry away. Many other insects are engaged in this work, but the ones mentioned are perhaps the more important. These little fellows are among the minor agencies of erosion, but the amount of work accomplished each year is immense and can not be neglected in a careful study of erosion and erosive agents. In nearly every case the action of these little animals serves to enrich and fertilize the soil, thus promoting the growth of vegetation while aiding in erosion.

KETTLE HOLES NEAR LAKE MAXINKUCKEE. By J. T. Scoville.

Kettle holes are phenomena incident to the retreat of glacial ice. They are very numerous in southeastern Massachusetts and are abundant throughout the glaciated area wherever the ice halted long enough to form morainic deposits. They vary greatly in size, but are usually somewhat conical in shape. They are often occupied by water forming ponds or small lakes. There are said to be more than 300 such bodies of water in Plymouth Township, Massachusetts. In many cases, however, their walls are of sand or gravel, which do not retain water for any great length of time, so that they are usually dry. The holes are supposed to have been formed somewhat as follows: The clay, sand, gravel and other morainic materials along the margin of the ice were irregularly distributed so that in some places it was so thick as to protect the ice underneath from the action of the sun until the ice on all sides had disappeared leaving an island or detached portion of ice, thickly covered with rocky fragments, and often surrounded by a deep layer of similar material left by the more rapidly melting ice. The drainage channels abundant along the margin of the ice sheet often aided no doubt in detaching such blocks of ice.

As these masses melted down, their loads of debris would shoot down the sides, forming a rim, while the core, as it melted, would leave a hole or cavity, often reaching much below the general level of the surface.

Kettle holes are so characteristic in form that they may be easily recognized, and are indications of morainic materials that almost anybody can appreciate and understand. On the west side of Lake Maxinkuckee, between Marmont and the Arlington station there are seven or eight kettle holes ranging from 100 to 300 feet in diameter and from 4 or 5 feet to 25 feet in depth. Some have been partially cut away by the lake, others are quite perfect. One near the end of Long Point has been about one-half cut away, and the big ice house of Holt & Co. occupies a portion of an old kettle hole. The lake itself doubtless occupies a portion of an old drainage channel, the deeper portions being simply old kettle holes. It is interesting to study these remains or relics of the glacier, so symmetrical in form, so perfect in outline that they seem as if made but yesterday, as if fresh from the hand of the builder, making one feel sure that the ice is just over them a little way, and that the hills have just barely had time to clothe themselves with verdure since the ice king yielded up his scepter to the sun.

A Relief Map of Arkansas. By T. F. Newson.

[Abstract.]

In 1893 Dr. J. C. Branner constructed a relief map of Arkansas for the Arkansas exhibit at the World's Fair. The horizontal scale used was three miles to the inch; the vertical scale was 2,000 feet to the inch.

Topographic maps of the entire State were first made. These were cut into sections, and placed on small blocks cut to fit them. Pins were driven through the sections at prominent points, and were then cut to the proper vertical scale. These pins were the guiding points in molding the map, which was done in ordinary molders' clay. After being molded the separate blocks were fitted together, forming the complete model of clay, from which a plaster of Paris negative was cast. From the negative the positive or final cast of the map was made.

Some Skew Surfaces of the 3d and 4th Degree. C. A. Waldo.

[Abstract.]

The theory of skew ruled surfaces has been specially studied by Cremona, Cayley, Rohn and others. Rohn of Dresden has contributed several important series of models of general and fundamental character.

The object of this paper is to discuss somewhat in detail by Cartesian coördinates a family of surfaces formed by a straight line generatrix moving along two non-intersecting straight lines and a plane curve whose plane is parallel to both right lines.

Let the plane curve be $f(m, n) = Am^K + Bm^{K-1} + Cm^{K-2} \dots L = 0$. Let the orthogonal projections of the straight lines on the plane of this curve be axes of X and Y, and their common perpendicular the axis of Z. Let the distance from the plane of the curve to one right line directrix be pb, to the other qb, the directrix parallel to the Y axis being the more remote. In this position, by similar triangles, it is easily shown that $m : x :: pb : pb - z$, and $n : y :: qb : z - qb$. Substituting these values in $f(m, n) = 0$ we have at once a general expression for the Cartesian equation of an unlimited number of skew surfaces of this description, viz.:

$$A\left\{\frac{pbx}{pb - z}\right\}^K + B\left\{\frac{pbx}{pb - z}\right\}^{K-1} \cdot \left\{\frac{qby}{z - qb}\right\} \dots L = 0$$

As shown by Salmon in another way the degree of this surface is at once seen to be twice that of the directing curve or twice the product of the degrees of the directing lines of the surface.

Plane sections of this surface are in general of the 2Kth degree, but when made by the plane Z=constant, they degenerate to the Kth degree.

If the directing curve be of the 2d degree the resulting surface will be of the 4th degree unless degraded by some special position. If we take the circle as our curvilinear directrix and place it half way between the two rectilinear directrices the resulting equation will be of the form

$$\frac{b^2 x^2}{(b - z)^2} + \frac{b^2 y^2}{(b + z)^2} = a^2 \quad (1).$$

If the circle be replaced by the equilateral hyperbola we have

$$\frac{b^2 x^2}{(b - z)^2} - \frac{b^2 y^2}{(b + z)^2} = a^2 \; (2).$$

If the directing curve be the parabola, $x n^2 = 4pm$, the surface is

$$\frac{b y^2}{(b + z)^2} = \frac{p x}{b - z} \quad (3),$$

a surface of the 3d degree.

In (1) if $b=a=1$, we have $x^2(1+z)^2+y^2(1-z)^2=(1+z)^2(1-z)^2$, a surface whose sections by planes perpendicular to the z axis give us between $z=0$ and $z=1$ ellipses of all possible eccentricities. A similar remark may be made of equation (2).

Among the deformations of which surface (1) is susceptible, one is worthy of special attention. If the threads representing the elements be weighted below the lower straight line directrix, and the upper directrix be then revolved until it comes into the plane of the lower directrix and the common perpendicular, the surface will gradually close up until it becomes a plane, but in every position the form of the Cartesian equation remains the same, while the axes of reference will be the equi-conjugate diameters of the ellipse cut out by the x y plane.

The Gravitational Attraction of a Homogeneous Ellipsoid of Revolution.

[Abstract.]

In this paper the following problem was discussed: Given an ellipsoid of revolution of given mass, but of variable eccentricity; find how its attraction on a particle at the end of the axis of revolution varies as the ellipsoid alters continuously from the infinitely prolate to the infinitely oblate form.

It was pointed out that this was the only case in which the expression for the attraction of a spheroid did not lead to elliptic integrals. An expression for the attraction in the above case was found by direct integration without recourse to the potential function. The integral took two forms according as the ellipsoid was prolate or oblate. The ordinary process of finding the value of the eccentricity corresponding to a maximum led to an insoluble equation. Hence the position of the maximum was approximated to by trial and interpolation. The conclusion was, that starting with the infinitely prolate form and passing through the spherical stage to the infinitely oblate form the attraction increased continuously, until that oblate stage was reached at which the axis of revolution was seventy-two hundredths of the equatorial axis, then it decreased until when the axis of revolution was fifty-one hundreths of the equatorial diameter, the attraction had fallen again to that at the spherical stage, from whence on it decreased to zero.

It was pointed out that this invalidates the common argument that the weight of a body at one of the earth's poles *must* be increased by the polar flattening.

NOTE RELATIVE TO PEIRCE'S "LINEAR ASSOCIATIVE ALGEBRA." JAMES BYRNIE SHAW, D. Sc.

I have no doubt many readers of Benjamin Peirce's classic work have found some difficulty in its perusal from the lack of examples of the algebras developed. That such a completion of the work was intended is shown by ¶ 2, p. 4, and the last three lines of page 119. The following method of exemplifying the subject may be of use or help. It is in a succinct form thus: Every unit in an algebra of this book is an operator of a matrical kind upon a ground of what we may call vectors. The whole work is thus a *treatise on groups of such operators.* This explains its abstruseness. Now for all cases in which the ground consists of two or three or four vectors, the units can be represented by the linear vector operators of quaternions, or linear quaternion operators. The relative forms given by Mr. C. S. Peirce may be immediately translated into such quaternion forms. Thus we may write, (α, β, γ, being vectors such that $S.\, \alpha\beta\gamma = 1$, and l_1, l_2, l_3, l_4, being quaternions such that $S.\, l_1 A.\, l_2 l_3 l_4 = 1$ *).

Algebra $\mathbf{a}_1$, $i = \alpha S.\, \beta\gamma\, (\;)$.

" $\mathbf{b}_1$, $i = \alpha S.\, \gamma\alpha\, (\;)$.

" $\mathbf{a}_2$, $i = \alpha S.\, \beta\gamma\, (\;) + \beta S.\, \gamma\alpha\, (\;)$; $j = \alpha S.\, \gamma\alpha\, (\;)$.

" $\mathbf{b}_2$, $i = \alpha S.\, \beta\gamma\, (\;)$; $j = \alpha S.\, \gamma\alpha\, (\;)$.

" $\mathbf{c}_2$, $i = \alpha S.\, \gamma\alpha\, (\;) + \beta S.\, \alpha\beta\, (\;)$; $j = \alpha S.\, \beta\gamma\, (\;)$.

" $\mathbf{d}_2$, $i = l_1 S.\, (\;)\, A.\, l_3 l_4 l_1$; $j = l_3 S.\, (\;)\, A.\, l_1 l_2 l_3$.

" $\mathbf{a}_3$, $i = \alpha S.\, \beta\gamma\, (\;) + \beta S.\, \gamma\alpha\, (\;) + \gamma S.\, \alpha\beta\, (\;)$; $j = \alpha S.\, \gamma\alpha\, (\;) + \beta S.\, \alpha\beta\, (\;)$;
$k = \alpha S.\, \alpha\beta\, (\;)$.

" $\mathbf{a}'_3$, $i = \alpha S.\, \beta\gamma\, (\;) + \beta S.\, \gamma\alpha\, (\;)$; $j = \alpha S.\, \gamma\alpha\, (\;)$; $k = \alpha S.\, \alpha\beta\, (\;)$.

" $\mathbf{a}''_3$, $i = -l_1 S.\, (\;)\, A.\, l_3 l_4 l_1 - l_4 S.\, (\;)\, A.\, l_1 l_2 l_3$; $j = -l_1 S.\, (\;)\, A.\, l_3 l_4 l_1$; $k = -l_3 S.\, (\;)\, A.\, l_1 l_2 l_3$.

" $\mathbf{b}_3$, $i = -l_1, S.\, (\;)\, A.\, l_3 l_4 l_1 + l_2 S.\, (\;)\, A.\, l_4 l_1 l_2 - l_3 S.\, (\;)\, A.\, l_1 l_2 l_3$;
$j = l_1 S.\, (\;)\, A.\, l_4 l_1 l_2 - l_2 S.\, (\;)\, A.\, l_1 l_2 l_3$; $k = -l_1 S.\, (\;)\, A.\, l_1 l_2 l_3$.

" $\mathbf{b}'_3$, $i = -l_1 S.\, (\;)\, A.\, l_3 l_4 l_1 + l_2 S.\, (\;)\, A.\, l_4 l_1 l_2$; $j = l_1 S.\, (\;)\, A.\, l_4 l_1 l_2$;
$k = -b_3 l_1 S.\, (\;)\, A.\, l_1 l_2 l_3 + l_4 S.\, (\;)\, A.\, l_4 l_1 l_2$.

" $\mathbf{c}_3$, $i = -l_1 S.\, (\;)\, A.\, l_3 l_4 l_1 + l_2 S.\, (\;)\, A.\, l_4 l_1 l_2$; $j = l_1 S.\, (\;)\, A.\, l_4 l_1 l_2$;
$k = -a\, l_1 S.\, (\;)\, A.\, l_3 l_4 l_1 - l_1 S.\, (\;)\, A.\, l_1 l_2 l_3 + l_4 S.\, (\;)\, A.\, l_4 l_1 l_2$.

" $\mathbf{d}_3$, $i = \beta S.\, \alpha\beta\, (\;)$; $j = \alpha S.\, \alpha\beta\, (\;)$; $k = \alpha S.\, \gamma\alpha\, (\;)$.

" $\mathbf{e}_3$, $i = -l_1 S.\, (\;)\, A.\, l_1 l_2 l_3$; $j = -l_1 S.\, (\;)\, A.\, l\, l_4 l_1 + l_3 S.\, (\;)\, A.\, l_1 l_2 l_3$;
$k - l_1 S.\, (\;)\, A.\, l_4 l_1 l_2 - l_2 S.\, (\;)\, A.\, l_1 l_2 l_3$.

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* $A\; l_2 l_3 l_4 = S.\, V l_2 V l_3 V l_4 - V l_2 . V. V l_3 V l_4 - V l_3 . V. V l_4 V l_2 - V l_4\, V. V l_2 V l_3$.
$S.\, l_1 A.\, l_2 l_3 l_4 = -S.\, l_2\, A.\, l_3 l_4 l_1 \quad S.\, l_3\, A.\, l_4 l_1 l_2 = -S\, l_4\, A.\, l_1 l_2 l_3$.

Algebra g_4, $i = \alpha S.\beta\gamma(\ )$; $j = \alpha S.\gamma\alpha(\ )$; $k = \beta S.\beta\gamma(\ )$; $l = \beta S.\gamma\alpha(\ )$.

" bp_5, $i = l_2 S.(\ ) A.l_4 l_1 l_2 - l_3 S.(\ ) A.l_1 l_2 l_3$; $j = -l_2 S.(\ ) A.l_1 l_2 l_3$; $k = -l_1 S.(\ ) A.l_3 l_4 l_1 - l_3 S.(\ ) A.l_1 l_2 l_3$; $l = l_1 S.(\ ) A.l_4 l_1 l_2$; $m = -l_1 S.(\ ) A.l_1 l_2 l_3$.

" bk_6, $i = l_1 S.(\ ) A.l_2 l_3 l_4 - l_2 S.(\ ) A.l_3 l_4 l_1 + l_3 S.(\ ) A.l_4 l_1 l_2$; $j = -l_1 S.(\ ) A.l_3 l_4 l_1 + l_2 S.(\ ) A.l_4 l_1 l_2$; $k = l_1 S.(\ ) A.l_4 l_1 l_2$; $l = -l_3 S.(\ ) A.l_1 l_2 l_3$; $m = -l_2 S.(\ ) A.l_1 l_2 l_3$; $n = -l_1 S.(\ ) A.l_1 l_2 l_3$.

bm_6, $i = \alpha S.\beta\gamma(\ )$; $j = \alpha S.\gamma\alpha(\ )$; $k = \alpha S.\alpha\beta(\ )$; $l = \beta S.\beta\gamma(\ )$; $m = \beta S.\gamma\alpha(\ )$; $n = \beta S.\alpha\beta(\ )$.

These examples can be used to illustrate the general theorems. For example: "*Every group of linear vector operators contains at least one idempotent or one nilpotent expresssion.*"

The group bm_6 contains the idempotents

$$\alpha S.\beta\gamma(\ ),\quad \beta S.\gamma\alpha(\ ),\quad \alpha S.\beta\gamma(\ ) + \beta S.\gamma\alpha(\ ).$$

The group bp_5 contains only nilpotents.

"*When an algebra contains an idempotent expression it may be assumed as the basis and the remaining expressions are then divisible into four classes.*"

In bm_6 if we assume $\alpha S.\beta\gamma(\ )$ as the idempotent then the units are, with reference to the basis,

idemfaciend, idemfacient, $\alpha S.\beta\gamma(\ )$;
nilfaciend, idemfacient, $\beta S.\beta\gamma(\ )$;
idemfaciend, nilfacient, $\alpha S.\gamma\alpha(\ )$, and $\alpha S.\alpha\beta(\ )$;
nilfaciend, nilfacient, $\beta S.\gamma\alpha(\ )$, and $\beta S.\alpha\beta(\ )$.

"*The fourth class are subject to independent investigation.*"

"*If the first class comprises any units except the basis, there is, besides the basis, another idempotent expression or a nilpotent expression, and we may free the class from this, when idempotent, by writing for the basis the difference between the two; in this case expressions may pass from idemfaciend to nilfaciend or from idemfacient to nilfacient, but not the reverse.*" Thus, if we had taken for our basis in bm_6 $\alpha S.\beta\gamma(\ ) + \beta S.\gamma\alpha(\ )$ there would have been only two classes,

1: $\alpha S.\beta\gamma(\ ) + \beta S.\gamma\alpha(\ )$; $\beta S.\gamma\alpha(\ )$; $\alpha S.\gamma\alpha(\ )$; $\beta S.\beta\gamma(\ )$;
2: $\alpha S.\alpha\beta(\ )$; $\beta S.\alpha\beta(\ )$.

The second idempotent basis is easily seen to be $\beta S.\gamma\alpha(\ )$, and the difference is $\alpha S.\beta\gamma(\ )$, as before. And making this change of basis, $\beta S.\gamma\alpha(\ )$ and $\beta S.\alpha\beta(\ )$ become fourth class, $\beta S.\beta\gamma(\ )$ becomes second class, $\alpha S.\gamma\alpha(\ )$ becomes third class.

"*When there is no idempotent basis, all expressions are nilpotent, and all powers of each expression that do not vanish are independent. We may take any expression as the* *basis, but it is well to select one which has the most powers that do not vanish."* Thus in b_p we take l_2 S. ( ) V. l i l_2 [illegible] l, S. ( ) V. l $l_2 l$, whose square is [illegible] l_2 S. ( ) A. $l_1 l_2 l$, the cube vanishing. This algebra is then of second order. If A, B are any two expressions of it,

$$A^2 B + A B^2 + A B A + B A B = 0.$$

These examples are sufficient to show the use of these forms in interpreting the subject. It remains only to show how they may be applied in a few cases. There are of course for every one of them two fields of application at once suggested by this method of writing them, viz.: linear transformations and homogeneous strains. E. g., the nilpotent algebra d_3. The general expression of this algebra is

$$\varphi = x\,\beta\, S.\,\alpha\,\beta\,(\ ) + \alpha\, S.\,(\,y\, V\,\gamma\,\alpha + z\, V\,\alpha\,\beta)\,(\ ).$$

This transforms $\rho = x_1\,\alpha + y_1\,\beta + z_1\,\gamma$ into

$$\varphi\,\rho = x\, z_1\,\beta + \alpha\,(\,y y_1 + z z_1\,)$$
$$= y y_1\,\alpha + z_1\,(z\,\alpha + x\,\beta).$$

This may represent any point of the plane (α, β). Since the value of x_1 does not enter $\varphi\,\rho$, every straight line parallel to α is made to correspond to a configuration of the (α, β) plane. Those lines parallel to α which cut the (β, γ) plane in a line parallel to β, correspond to a series of configurations of the (α, β) plane produced by slipping it along the direction α. The movement of a line which is parallel to α along a line parallel to the line γ, produces a series of expansions of the (α, β) plane from a point $y\,y_1\alpha$ as center. If both y_1 and z_1 vary, subject to a law, we have the configuration of the (α, β) plane

$$\varphi\,\rho = y y_1\,\alpha + f\,(y_1)\,(z\,\alpha + x\,\beta).$$

Again, consider the algebra a_3. The general expression here, is

$$\varphi = x\,(\alpha\, S.\,\beta\,\gamma\,(\ ) + \beta\, S.\,\gamma\,\alpha\,(\ ) + \gamma\, S.\,\alpha\,\beta\,(\ )\,) + y\,(\alpha\, S.\,\gamma\,\alpha\,(\ ) + \beta\, S.\,\alpha\,\beta\,(\ )\,)$$
$$+ z\,\alpha\, S.\,\alpha\,\beta\,(\ ),$$
$$= \alpha\, S.\,(x\, V\,\beta\,\gamma + y\, V\,\gamma\,\alpha + z\, V\,\alpha\,\beta)\,(\ ) + \beta\, S.\,(x\, V\,\gamma\,\alpha + y\, V\,\alpha\,\beta)\,(\ )$$
$$+ \gamma\, S.\, x\, V\,\alpha\,\beta\,(\ )$$

ρ becomes $\varphi\,\rho = \alpha\,(x x_1 + y y_1 + z z_1) + \beta\,(x y_1 + y z_1) + x z_1\,\gamma.$

This strain operator will convert ρ into any other vector σ, for if

$$\sigma = \xi\,\alpha + \eta\,\beta + \zeta\,\gamma$$

we have at once from

$$\varphi\,\rho = \sigma,$$
$$x x_1 + y y_1 + z z_1 = \xi,$$
$$x y_1 + y z_1 = \eta,$$
$$x z_1 = \zeta.$$

Whence

$$x = \frac{\zeta}{z_1},$$

$$y = \frac{\eta z_1 - \zeta y_1}{z_1^2},$$

$$z = \frac{\xi z_1^2 - \zeta (x_1 z_1 - y_1^2) - \eta y_1 z_1}{z_1^3}.$$

The exceptional cases are where $z_1 = 0$. That is, ϕ can be so chosen as to convert any vector into any other except those lying in the plane of (α, β), which is converted into itself, the line $x_1 \alpha$ being converted into itself. The cubic of ϕ is $(\phi - x)^3 = 0$. We may write $\phi \rho = x \rho + (yy_1 + zz_1) \alpha + yz_1 \beta$.

Hence the effect of any ϕ is to move the terminal point of ρ along its line in either direction, and then slide this extremity along a plane parallel to (α, β). Thus the infinite number of strains, which belong to this infinite group of strains, and that have the same x, represent a group of shears. Space nor time permit a fuller treatment of this interesting line of application of this algebra. The application of the other algebras might similarly be deduced.

I may say in closing that the natural classification of these algebras referred to by Professor Benjamin Peirce, who regarded his own classification as Linnean, is pointed to by these representations of the algebras.

ILLINOIS COLLEGE, Dec. 23, 1895.

VARIATION OF A STANDARD THERMOMETER. BY CHAS. T. KNIPP.

During the term just past I made a number of observations on a standard thermometer. The problem that presented itself was to observe the variations in a standard thermometer under given conditions, and the minimum limit of conditions that would produce the same.

Having a delicate cathetometer at hand, that reads directly to $\frac{1}{50}$ and accurately to $\frac{1}{100}$ of a mm., no hesitancy was felt in making the observations, feeling assured that the slightest variations in the reading of the thermometer could be detected.

The thermometer that was in question was one of Queen & Co's standardized thermometers of the centigrade scale, graduated in tenths over a range of 100 degrees. The bulb is cylindrical in form, thus having a maximum, or tending towards a maximum surface and consequently increased sensitiveness.

The thermometer was tested and standardized by the above named company on the 10th of October. After standardizing it was put in a brass case lined with a rubber tube. The tube is closed at the lower end and is some shorter than the thermometer, so that a little pressure is required to push it in far enough to allow the cap to screw on firmly. This pressure is directly on lower end of bulb, and is more than a person would at first think. By repeated tests I found it equivalent to 240 grams, or a little over a half pound. Such a pressure acting continuously for some length of time would certainly change the shape of the bulb, and consequently the zero mark.

The length of the bulb is 25 mm. Its volume is approximately .3 cu. cm., as near as can be ascertained by measurement of its dimensions. The weight of the thermometer is 43 grams.

On the 16th of November, after a period of five weeks, the pressure was released, the thermometer placed in an ice and water bath and the exact position of the mercury column noted. Observations were made twice per week from that date, the last one being Saturday, December 21. Great care was taken in making these observations. The bulb was placed in an ice and water bath, while the stem for five inches above the zero mark was packed with finely broken ice. The added water was to equalize the pressure on the bulb. An aperture in the side of the vessel, through which passed a tube, the outer end of which guarded by a plane glass window made it possible to readily observe the mercury column, and yet have it completely surrounded with ice. Each observation extended over a period of three hours. To guard against jarring, the cathetometer and vessel holding the thermometer were placed on a stone pier.

The apparatus was allowed to stand for one hour before taking a reading, after which readings were taken every half hour. It was observed that when great accuracy was expected, all of an hour is required as the glass is very slow to take up the temperature of the melting ice and adjust itself accordingly, while the mercury takes up the temperature in a very few minutes. The first readings, therefore, are always too low. Before taking a reading the stem was jarred to facilitate the adjustment of the mercury. To prevent radiation the vessel was covered with a towel. After putting ice in the vessel it was thoroughly washed with distilled water. This last precaution was at first overlooked and the result was that the readings were far too low, *i. e.*, the melting mixture was made colder by its containing foreign substances.

We would naturally expect that the pressure on the lower end of the bulb would considerably change its size, and that a pressure of over a half pound could not continue long without considerably altering the size, volume and accuracy of the thermometer. In the case under discussion the volume of the bulb would be increased by pressure on lower end. Also since the length of the bulb is 25 mm.

and only 4 mm. in diameter it would stand a greater strain before yielding than it would were it any other shape.

Considering it as above, the first reading would naturally be expected to be a mimimum, for as the volume of the bulb is a maximum the mercury stands lowest in the stem, and the readings on subsequent observations would increase until a fairly stationary point is reached, indicating that the bulb has regained its normal volume.

The first reading taken Saturday, November 16th, showed the thermometer to be in error 0.1479°. The second reading taken on the following Wednesday was 0.1528°. The third, taken on the following Saturday, was 0.1540°, and the fourth, taken on Wednesday, November 24th, was 0.1553°. These readings are each the mean of four and five separate observations. They show a gradual increase in the length of the mercury column which is in direct accordance with what was first expected, *i. e.*, that the pressure on the bottom of the bulb would increase the size of the same and which in consequence would lower the mercury column.

The part that seems strange to me, and that I can assign no direct reason for, is the behavior of the seven subsequent readings that were taken extending over a period of three and one-half weeks. The fifth reading shows a slight decrease, and so also does the sixth reading show a decrease compared with the fifth, after which it oscillated, as it were, about a mean of 0.1493°. The greatest deviation above this mean being .0036, and the greatest below .0026 of a degree.

It was found that the position in which the thermometer was kept had no appreciable effect upon its readings.

Graphical Representation of the Law of Falling Bodies.

By F. P. Stauffer.

[Abstract.]

It was shown that by subdividing a right-angled triangle by lines parallel to the hypotenuse and the sides into similar smaller triangles, the following could be graphically represented—the distance traversed each second, the velocity at the end of each second, the effect of gravity each second.

Rates of Combustion in Locomotive Furnaces. By R. A. Smart.

The following brief comparisons of the rates of combustion in locomotive and stationary furnaces, based upon data of tests made at the Purdue University Locomotive Testing Plant, will show some of the effects of the heavy duty which the limitations of space and the requirements of portability impose upon locomotive boilers.

In stationary boiler plants, the usual rate of combustion is between the limits of 8 to 20 pounds of coal per square foot of grate surface per hour. From the record of the rate of combustion of over half a hundred boilers tested by Geo. H. Barrns, a well known expert, an average of 11.5 pounds per foot of grate was found, which may be taken as representing good practice. Under certain conditions of speed and cut-off, it has been found that the Purdue locomotive, "Schenectady," which is a fair representative of its class, consumes 2,670 pounds of coal per hour, while developing 520 indicated horse power. To consume this quantity of coal economically at the rate given above would require a grate area of 232 square feet. Taking 8 feet as the extreme allowable width, this would give a furnace 29 feet long, which is of course much beyond the limits of available space. As the furnace of the Purdue locomotive has, however, only 17.5 square feet of grate surface, instead of 232, the rate of combustion under the conditions mentioned above reaches the abnormal figure of 153 pounds per square foot per hour.

It has been stated by Isherwood that the evaporative efficiency of horizontal return tubular boilers of ordinary design decreases as the rate of combustion increases, and if this holds in stationary practice it may be taken, in a measure, as applying to locomotive practice. From this it is apparent that where only 17.5 square feet of grate surface are provided to consume a quantity of coal requiring over 200 square feet for economical combustion, thereby raising the rate of combustion from 11.5 to 153 pounds per square foot, the evaporative efficiency will necessarily be low.

This extraordinary rapidity of combustion is still more striking when compared with the conditions existing in an open fireplace. For instance, the rate of combustion in an ordinary parlor grate is about 4 pounds per hour to the square foot. At this rate it would require a grate equal in area to that of a room 26 feet square to consume the coal burned during the tests mentioned.

Other comparisons may be made as follows: Stationary boilers are usually allowed about 12 square feet of heating surface per horse power developed, while the total heating surface of "Schenectady," about 1,200 square feet, allows, under ordinary conditions, 4 square feet to the horse power, and under extreme conditions, but 2 square feet.

The draft in a stationary plant having a chimney 50 feet high is less than 0.5 of an inch of water. The locomotive frequently runs under a draft as heavy as six inches, making it necessary for the fireman to keep a very thick fire on the grates.

With such great differences existing between the conditions apparently required by economy and those actually found in locomotive practice, it would be expected that the evaporative efficiency of the latter would be small by comparison. It is interesting to note, however, that in spite of the disadvantages under which the locomotive labors, its evaporation is seldom less than 50% of the best evaporation given by stationary plants.

The Influence of Heat, the Electric Current and Magnetism Upon Young's Modulus. Mary Chilton Noyes.

A series of experiments were carried out in the physical laboratory of Western Reserve University to determine the effects of heat, of an electric current and of magnetism upon the elasticity of piano wire, and of copper and silver wire. The wires were heated by means of an electric current from a storage battery, the current sometimes going through a magnetizing helix surrounding the wires, sometimes through a non-inductive coil, and sometimes through the wires themselves. The methods of heating were used in different order with different pieces of wire, in order to detect, if possible, any temporary or permanent effect which was not due to the heat, but no such effect could be found.

The thermal co-efficient of elasticity for the piano wire was found to be 4.6% for 100°. For the silver wire it was about 8% and for the two specimens of copper wire tested 13% and 7%. The permanent change in elasticity produced by repeatedly heating the wires was from one to two per cent.

With the silver and copper wires the effect of heat upon the elastic limit was determined. The limit was found to decrease quite rapidly and regularly as the temperature was raised. The two specimens of copper wire tested were found to give quite different results for the thermal co-efficient of elasticity, the co-efficient of expansion and the co-efficient of decrease in the elastic limit with rise of temperature.

The Surface Tension of Liquids. By Arthur L. Foley.

Although many methods of measuring the surface tension of liquids have been proposed and used, its absolute value is not known in a single instance. Various experimenters by various methods have obtained various results; these results differing from one another in many cases by as much as fifty per cent. For instance, Quincke, for the surface tension of water at 0°C, has obtained the following results by the methods named:

1. By measuring the rise of water at a vertical wall he obtained 8.7 mgm. per mm.

2. By measuring the axis of a bubble of air in the interior of a liquid, 8.2 mgm.

3. By the rise of water in capillary tubes, 7.6 mgm.

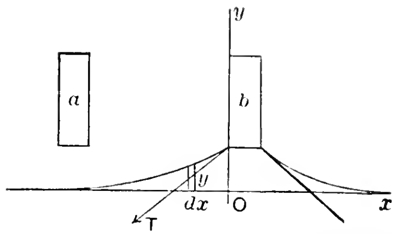
4. By measuring the size of falling drops, 6.5 mgm.

These results show an average variation of about ten per cent., and a difference between the first and last of thirty-four per cent. Many other methods have been used, but the results obtained are not more consistent than those given above. The method generally used, and that which probably gives as consistent results as any yet proposed, is the method of capillary tubes. But even if we restrict ourselves to this one method, and to the results obtained by a single experimenter, we find that they differ considerably. Let us again note the results obtained by Quincke—than whom there is no better authority upon this subject. In Wiedeman's Annalen, April, 1894, Quincke gives values ranging from 7.69 to 8.16 mgm. per mm. for different sizes of tubes made from the same specimen of Jena glass; and values from 7.8 to 8.1 for English flint glass. In the October number of the Annalen, 1894, Volkmann gives as widely different results for various specimens of glass. The age of the tube is found to influence the height to which the water rises in it. So it would seem that a better method of measuring the surface tension of liquids is greatly to be desired.

In the "Philosophical Magazine" of November, 1893, Mr. T. Proctor Hall describes some "New Methods of Measuring the Surface Tension of Liquids." Two years ago at the suggestion of Professor Michelson of the Chicago University, I undertook to repeat and to extend the investigation. In the present article, I shall confine myself to a brief statement of the results obtained by using Mr. Hall's method *c*, the maximum-weight method.[1]

[1] Philosophical Magazine, November, 1893, p. 402.

Fig 1



Let a (Fig. 1) be an end face of a rectangular parallelopiped suspended from one arm of a balance, with its lower face horizontal, and therefore parallel to the liquid surface OX. Call w' the weight of the frame (block) in this position. Lower the frame until it touches the liquid, and bring it again to the first position, as in b. The weight of the frame is now increased by the weight of the liquid raised above the level surface. As the frame is raised, the weight increases for a time then suddenly decreases, passing through a distinct maximum. Call w'' the total maximum weight. The net maximum weight is

$$w = w'' - w' = 2T\sin\alpha + \rho t y, \tag{1}$$

where T = the surface tension in grams per centimeter;

- α = the angle between the X-axis and the tangent to the liquid surface at the edge of the frame;
- t = the thickness of the frame;
- ρ = the density of the liquid;
- y = the height of the frame above the liquid surface;
- l = the length of the frame, one centimeter.

Also,

$$T\sin\alpha = \rho\int_{-\infty}^{0} y\,dx. \tag{2}$$

$$\frac{dx}{d\alpha} = -\frac{T\cos\alpha}{\rho y}.$$

Placing $c^2 = \frac{T}{\rho}$, and remembering that $\frac{dy}{dx} = \tan\alpha$,

$$\frac{dy}{d\alpha} = -\frac{c^2\sin\alpha}{y};$$

$$y^2 = -2c^2\cos\alpha + k.$$

When $y = 0$, $\alpha = 0$, and $k = 2c^2$.

$$\therefore y = 2c\sqrt{\frac{1-\cos\alpha}{2}} = 2c\sin\frac{\alpha}{2}$$

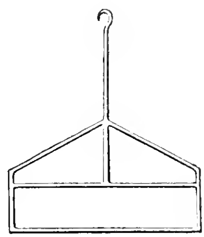
4

$$\cos\frac{\alpha}{2}=\sqrt{\frac{4c^2-y^2}{4c^2}}; \qquad (4)$$

$$\cos\alpha=\frac{2c^2-y^2}{2c^2}. \qquad (5)$$

Let us now suppose that the frame has vertical legs (as in Fig. 2) extending downward into the liquid. Let l be the length between the legs.

Fig 2



Equation (1) becomes

$$w = 2T(l-t)\sin\alpha + \rho t l y, \qquad (6)$$
$$= 2\rho c^2(l-t)\sin\alpha + 2lt\rho c\sin\frac{\alpha}{2}.$$

When w is a maximum, $\frac{dw}{d\alpha}=0$. Let t be very small compared with l, then

$$2c\cos\alpha + t\cos\frac{\alpha}{2}=0.$$

Eliminating α by (4) and (5), and inserting the value of c,

$$y=\sqrt{\frac{2T}{\rho}-\frac{t^2}{8}-t\sqrt{\frac{64}{t^2}+\frac{2\rho}{T}}}.$$

When t is small, a near approximation is

$$y=\sqrt{\frac{2T}{\rho}}. \qquad (7)$$

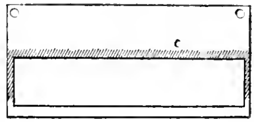
Supplying this value of y in (6), and solving for T,

$$T=\frac{w}{2(l-t)}+\frac{\rho l^2t^2}{4(l-t)^2}-\frac{lt}{4(l-t)^2}\sqrt{\rho^2l^2t^2+4w(l-t)\rho}. \qquad (8)$$

Table II gives the value of T calculated by the above formula for mica frames varying in thickness from 0.0013 cm. to 0.02067 cm.

Mr. Hall in his investigation used glass frames (made of cylindrical glass rods) of the shape indicated in Fig. 3. He deduced for them equations correspond-

Fig 3



ing to (6), (7) and (8). He admits, however, that these equations are so complicated as to be almost unmanageable, and that the correction is obtained more easily by determining the constants of a frame by using frames of different length and of the same diameter, and again of the same length but of different diameters. It is very difficult indeed to make such frames, and to use them after they are made.

The chief objections to glass frames may be summed up as follows:

The value of y, and hence the correction that must be applied to the maximum weight in order to obtain the true film weight which measures the tension, depends in a very complicated way upon the diameters of the rods of the frame.

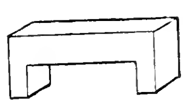
This correction forms a considerable part of the total maximum weight (see Table I.). Frames can not be made sufficiently rigid and less than 0.03 cm. in diameter. Hence the correction is at least ten per cent. of the whole.

The frames are difficult to make and they require delicate handling at every stage.

With cylindrical end rods the actual length of the film surface is uncertain.

It occurred to me that these troublesome corrections and inaccuracies might be partially avoided by using a different kind of frame. After experimenting with frames of various materials, among which I may mention thin sheet glass, platinum, aluminum and mica, I found that the latter offered decided advantages over glass. The general shape of the mica frame is given in Fig. 4. The frame is supported by a forked glass stem, and the method of using is exactly as with a glass frame.

Fig 4



My first frames were made by cutting the mica sheet as it lay under a steel rule upon a piece of plate glass. I afterwards had made two heavy steel plates of the exact shape of the frame desired. The inner surface of each plate was ground plane with emery dust upon plate glass. A sheet of mica was clamped between them and cut to their dimensions. The advantages of frames made in this way are:

The steel plates are accurately ground; the frames are correspondingly regular.

The mica does not split along the cut edge.

The edge is of the same thickness as the plate itself; there is no bur. Very thin frames are easily made, but it is difficult to work with them when they are much less than 0.002 cm. thick.

A difficulty experienced with the mica frame, as also with those of platinum and aluminum, is that the fluid does not readily and equally wet all portions of the surface. It has a tendency to collect in drops, rendering the after-weighing uncertain. This difficulty was entirely overcome by roughing the surface (darkened in Fig. 4) of the plate near the edge by rubbing very lightly with the finest French emery paper. Both weights could then be taken again and again with a variation of only a few hundredths of a milligram.

The advantages claimed for the mica frame are as follows:

1. They are easily made, and do not require careful handling.

2. They are of even thickness, with straight edges and square corners. Hence the film length is not so uncertain as with glass frames.

3. They can be made less than one-tenth of the thickness of a glass frame, reducing the correction correspondingly. Table 1 gives the relative corrections for glass and mica frames, obtained by determining the maximum weight for a soap solution, and then weighing the film itself. The film weight divided by twice the length of the frame gives the surface-tension. But with many liquids it is impossible to obtain the film weight, as the film breaks immediately after it is formed. The maximum weight can be determined in almost every case, and the film weight by correction. It is evident that a slight error in the value of this correction will be lessened by reducing the total correction, as is done by using the mica frame.

TABLE I.

Kind of Frame.	l	t	w	Film Weight.	Per cent. Difference.
Glass	6.346	0.0405	0.39226	0.34100	15
Glass	7.584	0.0510	0.48283	0.40302	19
Glass	10.163	0.0620	0.65420	0.53700	21
Glass	7.475	0.0920	0.52480	0.39660	32
Mica	6.012	0.0030	0.31202	0.30697	1.6
Mica	5.301	0.0051	0.27776	0.27092	2.5
Mica	5.140	0.0079	0.27222	0.26260	3.7

A fresh solution was used in the last three measurements.

4. The correction varies directly as the thickness of the frame, Fig. 5. Observations with two frames of varying thickness are sufficient to determine the actual film weight and hence the tension.

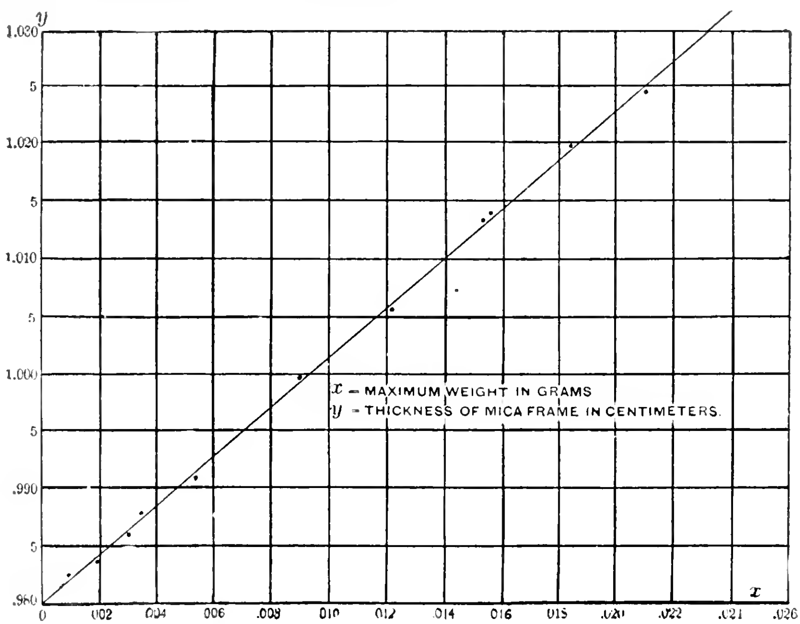


Fig 5

5. In the case of thin frames the tension can be determined at once from the maximum weight uncorrected, with results that vary less than do those obtained by the method of capillary tubes. For example, compare Table II with Table III, the latter giving selected results obtained by Quincke by the capillary tube method.[1]

TABLE II.

t	w	T by formula. $T=\frac{w}{2l}$	T by equation (8)	Temperature of Water.
0.00130 cm.	0.98260 g.	0.07396	0.07365	20°.7 C.
0.00190	0.98420	0.07408	0.07374	20°.7
0.00352	0.98791	0.07437	0.07372	20°.7
0.00516	0.99094	0.07458	0.07365	20°.7
0.00928	0.99991	0.07527	0.07352	20°.8
0.01206	1.00592	0.07572	0.07355	20°.8
0.01536	1.01358	0.07630	0.07345	20°.9
0.01828	1.01973	0.07676	0.07339	21°.0
0.02067	1.02468	0.07713	0.07332	21°.0

TABLE III.

(TEMPERATURE 18°.)

Kind of glass.	Diameter of tube.	Age of tube.	T
Common Jena glass	0.5832	0 hr.	0.07528
Common Jena glass	0.5851	24 hrs.	0.07336
English flint glass	0.6390	2 mos.	0.07490
English flint glass	0.5740	0 hr.	0.07411
Fusible (soft) Jena glass	0.6440	0 hr.	0.07258
Fusible (soft) Jena glass	0.9106	12 hrs.	0.07480

6. As y and t are small, a small error in the assumed value of p will not appreciably affect the calculated value of T, Eq. (6).

y being small, the film is much narrower than with a glass frame. Therefore there is less temperature change due to evaporation from the film surface and less absorption of gases and impurities from the air.

[1] Weidemann's Annalen, No. 5, 1894, p. 14.

7. The equations for x and y are not so complex that they can not be used. In Table II are given the values of T deduced by formula (8). It will be noted that the last frame is about sixteen times as thick as the first, yet the greatest difference in these values is but a little more than one part in two hundred. Of the results for the first four frames, the greatest difference is one part in seven thousand. The thicker frames can not be expected to give such consistent results, as the water tends to creep in between the thin layers of which the mica sheet is made up.

The Temperature Coefficient.

Previous determinations of the temperature coefficient of surface tension give results not more consistent than the values obtained for the tension itself. Brunner gives the coefficient as .14 dynes per degree, and Merian as .253 dynes. The latter result is almost double the former. Other observers give intermediate values. In view of these differences, I concluded to make a determination of the temperature coefficient by the mica frame maximum weight method. This investigation is not yet completed, so I shall not go into detail.

I am using a Troemner balance, No. 5, easily sensitive to one one-hundredth milligram. The arrangement of the balance and box or closet is very much the same as in Hall's experiment. Inside the wooden box I have a double-walled tin box, open on the side next the glass door. The space between the walls of the tin vessel (the walls being about two inches apart) may be filled with a bath to regulate the temperature of the enclosure. This temperature is obtained by reading three thermometers, placed in different positions. A rotary fan is used to equalize the temperature throughout the enclosure. It is arranged so that the water whose coefficient is to be determined is siphoned in and out of the vessel inside, without opening the door or disturbing the balance.

I have tried four methods of regulating the temperature of the enclosure. A current of air from a blower giving a very constant pressure was passed through an iron pipe heated by from one to a dozen Bunsen burners, and then through the tin box. By varying the air supply and the number of burners, a fairly constant temperature could be maintained. But I was not able to raise it above 50°. I next tried a water bath, the water being heated in a tube outside, but connected with the box—somewhat upon the principle of an incubator. I could easily maintain any desired temperature between 0° and 70°. But for higher temperatures I found that the convective circulation of the water was too slow to prevent the water in the tube from boiling. I substituted oil for water, but I was not able to extend my observations above 80°.

By far the most satisfactory method is to fill in between the walls of the tin box with mineral wool, and to use wire coils and an electric current to heat the enclosure.

In the earlier part of my work I used distilled water from the Chemical Laboratory. Subsequent tests showed that it contained considerable organic matter. I am now using water which has been distilled three times in glass; once with permanganate of potassium to remove organic matter. My observations range from 0° to 80°, and cover a period of four months.

Briefly, my conclusions are as follows:

Between 0° and 80° the temperature coefficient curve is concave toward the x axis, when we use tensions as ordinates and temperatures as abscissas. This coefficient increases with the temperature, its value being about .17 dynes.

The formula usually used to represent the tension (T) at any temperature (t°) is

$$T_t = T_0 - .14\, t^\circ.$$

I find that the tension can not be expressed as a linear equation, and that .14 dynes is too low for the average temperature coefficient.

Much of my work so far has been toward perfecting the method and my apparatus. I am now making some observations, using exceedingly thin mica frames, and standardized thermometers reading to one one-hundredth of a degree. For temperatures below 0° I shall use the method described by Messrs. Humphreys and Mohler in the "Physical Review," March-April, 1895. I shall endeavor to extend my observations above 100° by using the capillary tube method, the water and tubes being enclosed in an air-tight plate glass box and under whatever pressure is necessary to maintain the desired temperature without boiling the water.

Physical Laboratory, Indiana University, December, 1895.

Strains in Steam Machinery. By W. F. M. Goss.

Masses of metal when of considerable strength and weight would appear to be proof against distortion under the influence of any force which may be brought to bear upon them. We think of the *strength* of metals, but it is not often that we consider their elastic property, yet, physically speaking, nothing, probably, is more elastic than steel. A piano wire, if tightly strung, increases its length, and if loosened again it contracts. Within certain limits it behaves precisely like a spring. When force is applied it stretches, and when the force is withdrawn it recovers itself again. If the force is considerable, change in the length of the wire may be easily observed; with a less force it will not be so apparent but still measurable, and, finally logic requires us to believe that if the force applied and withdrawn is infinitely small, there will still be a change in the length of the wire acted upon.

That which is true of a wire is equally true of all masses of metal of whatever proportion. A cube of steel may resist an enormous load tending to crush it, and yet the application of a slight force effects a decrease in its height. The change in form under light loads is certainly small, but actual. nevertheless. That which is true of steel is, in a general sense, equally true of wrought and cast irons, and, in fact, metals of every sort.

The machine designer, therefore, can not, as some suppose, make the several parts of his machine so strong that they will remain fixed in form, but he must choose rather so to distribute the metal with reference to the stresses to be transmitted, that the change in form which is sure to occur, will not interfere with the action of the proposed machine.

Some years ago the writer became interested in tests involving a measurement of the strain, that is the change in form, of various parts of steam engines, parts supposedly invariable, while the engines were being worked under load. The apparatus employed consisted of a fine micrometer screw mounted upon a frame work wholly apart from the engine and having no connection with it, but so arranged that the screw could be brought in contact with the part to be examined. In making observations, one terminal wire from a telephone receiver was attached to the part of the engine which was under examination, and the other terminal from the telephone to the micrometer; the observer placed the telephone to his ear, and slowly screwed the micrometer in towards the desired point on the engine. If the part of the engine in question was in vibration it first touched the point of the advancing screw for an instant for each oscillation, the contact being made manifest to the observer by a sharp click in the telephone as the circuit was made and broken again. This fixed one boundary by which the amplitude of the vibration was to be determined. Next the micrometer was advanced towards the engine until the screw did not break contact with the machines, a condition which was denoted by a cessation of sound in the telephone, while for all intermediate points the clicking in the receiver kept time with the revolutions of the engine. It was assumed that this last position of the micrometer marked the other boundary of the vibration. The difference of the two readings of the micrometer gave the amplitude of the vibrations, or the extent of the motion in the part examined. A large number of readings from several parts of two engines in the Laboratory of Purdue University were taken by Mr. Adam Herzog, B. M. E., a summary of which is as follows:

First, measurements were taken from a 15 x 24 Corliss engine; this machine has unusually massive parts, the frame being a heavy girder, and the whole being mounted in an excellent manner upon a deep foundation. Observations were made while the engine was developing only 35 horse-power with an initial steam pressure of 80 pounds. The head end of the cylinder was found to move in a horizontal direction with every revolution of the engine, a distance of 0.009 of an inch; the frame over the guides moved in a vertical direction 0.014 of an inch, and the pillow block castings in a horizontal direction 0.030 inches.

Secondly, measurements from a 14x16 engine, having a modification of the box-bed, mounted upon a substantial foundation, capped by a single stone of massive size. The details of the engine are heavy and well designed. Its center line, however, is considerably above the line of resistance offered by the bed. Observations were taken during a time when the engine was running under an initial pressure of only 40 pounds and while developing only 14 horse-power, which is less than half its rated power. The head end of the cylinder was found to move horizontally 0.018″, and the top of the cylinder at the flange on the crank end to move vertically 0.022″.

These vibrations, while taking place with every stroke of the engines, would not ordinarily have been detected with the eye, and were not accompanied by any shock or other manifestation which would indicate their presence. The measurements will serve to show to what extent the heavy fixed parts of well-designed machines may move under the influence of the forces which they are designed to resist, and they emphasize the necessity for a distribution of the metal which will give strength in direct line with the stresses to be transmitted.

Viscosity of a Polarized Dielectric. By A. Wilmer Duff.

[Abstract.]

Very few observations of mechanical actions produced in liquid dielectrics by electro-static stress have been made. Faraday found that fibres of silk in the liquid set themselves along the lines of force. Quincke thought he had detected an alteration of volume, but his results have been doubted. König tried to find a variation of viscosity by finding the rate of flow through a capillary tube placed between charged plates, but failed. A limit was set to the accuracy of his method by the difficulty of maintaining the tube at a constant temperature.

The author has sought a variation of viscosity by observing the rate of descent of small drops of mercury through castor oil, which served as the dielectric n a plate condenser. The condenser consisted of a tall, glass tank, the middle part of which served as a condenser, tin-foil being glued to the middle half of the outsides of the glass plates. To eliminate temperature effects the ratio of the time of descent through the condenser part of the tank to the time of descent through the non-condenser part, the condenser being uncharged, was compared with the ratio similarly obtained when the condenser was charged. In this way any change of temperature affecting the whole tank may be eliminated. To further eliminate any variation affecting different parts of the tank unequally, a long series of readings was taken with the condenser alternately charged and uncharged; and each ratio obtained with the condenser charged was compared with the mean of the adjacent ratios obtained with the condenser uncharged. The experiment was performed in a cellar of fairly constant temperature, temperative effects being thus almost perfectly eliminated; long series of readings made as described showed invariable increases of viscosity on the application of electro-static stress. The variation of viscosity seemed to be dependent rather on a non-uniform or varying electro-static field than on a steady field. Castor oil and glycerine showed an increase of viscosity.

As the above method could only be applied to very viscous liquids, the author also constructed an analogous apparatus on the capillary tube principle suitable for mobile liquids. It consisted of a capillary tube placed vertically between condenser plates, and connected above to a large tube with four constrictions in it dividing it off into three compartments. The times of emptying of the compartments by flow through the capillary tube were observed, the condenser being first uncharged during the emptying of the middle chamber and then charged. If the ratio of the time of emptying of the middle chamber to the sum of the times of emptying of the other two be taken, the condenser being uncharged, and compared wi h the ratio similarly obtained, the condenser being charged, a method free from temperature effects is again obtained for detecting a viscosity variation. In this way it was found that under a varying electro-static field, carbon di-sulphide showed an increase of viscosity and paraffine oil a decrease.

The above methods are being applied to other liquids, and a determination of the law of variation of the effect discovered under varying strengths of electrostatic field will be made later.

On the Alternating Current Dynamo. By W. E. Goldsborough.

Consider the case of a simple alternator having but one armature coil that rotates in a magnetic field of uniform intensity about an axis at right angles to the direction of the lines of force. If successive instants of time during one revolution of the coil are counted from the instant that the coil passes a line drawn through its axis of rotation and perpendicular to both the axis of rotation and the direction of the magnetic flux, the value of the induction piercing the coil at any instant during one cycle is expressed by the equation

$$N = N_{max} \cos wt, \qquad (1)$$

in which N_{max} equals that portion of the flux that passes through the coil at the instant the plane of the coil is at right angles to the direction of the lines of force and w represents its angular velocity. The instantaneous value of the E. M. F. generated in the coil will be, by Faraday's law

$$e = -\frac{dN}{dt} = w N_{max} \sin wt,$$

$$= E \sin wt \qquad (2)$$

since its maximum value

$$E = w N_{max} \qquad (3)$$

If the coil is closed through a circuit of resistance R_1, inductance L_1 and capacity C_1, the resistance and inductance of the coil itself being R and L respectively a current i will begin to circulate and we can write the equation of E. M. Fs. of the circuit in the form

$$e = (R + R_1)\, i + (L + L_1)\frac{di}{dt} + \int\frac{idt}{C_1}.$$

From this expression we can derive the equation of the current in terms of the constants of the circuit and the maximum value of the E. M. F. developed in the coil and obtain

$$i = \frac{E}{\sqrt{[R + R_1]^2 + [\frac{1}{C_1 w} - (L + L_1)w]^2}}$$

$$\sin\left\{wt - \tan^{-1}\left[\frac{1}{C_1 w(R + R_1)} - \frac{(L + L_1)w}{R + R_1}\right]\right\} \qquad (4)$$

which expresses the instantaneous value of i as soon as a condition of cyclic stability has been attained.

Equations (1), (2) and (4) are the general equations that cover the working of alternating current dynamos; they have been subjected to graphical analysis, the results of which are exhibited in the figure opposite page 80, and are discussed in the following paragraphs:

Suppose a circuit in which the inductance is zero, the capacity infinite and the resistance variable, to be subjected to the influence of a simple harmonic E. M. F. that is generated by an alternator having a constant armature inductance for all values of armature current, a constant field excitation and a constant speed. Under these conditions the virtual value of the E. M. F. at the brushes of the alternator just before the circuit is closed will be.—

$$\overline{E} = w \, N_{max} \div \sqrt{2} \; ; \tag{5}$$

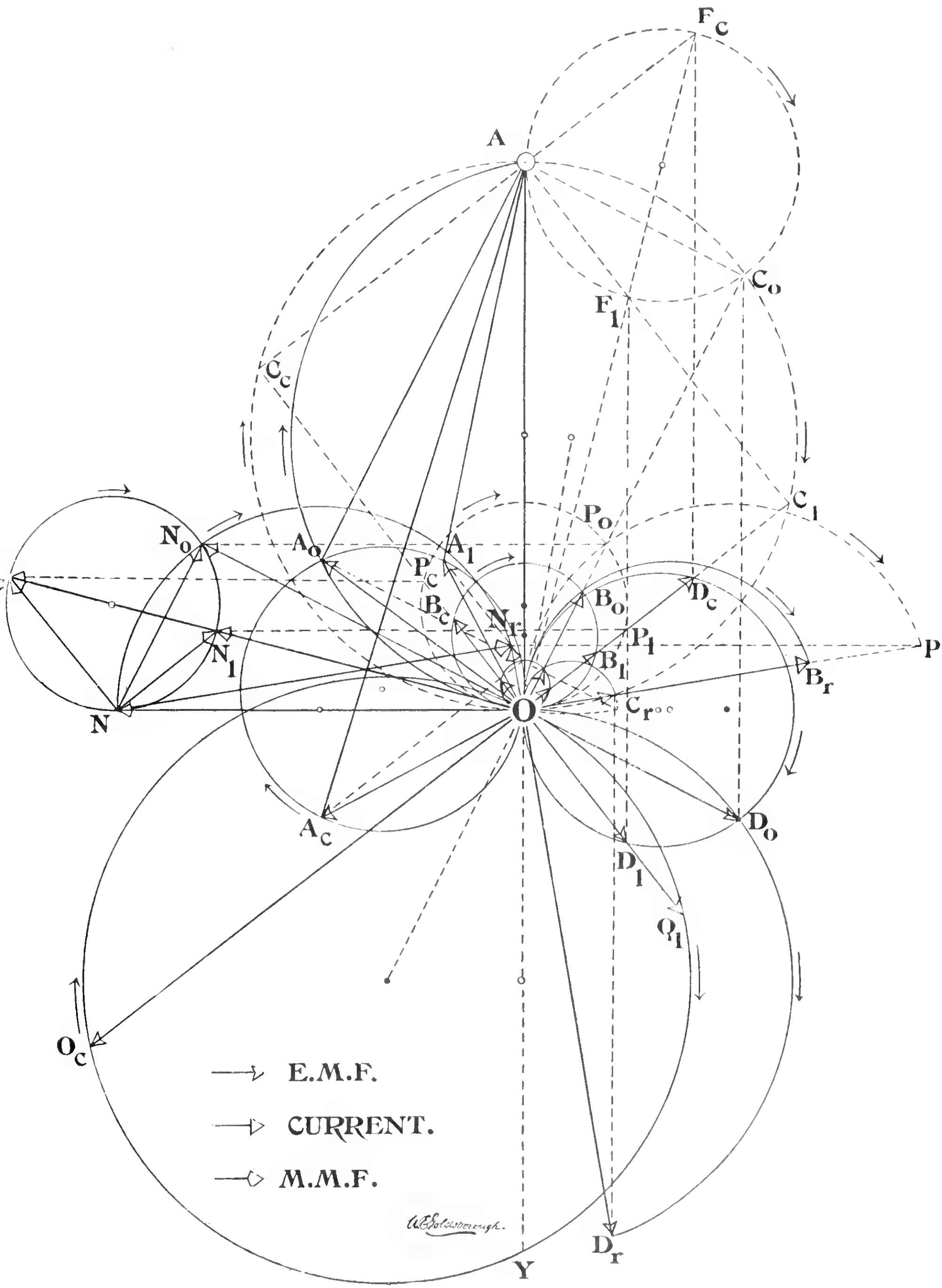
which is represented by the vector OA in the figure. The vector ON is laid off at right angles to OA to represent the value of the M. M. F. producing N_{max}. It is drawn 90° in advance of the E. M. F. it induces in accordance with the relation exhibited in equations (1) and (2). At the time of closing the circuit suppose the external variable non-inductive resistance to have a value R_1, and that the constant armature resistance has a value R and the constant armature inductance a value L. Then the equation of the current will assume the form:

$$i = \frac{E}{\sqrt{(R + R_1)^2 + L^2 w^2}} \sin \left[wt - \tan^{-1} \frac{Lw}{R + R_1} \right] \tag{6}$$

and its virtual value—

$$\overline{I} = \frac{\overline{E}}{\sqrt{(R + R_1)^2 + L^2 w^2}} \tag{7}$$

which we can represent by the vector OB_o lagging $\tan^{-1} \frac{Lw}{R + R_1}$ degrees behind OA. This armature current will react upon the magnetizing forces due to the constant field excitation, and by virtue of the inductance of the armature will produce an M. M. F. in phase with itself which is represented by the vector NN_o, drawn parallel to the current vector from the positive extremity of ON. This armature M. M. F. sets up a cyclic magnetization developing a counter E. M. F. OD_o lagging 90° degrees behind the current, and there is a loss of effective E. M. F. due to the armature resistance that is shown by the short E. M. F. vector in phase with OB_o, therefore the total loss of E. M. F. in the armature will be the resultant of these two vectors or OA_o. The effective E. M. F. that overcomes the resistance of the non-inductive external circuit will be the vector A_oA, since it completes the E. M. F. triangle on OA and is in phase with the current



F c
A
C o
F 1
C c
C 1
P o
N o
A o
A 1
P c
N c
B o
D c
B c
N r
P 1
P
N 1
B 1
B r
C r
O
N
A c
D o
D 1
Q 1
O c
E.M.F.
CURRENT.
M.M.F.
D r
Y

OB_o. The total effective E. M. F (OC_o) that overcomes the total ohmic resistance $(R + R_1)$ of the circuit, is due to the cyclic magnetization set up by the M. M. F. vector ON_o. ON_o is the resultant of ON and NN_o and as shown by the geometry of the figure it is 90° in advance of the current, and therefore of A_oA, as it should be. The projection of NN_o on ON is the component of the armature M. M. F. that acts against the field magnetization, *i. e.*, it is *a measure of the armature reaction.* The projection of NN_o on OA is likewise a measure of the cross-magnetizing action of the armature.

Having constructed the initial diagram we can now follow out what takes place when the resistance of the external circuit is varied. Suppose R_1 is reduced to a value R_r. The current vector head B_o will move out along the semicircle OB_oB_r until equilibrium is again established in the circuit by the current reaching its maximum possible value under the new conditions.* The vectors OA and ON retaining their positions, all the other vectors involved will reach their final values corresponding to the new current by following the arcs of the circles passing through their positive extremities to the positions designated by the common subscript letter (r). The correctness of the variations indicated can be readily verified by an inspection of the geometry of the figure in connection with equation (7).

In the present case R_1 has been reduced to zero; in other words the subscripts (r) indicate what takes place when a machine whose armature inductance is large, as well as constant, is short circuited. A_o moves up to A, and the E. M. F. at the brushes is zero. The current assumes an angle of lag of almost 90° behind the total internal armature E. M. F. OA, the *armature reaction* almost counterbalances the M.M.F. of the fields, and the resultant M. M. F. ON_r is just sufficient to develop the E. M. F. OC_r that overcomes the resistance of the armature.

Returning to the initial conditions, suppose we increase the value of L_1 from zero to some value L_l, *i. e.*, suppose we introduce inductance into the external circuit. The virtual value of the current will then be expressed by the equation

$$\bar{I} = \frac{\bar{E}}{\sqrt{(R + R_1)^2 + (L + L_l)^2 \omega^2}} \qquad (8)$$

and it will lag behind the internal E. M. F. $\bar{E}$ or OA, by an angle

*See Bedell and Crehore's Alternating Currents, page 223.

$$\varphi = \tan^{-1}\left(\frac{L + L_1}{R + R_1} w\right). \qquad (9)$$

Referring to the figure, the new positions assumed by the variable vectors, owing to the introduction of L_1, are designated by the subscript letter (1). The current will decrease and its vector head move along the circle $OB_cB_oB_1O$ until a state of equilibrium exists between the forces involved. The E. M. F. that overcomes the resistance and inductance of the armature will decrease also and move to the position OA_1, its vector head following the circle $OA_cA_oA_1O$, and the E. M. F. at the collector rings will first decrease and then increase to a final value A_1A. The introduction of inductance into the external circuit brings the E. M. F. at the collector rings and the total internal E. M. F. (OA) more nearly into phase; it, however, causes a lag angle F_1OB_1 to be introduced between the collector E. M. F. and the current. The inductance E. M. F. of the armature decreases along the circle $OD_cD_oD_1O$ to a value OD_1 and the inductance E. M. F. of the external circuit increases from zero along the circle YQ_cOQ_1Y to a value OQ_1. The resultant M. M. F. will be ON_1, and it is seen that while the armature reaction has remained very nearly constant the cross-magnetizing effect has been reduced about 50 per cent.

From our initial conditions as indicated by the subscript letter (o) we can also study the effects produced by the introduction of capacity into the external circuit. If the value of C_1 is reduced from infinity to some value C_c, the virtual value of the current will change to

$$\bar{I} = \frac{\bar{E}}{\sqrt{(R + R_1)^2 + \left(\frac{1}{C_c w} - Lw\right)^2}} \qquad (10)$$

and the angle between OA and the current will have a value

$$\varphi = \tan^{-1}\left[\frac{1}{(R + R_1)C_c w} - \frac{Lw}{(R + R_1)}\right] \qquad (11)$$

In consequence of this change the current vector will assume the position OB_c and the other variable vectors will move to their corresponding positions shown by the subscript letter (c). The current in its new position is not only in advance of the E. M. F. (A_cO) at the brushes, but is also in advance of the E. M. F. OA, since it has moved from B_o to a maximum value when passing OA, and then decreased in value.[1]

1. See Bedell and Crehore's Alternating Currents, p. 297.

The collector E. M. F., on the other hand, steadily increases as the capacity decreases till it reaches a value A_eA much greater than the open circuit E. M. F. of the machine. A resonant effect comes into play here after the capacity of the line neutralizes the inductance of the armature that is very well illustrated by the figure: the line A_eA will be a maximum when it passes from A through the center of the circle $OA_eA_0A_1O$, and will represent the greatest difference of potential that can possibly exist between the brushes so long as R and R_1 remain unchanged in value. This rise in potential is due to the current being in *advance* of the vector OA, for the position of the armature M. M. F. vector is also advanced, and NN_e increases the total flux in the air-gap instead of diminishing it. The cross-magnetizing action of the armature, however, remains approximately the same.

The introduction of capacity into the line causes the inductance E. M. F. of the armature to move to the position D_e, and the reactance E. M. F. of the external circuit to decrease through zero and then increasing, assume a position Q_eO, considerably in advance of the collector E. M. F., and 90° in advance of the current OB_e.

The arrows indicate the relative direction of motion of the vectors as the resistance is varied from infinity to zero, or as the reactance is carried from zero capacity to an infinite inductance.

By following out a similar line of constructions the effects produced by variations of the armature inductance can be studied, and by successfully varying the resistance, inductance, capacity and frequency constants, and constructing corresponding diagrams, a large variety of problems involving the simultaneous variation of several terms can be successfully treated.

A Method of Measuring Permeability. By A. Wilmer Duff.

[Abstract.]

The most common method of measuring the permeability of iron, or the ratio in which the presence of iron strengthens the magnetic field, is to make a ring of the specimen, cover it with two layers of wire, one connected with a source of current to magnetize the ring, the other with a ballistic galvanometer to measure the quantity of electricity induced in this secondary coil by making or breaking the primary current. The galvanometer is calibrated by means of a straight calibrating coil consisting of a non-magnetic core similarly wound with a primary

and secondary. Then from the various dimensions of the ring and the calibrating coil as regards number of turns of the primary and secondary, cross-section and length of core, intensity of primary currents and throws of the galvanometer, the permeability of the specimen can be calculated.

The objections to the above method are the tediousness of observing the constants (about a dozen in all) and making the calculation therefrom, and, further, the inaccuracies involved in assuming the areas of windings and core to be the same, in neglecting the difference in closeness of winding between the inside and outside of the ring, etc.

For the last two years the author has recommended the following method to his students. An exact non-magnetic copy of the ring specimen is made in the form of a plaster of Paris cast therefrom. This cast is wound precisely similarly to the iron ring. The permeability is then simply the ratio of the throws given by the iron ring and the plaster of Paris ring on making or breaking equal currents in the primaries. The calculations are thus greatly simplified and the inaccuracies involved in the above mentioned assumptions are greatly reduced and can be completely eliminated by winding the primaries and secondaries in alternate turns on the core. It is not claimed that by this method the galvanometer is more exactly calibrated, but it is calibrated under the exact conditions under which the actual measurements on the specimen of iron are made. It is calibrated, in fact, by the actual windings on the ring specimen, the iron core being replaced by a non-magnetic core.

With a view to testing the sum total of the errors inherent in the ordinary ring method, simultaneous determinations of the permeability of the same specimen were made by the two methods. It was found that the total error involved in the use of the ordinary calibrating coil was often large, amounting in some cases to as much as thirty-eight per cent.

Empirical Formula for the Temperature Variation of Viscosity. By A. Wilmer Duff.

[Abstract.]

A careful determination was made of the viscosity of glycerine between zero and thirty degrees. The method employed depended on Stokes' formula for the rate of descent of a sphere through a viscous liquid. Several different forms of formula have been proposed for the representation of this temperature variation. It was shown that none of these would apply throughout a wide range of

temperature variation. By plotting a curve of the sub-tangent of the viscosity-temperature curve against the temperature, a subsidiary curve was formed which should, in all the types of formula proposed, be a straight line, but which turned out to be a parabola. On determining the constants of the parabolic equation and integrating this to obtain the equation of the viscosity-temperature curve, a formula was deduced which represented the experimental results to within the limits of experimental accuracy. This formula was an exponential one, the exponent being the inverse tangent of a linear function of the temperature. Reasons were given for believing that this would represent the temperature variation of the viscosity of any liquid.

THE EFFECT OF GRAPE-SUGAR UPON THE COMPOSITION OF CERTAIN FAT-PRODUCING BACTERIA. BY ROBERT E. LYONS.

It has been observed by Dr. E. Cramer* and others† in studies upon the composition of bacteria, that the same micro-organism grown upon Peptom and Grape-sugar Agar-Agar produces in each case different quantities of nitrogenous substances and matter which is soluble in alcohol and ether.

In this same direction Ducleaux‡ demonstrated that yeast cells grown upon a material containing grape-sugar produced fat, while the same yeast grown upon pure nitrogenous material did not produce fat.

To study how grape-sugar affects the quantities formed of nitrogen, ash, fat and matter to be extracted by means of alcohol and ether, three varieties of capsule bacilli were selected:

Pfeiffers' Capsule Bacillus.
 Fadenziehender Capsule Bacillus.
 No. 28 Capsule Bacillus.

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*Dr. E. Cramer—"Zusammensetzung der Bacterien in ihrer Abhängigkeit von dem Nährmaterial." Arch. für Hygiene—*16*, 151-191.

†Tayosaka-Nishimura—"Zusammensetzung eines Wasserbacillus." Arch. für Hygiene *18*, 318-333.

‡Ducleaux—"Sur la nutrition interacellulaive." Ann. de l'Institute Pasteur—1889 No. 8, p. 413.

Fadenziehender and No. 28 are forms from the water of the River Lahn, near Mosbourg.

The culture medium employed was a neutral 1 per cent. meat extract, agar agar, with the addition of varying quantities of grape-sugar, 1, 5 and 10 per cent., respectively.

The agar was prepared in an autoclave after the method of v. Meyer & Buchner and every care taken in each preparation to obtain as uniform a material as possible.

To control the uniformity of the various preparations, estimations were made from time to time of the solids (105° C.) in the nutrient media, for example:

10 cc. 1 % grape-sugar agar = 0.369 grm. Residue.
10 cc. " " " = 0.383 " "
10 cc. " " " = 0.374 " "

To grow the organisms agar agar plates were inoculated with a fresh bouillon culture, by means of a roll of thin platinum foil and within a moist chamber placed in the thermostat at 37.°5 C.

At the expiration of 48 hours the purity of the culture was controlled and the bacteria-mass carefully removed with a scalpel and dried in a vacuum over sulphuric acid.

Dr. F. Smith (1) maintains that the presence of grape-sugar in the culture medium causes an increased production of gas and acids.

However, when the drying operation was conducted in the apparatus of Arzberger & Zulkowsky, connected with a condenser, the presence of acid in the distillate could not be demonstrated.

The gas production varied, as the amount of sugar, and the odor of ethylic alcohol was always present, but the odor of the fatty acids was never encountered.

That volatile acids are formed during the growth of the cultures, under the conditions given, could not be demonstrated.

The material dried finally at 105° C. was subjected to analysis.

Estimation of ash:
" " Nitrogen (Kjeldahl N×6.25=nitrogenous substances.
" " Ether extract (Soxhelet's app., 48 hours.)
" " Alcohol extract (Soxhelet's app., 90 hours.)

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(1) Dr. F. Smith—"Bedeutung des Zuckers. in Kultur Medien." Centralblatt für Bact. u. Parsit 18, 1–s. 1.

		1 per cent. Grape-sugar Agar Agar.	5 per cent. Grape-sugar Agar Agar.	10 per cent. Grape-sugar Agar Agar.
Pfeiffer	N. Subst.	62.75	58.88	45.88
	Ether Extr.	1.68	3.50	2.67
	Alcohol Extr.	12.17	17.30	29.60
	Ash	7.16	2.97	3.09
	Total	83.76	82.65	81.24
No. 28	N. Subst.	71.81	59.12	46.25
	Ether Extr.	3.32	3.84	2.84
	Alcohol Extr.	11.39	15.91	22.78
	Ash	6.51	3.66	4.18
	Total	93.03	82.53	76.05
Fadenziehender	N. Subst.	61.05	44.31	33.25
	Ether Extr.	1.75	2.24	1.87
	Alcohol Extr.	18.40	21.80	27.50
	Ash	8.09	4.50	3.02
	Total	89.29	72.85	65.64

On examination of the table it is seen that a constant decrease in nitrogenous substances of the bacteria-mass accompanies the increasing per cent. of sugar in the culture medium.

Whether or not the total nitrogen consists in part of albumen-nitrogen, or in part of extract-nitrogen; and, further, if the extracted nitrogenous substances contain a lower per cent. of nitrogen than the albumen of the bacteria, can not as yet be determined owing to the very small amount of material.

The increase in the quantity of extract matter goes hand in hand with the increasing per cent. of sugar in the agar agar.

For the matter soluble in ether this is true only to five per cent. grape-sugar; at ten per cent. sugar the maximum production of fat seems to have been attained.

In this connection it is interesting to observe the relationship between the ether extract and the ash.

A decrease in the ash and an increase of fat corresponds to five per cent. sugar and to ten per cent., vice versa.

It might seem that the apparent increase in fat was due wholly or in part to the relative decrease in the ash.

It is readily seen that this is not the case by calculating the per cent., excluding the ash; on the contrary, the three forms studied produce more matter soluble in ether and alcohol when they are grown upon media with a high per cent. sugar than when they are grown upon such containing a lower per cent. sugar.

Briefly stated the results of the investigation are:

1. The quantity of nitrogenous material is inversely proportioned to the quantity of sugar present.

2. To a certain limit the increase of sugar is accompanied by a decided increase in the quantity of fat.

At ten per cent. sugar the most favorable conditions for fat production appear to be overstepped.

3. Matter soluble in alcohol increases constantly with the increasing per cent. of sugar.

A New Method for the Preparation of Phenyl-Compounds With Sulphur, Selenium and Tellurium. By Robert E. Lyons.

The very great similarity between the compounds of sulphur, selenium and tellurium was observed by Frederick Woehler and other chemists of his time.

To trace this similarity further I was led to attempt preparing certain bodies to fill up the gaps between the known compounds of the organic radicals, methyl, ethyl and phenyl, with sulphur, selenium and tellurium.

C. Chabrie* gives the results of several years' study of aromatic compounds of selenium prepared after the Friedel-Crafts' reaction, but this method in my hands did not lead to satisfactory results.

On the other hand, the method proposed by Drs. F. Krafft and W. Vorster,† *i. e.*, the replacement of the SO_2 group in the sulfone by sulphur or selenium:

$$C_6H_5.\,SO_2.\,C_6H_5 + S = C_6H_5.\,S.\,C_6H_5 + SO_2.$$

Diphenylsulfone. Diphenylsulfid.

was easily carried out and afforded 60-70 per cent. of the theoretical amount.

As excellent as this method is for the preparation of sulphur and selenium compounds, it was nevertheless found, that the sulfobenzid, even after prolonged heating with powdered tellurium, remained unchanged.

Tellurium dichloride. $Te\,Cl_2$, was next prepared in the hope that through its action upon mercury diphenyl, $Hg\,(C_6H_5)_2$, the diphenyltelluride would be obtained according to the following reaction:

$$C_6H_5.\,Hg.\,C_6H_5 + Te\,Cl_2 = C_6H_5.\,Te.\,C_6H_5 + HgCl_2.$$

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* Ann. de Chemie et de Physique. **VI** sirie t. **XX**. p. 202–286 (1890); also, Compt. rend. **109**. 182 et 568 (1889).

† Berichte der Deutschen Chem. Gesell. 26. 2813.

However, the reaction did not take place according to the above equation, but the tellurium and the mercury combined in the final reaction, with the formation of monochlorbenzene.

$$(C_6 H_5)_2 Hg + Te Cl_2 = 2C_6 H_5 Cl + Hg Te.$$

From this change I was led to expect the formation of the desired body, Diphenyltellurid, by the double decomposition of Diphenyl-mercury, by means of metallic tellurium alone—and the expectation was happily confirmed by experiment.

$$(C_6 H_5) Hg + Te_2 = C_6 H_5 Te C_6 H_5 + Hg Te.$$

If tellurium and mercury-diphenyl in the proportions by weight indicated by the equation be heated together in a sealed tube filled with CO_2 gas, 4–5 hours, at a temperature of 200° Cent., there results a grayish black crystalline mass, saturated with a thick, heavy oil.

This oil, by extraction with ether and purification by rectification, was found to be Diphenyltellurid, 78 per cent. of the theoretical quantity.

Thus I succeeded in preparing the, till then unknown, diphenyltellurid.

The method is a general one.

Dreher and Otto* studied the action of sulphur upon mercury-diphenyl and were of the opinion that diphenyl-sulphide was formed only at a *red heat*.

However, the corresponding sulphides and telsurides may be obtained with the greatest ease by heating mercury-diphenyl with sulphur or selenium to 200° C. under the conditions given.

Camphoric Acid. By W. A. Noyes.

In a paper presented to the Academy last year two acids, which were called cis-campholytic acid and cis-transcampholytic acid were described. The cis-campholytic acid has now been reduced and a dihydro acid obtained from which the α-brom derivative has been prepared. This, on treatment with alcoh lic potash yields the cis-campholytic acid again, thus proving conclusively that the double union in the latter is in the β position.

Xylyllic acid, $C_6 H_3 \begin{cases} CH_3 & 1. \\ CH_3 & 3. \\ CO_2 H & 4. \end{cases}$ has been reduced by means of amyl alcohol and sodium and the α-brom derivative of the hexahydro acid obtained, was prepared. The latter, on treatment with alcoholic potash, does not give either of the

* Berichte der Deutschen Chems., Gesell, 2. 543.

campholytic acids. This furnishes quite conclusive proof that the formula for camphor proposed by Armstrong* is not correct.

The preparation of the acid, $C_6 H_3 \begin{cases} CH_3 & 1. \\ CO_2\ H & 2. \\ CH_3 & 3.7 \end{cases}$ has been undertaken and by a study of its derivatives it is hoped to secure proof of the truth or falsity of Collie's† formula for camphoric acid.

Note on Milk Inspection. By Geo. W. Benton.

The milk supply of cities is becoming a matter of scientific interest. Formerly milk sophistication consisted of skimming or watering or both. More recently various well authenticated rumors of the employment of chemists in the preparation of adulterants, and the marketing of preparations which enables the creamery to substitute foreign fats for milk fats have caused increased attention and greater care in their examination. The inspector, devoid of scientific skill, relies upon the lactoscope, the lactometer, the hydrometer and the Babcock machine, instruments sufficiently accurate and reliable for the cases of skimming and watering for which they were made, but entirely unreliable when taken alone in the detection of the preparations made by chemists for the express purpose of deceiving those using the instruments.

In my two years' experience in the work of milk analysis, abundant evidence of the untrustworthiness of ordinary inspection came to my notice. Besides the watered and skimmed milk, samples of pure cream, common herd and Jersey milk, were passed upon and pronounced suspicious by the ordinary methods in the hands of the inspector. And, finally, it became necessary, in view of the fabrications employed, to do away with such tests, and subject everything to a more searching examination, as the only sure way to get at the truth.

A case in point came under my observation in December, 1892, as follows:

An inspector brought in a sample of milk which, by his testing instruments, gave evidence of being rich, but the appearance, on close examination, was not in strict conformity with the other indications, and he submitted it for analysis. Results attained were as follows, the data taken from my notes made at the time:

A careful physical examination showed the milk to be abnormally thick for milk, but not for cream. A portion, on standing several hours, failed to show a

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* Ber. d. Chem. Ges. (16. 2260.)

† Ibid. 25, 1116.

cream separation, although there was evidence of an oil separation, lacking only the true color of cream. No artificial color had been used.

The further analysis was as follows:

	Per cent.
Sp. G. at 60° C.	1.024
Water, by evaporation	80.30
Solids, by evaporation	19.70
Solids, by the Lactometer (N. Y.)	13.50
Fats, by Feser's Lactoscope	5.00
Fats, by extraction	4.95
Solids, not fat	14.75

By some oversight the ash, if taken, was not recorded. Absence of a record in this instance would indicate that the ash was not abnormal, as it was my invariable custom to take it. No effort was made to determine the nature of the solids not fat, as the purpose of the analysis was not to determine the kind, but the extent of the sophistication, and, at the time, a press of work prevented my taking up the matter from scientific interests.

The microscope confirmed the indications already observed. The familiar milk-fat corpuscles were almost wholly absent, and in their stead was a mass of irregular fatty bodies, twenty-five to fifty times the size of milk-fat corpuscles, whose appearance suggested some vegetable oil admixture, possibly cotton-seed. Consideration of the results shows that the addition of a little coloring matter would have placed the milk beyond the reach of ordinary inspection methods, while the determination of solids and the microscope proved conclusively a skillful adulteration. It will be noted that the lactometer failed to detect the abnormal solids, as it depends for its data upon Sp. G., while the lactoscope and extraction processes showed about five per cent. of fat, which the microscope proved to be almost wholly foreign to milk.

My own experiments, confirmed by many others, show that milk solids are among the least variable factors in milk analysis, as the average milk containing 3.5 per cent. of milk fat is nearly always found to contain about 12.5 per cent. of solids, while Jersey milk with 4.5 to 5.0 per cent. of fats never exceeds 14.5 per cent. of solids. It will be observed, that the milk referred to gave 19.7 per cent. of solids and nearly 5.0 per cent. of a substituted oil.

As long as milk inspection is confined to the use of instruments in the hands of unskilled inspectors, the dishonest creamery, backed up by professional chemical skill, will continue to furnish a cheap, fabricated article, which savors less and less of its reputed origin and character.

INDIANAPOLIS, Dec. 2, 1895.

RATIO OF ALCOHOL TO YEAST IN FERMENTATION. BY KATHERINE E. GOLDEN.

Fermentation is, essentially, the breaking up of chemical compounds into simpler and more stable compounds. Some form of fermentation goes on in all living cells, the nature of the fermentation and the resulting products depending on the organism and the body fermented. The results may be simple, as, for example, where a single organism is used, or complex where a number of organisms are working together. Where a single organism is used, the predominating resulting product gives the fermentation its name.

In the alcoholic fermentation, besides the alcohol are formed CO_2, succinic acid, glycerine and a number of by-products, the nature and quantity of which depend on the orgenism, and the conditions under which it is grown. Beers and wines depend mainly on these by-products for their aroma and special character, so that experimenters, using the same kind of grape, have obtained many different wines; the same way for beers, using the same wort, but varying the yeast, different beers are obtained. Even from apple must good wines have been produced, by the use of certain yeast cultures. Again, mixing certain yeasts in the brewing, characteristics are obtained which are impossible with a single form. Large breweries now have competent bacteriologists, who seem to the uninitiated, to be able to manipulate their yeasts, molds and bacteria much as a juggler does his implements.

Yeast is the organism most commonly used to induce the alcoholic fermentation, though it can be induced also by certain bacteria and molds. The yeast which is used in brewing is S. cerevisiæ, there being two well marked varieties, the cerevisiæ, which produces top fermentation, and that which produces bottom fermentation. Top yeast works at a comparatively high temperature, the action is rapid, and the yeast rises to the surface of the liquid; this is used in the brewing of ale and porter. Bottom yeast works at a low temperature, the action is slow, and the yeast is at the bottom of the liquid; the bottom yeast is used in the brewing of lager beer.

Wort, which is the basis of beer, is made in the following manner: First there is the malting of the grain, which consists of the germination; then the stoppage of the germination by heat. The first stages are for the purpose of changing the chemical constitution of the grain; diastase is developed from the albuminoid matter; the diastase then acts on the starch, changing it to maltose and dextrine. When this development has reached the proper point, the germ is killed by drying. The grain is then cleaned and crushed and placed in warm water to allow the diastase to act still further on the starch, the completion of this process being determined by the iodine test. The solution is then drawn off and boiled, hops being added. The hops give to the beer a bitter taste, besides aiding in its keeping; they also, by means of their tannic acid, facilitate the coagulation of the protein material, which is going on by means of the boiling. The wort is then cooled rapidly, after which it is ready for fermentation.

There are different methods used by manufacturers in the fermenting of the wort, but by whatever method there are always three stages into which the fermentation can be divided: the *main fermentation*, which begins in a short time after the yeast is added, during which time the maltose is decomposed, new yeast cells are formed and a rise in temperature takes place; the *after fermentation* is the next stage; maltose continues to be decomposed, the formation of yeast cells nearly ceases, the yeast settles and the beer clears; the last stage is the *still fermentation*, maltose is still decomposed, dextrine is changed into maltose, but no new yeast cells are formed. The *main fermentation* lasts from four to eight days; the other stages vary in time, and are controlled by changing the conditions.

In the experiments which I made the study was on the main fermentation, and was to determine the ratio between the amount of alcohol and the number of yeast cells formed. Wort, that was ready for fermenting, was obtained from one of the breweries, filtered, then placed in flasks, and sterilized by the fractional sterilization method. Two litres were used in a flask. Pure yeast, which had been separated from a compressed cake by the Hansen orientation method, was used; a colony, which had been grown from a single cell, was placed in 5cc. of wort in a test tube, and allowed to remain there twenty-four hours. This quantity was then added to the wort in the flask. This corresponds to the method employed in breweries, where a quantity of yeast is first grown in a small amount of wort; this quantity, called "pitching yeast," then added to the main quantity that is wanted for beer. After the addition of the pitching yeast, the flask was shaken thoroughly, and 1 cc. taken out with a sterilized pipette, for the purpose of counting the yeast cells. To the 1 cc. was added 1 cc. dilute H_2SO_4 for preventing further growth of yeast, and also for dilution. The wort was kept in a constant temperature oven at 25°c., this being a temperature at which the yeast grows vigorously.

At the end of every twenty-four hours for seven days the flask containing the wort was shaken vigorously for some time, so as to distribute the yeast cells thoroughly, then 1 cc. taken in the manner described, and also 200 cc. for determining the alcohol. The alcohol was estimated by direct distillation; 100 cc. was distilled over, then an accurately tared pycnometer of 50 cc. capacity used for the weighing. When the temperature varied from 15.5°c., Allen's formula for correcting the density was used. $D = D' + d\ (.00014 + \frac{1-D}{150})$ D = required density; D' = observed density; d = difference in temperature between 15.5°c. and observed temperature.

After the specific gravity of the distillate was obtained, Allen's tables were used for determining the per cent. of absolute alcohol.

The apparatus for counting the yeast cells was made by taking a thin strip of brass, cutting an oblong hole through it, then cementing a strip of glass to one side of it, and using a similar strip for a cover on the other side. This gave a chamber of known dimensions, so that when the yeast liquid was placed in it the thickness of the layer was known. To obtain the other two dimensions, a micrometer having small squares engraved on it was placed in the eye-piece of the microscope, and the value, with a system of lenses then determined. The cell contents of a number of these squares were counted, and the average obtained. To determine the number of squares to be counted, countings and determinations were made until the number obtained had no influence on the average. This number of squares was then used on duplicate samples:

ALCOHOL.

No.	*Hours.*	*Sp. gr. alc.*	*Per cent. abs. alc. by wt.*	*Per cent. inc. alc. per day.*
1.	24	.9915	2.41	
2.	48	.98498	4.60	2.19
3.	72	.984215	4.89	.29
4.	96	.98337	5.22	.33
5.	120	.98297	5.405	.185
6.	144	.98277	5.500	.095
7.	168	.9826	5.575	.075

YEAST.

No.	*Hours.*	*No. cells in .02 c. mm.*	*Increase per day.*
1.	½	1.9	
2.	24	36.5	34.6
3.	48	55.6	19.1
4.	72	74.8	19.2
5.	96	95.6	20.8
6.	120	107.1	11.5
7.	144	112.6	5.5
8.	168	118.2	5.6

The table shows clearly that as the yeast cells increased in number the quantity of alcohol also increased in a nearly corresponding degree, so that, taking the results at the end of twenty-four hours, there is a direct ratio between the two. During the first twelve hours this does not hold good, as during approximately that period there is a large growth of yeast, but no apparent fermentation, as is evidenced by the lack of gas given off. For this reason the time between the "pitching," or inoculation of the wort, and the beginning of active fermentation is called the "incubation" period.

Thanks are due to Mr. W. H. Test for assistance rendered in the work.

The Circulation of Protoplasm in the Manubrium of Chara—Chara Fragilis. By D. W. Dennis.

About the middle of May last Mr. Omer Davis, a student in the Biological Laboratory, at Earlham, while studying the fertilization of Chara Fragilis noticed that the nucleus of the manubrium traveled rapidly around the periphery of the cell, with the circulating protoplasm. The phenomenon was subsequently noticed by all the members of a class of eighteen, and the attention of many other persons was called to it, some of whom were familiar with many of the phenomena of moving protoplasm in the leaves of Chara, the stamen hairs of Tradescantia and in other stock illustrations, it astonished all alike. The circuits of the nucleus were timed by Mr. Davis and myself, and found to range from 15, when the phenomenon was first noticed, to 26, something like a half hour later in a minute.

The circuit of this particular cell was not measured, but a measurement of a large number of cells later convinces me that it could not have been less than five-eighteenths of a mm. This gives a rate of 7.2 millimeters in a minute, or more than four times as fast as the fastest rate given in Goodale's Physiological Botany for protoplasm in a closed cell. I reported these facts to Prof. Barnes, who said they were, so far as he could learn, entirely new, and he asked me to prepare the matter for publication in the "Botanical Gazette." Early ni June I began what I hoped to make an exhaustive study of the phenomenon for this purpose, but could not find a single case in which the motion was going forward. Disintegration had taken place in most of the cells, and in all the motion had stopped. The phenomenon seems, therefore, to be one connected with the growth and maturation of the cell in which it occurs. All I can say is that next May we shall permit nothing to interfere with the most exhaustive study we can give to the phenomenon. The observation requires no skill except what is necessary to find the male organs of reproduction at the right time, and crush them under the coverglass and recognize the manubrium. If nothing else comes of it it can not fail to add one, and that one the most striking and one of the most easily attainable of all, to the stock illustrations of the circulation of protoplasm.

FUNGICIDES FOR THE PREVENTION OF CORN SMUT. BY WM. STUART.

During the present century the disease of the corn popularly known as "corn smut" (*Ustilago zea-mays*, [*DC.*] *Wint.*) has engaged the attention of some of its most eminent botanists. It has only been within the last half of the present century that the life history of the fungus has been well understood. When we consider that corn is the principal cereal crop of America, it is not to be wondered at that any fungus disease causing it much apparent injury should arouse a desire on the part of investigators to devise some means of preventing it.

The successful treatment of the smuts of wheat and oats by disinfection of the seed, either by hot water or chemical solutions, naturally turned the attention of Experiment Station workers to employing the same remedies for the smut of corn. The experiments of Arthur,[1] of Indiana, Kellerman and Swingle,[2] of Kansas, and those of Pammel and Stewart,[3] of Iowa, are perhaps the most noteworthy. These experiments included the disinfection of the seed by hot water and chemical solutions; the attempted infection of the seed by rolling in the spores of the smut; and the spraying of the plants with fungicides, the latter experiment being conducted by the Kansas Experiment Station[4] in 1890. The results of all these experiments were of a negative character, due to the fact that the fungus plant of the corn smut, unlike that of wheat and oats, can enter any young growing tissue of the host, while in the last two mentioned it can only enter the host when it is very young. This point has been ably demonstrated by Brefeld,[5] who, by a long series of carefully conducted experiments, showed conclusively that the germinating spores, or conidia, are capable of penetrating any portion of the young

[1]Fourth Annual Report Indiana Experiment Station.

[2]Kansas Experiment Station Bulletins, Nos. 22, 23, 40, 41.

[3]Iowa Experiment Station Bulletins Nos. 16, 20, Proceedings of Iowa Academy of Sciences, 1894, p. 74.

[4]Kansas Bulletin No. 23, p. 101.

[5]Journal of Mycology, Vol. VI, Nos. I, II, and IV. (Translated from Nachrichten aus dem Klub der Landwirthe zu Berlin, Nos. 220, 222, by Erwin Smith.)

growing tissue of the host. It would therefore follow that the growing corn plants are susceptible to infection during the greater part of their growth, or until the fertilization of the pistils.

Realizing the importance of ascertaining some method for the prevention of the smut, the botanical department of the Indiana Experiment Station undertook, during the past season (1895), to carry out an experiment having as its main object the spraying of the plants with the best known fungicides. A portion of one of the Station cornfields was set aside for the experiment. In order to avoid any possibility of infection through smutted seed, a portion of the seed was treated with a copper sulphate solution, another with an ammoniacal copper carbonate solution, and a third with hot water, while a fourth portion was infected with germinating smut spores. The experimental plat was divided into five sections, as follows:

Section I. Seed untreated.

Section II. Seed treated with copper sulphate solution one-half hour.

Section III. Seed treated with ammoniacal copper carbonate solution one hour.

Section IV. Seed treated with hot water at 60° C. for five minutes.

Section V. Seed dipped in a nutrient solution containing germinating smut spores.

The plat was planted May 18th, and on June 8th when the plants were about six inches high, two cross sections containing five rows each were sprayed by means of a knapsack sprayer, the one with Bordeaux mixture and the other with ammoniacal copper carbonate. This divided the plat into twenty-five lesser ones, as will be seen by the following diagram:

1	6	11	16	21	Sec. I.
2	7	12	17	22	Sec. II.
3	8	13	18	23	Sec. III.
4	9	14	19	24	Sec. IV.
5	10	15	20	25	Sec. V.

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The strength of the Bordeaux solution consisted of six pounds of copper sulphate, four pounds of lime and fifty gallons of water, while that of the ammoniacal copper carbonate consisted of one ounce of copper carbonate dissolved in ammonia and diluted with nine gallons of water. The latter solution proved too strong, some of the plants showing considerable injury two days afterwards. Subsequent sprayings were made with a much weaker solution.

The plats were sprayed quite frequently during June. In July, owing to the absence of the writer during the early part of the month, and frequent showers during the middle part of it, the sprayings were somewhat interrupted. The partial failure of the fungicides in completely preventing the smut may be largely attributed to these facts:

On July 20th some injury to the plants from the Bordeaux was noted, and for the remaining sprayings the strength of the solution was reduced one-third. The last spraying was made August 14th, the plants being then supposed to be too mature for infection.

The dates of spraying were as follows:

Bordeaux.	Ammoniacal Copper Carbonate.
June 8	June 8
	June 12
June 13	June 13
June 17	June 17
	June 19
June 21	June 21
June 27	June 27
July 5	July 5
July 20	July 20
July 25	July 25
August 3	August 3
August 14	August 14

Just previous to harvesting the crop a careful record of the number of smutted stalks was made and gave the following percentages of smutted stalks:

Unsprayed plants .... 13.37 per cent.

Those sprayed with Bordeaux .... 3.83 per cent.

Those sprayed with ammoniacal copper carbonate, 6.72 per cent.

It will be readily seen from the above figures that there is a marked difference in the amount of smut between the sprayed and unsprayed plats.

SUMMARY.

The results of this experiment show conclusively:

That the Bordeaux mixture, properly applied to the plants during their period of growth, does materially lessen the smut.

That the ammoniacal copper carbonate was not as effective as the Bordeaux in preventing the smut.

That frequent applications of the fungicides are necessary during the growing period of the plant in order to be effective.

A NEW STATION FOR PLEODORINA CALIFORNICA SHAW. BY SEVERANCE BURRAGE.

During an investigation of the sanitary condition of the Wabash and Erie Canal as it runs through Lafayette, made in the laboratories at Purdue in September of the present year, *Pleodorina* was found in considerable abundance in the canal water. This comparatively new member of the *Volvox* family was first described by Walter R. Shaw, of Leland Stanford University, who found the plant in a ditch in Palo Alto in September, 1893 ("Botanical Gazette," Vol. 19, p. 279). Since then D. M. Mottier has reported it in Bloomington, Indiana, in May, 1894, and Messrs. Clinton and Burrill in Havana, Illinois ("Botanical Gazette," Vol. 19, p. 383), in June of the same year. It is now possible to add another station in Indiana, namely, Lafayette.

The microscopical examinations were made according to the Sedgwick-Rafter method, which has been used for several years by the Massachusetts State Board of Health in the enumeration of microscopical organisms, exclusive of bacteria, in water supplies. The average number of *Pleodorina* in one cubic centimeter of the canal water was four. The census of other organisms found in the same samples included, on the vegetable side, *Hydrodiction*, *Chara*, and *Spirogyra*, too large and abundant to enumerate; *Diatoms*, per cubic centimeter, eight; *Oscillaria*, fifty-six; *Anabaena*, three; *Scenedesmus*, one; *Protococcus*, eight; *Crenothrix*, ten; *Pandorina*, one; *mold hyphae*, three; and, on the animal side, principally *infusoria*, as *Peridinium*, two hundred and ninety-six; *Monas*, four; *Trachelomonas*, three; *Dinobryon*, three; and a few *Rotifera* and *Acarina*. The water was quite turbid, and had the general appearance of dilute sewage, and in fact the water of the canal was evidently polluted. This shows the nature of the water in which *Pleodorina* seems to flourish in Lafayette, and also many of its companions.

But, aside from the interest attached to this new genus of the *Volvocinae* from the botanical point of view, it may be found to have important relations to odors and tastes in water supplies, when it will become the enemy of engineers and water commissioners, as other members of this group have done before. For example, *Volvox globator* has caused much trouble in Rochester, N. Y., by imparting a disagreeable fishy odor to the city water supply, and in Massachusetts *Pandorina* and *Eudorina* have caused similar troubles on a smaller scale. *Pleodorina*, coming as it does between *Volvox* and *Eudorina* in the classification, may be looked upon with suspicion in this respect, if it ever infects a water supply in a sufficient quantity. On account of the filthy condition of the canal water in which it was found in Lafayette, and the number of other forms growing with it, no idea could be formed as to the nature of the odor, if any, of *Pleodorina*.

Forms of Xanthium Canadense and X. strumarium. By J. C. Arthur.

In the absence of the author the outline of the paper was presented by Mr. Wm. Stuart and photographs of the two species were shown. The species in their most typical forms differ widely in the outline of the leaf and character and size of the burs. *X. Canadense* has a flowing sub-entire outline to the leaf, and large, strongly hispid fruit covered thickly with prickles, while *X. strumarium* has dentate leaves and smaller glabrous fruit with fewer prickles. All gradations exist between the two types, due possibly to hybridization.

Notes on Wood Shrinkage. By M. J. Golden.

The increase or diminution in size of a piece of wood, due to its possession of a greater or less amount of moisture, is well known, as is also the fact that this change in size may be accompanied by the expenditure of a great deal of force. If an unseasoned piece of wood has two sides fastened rigidly so that it can not shrink across the grain, and then be exposed to a current of comparatively dry air, it will very soon break, the break being in the direction of the length of the cells of which the wood fibers are composed; or if a piece of dry wood be confined rigidly to prevent any *increase* in size and then be saturated with moisture, it will tend to swell and the force will be sufficient to crush the fibers where they are in contact with whatever confines them.

This change in size occurs across the grain of the wood, or across the cells of which it is composed, and only to a slight degree in the direction of their length.

Some pieces of unseasoned poplar had iron bars ten inches long placed between the projecting ends to prevent the ends coming any nearer together, and were then allowed to remain in the conditions of ordinary workshop atmosphere until they broke, which they did in the average time of four hours after adjustment.

A number of tests made in a testing machine showed that a force of about 370 pounds to the square inch was required to break them.

Trials made with other wood gave corresponding results; in a few hours each piece broke, the force required to break it depending on the kind of wood. In some cases the force was over 600 pounds to the square inch.

A microscopic examination of sections made from some of the pieces after they had been allowed to dry, showed, first, a loss of the contained moisture, and, as the drying continued, in some cases what seemed a shriveling of the tissues of the side walls.

An examination, previously made, of the cell walls of some wood that had been in a dry place during some years showed a disintegration of the tissue, the cell walls having a rough and fibrous appearance.

In order to record any microscopic change taking place in the cell walls, two sections, one a transverse and the other a longitudinal radial one, were made from a freshly cut branch of *Pinus sylvestris* and mounted dry under cover glasses. They were photographed at intervals and records made of changes occurring in them. The moisture first dried out, the cells in transverse section becoming slightly less in size. After a few days when the moisture had dried from between the walls, the greater change seemed to take place in the longitudinal section, the walls of which began to shrivel slightly. This change continued for some weeks in a constantly lessening degree, however.

Botanical Literature in the State Library. By John S. Wright.

As a member of the Academy Committee on the State Library, sometime ago I made a list of the works in that institution which are upon botany and related subjects. The number of such books is small, the authorities who have in charge the purchases are inclined to increase the collection in lines of literature, biography and history rather than science. While it may be true that those who most use the library have greatest use for works of that nature, yet the State Library should also be the repository of the standard and best works in the various departments of science, especially of the larger and more expensive sets which are often beyond the purse of the individual worker.

In talking over this matter with the present Librarian and her predecessor each expressed a desire to make the sections of botany and other sections of scientific works what they should be. They also said that they would be glad of any suggestions, from those competent, as to additional purchases. In accordance with this wish about two years ago I prepared a circular letter addressed to the professors of botany in the several colleges of the State. This letter contained a list of the main botanical works then in the Library, and a request that they would recommend such others as they thought it should contain, giving the name of the publisher, place and date of publication and cost of each work so recommended. Nearly every one to whom a letter was addressed responded, and from these letters a list of books was compiled and recommended to the State Librarian for purchase, each one of which was accompanied by the name of the person or persons requesting its purchase and the other data mentioned. Since that time, however, the Library has changed management, has been thoroughly overhauled and rearranged, so the purchases asked for have not been made. The present Librarian, however, is quite favorable to the improvement of the Library in this respect and I believe that it is only necessary to bring a little influence to bear upon other library officials in order to secure to the Library a creditable number of botanical works of reference. While it will be impossible to withdraw books from the State-house, the establishment of such a collection should, nevertheless, be of interest to botanists of the State.

LIST OF WORKS IN STATE LIBRARY ON BOTANY AND RELATED SUBJECTS.

An accurate classification could not well be made; many pamphlets on diverse subjects are bound together in one volume, and other works are general in character, not falling wholly under any single division.

Agriculture—

1. How Crops Feed, S. W. Johnson, 1882.
2. How Crops Grow, S. W. Johnson, 1888.
3. Resena sobre el cultive de algunas plantas industriales que se explo tan son susceptibles oe explotarse, J. C. Sequra, 1844.
4. Sugar Cane, the Nature and Property of, Geo. R. Porter, 1843.

Botany, General Works on—

British Wild Flowers in Relation to Insects, Sir John Lubbock, 1882.
Chronological History of Plants, Chas. Pickering, 1878.
Desmids of the United States, Francis Wolle, 1884.
Dictionary of Economic Plants, John Smith, 1882.
Encyclopedia of Plants, J. C. London, 1841.
Ferns of North America, D. C. Eaton.
Ferns of North America, Native and Foreign, D. J. Browne, 1846.
Flora America Septentrionalis, Frederick Pursh, 2 vols., 1861.
Floral Stuctures, Origin of, Geo. Henslow, 1888.
Flowers and Ferns of the United States, Native and Foreign, Thos. Meehan, 188–.
Flowers, Fruits and Leaves, Sir John Lubbock, 1886.
Flowers, How to Know the Wild Flowers, Mrs. Wm. Starr Dana, 1893.
Fungi, Their Nature and Uses, M. C. Cooke, 1830.
Genera of the Plants of the United States, Gray & Sprague, 1849.
Genera Plantarum, 3 vols. of 7 parts, Benthan & Hooker, 1862.
Geological History of Plants, Sir Wm. Dawson, 1888.
Manual of Botany of North America, Amos Eaton, 1836.
Manual of Botany of Northern United States, Asa Gray, 1848.
Manual of Flora of the Rocky Mountains, J. M. Coulter, 1885.
Manual of Flora of Southern United States, Chapman, 1889.
Origin of Cultivated Plants, Alphonse DeCandolle, 1885.
Pamphlets on Botany (bound in one volume)—
Fern List of United States, Eaton.
Plants of United States, Horace Mann.
Forests and Forestry of Sweden, C. C. Andrews.
Duty of Preserving Forests, F. A. Hough.
Medicinal Plants of United States, A. C. Clapp.
El Algedoners, Donato, Gutierrez.
Development of Cork Wings, Emily Gregory.
Woody Plants of Ohio, J. A. Warder.

Plants of Michigan. Wheeler & Smith.

Physiology of Plants, J. Von Sachs, 1887.

Plants of Boston and Vicinity (Florula Bostoniensis). Jacob Bigelow, 1824.

Plants of North America, The, Frederick Pursh, 1816.

Plants of the United States, Geo. Putnam, 1849.

Sylva, The North American, 3 vols. 2 parts, Michaux, 1865.

Systematic and Physiological Botany, Introduction to, Nuttall, 1830.

Vegetable Mold, The Formation of, Darwin, 1882.

Forestry—

American Grove, Humphrey Marshall, 1785.

Forests and Moisture, J. C. Brown, 1877.

Forests of Northern Russia, J. C. Brown, 1884.

Forestry in Norway, J. C. Brown, 1884.

French Forest Ordinance of 1669, J. C. Brown, 187–.

Hydrology of South Africa, J. C. Brown.

Pine Plantations on Sand Wastes of France, J. C. Brown.

Practical Forestry, A. S. Fuller, 1884.

Schools of Forestry in Germany, J. C. Brown.

Trees of America, J. Brown, 1846.

Trees and Shrubs of Massachusetts, By Order of State Legislature, 1846.

Government Reports—

Agricultural Grasses and Forage Plants of the U. S., Geo. Vasey, 1889.

Contributions from U. S. National Herb. Botany of Western Texas, Coulter, 1891-4.

Journal of Mycology, Vols. 1-6, Bound.

Forestry—

Reports on Four Years, 1877, '78, '79, '82, '84, and '88.

Horticulture—

Elementary Treatise on American Grape Culture, W. R. Prince, 1830.

An Elementary Treatise on Grape Culture and Wine Making, P. B. Meade, 1867.

Cultivateur de Dahlias, Legrand, 1848.

Du Fuchsia, son Histoire et sa Culture, etc., ——— 1844.

Gardening, Encyclopedia of, J. C. London, 1834.

Grape Culture, Wines and Wine Making, A. Haraszthy, 1862.

Hortus Botanicus Americanus, Sketches toward, W. J. Titford, 1812.

Horticulture Practique, G. Laroque, 1883.

Journal of Visit to Vineyards of Spain and France, Jas. Bushby, 1835.

Observations on Character and Cultivation of European Wine, S. I. Fisher, 1834.

Rural Essays on Horticulture, A. J. Downing, 1858.

The American Grape Growers' Guide, Wm. Charlton.

The Fruits and Fruit Trees of North America, A. J. Downing, 1886.

Theory of Horticulture, John Lindley, 1841.

Plants, Henderson's Hand Book of, Peter Henderson, 1881.

Plants and Fruits, Hand Book of, L. D. Chapin, 1843.

Trans. of Mississippi Valley Horticultural Society, 1883.

Vineyard Culture, A. Du Breuil, 1867.

Western Fruit Book, F. R. Elliott, 1859.

Medical Botany—

Flora Medica, John Lindley, 1838.

Medical Botany, R. E. Griffiths, 1847.

Periodicals—

Botanical Gazette, partially bound, Vols. viii, x, xix, bound, x, xvi, xvii, xviii, incomplete and unbound.

Botanical Magazine, Curtis, Vols. 1-10 inclusive, 1793———.

Microscope Slides of Vegetable Material for Use in Determinative Work. By John S. Wright.

In the determination of plants it is frequently necessary, or at least desirable, to make examinations of various organs with the aid of a lens. Seed markings, glandular structures and many portions of the flower upon which determinations are partly based may be so minute as to necessitate slight magnification for satisfactory work. For example we have in the *Euphorbias* and *Lobelias* many species in which the seeds are to the naked eye mere granules, but under a hand lens their surfaces are seen to be decidedly marked with irregular ridges and pits, or are handsomely sculptured. Many leaves contain glandular structures, or are covered with hairs or scales which can be best seen under the lens. In determining specimens on which such structures exist and are of value in classification, it is often desirable to compare them with like material from well determined herbarium specimens. Commonly the material for these comparisons is dug out of or cut off the herbarium specimen as it is needed from time to time and placed loosely under the lens for examination, and after it has served the purpose of the moment is brushed aside and lost, or at best preserved in packets upon the sheet with the specimen from which it was taken. This method is mussy and eventually impairs the mounted specimens of an herbarium, and where there are many workers it is not economical of time. To avoid this is quite practicable through the preservation of all such materials dry in cells upon glass slips as opaque mounts for the microscope. The cells are built by gluing to the glass slips brass rings, and the specimens are enclosed by cementing to the top of this ring the ordinary circular cover glass. The method of building this form of cell was suggested by Dr. Griffiths some years ago and is quite familiar. A cell of this form will not accommodate leaves and some other plant structures as well as another form of cell, which is made by gluing a rectangular frame cut from cardboard to the glass slip. A cell of this construction will contain small leaves entire or the tip and basal portions of larger leaves, which can be viewed from either side. A cell of this type must be enclosed by a rectangular cover glass. A supply of slips, upon which cells of various sizes have been built, may easily be kept on hand, and whenever it becomes necessary to remove from an herbarium specimen material for examination, it may be placed in a cell in manner best adapted for its display, labeled, and you have at once, at very small expense, a slide of vegetable material which will be ready for use at any future time; and, if such a collection of slides is properly classified and arranged, it forms a working adjunct to the herbarium of much value, and, besides, provides one constantly with available material for numbers of demonstrations in botanical work.

Hemaglobin and Its Derivatives. By A. J. Bigney.

On subjecting a dilute solution of arterial blood to spectroscopic examination, certain parts of the spectrum of natural or artificial light will be absorbed. The amount of this depends upon the degree of concentration of the blood; if a one per cent. or two per cent. solution be used, two narrow dark bands are seen in the orange-yellow between the Frauenhofer lines D and E, the one next to E being a wider, but not so deep a band as the one next to D. A little of the red is absorbed and the violet, indigo, and a part of the blue. This is the spectrum of *Oxy.-Hæmoglobin.*

If arterial blood or venous blood which has been shaken with air be treated with some reducing agent such as ammonium sulphide or alkaline iron sulphate with tartaric acid, a decided change occurs in the spectrum, instead of the two bands only one appears, which is between the two lines of *Oxy.-Hæmoglobin*, and is much broader than either of the bands mentioned above. This is the spectrum of reduced *Oxy.-Hæmoglobin* or simply *Hæmoglobin*.

METHÆMOGLOBIN.

The spectrum of *Methæmoglobin* is obtained by first preparing *Oxy.-Hæmoglobin* crystals by treating dog's blood with ether and shaking it until it becomes laky, then allowing it to stand in a cool place for an hour or so, at which time a firm mass will be formed, due to the crystals. The mother liquor is separated from the crystals by filtering through muslin or linen, squeezing the mass so as to obtain the crystals in as pure a form as possible. The crystals are dissolved in distilled water and a dilute solution is examined with the spectroscope. The two bands of *Oxy.-Hæmoglobin* appear. A few drops of potassium permanganate are added and the solution gently warmed. If sufficient time has elapsed for the oxidation of the *Oxy.-Hæmoglobin*, the two bands will have disappeared and instead a single band in the red near the line C between C and D. Nearly the entire spectrum is absorbed. Sometimes it is a little difficult to get this band, but if the oxidation has taken place it will be seen. In the experiment at hand I left the solution until the next day before it would give the above result.

CARBON-MONOXIDE HÆMOGLOBIN.

If coal gas be passed through blood which has been defibrinated, it will assume a cherry-red color, the carbon-monoxide of the gas having driven off the oxygen of the *Oxy.-Hæmoglobin* and taken its place. The reducing agents have no influence upon this new substance, it being more stable than *Oxy.-Hæmoglobin*. The two absorption bands are nearer to E than in the *Oxy.-Hæmoglobin* spectrum.

HÆMATIN.

The red corpuscles are composed of a *proteid stroma* and a brownish pigment which is called hæmatin. The iron is a part of the hæmatin. It can be obtained either as the acid hæmatin or the alkaline hæmatin.

In making the acid hæmatin, I took 100 cc. of 95 per cent. alcohol and added 2 cc. of sulphuric acid, and then 10 cc. of blood; the mixture was boiled for about an hour in a flask tube three or four feet long so that the vapor passing off would be condensed in upper part of the tube and flow back into the flask.

During this process a precipitate is formed which is acid hæmatin. The solution is filtered and the precipitate is dissolved in alcohol and then examined

Since the precipitate is soluble in alcohol, that which is obtained by filtering does not represent all the hæmatin, for a part would be dissolved while boiling. The spectrum has one broad band near C. Most of the remaining portion of the spectrum is also absorbed.

If 95 per cent. alcohol be added to blood and a small quantity of caustic soda, a still different spectrum is obtained. This is the alkaline hæmatin spectrum. It is similar to the acid hæmatin except the dark band is near and often on D.

Effect of Heat Upon the Irritability of Muscle. By A. J. Bigney.

In these experiments the gastroenemious muscle of the frog was used. It was suspended in a moist chamber and the tendon attached to a lever for recording movements in contraction on a revolving drum. Surrounding the cylindrical moist chamber was another similar cylinder filled with water; near the bottom was a small tube about one-half inch in diameter passing from it at right angles and forming two sides of a rectangle, returned to the cylinder filled with water. By this arrangement the water could make a circuit through this tube and the cylinder. Heat was applied to the tube, and a thermometer was placed in the moist chamber.

The muscle was stimulated at different temperatures and the result recorded on the drum. Only making shocks were used in stimulation, this being regulated by the automatic maker, or breaker. Between 36° and 38° C. the contractions were the greatest, showing an increase in irritability. Between 39° and 40° the contractions ceased, heat rigor having set in. At the time the contractions ceased, the temperature was lowered and the muscle became irritable again. It would continue irritable for some time, but would soon become exhausted. After several hours' rest it would become quite irritable again.

Heat rigor began to set in at a little more than 36°, sometimes not until nearly 39°. It is different in different frogs and in different seasons. From 45° to 55° C. the rigor would usually be complete. The most important point to be secured is that temperature at which contractions cease and still when the temperature is lowered the muscle will be found to be alive so as to give contractions. When the heat rigor would once begin, it would continue even if the temperature is lowered. This holds true only for a few degrees. Long rest would allow it to pass out of rigor if it had not gone too far. After at least 24 hours had elapsed good contractions were obtained, and this with muscle that had once been exhausted.

A Revision and Synonymy of the Parvus Group of Unionidæ. (With Six Plates.) By R. Ellsworth Call.

The type of this group is a small unionine bivalve from the Fox river, Wisconsin, collected by Mr. H. R. Schoolcraft, while engaged in work on the Northwest Expedition, of the early part of the present century. The type was described by Mr. D. H. Barnes, in 1823, in the following words:*

"Shell oblong-ovate, small, convex, sides rounded; beaks slightly elevated, inside pearly white, iridescent. * * *

"Diameter, .35—.525; length, .4—.6; breath, .75—1.2.

"Shell rather thin, beaks placed about one-fourth of the length from the posterior extremity, ligament very narrow, anterior lunule distinct and obsoletely ribbed; basal margin slightly shortened; epidermis brownish; an obtuse, slightly elevated rib from the beaks to the anterior basal margin; lateral tooth rectilinear rounded at the end, and parallel to the base; nacre very brilliant."

Mr. Barnes completes his diagnosis of this form with the remark that it is "the smallest and most beautiful of all the genus yet discovered in America."

In geographic distribution this small mollusk ranges from Western New York and Florida, to Minnesota, Texas and Arkansas. In this wide range there are numerous diverse environmental conditions, and the species appears, in a definite sense, to have responded to these, and thus have been produced a number of variations, which passing through the hands of different naturalists, have been elevated into specific rank. In some cases, indicated below, the sexes have been made to serve as the basis of new species; full series collected over the wide area of distribution confirm the following synonymy, in which the geographic distribution of several of the forms conveys its own argument:

†Unio parvus Barnes.

Am. Jour. of Sci. and Arts, 1st series, Vol. vi, 1823, p. 274, Fig. 18; Lea figures the animal in Jour. Phila. Acad. Nat. Sci., 2d series, Vol. iv, Pl. xxix, Figs. 102, 102a; Conrad, Monography of Unio, 1836, Pl. ix, Fig. 1; Reeve, Conchologia Iconica, Vol. xvi, *Unio* Pl. xxxv, Fig. 186, a very poor figure from a specimen in the Museum Cuming. (Pl. i, Figs. 1-3.)

Unio paulus Lea. Trans. Am. Philos. Soc., Vol. viii, 1840, p. 213, Pl. xv, Fig. 29. From the Chattahoochee river, Georgia. (Pl. ii, Figs. 11-13.)

Unio minor Lea. Trans. Am. Philos. Soc., Vol. ix, 1843, p. 276, Pl. xxxix, Fig. 3. From Lakes Monroe and George, Florida.

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* American Jour. of Sci., 1st Ser., Vol. VI, No. 2, p. 274, pl. 13, fig. 18, *outline only*.

† The plate references in parentheses are to the several plates accompanying this article. The sexes are indicated on the plates.

Unio marginis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. vi, p. 255, 1868, Pl. xxxi, Fig. 69. From Dougherty county, Georgia. (Pl. ii. Figs. 7-9.)

Unio corvinus Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. vi, 1868, p. 310, Pl. xlviii, Fig. 123. From Flint river, Georgia, and Neuse river, North Carolina. (Pl. i, Figs. 4-6.)

Unio vesicularis Lea. Jour. Acad. Nat. Sci. Phila., 2d series, Vol. viii, 1874, p. 37, Pl. xii, Fig. 34. From Lake Okeechobee, Florida. (Pl. v, Figs. 35-37.)

So few of the animals of the *Unionidæ* have been described that it may not be superfluous to give at this place a description of the animal of *Unio parvus* (plate ii, fig. 10), based upon the examination of a fresh specimen from the Des Moines river in Central Iowa.

Animal of *Unio parvus*. Color of the mass, whitish; tentacular portion of mantle, dark brown, ending in a caruncle; labial palps, large, white, triangular, united at base and partially so over the posterior margin; external ctenidium, smaller than the internal, thicker and larger at the posterior extremity, which is rounded, and on the margin, which is marked by a double row of minute, white papillæ; ctenidia united above throughout their entire length, free below; internal ctenidium, white, ovate.

The mass of the animal within the cavity of the beak is light brown owing to the color of the large liver which shows through the thin tissues separating it from the chamber of the ctenidia.

The chief anatomical peculiarity *is the presence of the caruncle in the female.* This is somewhat separated from the main tentacular mass and is supported by a slender pedicel. Its function is unknown.

To complete the history of this species the following redescription of the shell of *Unio parvus* is presented, based upon specimens collected in the Wabash River, Indiana:

Shell, small, compressed, rather thin, elliptical, rounded anteriorly and slightly thicker, posteriorly triangulate in the male and occasionally sulcate in the female, thinner; *umbonal* slope somewhat depressed; *umbones* rather prominent, with four to five coarse undulations; *epidermis*, thin, olive-green over most of disk, but much lighter on the umbones, striate, especially over the middle disk thence to the margin; in the young two broadening green bands often extend from the umbones over the posterior slope to the posterior margin, otherwise eradiate; *ligament* small, light brown in color, thin, rather long, but very narrow; *hinge teeth* small, all double in the left and single in the right valve, the *cardinals* erect, thin, lamellar, acuminate, crenulate, separating, the *laterals* long, lamellar, straight, smooth, forming a very obtuse angle with the cardinals; *anterior adductor cicatrices* distinct, deep, that of the *protractor pedis* very small; *posterior adductor cicatrix* scarcely evident, confluent; *pallial line* distinct for the anterior two-thirds; *dorsal cicatrices* irregularly grouped in the rather large cavity of the beaks, minute; nacre white, iridescent posteriorly.

	Length.	*Height.*	*Width.*	
No. 1.	42.00 mm.	26.00 mm.	23.00 mm.	Female.
No. 2.	36.30 mm.	27.57 mm.	19.25 mm.	Female.
No. 3.	*36.10 mm.	18.00 mm.	14.60 mm.	Male.

UNIO TEXASENSIS Lea.

Proc. Acad. Nat. Sci. Phila, Vol. ix, p. 84, 1857; Jour. Acad. Nat. Sci. Phila., Vol. iv, pp. 357, 359, 362, Pl. lxi, Fig. 184, 1860; Observations on the *Genus Unio*, Vol. viii, p. 39, Pl. lxi, Fig. 184 (Pl. v, Figs. 38-40). Dewitt Co., Texas.

Unio bairdianus Lea. Proc. Acad. Nat. Sci. Phila., Vol. ix, p. 102, 1857; Jour. Acad. Nat. Sci., Vol. iv, pp. 360, 361, Pl. lxi, Fig. 186, 1860; Observations on the *Genus Unio*, Vol. viii, p. 42, Pl. lxi, Fig. 186 (Pl. vi, Figs. 41-43). Devil's River, Texas.

Unio bealii Lea. Jour. Acad. Nat. Sci. Phila., Vol. v, p. 204, Pl. xxx, Fig. 273, 1866; Observations on the *Genus Unio*, Vol. ix, p. 26, Pl. xxx, Fig. 273 (Pl. vi, Figs. 44-46). Leon County and Rutersville, Texas.

The conchologic characters of this form do not widely vary. As may be seen the species only comes from Texas, and contiguous portions of Louisiana.

The following description may assist in understanding the relation which this form sustains to the common and widely distributed type of the group.

Shell small, very elliptical, especially in the female, compressed laterally, rounded before, biangulate posteriorly though this character is less marked in the female, which is somewhat regularly rounded, striate; valves rather thin though somewhat thickened anteriorly; epidermis rather thick, olive-green, in young specimens with occasional rather broad greenish lines along the angles of the posterior umbonal slope; lines of growth numerous, fine and closely arranged, in old specimens often forming raised ridges along the ventral posterior margins; ligament long, smooth, light horn colored and shining, very narrow; umbones scarcely prominent, close together, rather coarsely undulate, the undulations being concentrically arranged as seen in young specimens; in the young the

*This is a large male specimen from the Wabash River, Indiana. In it the cardinal teeth are *double in both valves*; the posterior cardinal in the left valve is curved *dorsad* and is very long and thin, its edges are sharply serrate.

epidermis over the umbones is very light or straw-yellow in color; the dorsal aspect of the posterior umbonal slope is characterized by the presence of two rather indistinct and obtuse angles which extend from the umbones and, reaching the posterior margin, form the characteristic biangulation seen in the male; *cardinal* teeth short, acuminate, single in the right and double in the left valve, the single tooth being flattened and plate-like, the double tooth somewhat more trigonal and heavier, all crenulated on the margins; the posterior teeth are long, slightly curved, and lamellar; plate between the cardinal and posterior teeth scarcely evident; the anterior adductor cicatrices are large, and deeply impressed, entirely distinct from that of the *protractor pedis* impression which is deep and often pit-like; the posterior cicatrices are confluent, scarcely evident, that of the *retractor pedis* muscle being placed at extreme end of the posterior hinge teeth; dorsal cicatrices arranged, usually, in a line of five or more in the shallow cavity of the umbones, though in an occasional specimen they are grouped; the pallial cicatrix is faintly but regularly impressed throughout its entire length; nacre white, with tendency to salmon in the cavity of the umbones, beautifully iridescent posteriorly.

The four specimens on which this diagnosis is based are from Lake Caddo, Louisiana. Their dimensions are the following, the first being that of a female; comparison with the remaining three will evidence the more compressed character of the male shell:

	No. 1.	No. 2.	No. 3.	No. 4.
Length . . .	40.00 mm.	36.50 mm.	39.50 mm.	38.50 mm.
Height	24.00 mm.	20.00 mm.	22.00 mm.	21.50 mm.
Breadth	18.51 mm.	14.50 mm.	14.50 mm.	13.00 mm.

The habits of this form are quite similar to those of the type of the group. It delights in still water with muddy bottoms, and usually occurs in very great numbers wherever it is found at all.

As may be seen by comparing the figures given in the plates, which are copies of Lea's original figures, this form illustrates the erection of a species name upon characters that are but an expression of sex.

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*The anatomy of the animal has been considered, rather than authority, in the terminology adopted. Thus the *length* is the extreme distance from the anterior to posterior margin; the height the distance from ligament to the ventral margin; the width the distance measured by a line drawn through the animal, transversely, from valve to valve. This appears both natural and satisfactory. Say, Kirtland, Barnes, Sowerby and others with them confused the anterior and posterior ends; Lea did not make this blunder, but made others equally reasonless. Thus the distance from valve to valve he calls the *heighth*, as if the normal or proper position of the animal was on one of its valves. Some later writers apparently have such reverence for these blunders that they still employ an obsolete terminology.

Unio glans Lea.

Trans. Am. Philos. Soc., Vol. iv, p. 82, Pl. viii. Fig. 12, 1830; Observations on the *Genus Unio*, Vol. i, p. 92, Pl. viii, Fig. 12. Ohio River (Pl. iii, Figs. 14–16).

Unio pullus Conrad. Monography Family *Unionidæ*, pp. 100, 101, Pl. lv, Fig. 2, 1836. Wateree River, South Carolina (Pl. v, Figs. 32–34).

Unio granulatus Lea. Proc. Acad. Nat. Sci. Phila., Vol. xiii, p. 60, 1861; Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 48, Pl. xvi, Fig. 46, 1866; Observations on the *Genus Unio*, Vol. xi, p. 52, Pl. xvi, Fig. 46. Big Prairie Creek, Alabama (Pl. iv, Figs. 23–25).

Unio germanus Lea. Proc. Acad. Nat. Sci. Phila., Vol. xiii, p. 10, 1861; Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 49, Pl. xix, Fig. 54, 1866; Observations on the *Genus Unio*, Vol. xi, p. 53, Pl. xix. Fig. 54. Coosa River, Alabama (Pl. iv, Figs. 26–28).

Unio cromwellii Lea. Proc. Acad. Nat. Sci. Phila., Vol. xvii, p. 89, 1865; Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 258, Pl. xxxi, Fig. 73, 1868; Observations on the *Genus Unio*, Vol. xii, p. 18, Pl. xxxi, Fig. 73. Kiokee Creek, Albany, Georgia (Pl. iv, Figs. 29–31).

Unio cylindrellus Lea. Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 308, Pl. xlviii, Fig. 121, 1868; Observations on the *Genus Unio*, Vol. xii, p. 68, Pl. xlviii, Fig. 121. East Tennessee, North Georgia, North Alabama (Pl. iii, Figs. 17–19).

Unio corvunculus Lea. Jour. Acad. Nat. Sci. Phila., Vol. vi, p. 314, Pl. l, Fig. 127, 1868; Observations on the *Genus Unio*, Vol. xii, p. 74, Pl. l, Fig. 127. Swamp Creek, Whitfield County, Georgia (Pl. iii, Figs. 20–22).

The following conchologic description is based upon material taken in the White River, Indiana, where the species attains its maximum development, both in point of size and abundance.

Shell small, elliptical, striate, rather thick and subangulate posteriorly, much thicker anteriorly and rounded; *umbones* elevated, coarsely undulate, with irregularly crescent-shaped folds, three or four in number; epidermis rather thick, dark greenish, obscurely radiate over the anterior portion of the disk, a character best seen by transmitted light, somewhat polished over the umbonal slope and generally glossy, lighter colored on the umbones; posterior margin sulcate in the female, dorsal portion produced; *ligament* small, horn-colored, thin; both cardinal and posterior *hinge teeth* double in the left and single in the right valve, the *cardinals* short, thick, heavy, serrate; *laterals* rather long, striate, straight, lamellar;

anterior adductor cicatrices distinct, pit-like and deep; *posterior adductor cicatrices* shallow, confluent, that of the *retractor pedis* muscle impressed at tip of the laterals and below; *pallial cicatrix* evident, regularly impressed and linear; *dorsal cicatrices* several, crowded, in the deep cavity of the umbones or on the margin of the plate joining the hinge teeth; *cavity* of the umbones rather deep; nacre purple, with anterior margin usually white, whole posterior region beautifully iridescent.

NUMBER.	LENGTH.	HEIGHT.	BREADTH.	SEX.
1	34.40 mm.	22.10 mm.	19.51 mm.	Female.
2	28.00 mm.	20.00 mm.	16.12 mm.	Female.
3	28.50 mm.	20.20 mm.	17.00 mm.	Female.
4	37.10 mm.	22.32 mm.	17.24 mm.	Male.
5	37.56 mm.	23.44 mm.	18.50 mm.	Male.
6	33.00 mm.	21.50 mm.	16.88 mm.	Male.
7	30.28 mm.	20.10 mm.	16.50 mm.	Female.
8	34.60 mm.	22.92 mm.	17.10 mm.	Male.

Some interesting features connected with the comparative dimensions of the sexes may be shown from this table of measurements. If the two longest males be selected the ratio of length to height is $\frac{37.56}{23.44} = 1.60+$ and $\frac{37.10}{22.32} = 1.66$. In these same shells the ratio of length to width is as follows: $\frac{37.56}{18.50} = 2.00$ and $\frac{37.10}{17.24} = 2.15$.

A comparison of the same dimensions for the two longest females develops the following ratios: $\frac{34.40}{22.10} = 1.55$ and $\frac{30.28}{20.10} = 1.50$. Comparing the lengths with the widths the ratio established is $\frac{34.40}{19.51} = 1.76$ and $\frac{30.28}{16.50} = 1.83$. The ratios show that the females are much wider than the males, a relation probably due to the requirements of the *ctenidia* of the female shells when functioning as gestatory sacs. So marked, even to casual observation, are these relations that it is an easy matter to select the sexes in any considerable number of shells.

The habits of *Unio glans* are somewhat different from those of *Unio parvus*. It more commonly affects gravelly beds, in shallow running water. The writer has taken the *corvunculus* form in great abundance in the typical locality, whence it was traced into nearly all the streams of north Georgia and Alabama, in the Gulf drainage. The *cylindrellus* form is very abundant in the smaller streams of south Tennessee and in the Black Warrior River of Alabama. The heaviest, largest and *glans* like forms from the south occur in the Coosa River, a tributary to the Alabama, just above Wetumpka. Similar shells were taken in numbers in the Cahaba River, in Bibb County, also tributary to the Alabama.

UNIO AMGDALUM Lea.

Observations on the Genus Unio, Vol. IV, p. 33, pl. XXXIX, fig. 1, 1843, from Lake George, Florida; Trans. Am. Phil. Soc., 2d Ser., Vol. IX, pl. 39, fig. 1, pp. 275, 276. See also Simpson, "Notes on Florida Unionidae," Proc. U. S. Nat. Mus. Vol XV, pl. LXVII, fig. 3, p. 426, 1892.

Unio papyraceus Gould. Proc. Bost. Soc. Nat. Hist., Vol. II, p. 53, 1845. Florida. Latin diagnosis; no figure.

The following description of *Unio amgdalum* is based upon excellent specimens from the original locality.

Shell small, striate, somewhat inflated, nearly oval in outline, rounded before, subangular posteriorly, viewed dorsally the outline is rounded cuneate posterior to the umbones, female slightly emarginate on the ventral border; epidermis striate, light straw colored over the disk, greenish to greenish-yellow near the ventral margin, faintly rayed on the posterior dorsal slope in the manner characteristic of all the *parvus* group; ligament short, thin, light horn-colored; lines of growth distinct, broad, and much darker than the balance of the disk; anterior or cardinal teeth double in the left and single in the right valve, though an occasional specimen exhibits a tendency to double teeth in both valves, flattened, plate-like, crenate; posterior teeth double in the left and single in the right valve, long, lamellar, straight, striate, particularly toward the extremities; anterior cicatrices distinct, the adductor rather deeper or impressed, that of the *protractor pedis* rather large, oval, but slightly impressed; posterior cicatrices confluent, scarcely impressed, very iridescent; cavity of the beaks rounded and shallow, with a row of pit-like and minute cicatrices just under the dorsal plate; nacre white, pinkish or salmon tinged towards the cavity of the beaks, beautifully iridescent over the entire posterior half, but the play of iris-like colors is most marked on the posterior margin beyond the pallial cicatrix, which is very faintly impressed.

The average dimensions are: Length, 3.1 mm.; width, 1.22 mm.; heighth, 1.82 mm.

Some specimens of this shell approach the form of *Unio minor* Lea in that the cardinals are much heavier than usual and the substance of the shell is much thicker; in these forms also the posterior teeth are incrassate. The *tout ensemble* of this shell is in no respect dissimilar from forms of *Unio parvus* found in gravelly river bottoms in more northern regions, and it is very doubtful if it can maintain a place in the system as a separate or distinct species. The species belongs to the *parvus* group without a question, though the specimens under examination are eroded and do not exhibit the characteristic coarse undulations on the umbones. In all other particulars my shells are typical.

To complete the history of these small and difficult forms the original diagnoses of Lea, except one, and Conrad have been tabulated and thrown into synoptical form as follows:

SYNOPSIS OF THE SPECIFIC CHARACTERS OF THE PARVUS GROUP.

UNIO.	PARVUS.	CORVINUS.	MARGINIS.	PAULUS.	GLANS.	CYLINDRELLUS.	CROMWELLII.	GRANULATUS.
Outline	Elliptical, somewhatcompressed.	Elliptical, inflated.	Elliptical, inflated.	Elliptical, inflated.	Ovate-elliptical, inflated.	Widely elliptical, somewhat cylindrical.	Elliptical, somewhat inflated.	Elliptical, somewhat inflated.
Substance of shell	Thin, slightly thicker before.	Somewhat thick, thicker before.	Somewhat thick, thicker before.	Thick, thinner behind.	Rather thick.	Thick, thicker before.	Rather thin, thicker before.	Rather thin, slightly thicker before.
Beaks	Slightly prominent, coarsely and concentrically wrinkled.	A little prominent.	Somewhat prominent.	Somewhat prominent.	Somewhat prominent.	Slightly prominent.	Somewhat prominent; concentrically folded.	A little prominent, undulate, granulate.
Ligament	Small, thin, light straw-colored.	Short, thin, very dark brown.	Small, thin, light brown.	Short, thin.	Small.	Rather long, thin.	Small, thin, rather light brown.	Small, thin, light brown.
Epidermis	Yellowish green, lighter on beaks, striated, lines of growth distant, black.	Black, eradiate, subsquamose, growth lines close.	Dark olive striate, obscurely rayed, margin greenish-yellow.	Nearly black.	Black or dark brown, sometimes rayed.	Yellowish, eradiate, lines of growth distant.	Striate, brownish or greenish rayed, growth lines distant, broad.	Dark olive, eradiate, striate, lines of growth distant.
Cardinal teeth	Small, elevated, acuminate, crenulate, double in the left, single in the right valve.	Small, decussate.	Small, sulcate, crenulate.	Small, disposed to be double in both valves.	Rather large, elevated, double in left, single in right valve.	Small, sub-conical, corrugate.	Small, compressed, corrugate, double in both valves.	Small, compressed, crenulate, oblique, double in both valves.
Lateral teeth	Slightly curved, long, lamellar.	Long, somewhat straight.	Rather short, straight.	Long, curved.	Straight, lamelliform.	Long, somewhat curved.	Rather long, somewhat curved.	Long, acicular nearly straight.
Anterior cicatrices	Distinct, moderately impressed.	Distinct, small, well-impressed.	Confluent, small, deeply impres'd.	Distinct.	Distinct.	Distinct, small, well impressed.	Scarcely distinct, large, well imp.	Distinct, rather large, well imp.
Posterior cicatrices	Confluent, slightly impressed.	Confluent, slightly impressed.	Confluent, small, slightly imp.	Confluent.	Confluent.	Distinct, small, slightly imp.	Confluent, rather large, slightly im.	Confluent, rather large, slightly im.
Dorsal cicatrices	Center of cavity of the beaks.	Center of cavity of the beaks.	Center of cavity of shell [beaks].	On inferior part of tooth.	Center of cavity of the beaks.	Center of the cavity of the shell.	Center of cavity of the beaks.	Center of cavity of the beaks.
Cavity of shell	Shallow, white.	Deep, wide.	Rather shallow.	Deep.		Deep, wide.	Deep, wide.	Deep, wide.
Cavity of beak	Shallow, rounded.	Shallow, obtusely angular.	Shallow, rounded.	Very small.	Wide, subangulated.	Rather deep, subangular.	Small, obtusely angular.	Shallow, subangular.
Nacre	White, inclined to salmon in cavity of beaks.	White, iridescent.	White, iridescent.	White, iridescent.	Purple.	Purple, iridescent.	Purple, iridescent.	Purplish, iridescent.
Habitat	Ohio river.	Flint River, Ga. Neuse River, N. C.	Dougherty Co., Ga.	Chattahoochee River, Ga.	Ohio River.	E. Tennessee, N. Ga., N. Ala.	Kiokee Creek, Albany, Ga.	Big Prairie Creek, Ala.
Width	0.6 inch.	0.7 inch.	0.5 inch.	0.4 inch.	0.7 inch.	0.7 inch.	0.4 inch.	0.45 inch.
Height	0.8 inch.	0.8 inch.	1.0 inch.	0.6 inch.	0.8 inch.	0.8 inch.	0.7 inch.	0.62 inch.
Length	1.6 inch.	1.3 inch.	1.1 inch.	0.9 inch.	1.3 inch.	1.5 inch.	1.1 inch.	1.10 inch.

SYNOPSIS OF THE SPECIFIC CHARACTERS OF THE PARVUS GROUP.

GERMANUS.	CORVUNCULUS.	PULLUS.	VESICULARIS.	TEXASENSIS.	BAIRDIANUS.	BEALII.	MINOR.
Elliptical, somewhat inflated.	Elliptical, somewhat inflated.	Elliptical, somewhat inflated.	Elliptical, inflated.	Elliptical, sub-compressed.	Elliptical, slightly inflated.	Elliptical, somewhat compressed.	Elliptical, rather inflated.
Somewhat thick, thicker before.	A little thick, thicker before.	* *	A little thick, thicker before.	Rather thin, thicker before.	Rather thin, thicker before.	Slightly thickened, thicker before.	Thick, thinner behind.
Rather prominent, concentrically undulate.	A little prominent, concentrically undulate.	Slightly prominent.	Slightly prominent.	Slightly prominent, sub-concentrically undulate.	Slightly prominent, concentrically undulate.	A little prominent.	Rather prominent.
Short, thin, lightish brown.	Short, thin, brown.		Rather long and thin.	Small, thin, yellowish brown.	Small, thin, yellowish brown.	Short, thin, dark brown.	Short, thin.
Dark brown, eradiate, transversely striate.	Blackish, eradiate; lines of growth distant.	Dark, olivaceous, wrinkled.	Dark olive, obscurely rayed, growth marks distant.	Dark olive, shining, obsoletely rayed, marks of growth distant.	Dark brown, obsoletely radiate, growth lines distant.	Dark brown or blackish, obscurely radiate, marks of growth distant.	Striate, nearly black.
Small, erect, compressed, crenulate, acuminate.	Small, erect, compressed, crenulate.	Oblique, single in one, double in the other valve.	Small, sulcate, somewhat compressed, double in both valves.	Small, erect, crenulate.	Small, erect, acuminate, crenulate, double in both valves.	Small, compressed, crenulate, pointed, double in both valves.	Rather large.
Thin, somewhat curved.	Rather long, slightly curved.	* *	Rather long, lamellar, nearly straight.	Long, lamellar, somewhat curved.	Long, lamellar, somewhat curved.	Very long, slightly curved, lamellar.	Small, curved.
Distinct, small, well impressed.	Distinct, small, well impressed.	*	Distinct, small, well impressed	Distinct, small, well impressed	Distinct, small, somewhat impressed.	Distinct, rather large, moderately impressed.	Distinct.
Confluent, slightly impressed.	* * * *	* * *	Confluent, rather large, moderately impressed.	Confluent, slightly impressed.	Confluent, slightly impressed.	Confluent, slightly impressed.	Confluent.
Center of cavity of beaks.	Center of cavity of the beaks.	* *	Center of cavity of the beaks.	Across the cavity of the beaks.	Across the cavity of the beaks.	Across center of cavity of the beaks.	Center of cavity of the beaks,
Rather deep, wide.	Deep, wide.	Very capacious.	Deep, wide.	Somewhat deep, wide.	Small, wide.	Shallow, wide.	Deep.
Shallow, obtusely angular.	Shallow, obtusely angular.	Very capacious.	Shallow, obtusely angular.	Shallow, obtusely angular.	Shallow, obtusely angular.	Shallow, obtusely angular.	Rather deep, angular.
Purplish, iridescent.	Purple, iridescent.	Chocolate purple.	Whitish, iridescent.	Bluish, very iridescent.	White, very iridescent.	White or pale salmon, iridescent.	Pearly white, iridescent.
Coosa River, Ala.	Swamp Creek, Whitfield Co., Ga.	Wateree River, S. C., Warm Spa, N. C.	Lake Ochechobee, Fla.	DeWitt Co., Texas.	Devil's River, Texas.	Leon Co., and Rutersville, Texas.	Lakes Monroe and George, Fla.
0.55 inch.	0.5 inch.	* * * *	0.5 inch.	0.5 inch.	0.4 inch.	0.6 inch.	0.4 inch.
0.82 inch.	0.7 inch.	* * * *	0.7 inch.	0.8 inch.	0.7 inch.	1.0 inch.	0.6 inch.
1.40 inch.	1.2 inch.	* * * *	1.3 inch.	1.4 inch.	1.2 inch.	1.7 inch.	0.9 inch.

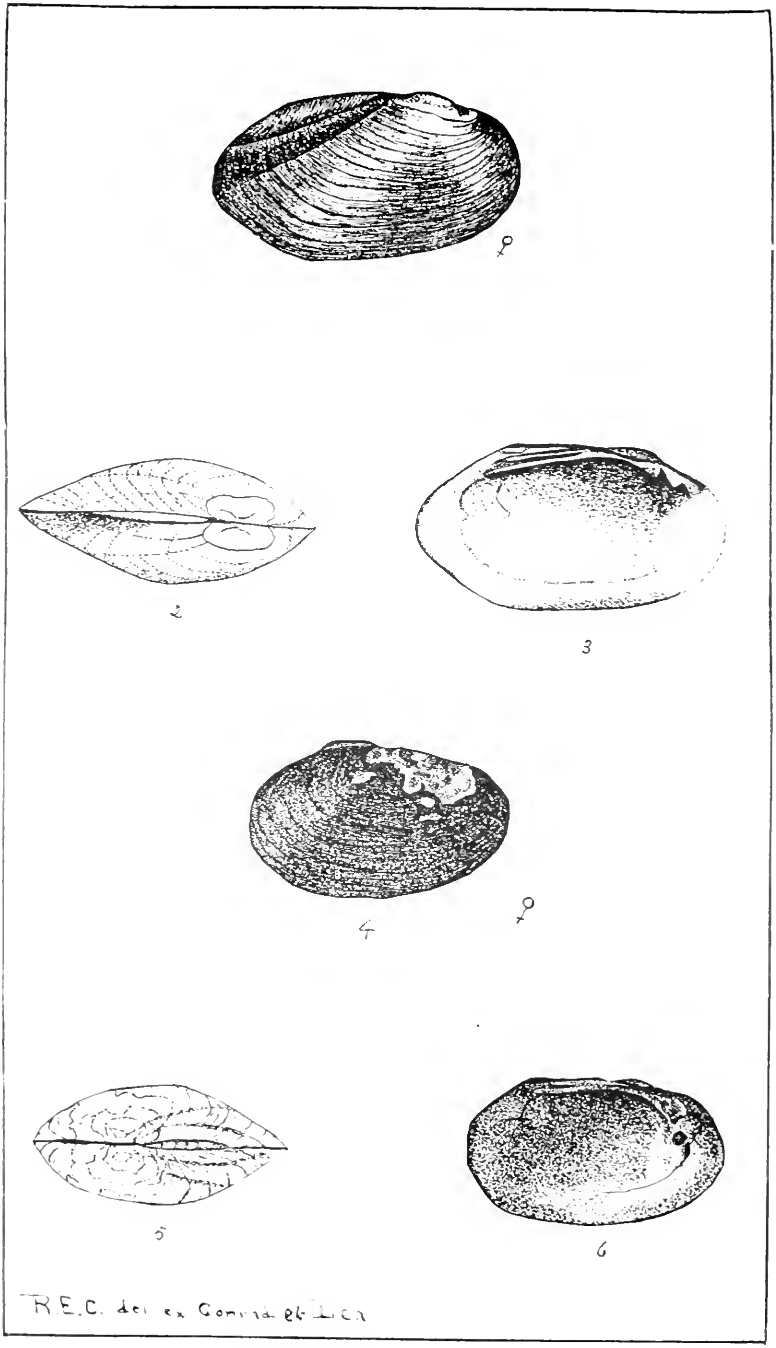
ADDITIONAL NOTE.

Since the work on this group of Unios was completed I have had the opportunity to re-examine a carefully prepared paper by Mr. Chas. T. Simpson on the "Unionidæ of Florida." I must dissent from some of the conclusions Mr. Simpson reaches, though in the main he is, beyond question, correct. That author places *Unio lepidus* Gould and *Unio trossulus* Lea in the *parvus* group. Both these shells are here out of place. *Unio trossulus* has the fine concentric undulations on the umbones which are so characteristic of many Unios typified by *Unio fallax*, *Unio lienosus et cetera*. Both Lea's figure and his description do not permit that this form go into the present group. The character of the radiation, as given by Mr. Simpson in his very poor outline figure of *Unio lepidus* places it elsewhere, for if there is any such thing as a characteristic in the *parvus* group its radiation, when present, is very remarkable and quite uniform. There is no doubt that *Unio trossulus* and *Unio lepidus* are synonyms. The paper of Mr. Simpson is to be commended as marking a distinct advance in the study of the southern representatives of this great family. It appeared in volume XV of the Proceedings of the United States National Museum, 1892, and should be in the hands of every student of *Unio*.

The proofs of this article reached me when consultation of my library on one or two points suggested by careful re-reading was impossible. The synonymy of *Unio parvus* should have included the following:

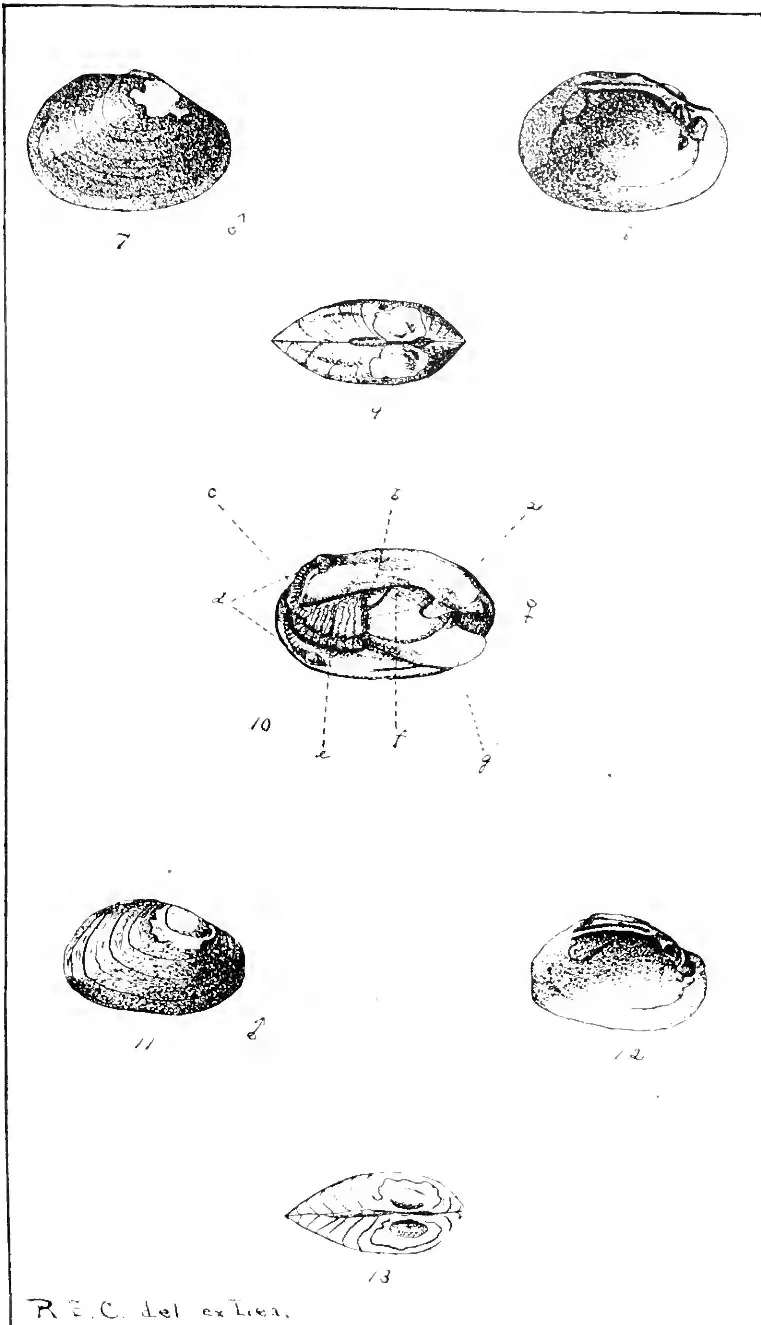
Unio singleyanus Marsh. Ephemerally described in the Joliet Weekly, a newspaper of Illinois, May, 1891. See also the "Nautilus," Vol. V, p. 29; Simpson, "Notes on Florida Unionidæ," Proc. U. S. Nat. Mus., Vol. XV, pp. 426, 427, pl. LXVIII, figs. 4, 5 (1892). Without doubt a synonym for Lea's *Unio marginis*, itself a southeastern representative of *Unio parvus*.

Plate I.



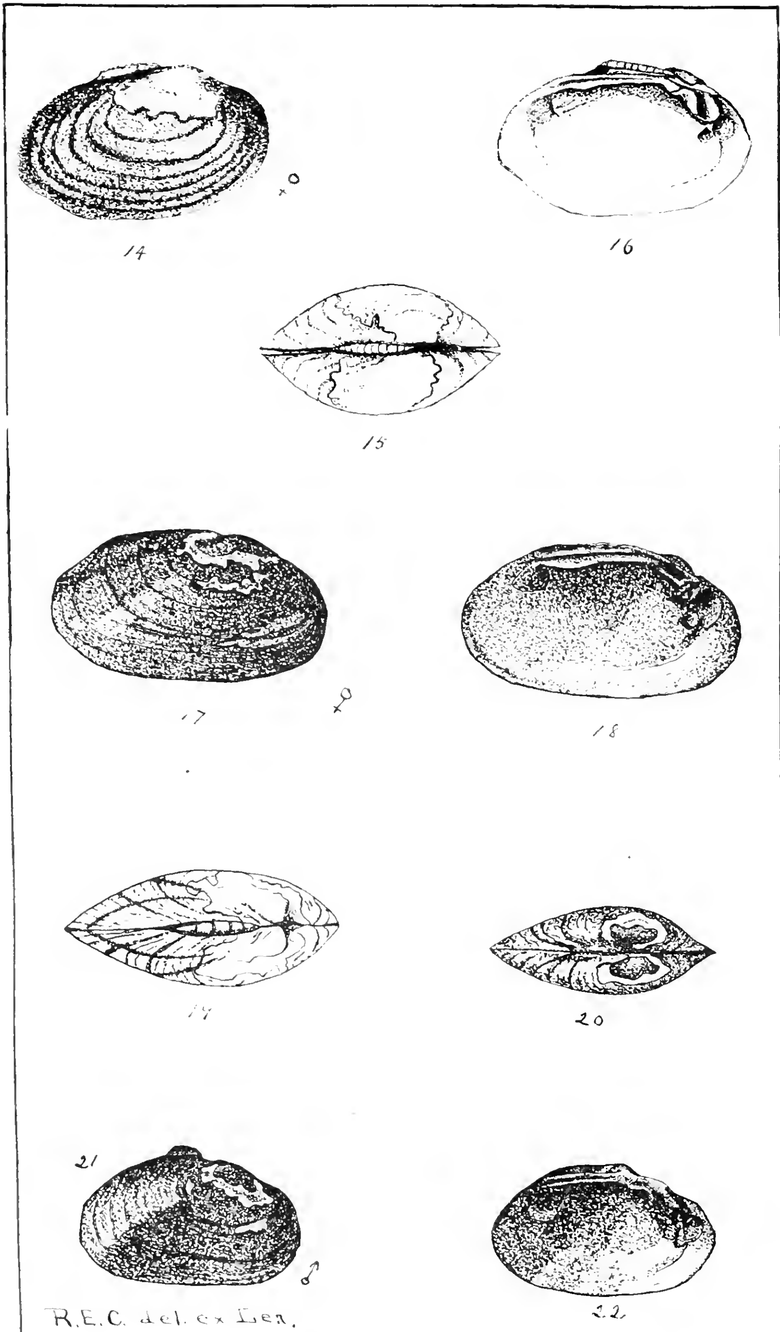
CALL, ON PARVUS GROUP OF UNIO.

Plate II.



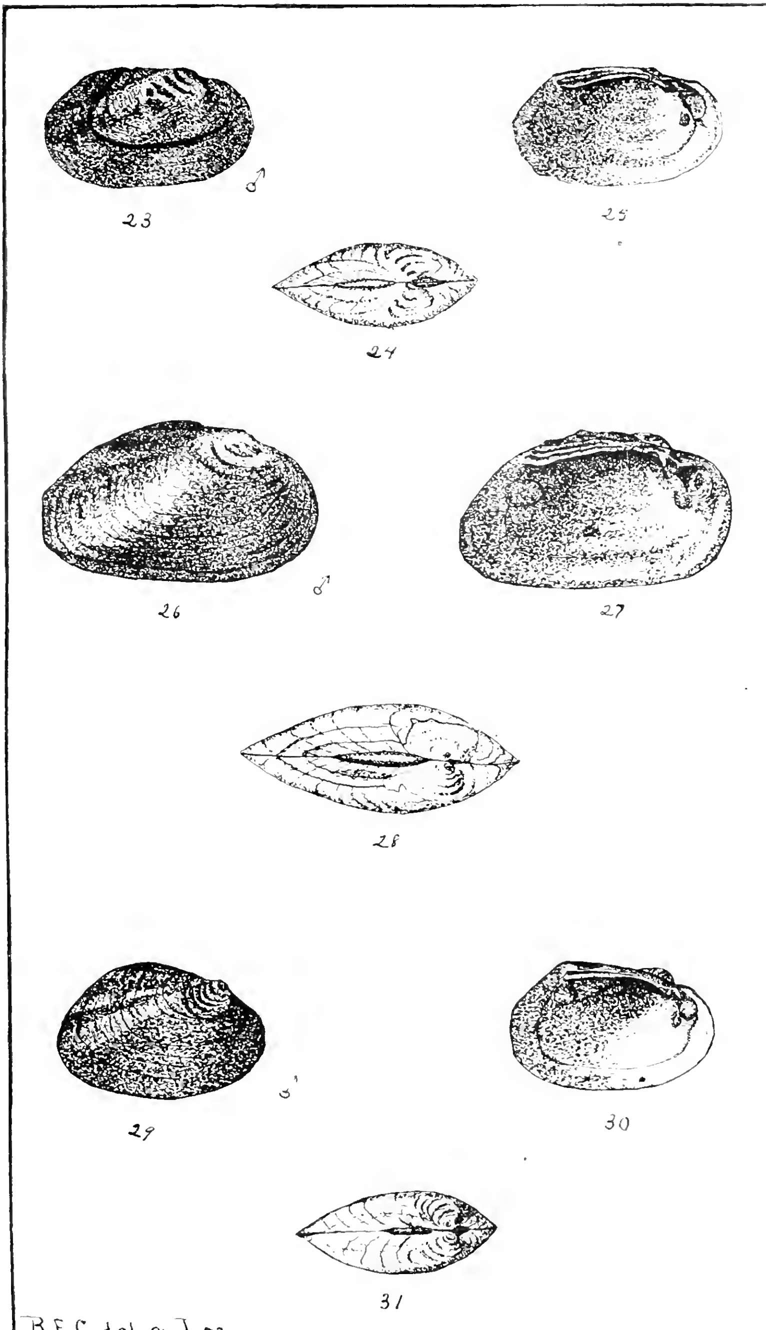
CALL, ON PARVUS GROUP OF UNIO.

Plate III.



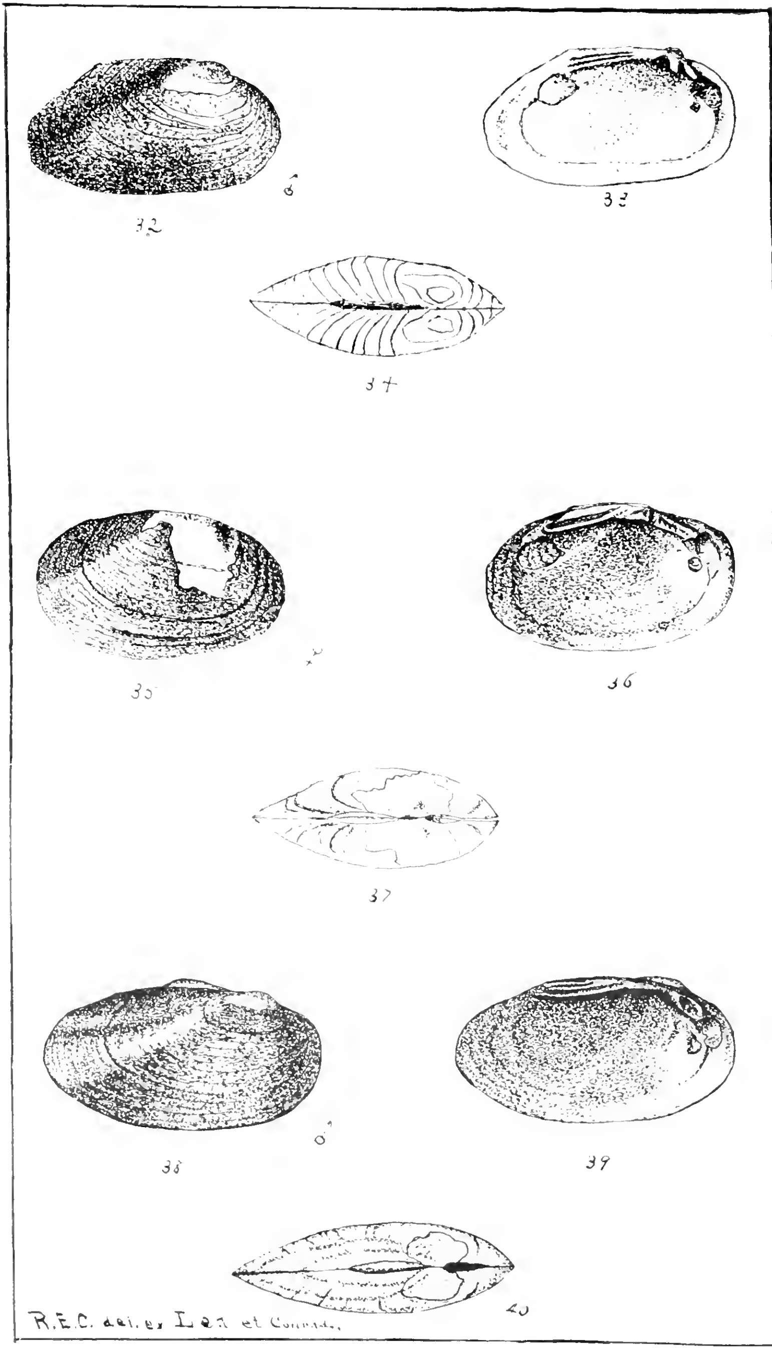
CALL, ON PARVUS GROUP OF UNIO.

Plate IV.



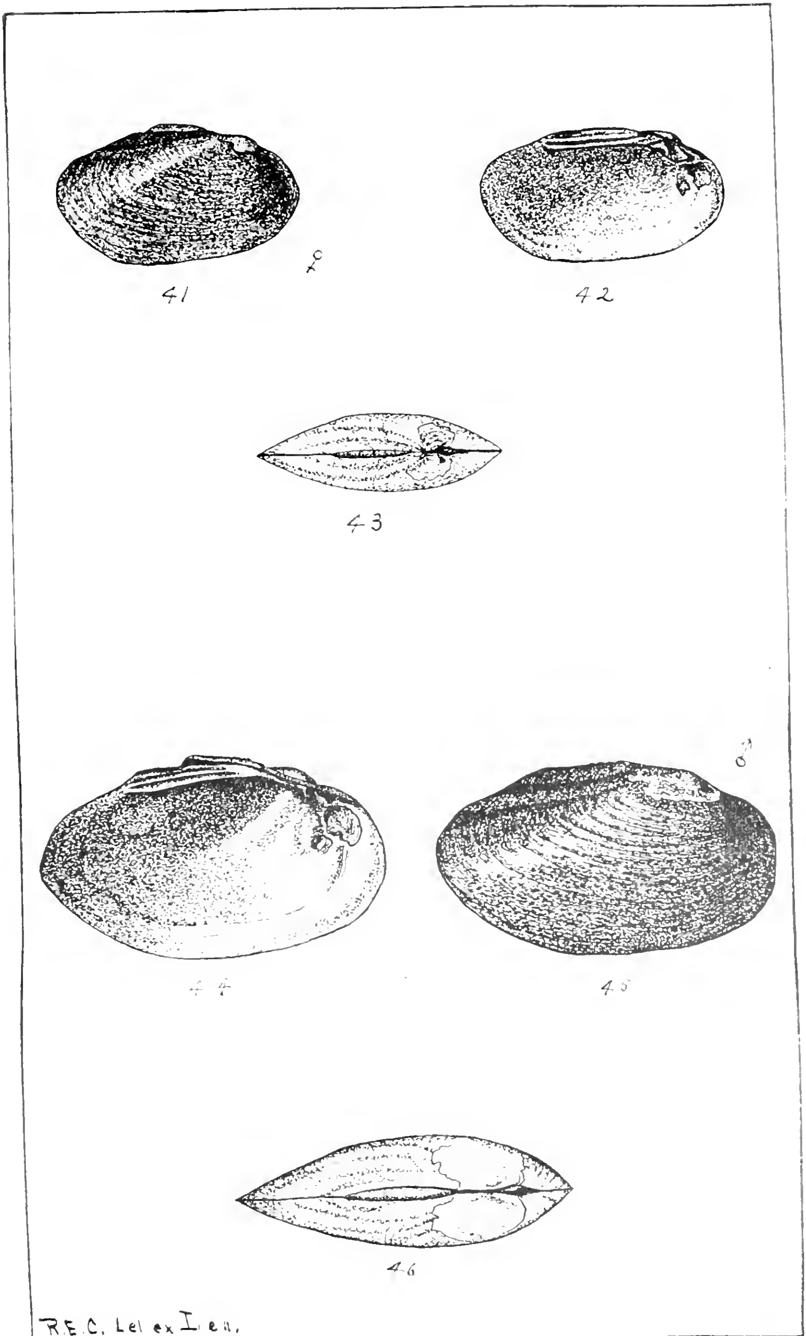
CALL, ON PARVUS GROUP OF UNIO.

Plate V.



CALL, ON PARVUS GROUP OF UNIO.

Plate VI.



CALL, ON PARVUS GROUP OF UNIO.

THE FISHES OF THE MISSOURI RIVER BASIN. BY BARTON W. EVERMANN AND J. T. SCOVELL.

In 1892 and again in 1893 Dr. Evermann made extended investigations in Iowa, South Dakota, Nebraska and Wyoming for the purpose of selecting a site for a fish-cultural station somewhere in that region. In 1891 he had made similar investigations in Montana and Wyoming and primarily for the same purpose.

While engaged in this work we examined a great many streams and made large collections of fishes representing a great many localities.

Studying these collections very naturally led to a consideration of the entire fish-fauna of the Missouri basin, and it is with some of the interesting features of this fauna that the present paper deals. That we may understand more clearly the distribution of the fishes a few words concerning the characteristic features of the basin may not be out of place.

The Missouri River Basin. The Missouri is the longest river in North America. Its headwaters are among the Rocky Mountains of Montana, Wyoming and Colorado. At numerous places its sources are but a few miles from those of the Saskatchewan, the Columbia and the Colorado. In northwestern Montana are the sources of Milk River which are said to be connected directly with those of the Saskatchewan, while only a few miles to the westward the drainage is into Flathead River and thence into the Columbia. In southwestern Montana the headwaters of the Big Hole, Beaverhead, Red Rock and Madison on one hand closely approach those of the Bitter Root, Salmon and Snake on the other. In northwestern Wyoming, just south of the Yellowstone National Park, the headwaters of the Columbia and Missouri actually unite in Two-Ocean Pass, forming a continuous waterway from the mouth of the Columbia to that of the Mississippi.*

In Wyoming the Sweetwater, a tributary of the North Platte, and in Colorado the South Platte, rise within a few miles of streams which are tributary to the Colorado of the west.

The headwaters of these various tributary streams are 8,000 to 14,000 feet above sea level. Gallatin, Montana, where the Jefferson, Madison and Gallatin rivers unite to from the Missouri proper is 4,132 feet altitude, the sources of Madison River are over 8,300 feet above the sea, while Two-Ocean Pass is about 8,200 feet.

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*For a full description of this phenomenon and its bearing upon the distribution of fishes see Evermann, in Popular Science Monthly, for June, 1895.

The mouth of the Missouri River is about 400 feet above sea level; the total fall of this river is over 7,000 feet, or 3,732 feet between Gallatin and the Mississippi. The length of the Missouri proper is given as 3,000 miles; add to this the length of Madison River and we have 3,230 miles, which may properly be regarded as the total length of the Missouri. Among the important tributaries may be named Milk River; Jefferson Fork, 140 miles; Gallatin Fork, 170 miles; Yellowstone River, 1,100 miles; Platte River, 1,250 miles (including the North Platte); and the Kansas River, 900 miles (including the Smoky Hill Fork). The area drained by this great river is given as 518,000 square miles. This includes the entire State of Nebraska, all of South Dakota, except a few square miles in the northeast corner; nearly all of Montana, North Dakota and Wyoming, about half of Kansas, more than half of Missouri, and large parts of Iowa and Colorado.

The Missouri basin may very properly be divided into three parts, viz., the western or mountainous, the middle or plains portion, and the eastern or region of deciduous trees.

The mountainous belt includes western Montana, northwestern and central Wyoming, and a small portion of central Colorado. This includes the portion with an altitude of about 4,000 feet or over, and is the region of coniferous forests and swift, clear and cold mountain streams.

The middle belt includes most of northern and eastern Montana, a part of eastern Wyoming and Colorado, and, excepting a narrow strip along their eastern edge, all of the Dakotas, Nebraska and Kansas. This is, in its general features, a broad, level plain, with slight irregularities here and there. It is a region without forests, and over much of its surface not much vegetation of any kind is found. The only timber of any importance is the narrow strip of cottonwoods and willows covering the bottom lands along the streams. The western and central portions of this belt are very barren, in places even desolate, particularly in the Bad Lands, or Mauvais Terre of South Dakota, and parts of North Dakota, Wyoming, Montana and Nebraska. These tertiary beds are of great thickness, usually full of alkali, and very easily eroded.

The Black Hills constitute a mountainous island of evergreen forests and beautiful, clear, cold streams in this desert plain, but need not concern us in the consideration of the basin as a whole. The eastern part of this belt receives more moisture and is a typical prairie region, but its streams are slow, shallow and shifting, still carrying much solid matter in suspension from the region to the westward.

The third or eastern belt embraces a narrow strip along the eastern border of South Dakota, Nebraska and Kansas, and the portions of Iowa and Missouri lying within the Missouri basin. This is essentially a region covered with forests of deciduous trees. It is true that some parts of it are prairie, but the soil contains little or no alkali, and the small streams having their rise in it are fairly clear and pure.

In the mountains at the headwaters of the various tributary streams there is an abundance of rainfall in summer and snow in winter; as a rule the mountains were originally heavily timbered and the moisture was therefore conserved and fed out slowly during the season of drought. This is still true in general, but the reckless destruction of the forests in many places is having its effect upon the streams.

After leaving the mountains the tributaries of the Missouri, with scarcely an exception, enter the broad treeless plain of the middle belt. Here the alkali soil erodes easily, the current becomes slower, the bed broadens, the channel shifts from year to year, and the water becomes warmer and often of the consistency of thin soup. This is the character of all the larger streams as they pass through this middle belt, and the character of the water is the same in all the smaller streams which start in this belt.

The Missouri Basin as a whole, however, is a country whose soils erode with unusual ease and, after getting out of the mountains and upon the plain, few of the streams are ever really clear The Missouri River is always carrying vast amounts of solid matter in suspension and justly deserves the name "Big Muddy." The channels of the Missouri and all the larger tributaries are constantly changing and shifting the beds of the streams.

THE FISHES OF THE MISSOURI RIVER BASIN.

All this, of course, has its effects upon the fish fauna of this river system. Each of the three belts possesses a fish fauna differing very materially in the aggregate from that of each of the other belts.

The total number of species and subspecies of fishes now recognized from the entire Missouri basin is 143. These are distributed among 24 families and 68 genera. The families with large numbers of species are:

The Cyprinidae, with 50 species.

The Percidae, with 20 species.

The Catostomidae, with 16 species.

The Centrarchidae, with 12 species.

The Siluridae, with 10 species.

Only 10 species are characteristic of the western belt, the most characteristic ones being the cut-throat trout, Williamson's whitefish, the blob, the grayling, the long-nosed sucker, Jordan's sucker, and the western dace.

Only 45 species are known from North Dakota, Montana, Wyoming and Colorado. On the other hand, Missouri and the small part of Iowa drained by the Missouri, furnishes 94 species, or, if we include the narrow timbered and abundantly watered strip of eastern Kansas, Nebraska and South Dakota, we have about 100 species occurring in this eastern or lower belt of the Missouri Basin. The middle belt has such characteristic species as *Platygobio gracilis*, *Hybopsis gelidus*, *Hybognathus nuchalis evansi*, and the like. Few if any of these are confined to this belt, but they probably all extend more or less into the lower and upper belts.

In the lower portion of the middle belt is found the limit in the western extension of spiny-rayed fishes. West of the 96th meridian, which is approximately the eastern boundary of Nebraska and the Dakotas, not over a dozen species of spiny-rayed fishes are known to occur. This fact becomes interesting when we recall that a single small creek in Indiana (Bean Blossom Creek, Monroe County*), is known to contain not fewer than thirty-five species of spiny-rayed fishes, and from the streams of Indiana alone we know at least fifty-one species of that group—nearly as many as the total number of species found in the entire fish-fauna of the Missouri basin west of the 98th meridian.

In the Missouri itself and in its larger tributaries are found such large river species as *Polyodon spathula*, *Scaphirhynchus platorynchus*, *Leptops olivaris*, *Ictalurus punctatus*, species of *Ictiobus*, and the like; but in the smaller streams *Catostomus*, *Hybognathus* and *Notropis* are the principal genera represented. *Micropterus*, *Perca*, *Lepomis*, and *Etheostoma* are not rare on the eastern edge of this region, but they become more and more rare as we go westward and very soon disappear altogether. *Perca* has not yet been found west of Mitchell, S. D., 98° west; *Micropterus* has not been found west of Ravenna, Neb., 98° 30′ W., and it is not likely that it occurs naturally even that far west.

Of the four darters whose range extends farthest west in this basin, *Boleosoma nigrum* reaches only to Mitchell, S. D., *Hadropterus aspro* to Ewing, Neb., 98° 20′ W., *Etheostoma iowae* extends still further west, having been found by us at Valentine, Neb., 100° 30′ W., while *Boleichthys exilis*, a somewhat doubtful species, was found even a little farther west in North Dakota.

The Flat-headed Chub is pre-eminently the characteristic fish of the shallow, alkali streams of the middle Missouri basin, and shows better than any other the

* Eigenmann and Fordice, Proc. Phil. Acad. Sci. 1885.

peculiar bleaching effect of the alkaline waters of that region. The fishes are all reduced to a nearly uniform pale or faded appearance. Except those found in the headwaters above the alkali, they seem to be almost wholly without pigment cells of any kind. Perhaps the most extreme case of bleaching is that of *Platygobio gracilis*, which, of all American fishes, seems to be the one most perfectly adapted to life in these alkaline streams.

An examination of the literature shows that seventy four nominal species have been described as new from Missouri basin localities. These seventy-four names represent fifty-one species as now understood, but all but twenty-eight of the seventy-four nominal species had already been described, so only twenty-eight of them were really new. Indeed, we are inclined to think that a little closer investigation will show at least eleven of these twenty-eight to have been not new, so that of the seventy-four fishes which have been described as new from the Missouri basin only seventeen, or about 23 per cent., were really so.

TABLE GIVING NAMES OF DESCRIBERS OF MISSOURI BASIN FISHES, THE NUMBER DESCRIBED BY EACH, AND THE NUMBER OF EACH WHICH STILL HOLD.

AUTHORS.	No. of Species Described.	No. Which Still Hold.
Agassiz	3	1
Abbot	4	0
Cope	21	8
Duméril	3	0
Evermann	1	1
Evermann and Cox	2	2
Gilbert	2	1
Garman	2	1
Gill	5	1
Girard	20	8
Hay	3	0
Jordan	4	1
Jordan and Evermann	1	1
Meek	2	2
Milner	1	1
Total	74	28

RECENT INVESTIGATIONS CONCERNING THE REDFISH, ONCORHYNCHUS NERKA, AT ITS SPAWNING GROUNDS IN IDAHO. BY BARTON W. EVERMANN AND J. T. SCOVELL.

Of the 130 or more families of fishes now recognized as constituting the fish-fauna of North America, the one of greatest and most general interest is the *Salmonidae*, the family to which belong the whitefish, the salmon, and the trout.

Whether we consider beauty of form and color, activity, gaminess, quality as food, or abundance and size of individuals, the different members of this family stand easily with the first among fishes.

Confined to the north temperate and arctic regions, they abound wherever suitable waters are found. In North America alone no fewer than sixty-two species are found. Some of these species are confined to the smaller rivers and running brooks, entering lakes or the sea as occasion serves, but not habitually doing so. Such are some of the species of trout of the genera *Salvelinus* and *Salmo*. Others again are lake fishes, approaching the shores or entering the tributary streams only at spawning time and then retiring again to deeper waters. These are the whitefishes and lake herrings.

Then there is another group made up of species that are marine and anadromous, living and growing in the sea, but entering fresh waters at spawning time. Such are the five species of salmon of our west coast.

From California to northern Alaska and across to Kamchatka are found five species of true salmon of the genus *Oncorhynchus*, viz.:

1. The Hump-back salmon, *O. gorbuscha*,
2. The Dog salmon, *O. keta*,
3. The Silver salmon, *O. kisutch*,
4. The Blue-back salmon, *O. nerka*, and
5. The Chinook salmon, *O. tschawytscha*.

The most interesting and by far the most important of the five are the Chinook and the Blue-back; and it is to the last of those two species that this paper is devoted.

In Kamchatka and Alaska this species is known as the Red salmon and is commercially worth more than all the other salmon of Alaska combined. It here ranges in weight from five to eight pounds, and in late summer and early fall they enter the rivers and lakes of Alaska in myriads at spawning time. In the Columbia River it is called the Blue-back salmon and, next to the Chinook, is the most valuable fish of that river.

The Blue-backs enter the Columbia along with the Chinooks early in the spring, the height of the run being in the month of June; and the catch in the lower Columbia amounts to several hundred thousand fish annually. Such as escape the labyrinth of nets, traps and wheels which for miles literally fill the lower Columbia, pass on to their spawning grounds. We do not yet know just where all their spawning grounds in the Columbia basin are located, but we do know that there are important ones in the inlets of Wallowa Lake in Oregon, and Payette Lake and the Redfish Lakes in Idaho.

It was not, however, until 1894 that any naturalist visited these lakes at the spawning time and made any study of the spawning habits.

In September of that year we made a brief visit to Alturas and Pettit lakes and Big Payette Lake, where we found this salmon spawning.

Big Payette Lake is situated near the head of Payette River about 120 miles northeast from Weiser, Idaho. Alturas and Pettit lakes are two of a group known as the Redfish Lakes, lying among the eastern spurs of the Sawtooth Mountains, forty-five to seventy-five miles northwest from Ketchum, Idaho, the nearest railroad station. These Redfish lakes are really the headwaters of Salmon River, the principal tributary of the Snake, and their distance by water from the sea is more than a thousand miles.

The investigations of 1894 showed that the vicinity of those lakes afforded excellent facilities for studying the habits of the salmon which spawn there, and it was decided to visit them again in 1895.

It should be here stated that the Blue-back salmon which enter the Columbia River are no longer known by that name when they reach their spawning grounds, but are known as Redfish. When they enter the river from the sea they are a clear, bright blue above and silvery on the sides, but when they reach their spawning grounds they have become more or less red, especially the males, which are often a bright scarlet red on the back and sides, the head being a light olive-green. At these Idaho lakes two forms of the Redfish have long been known to occur, a large form weighing four to eight pounds and corresponding to the regular Blue-backs taken in the mouth of the Columbia; the other is a small form weighing almost invariably a half pound each and not corresponding to any salmon ever taken in the lower Columbia. Structurally it does not appear to differ from the large form in anything except size, and the two forms are regarded as being specifically identical.

But a number of questions concerning this fish were veiled in more or less obscurity, among which may be mentioned the following:

1. Do the Redfish which spawn in the inlets of the Idaho lakes really come up from the sea, and when do they first arrive?

2. During the spawning season the Redfish are observed to have their fins more or less worn or frayed-out and to have sores upon the body. Are these mutilations received on the spawning grounds, or are they injuries incident to the long and perilous journey from the sea?

3. What are the habits of the Redfish during spawning time?

4. What becomes of them after done spawning? Do they return to the sea, to the lakes, or do they all die?

In order to answer as many of these questions as possible, it became at once evident that an extended series of observations at one of the lakes would be necessary. A camp was therefore established at Alturas Lake last summer on July 20, and the observations begun then were carried on continuously until September 24.

Alturas Lake is situated at an altitude of 7,200 feet, between two immense glacial moraines extending downward from the eastern spurs of the Sawtooth Mountains. It is about two miles long, four-fifths of a mile wide, and has a maximum depth of 158 feet. Its inlet is a small mountain stream about eight miles long, and thirty feet wide at the mouth. The outlet of Alturas Lake is somewhat larger, and after flowing through Perkins Lake (a small lake about a half mile below) enters Salmon River Valley. After a course of about five miles to the northeast, Alturas outlet joins Salmon River.

Just above the lake on either side of the inlet tower extremely rugged mountains whose peaks are 9,000 to 11,000 feet above the sea, and the scenery is as wild as any to be found in America.

In order to study the Redfish effectually, we set gill nets in the outlet and in the inlet and examined them from day to day. The nets in the outlet would tell us when the fish arrive from below on their way to the spawning grounds. The nets in the inlet would tell us when the fish run up out of the lake to their spawning beds, and also whether they return to the lake after done spawning.

Without going too much into detail, it will suffice to say that daily observations of the lake, outlet and inlet, were made, and the nets, though not kept continuously set, were so regulated as to assist in solving as many as possible of the problems involved.

Not a single Redfish was ever caught in any of the nets in the outlet. If they come up from the sea, they had reached Alturas Lake before July 20, when our nets were set.

On July 24 four small Redfish were caught on the net in Alturas inlet, and in a day or two they were abundant in this stream. Evidently, therefore, they had entered the lake at some date prior to July 20, and had remained in it until the evening of July 23 when they first entered the inlet.

Beginning with July 23 the fish continued to enter the inlet until early in September. During this time at least 2,000 Redfish, only about a dozen of which were of the large form, entered this small creek. Hundreds of these were examined as they were running up into the inlet from the lake, and not one of them showed any sores, frayed-out fins, or mutilations of any kind. Toward the close of the spawning season there was scarcely a fish whose fins were not more or less worn out (frequently the caudal was entirely gone) and whose back or sides were not sore. And we were able to see how these mutilations were received.

During the spawning period there is a rather definite pairing off of the sexes. The spawning beds are usually in very shallow water on a bottom of fine gravel and sand. While spawning, this gravel and sand is moved about a good deal and made up into so-called nests, both sexes taking part in the work. The gravel is moved about by the fish striking it with the tail, or by pushing against it with the lower fins, or sometimes even with the dorsal fin and the back. The gravel is moved by a rapid, quivering movement of the body as the fish swims over the nest; then she circles around down stream a few feet and approaches the nest to repeat the act again. The male follows closely behind the female, and frequently moves the gravel in the same way.

The fish move about to some extent in the inlet, but there is no evidence that they ever try to return to the lake. Our nets caught a good many from the upper side, but they were nearly all dead or dying fish which had been carried down by the current, and were only slightly gilled or simply lodged against the upper side of the net. We saw no evidence whatever indicating any tendency to return down stream, and it is not easy to believe that any fish, so seriously mutilated as these all are at the end of the spawning season, could survive. On September 5 we counted about 1,000 fish in Alturas inlet; two weeks later all had died but about 150, and a week later practically all had died.

We consider it, therefore, absolutely proved that the Redfish which spawn in the inlets of the Idaho lakes spawn only once and then die, and that the mutilations are received on the spawning beds.

A New Habitat for Gastrophilus. By A. W. Bitting.

The genus *Gastrophilus* contains two well known species, *Gastrophilus equi* and *Gastrophilus haemorrhoidalis.* These parasites are commonly known as bots and inhabit the stomach and duodenum of the horse.

The life cycle is as follows: The female deposits her eggs upon the ends of the hairs upon the fore limbs or some other part of the body that the horse is likely to touch with his mouth in fighting flies. The eggs hatch and the lid breaks open to permit their escape in from five to fifteen days. They attach themselves to the lips or tongue when the host is fighting flies and soon find their way into the stomach or interior part of the duodenum. Here they pass a period of development lasting about seven months. Their food consists of the nutriment found in solution in the juices of the stomach. They escape from the body with the excrement, pass a pupa state in the ground to emerge in a short time as adult.

The particular observation to be recorded here is the finding of this parasite in the alveoli of the horse's teeth.

Last September there were an unusual number of cases of caries of the teeth at the clinics.

While extracting teeth six larvae were obtained attached to the tissues of the teeth or alveolar cavity. They were alive and active. They were about three centimeters from the surface of the gums and there was no visible point for entrance.

The question remains how did they get to their destination and how did they accommodate themselves to take nutriment from the blood when it is believed that they are dependent upon the juices of the stomach?

Are they a factor in producing caries of the teeth?

Second Contribution to a Knowledge of Indiana Mollusca. By R. Ellsworth Call.

The sources of information on which the facts stated in this brief paper are based are various. No single source has availed largely in determining the locality references that are given, though the collection in the Geological Museum, in the State Capitol, has furnished the greater number. All the rest have been contributed by specimens submitted through several gentlemen practically interested in the work of the biological survey of the State. For this aid thanks are due W. S. Blatchley, State Geologist; Dr. J. T. Scoville, Terre Haute High School; Dr. C. H. Eigenmann, State University, Bloomington; Mr. Harry Dodge, Charleston, Indiana, and Mr. Charles Dunn, Chicago.

The specimens which have been seen are mainly the most common forms. In some few cases they have been found to be widely distributed over the State; others are, apparently, confined to the Ohio and its principal tributary stream, the Wabash. North of the divide that separates the Ohio and lake drainages fewer forms of *Unionidæ* occur, but the *limnæid* fauna appears to represent both an increased number of individuals and of species. The land shells of the Ohio drainage are both more abundant and varied. But no really final generalizations can yet be ventured in the absence of extended collecting and large numbers of shells—a condition which the present activity of members in this branch of the State's biological survey indicates to be very remote. The facts collected for the year past are the following:

Land Mollusca.

Mesodon albolabris Say.

Charleston, Terre Haute, Indianapolis, New Albany.

Mesodon clausus Say.

Vigo County, Indianapolis, Peru.

Mesodon elevatus Say.

Terre Haute, Indianapolis, Corydon.

Mesodon exoletus Binney.

Vigo County, Indianapolis.

Mesodon multilineatus Say.

Terre Haute, Indianapolis.

Mesodon profundus Say.

Charleston, Indianapolis, Terre Haute.

Mesodon thyroides Say.

Vigo County, Indianapolis, Charleston.

Patula alternata Say.

Vigo County, Charleston.

Patula solitaria Say.

Vigo County, Charleston.

Patula perspectiva Say.

Vigo County.

Patula striatella Anthony.

Vigo County.

Zonites arboreus Say.

Vigo County, Bloomington, Charleston.

Zonites ligerus Say.

Vigo County.

Zonites gularis Say.

Charleston.

Zonites fuliginosus Griffith.

Gibson County.

Triodopsis fallax Say.

Vigo County, Indianapolis.

Triodopsis inflecta Say.

Charleston, Vigo County.

Triodopsis appressa Say.

Vigo County, Indianapolis.

Triodopsis palliata Say.

Vigo County.

Triodopsis tridentata Say.

Charleston, Vigo County.

Tebenophorus dorsalis Binney.

Vigo County.

Limax campestris Binney.

Vigo County, Turkey Lake.

The "slugs" or shell-less terrestrial mollusks of Indiana are hardly known. Very few collections contain any representatives. Inasmuch as they do not appeal to the conchologist and are rather difficult of preservation, requiring alcoholic methods, they have been neglected. They promise useful facts if particular attention is directed to their systematic collection. They are to be sought under chips, boards, logs, flat rocks, bark, sidewalks, in cellars and about barns and other outhouses in damp situations. A track of dried mucus will often lead one to their hiding place, if carefully traced. They should receive especial attention from the collectors of the survey.

Stenotrema monodon Rackett.

Vigo County.

Stenotrema hirsutum Say.

Vigo County.

Macrocylis concava Say.

Charleston, Indianapolis, Terre Haute.

Succinea avara Say.

Vigo County.

Succinea obliqua Say.

Vigo County.

FRESH WATER UNIVALVES.

Bulinus hypnorum Linnæus.

Coffee Chute, Gibson County.

Limnæa caperata Say.

Vigo County.

Limnophysa humilis Say.

Very abundant on marshy banks of the Ohio, in springs at New Albany; found in 1894 in myriads.

Limnophysa reflexa Say.

Ponds, Vigo County.

Physa gyrina Say.

Marion County; probably found everywhere in the State; exceedingly abundant in pools on the Falls of the Ohio.

Helisoma trivolvis Say.

Vigo County.

Planorbella campanulata Say.

Ponds, Vigo County; Lake Maxinkuckee.

Pleurocera subulare Lea.

Wabash River, Vigo County.

Plurocera canaliculatum Say.

Very abundant on the Falls of the Ohio; on muddy banks of the Wabash River, at Terre Haute, occurs in myriads. A large number of specimens were collected in October, 1895, at the last named locality, which present a wide range of variation, both in the characteristic grooving of the body-whorl and in coloration. Many specimens occurred without any indication of a groove; in others the angle, which is found along the lower border of the body-whorl, may be sharp, or obtuse, and is frequently thickened at intervals, constituting a character that makes a number of specimens approximate *Pleurocera moniliferum* Lea. Any one of a half dozen species belonging to the pleurocerid group, of which *canaliculatum* is a type, might be separated from the material before me. Many thousands of this shell have been taken at the Falls of the Ohio opposite Louisville. They present a still wider range of variation, perhaps from the character of their habitat. The very wide range of variation suggests some interesting synonymic conclusions that it is hoped will be elaborated during the coming year.

Goniobasis pulchella Anthony.

Wabash River, Ohio River at the Falls, Turkey Creek.

Widely distributed over the State, and with *Goniobasis livescens* Menke, ranges farthest north.

Goniobasis livescens Menke.

Turkey Creek, St. Joseph River.

Goniobasis sp.

A very great quantity of these small shells were collected by me at the Falls of the Ohio during the past three years, but opportunity to work it up has not yet been afforded. As in the pleuroceroid section, this material promises an abundant synonymy.

Lioplax subcarinata Say.

Wabash River, Ohio River.

Vivipara intertexta Say.

Wabash River, Gibson County, Lake Maxinkuckee.

Vivipara contectoides Binney.

Lake Maxinkuckee, ponds along Wabash River.

Campeloma decisum Say.

St. Joseph River, Lake Maxinkuckee.

Campeloma ponderosum Say.

Ohio River, Wabash River, ponds in Vigo County.

Campeloma rufum Haldeman.

St. Joseph River.

Campeloma subsolidum Anthony.

Peru, Lake Maxinkuckee, White River.

The very interesting and very difficult group of shells comprised in *Campeloma* is probably the least understood and the most abused of any in the North American fauna. At brief intervals some tyro arises to declare his "discovery that after all there is but one species," etc., etc., the latest of these being a writer in the "Proceedings of the Iowa Academy of Sciences."* In this paper the remarkable suggestion is confidently made that "Mr. Binney's disposition of these forms is still the best." Now, Mr. Binney wrote on these mollusks thirty

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* Proc. Iowa Acad. of Sciences, 1893 [1894], p. 108. Shimek, "Additional Notes on Iowa Mollusca."

years ago, with poor and scanty materials at his command. He succeeded in involving the group in almost inextricable confusion for nearly a quarter of a century, a result hardly to be wondered at with paucity of material and want of familiarity with fresh water forms. So far from the truth is it that Mr. Binney's disposition of these forms was wise that, without detracting a whit from his well earned reputation as a student of our terrestrial mollusca, it may be fairly stated that had he left the group severely alone its limitations would sooner and better be reached. As species go, every form listed from Indiana is distinct and is easily separable, no matter how mixed the material may be. The embryonic forms differ; the mature shells differ; their character is obvious to any who will carefully study extensive series. What the specific value of certain forms may eventually prove to be does not in the least affect the general proposition that the group is composed of a number of forms which must be recognized as species. It would, indeed, be a striking commentary on the acumen of American conchologists if, after thirty years, no advance had been made in this group. And this same writer accepts several undoubted synonyms of the circumpolar *Vallonia pulchella* Müller, as good species!

Corbiculadæ.

Sphærium sulcatum Lamarck.

Ponds, Vigo County.

Sphærium striatinum Lamarck.

Turkey Creek; Ohio River; Ponds, Vigo County.

Sphærium transversum Say.

Abundant in the Ohio at Charleston.

Unionidæ.

**Anodonta edentula* Say.

Ponds, Vigo County; Bennett's Creek; Wabash River; Cedar Creek; St. Joseph River.

**Anodonta ferussaciana* Lea.

Bennett's and Coal creeks, Vigo County; Five Mile Pond, Vigo County; St. Joseph River.

Anodonta footiana Lea.

Lake Hamilton; Lake Maxinkuckee.

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*All names thus marked have Indiana representatives in the State Museum, at Indianapolis.

Anodonta grandis Say.

Fourteen Mile Creek, Charleston; Lake Hamilton; Five Mile Pond, Vigo County; Raccoon Creek.

Anodonta imbecillis Say.

Bennett's Creek, Vigo County.

Anodonta pavonia Lea.

Pond, near Terre Haute; Bennett's and Coal creeks, Vigo County.

Anodonta salmonia Lea.

Yellow River; Cedar Creek; St. Joseph River.

**Anodonta suborbiculata* Say.

Wabash River.

**Anodonta subcylindracea* Lea.

Wabash River; Cedar Creek.

Anodonta undulata Say.

Lake Maxinkuckee.

Anodonta wardiana Lea.

Fourteen Mile Creek, Charleston.

**Margaritana calceola* Lea.

Wabash River, White River, Turkey Lake.

**Margaritana complanata* Barnes.

Wabash River, White River, Ohio River, Bruiett's Creek.

**Margaritana confragosa* Say.

Wabash River.

**Margaritana dehiscens* Say.

Wabash River, Ohio River.

**Margaritana deltoidea* Lea.

Lake Maxinkuckee, St. Joseph River.

This form is a synonym of *Margaritana calceola* Lea.

**Margaritana hildrethiana* Lea.

Wabash River.

**Margaritana marginata* Say.

Wabash River, White River, Ohio River, St. Mary's River.

**Margaritana monodonta* Say.

Ohio River, Wabash River.

This shell was described, in 1830, from the Falls of the Ohio, by Mr. Say, but was by him regarded as a *Unio*. Mr. Lea described it the same year as *Unio soleniformis*. Mr. Lea's shell is given the indefinite locality "Ohio," and the shell probably came from the Ohio River, near Cincinnati. Mr. Say's name has priority, even though it is now recognized that the species falls in *Margaritana* rather than in *Unio.*

In habit the species resembles *Margaritana dehiscens* in that it is often deeply buried in the gravelly banks it affects, in rather swiftly flowing water. Most commonly, however, it may be found buried deeply under large flat rocks, and between clefts in rocky bottoms. It is a rather rare shell in collections.

* *Margaritana rugosa* Barnes.

Wabash River, White River, Blue River, Fourteen Mile Creek.

* *Unio æsopus* Green.

Wabash River, Ohio River.

* *Unio alatus* Say.

White River, Ohio River, Wabash River.

* *Unio anodontoides* Lea.

Wabash River, Ohio River, Bruisett's Creek, Vigo County.

* *Unio asperrimus* Lea.

Wabash River, Ohio River, at the Falls; this form is equivalent to *Unio lachrymosus* Lea.

* *Unio camelus* Lea.

Ohio River; this is an old and heavy *Unio phaseolus*, of which it is a synomym,

* *Unio camptodon* Say.

Wabash River, Ohio River.

* *Unio capax* Green.

Wabash River. Ohio River.

* *Unio cicatricosus* Say.

Wabash River, Ohio River.

* *Unio circulus* Lea.

St. Mary's River, Ohio River, Wabash River, Peru.

* *Unio clavus* Lamarck.

Wabash River, very abundant; St. Joseph River.

* *Unio coccineus* Hildreth.

Wabash River, Ohio River.

* *Unio cooperianus* Lea.

Wabash River, Ohio River.

* *Unio cornutus* Barnes.

Ohio River, Wabash River.

**Unio crassidens* Lamarck.

Wabash River, Falls of the Ohio, abundant.

**Unio cylindricus* Say.

Ohio River, Wabash River, White River.

These shells, as are indeed most others from the Wabash River, are singularly beautiful and perfect. Even the largest and oldest examples present perfect umbones, with epidermis and apical crenulations entire. It is rare indeed to find these forms so perfect. Both this species and *Unio metanevrus*, which are characterized by peculiar arrow-shaped green color-markings over the whole disk, present this feature in singular beauty. The State Collection, at Indianapolis, contains several well-marked and beautiful specimens.

**Unio donaciformis* Lea.

Wabash River, Ohio River at Falls of the Ohio; found, also, in collections under the name of *Unio zigzag* Lea. The latter name was given two years after *Unio donaciformis* was characterized.

**Unio ebenus* Lea.

Wabash River, Ohio River, Falls of the Ohio.

**Unio elegans* Lea.

Wabash River. Ohio River, Falls of the Ohio.

**Unio ellipsis* Lea.

Wabash River, Ohio River, Falls of the Ohio, common.

**Unio fabalis* Lea.

Wabash River.

Unio lapillus Say, is a synonym of this form.

**Unio fragosus*, Conrad.

Wabash River. Ohio River, White River.

**Unio gibbosus* Barnes.

Wabash River, Sand Creek, Ohio River, Turkey Lake, Lake Tippecanoe, St. Joseph River, Lake Maxinkuckee, Falls of the Ohio, St. Mary's River.

The white and heavy variety of this shell, called by Dr. Lea, *Unio arctior*, occurs somewhat commonly in both the Ohio and Wabash rivers.

**Unio glans* Lea.

Wabash River, White River, Lake Maxinkuckee.

**Unio gracilis* Barnes.

Wabash River, Ohio River on Falls of the Ohio, Muscatatuck Creek, Jennings County.

* *Unio graniferus* Lea.

Wabash River, Ohio River.

* *Unio iris* Lea.

Wabash River, Delaware River, Lake Maxinkuckee.

* *Unio irroratus* Lea.

Wabash River, Ohio River. Very abundant, perfect and beautiful in the Wabash.

* *Unio lens* Lea.

See *Unio circulus*, of which it is a synonym.

* *Unio ligamentinus* Lamarck.

Wabash River, Ohio River, Yellow River, Turkey Creek, Delaware River, St. Joseph River. Widely distributed over the State. The most common *Unio* of our waters, with the possible exception of *Unio luteolus*.

* *Unio luteolus* Lamarck.

Whitewater River, White River, Wabash River, Ohio River, St. Mary's River, Turkey Creek, Cedar Creek, Fourteen Mile Creek, Charleston; Lake Maxinkuckee.

* *Unio metanevrus* Rafinesque.

Wabash River, Ohio River.

* *Unio multiplicatus* Lea.

Wabash River, Ohio River; a mud-loving form which reaches gigantic size in both these streams. Very large and fine specimens are in the State collection.

* *Unio multiradiatus* Lea.

Wabash River, White River, St. Joseph River.

* *Unio mytiloides* Rafinesque.

Wabash River, Ohio River.

* *Unio nigerrimus* Lea.

Wabash River; a single specimen is in the State collection, labelled correctly as above—though the locality can not be vouched for. Mr. Lea described the form from Alexandria, Louisiana. The collection contains many southern shells and I am inclined to regard this locality reference as an error and to think the shell should not be reckoned as an Indiana form.

* *Unie obliquus* Lamarck.

Wabash River, Ohio River; probably the same form Rafinesque called *mytiloides*.

Unio occidens Lea.

Decatur County, Ohio River, Wabash River, Falls of the Ohio, Bennett's Creek, Vigo County.

* *Unio orbiculatus* Hildreth.

Wabash River; Mr. Lea later described the female of this species under the name of *Unio higginsii*.

* *Unio parvus* Barnes.

Wabash River, Ohio River, Creek at Greencastle (Underwood), Lake Maxinkuckee.

Very large specimens of this usually small shell are obtained in the Wabash. So marked is their development that they are commonly known as "the big *parvus* of the Wabash."

* *Unio perplexus* Lea.

Wabash River, White River.

Mr. Lea later twice described again this form, once as *Unio rangianus* and then as *Unio sampsonii*, both the latter from Indiana waters. It has other synonyms, by the same writer, in Tennessee waters.

* *Unio phaseolus* Barnes.

Wabash River, Ohio River, St. Joseph River, Lake Maxinkuckee, Fourteen Mile Creek, near Charleston.

* *Unio plenus* Lea.

Wabash River.

* *Unio plicatus* Le Sueur.

Ohio River, Wabash River.

This shell, widely distributed, has a number of synonyms which I have elsewhere indicated.† It is also often confounded with *Unio undulatus* Barnes, which is, however, a markedly different shell, very much more compressed.

* *Unio pressus* Lea.

Sand Creek, Decatur County; Bruiett's Creek, Vigo County; St. Joseph River, Lake Maxinkuckee.

* *Unio pustulatus* Lea.

Ohio River, Wabash River, White River.

* *Unio pustulosus* Lea.

Wabash River, Ohio River.

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† See Trans. St. Louis Acad. Sci., Vol. VII, No. 1, pp. 36, 37; 1895.

* *Unio rectus* Lamarck.

Wabash River, Ohio River, White River, St. Joseph River.

* *Unio retusus* Lamarck.

Wabash River.

* *Unio ridibundus* Say.

White River, Wabash River.

* *Unio rubiginosus* Lea.

Ohio River, Wabash River, Lake Maxinkuckee.

Unio securis Lea.

Wabash River, Ohio River.

* *Unio solidus* Lea.

Wabash River.

* *Unio subovatus* Say.

Wabash River, Ohio River, White River.

* *Unio subrostratus* Say.

Wabash River, Lake Maxinkuckee, Bruiett's Creek, Vigo County.

Wrongly labelled *Unio nasutus* in the State collection.

* *Unio sulcatus* Lea.

White River, Marion County.

* *Unio tenuissimus* Lea.

Wabash River, Ohio River.

A specimen in the State collection is labelled *Unio vellum* Say.

Unio triangularis Barnes.

Wabash River, White River.

* *Unio trigonus* Lea.

Wabash River, Ohio River.

Unio tuberculatus Barnes.

Ohio River, Falls of the Ohio, Wabash River.

* *Unio undulatus* Barnes.

White River, Ohio River, Wabash River, Bruiett's Creek, Vigo County.

Unio varicosus Lea.

Ohio River.

Unio ventricosus Barnes.

Lake Maxinkuckee, St. Joseph River.

Unio verrucosus Barnes.

Wabash River, Ohio River, White River.

Cincinnati, Ohio, December 23, 1895.

CONTRIBUTIONS TO THE BIOLOGICAL SURVEY OF WABASH COUNTY. BY ALBERT B. ULREY.

The present paper is intended (1) to indicate the progress made during the year in listing the fauna and flora of Wabash County, and (2) to give a summarized statement of the work already done, thus placing the material collected within access of those interested in special lines.

I have included in these lists, with but a few exceptions, only those forms of which specimens were preserved:

I. THE FAUNA:

1. The list of fishes includes forty-two species, seven of which were not noted in the last published report. I have included in the list the Brook Lamprey (*Ammocœtes branchialis*). Several specimens were taken in a creek near North Manchester, about May 15, 1895.
2. Batrachians, 19.
    - *a.* Salamanders and Water Dog (*Urodela and Proteida*), 10.
    - *b.* Tailless Batrachians (*Salientia*), 9.
3. Reptiles, 18.
    - *a.* Snakes (*Ophidia*), 11.
    - *b.* Lizards (*Lacertilia*), 1.
    - *c.* Turtles (*Testudinata*), 6.
4. Birds.

    The list of birds includes 186 species. Two specimens of the Horned Grebe (*Colymbus auritus L.*) were taken along the roadside November 27, 1895, after a severe storm. This is the first record of the bird in the county. Mr. W. O. Wallace has taken another specimen of the rare Kirtland's Warbler (*Dendroica kirtlandi*) at Wabash. It was taken some time in May, 1895.
5. The mammals listed include about twenty species.

II. THE FLORA:

Among Phanerogams the list comprises about 750 species representing eighty-nine families. Only a few of the forest trees are included, 116 species of grasses and twenty-three sedges. About 400 species have been added during the year.

The Cryptogams have not been listed, but some valuable material has been collected in certain groups, such as the ferns and some forms of fungi.

In the collection of Dr. A. Miller, of North Manchester, Ind., there are probably 175 species of parasitic fungi and perhaps twenty-five species of the Slime Moulds, if I may, for convenience, still place them among the fungi.

Nearly a complete list of the Phanerogams may be found in the herbarium of Mr. John N. Jenkins, North Manchester, Ind., who has done valuable work in collecting these forms.

BIRDS OF WABASH COUNTY. BY ALBERT B. ULREY AND WILLIAM O. WALLACE.

The present list enumerates 188 species of the birds of Wabash County. Under each species are given notes concerning its abundance and in some instances we have incorporated other observations which pertain to the life-history of the species.

Most of the work was done at intervals during the years 1890 to 1893. Part of the observations were made in the extreme northern portion of the county in the Eel River valley, near North Manchester. About an equal amount of work was done in the Wabash valley near Wabash, and some observations were made nine miles north of Lagro by Mr. Orrin Ridgley.

We have included in the list only those species identified by us, and with only a few exceptions skins of each species have been preserved. We have noted the breeding habits of those species only which came under our own observation. We may expect to find two hundred or more birds within the county. The list is quite complete in warblers, containing 31 species, one of them the very rare *Dendroica kirtlandi*. Perhaps three more would complete the list to be found in the county. We shall probably find *Protonotaria citrea*, *Helmitherus vermivorous* and *Geothlypis formosa*. The deficiencies in our list are mainly among the water birds. Our only large stream, the Wabash, flows nearly eastward here and is not rich in migrating water birds. The region in the northwestern part of the county, containing numerous small lakes, has not contributed many species to our list, because only a few of the rarer birds taken there by the hunters have been identified by us.

The Wabash River flows in a northerly direction to Logansport, where it bends abruptly to the east and continues in this direction through the county. Near Wabash one of the tributaries of the Wabash River flows nearly due southward. A heavy growth of timber extends along the stream northward some distance from the Wabash and ends abruptly at a large tract of land under cultivation. During the spring migrations the birds collect in the north edge of this woodland in great numbers. It seems that in their northward migrations along the Wabash River the birds attempt to follow the wooded region of the smaller stream instead of pursuing the eastward course of the Wabash, and on reaching the open fields find themselves in a sort of trap. It was at this place that a large per cent. of the birds inhabiting the woodland were taken.

1. *Podylimbus podiceps* Linnaeus. Pied-billed Grebe. Rather common migrant.

2. *Colymbus auritus* L. Horned Grebe. Two specimens were taken November 27, 1895, after a severe storm.

3. *Urinator imber* Gunner. Loon. Great Northern Diver. Not infrequently taken on the lakes. Five or six were taken on the Wabash River near Wabash.

4. *Larus argentatus smithsonianus* Coues. American Herring Gull. One specimen taken as it flew over the house four miles west of Wabash. The specimen was taken by Mr. E. Wright and is now in his possession.

5. *Larus philadelphia* Ord. Bonaparte's Gull. One specimen taken on Lake Maxinkuckee. It will probably be taken here.

6. *Sterna forsteri* Nutt. Forster's Tern. Several specimens were taken on Lake Maxinkuckee.

7. *Hydrochelidon nigra surinamensis* Gmel. Black Tern. Probably taken here. We have a specimen from the same place as the last.

8. *Phalacrocorax dilophus* Sw. and Rich. Double-crested Cormorant. A male and female were taken on Long Lake, November 15, 1890.

9. *Merganser americanus* Cassin. American Merganser. Not uncommon migrant and winter resident.

10. *Lophodytes cucullatus* Linnaeus. Hooded Marganser. Rare. Three specimens taken.

11. *Anas boschas* Linnaeus. Mallard. Abundant migrant; sometimes taken in midwinter, and three were killed July 3, 1892, by Mr. E. Wright. Hunters report its breeding, but we have not observed it.

11*a*. *Anas obscura* Gmelin. Black Duck. One specimen taken at Wabash.

12. *Anas discors* Linnaeus. Blue-winged Teal. Only one specimen. It was taken April 15, 1891.

13. *Aix sponsa* Linnaeus. Wood Duck. Abundant summer resident. I have taken the young when still unable to fly. Wallace.

13*a*. *Spatula clypeata* L. Spoon Bill. Only one specimen taken. Wabash.

14. *Aythya affinis* Eyt. Lesser Scaup Duck. A specimen was taken on Long Lake, November 15, 1890.

15. *Charitonetta albeola* Linnæus. Butter Ball. One specimen from Long Lake. Occasionally killed on Eel River by hunters.

16. *Branta canadensis* Linnæus. Canada Goose. One specimen taken; frequently seen migrating.

17. *Olor columbianus* Ord. Whistling Swan. One specimen taken November 15, 1894, on Long Lake.

18. *Botaurus lentiginosus* Montag. American Bittern. Several specimens known to have been taken.

19. *Botaurus exilis* Gmelin. Least Bittern. Two specimens taken, April 19 and May 1, 1894.

20. *Ardea herodias* Linnæus. Great Blue Heron. Common summer resident.

21. *Ardea egretta* Linnæus. American Egret. A specimen taken just beyond the north line of Wabash County, in Kosciusko County.

22. *Ardea virescens* Linnæus. Green Heron. Abundant summer resident. Breeds.

23. *Nycticorax nycticorax nævius* Bodd. Black-crowned Night Heron. Two specimens taken. One at North Manchester and one at Wabash.

24. *Rallus virginianus* Linnæus. Virginia Rail. One specimen taken at Rock Lake, in Fulton County just across the line, September 1, 1894.

25. *Porzana carolina* Linnæus. Carolina Rail. Not infrequently taken by hunters.

26. *Fulica americana* Gmel. American Coot. Abundant migrant.

27. *Philohela minor* Gmel. American Woodcock. Not very common.

28. *Gallinago delicata* Ord. Wilson's Snipe. I took a specimen January 1, 1892, and the same winter two were killed between December 25th and January 1 by a friend of mine. I have seen them in midsummer. Wallace.

29. *Tringa maculata* Vieillot. Jack Snipe. Very common during migrations, especially in September. It may be found at this time in great abundance along the Wabash River in company with the Solitary Tattler and Killdeer.

30. *Tringa minutilla* Vieillot. Least Sandpiper. Rare. One specimen taken from a flock of Solitary Tattlers, August 29, 1893.

31. *Tringa bairdii* Coues. Baird's Sandpiper. Rare. Only one specimen taken. This is apparently the only record of the bird in the State. [Proc. Ind. Acad. Sci. 1893, p. 118].

32. *Totanus melanoleucus* Gmelin. Greater Yellow-legs. I have never seen this bird except on September 24 and 25, 1893, when I observed a number along the river, three of which I shot. Wallace.

33. *Totanus solitarius* Wilson. Solitary Tattler. Very common summer resident. Breeds.

34. *Bartramia longicauda* Bechst. Upland Plover. One specimen taken from a flock of three.

35. *Actitis macularia* Linnaeus. Spotted Sandpiper. Very common summer resident. Breeds.

36. *Ægialites vocifera* Linnæus. Killdeer. Abundant summer resident. Breeds.

37. *Colinus virginianus* Linnæus. Bob-white. Formerly very abundant, but much less so since the winter of 1892-3, when they were destroyed in great numbers by the severe cold and snow.

38. *Bonasa umbellus* Linnæus. Pheasant. Formerly common, now becoming rare.

39. *Tympanuchus americanus* Reich. Prairie Hen. Occasionally taken on the prairie region near Wabash.

40. *Meleagris gallopavo* Linnæus. Wild Turkey. Formerly common, now probably extinct. The last one known to have been taken was in 1880.

41. *Ectopistes migratorius* Linnæus. Wild Pigeon. Formerly abundant, but none have been seen recently.

42. *Zenaidura macroura* Linnæus. Turtle Dove. Very common resident. Breeds.

43. *Cathartes aura* Linnæus. Turkey Buzzard. Abundant summer resident. Breeds in hollow logs, trees, etc.

44. *Circus hudsonius* Linnæus. Marsh Hawk. Rather common about prairie regions. Extremely variable in color. Breeds.

45. *Accipiter cooperi* Bonaparte. Cooper's Hawk. Common. Probably our most common injurious hawk.

46. *Buteoborealis* Gmelin. Red-tailed Hawk. Abundant resident. Breeds.

47. *Buteolineatus* Gmelin. Red-shouldered Hawk. One specimen taken.

48. *Buteolatissimus* Wilson. Broad-winged Hawk. Two specimens taken.

49. *Falcosparverius* Linnæus. American Sparrow Hawk. Quite abundant resident. Breeds.

50. *Strix pratincola* Bonaparte. American Barn Owl. A single specimen taken by Mr. Frank Bell at North Manchester.

51. *Asio wilsonianus* Less. American Long-eared Owl. A specimen was taken near the north county line. It is in the collection of Mr. M. L. Galbreath.

52. *Asio accipitrinis* Pallas. Short-eared Owl. Four specimens taken at Wabash and one just north of the county line in Whitley County.

53. *Syrnium nebulosum* Forst. Barred Owl. Quite abundant resident.

54. *Nyctala acadica* Gmelin. Saw-whet Owl. One specimen taken November 20, 1894.

55. *Megascops asio* Linnæus. Screech Owl. Abundant, both red and gray phases.

56. *Bubo virginianus* Gmelin. Great Horned Owl. Abundant resident. Breeds.

57. *Nyctea nyctea* Linnæus. Snowy Owl. A specimen of this owl was taken near Roann, probably during the winter of 1891–2, another near North Manchester during the winter of 1893 and one in 1894.

58. *Coccyzus americanus* Linnæus. Yellow-billed Cuckoo. Abundant summer resident. Breeds.

59. *Coccyzus erythrophthalmus* Wilson. Black-billed Cuckoo. One or two specimens taken. Perhaps rather common.

60. *Ceryle alcyon* Linnæus. Belted Kingfisher. Abundant summer resident. Breeds.

61. *Dryobates villosus* Linnæus. Hairy Woodpecker. Abundant resident.

62. *Dryobates pubescens* Linnæus. Downy Woodpecker. Abundant resident. Breeds.

63. *Sphyrapicus varius* Linnæus. Yellow-bellied Woodpecker. Common migrant.

64. *Ceophlœus pileatus* Linnæus. Pileated Woodpecker. Formerly common, but none have been seen recently.

65. *Melanerpes erythrocephalus* Linnæus. Red-headed Woodpecker. Abundant, some years resident. Breeds.

66. *Melanerpes carolinus* Linnæus. Red-bellied Woodpecker. Abundant resident, more common in winter.

67. *Colaptes auratus* Linnæus. Flicker. Abundant resident. Breeds.

68. *Antrostomus vociferus* Wilson. Whip-poor-will. Abundant summer resident.

69. *Chordeiles virginianus* Gmelin. Night Hawk. Common summer resident, more common in late summer.

70. *Chætura pelagiea* Linnæus. Chimney Swift. Abundant summer resident. Breeds.

71. *Trochilus colubris* Linnæus. Ruby-throated Humming-bird. Common summer resident. Breeds. On May 19, 1894, two were found dead after a few days cold weather.

72. *Tyrannus tyrannus* Linnaeus. Kingbird. Very common summer resident. Breeds.

73. *Myiarchus crinitus* Linnaeus. Crested Fly-catcher. Common summer resident. Breeds.

74. *Sayornis phœbe* Latham. Phœbe. Abundant summer resident. Breeds.

75. *Contopus virens* Linnaeus. Wood Pewee. Very common summer resident. Breeds.

76. *Empidonax flaviventris* Baird. Yellow-bellied Fly-catcher. Not very common migrant.

77. *Empidonax acadicus* Gmelin. Acadian Fly-catcher. A common migrant.

78. *Empidonax minimus* Baird. Least Fly-catcher. Not very common migrant.

79. *Otocorys alpestris praticola* Hensh. Prairie Horned Lark. Resident. Breeds. More abundant during severe cold in winter.

80. *Cyanocitta cristata* Linnaeus. Blue Jay. Abundant resident. Very destructive to young birds and eggs.

81. *Corvus americanus* Aud. American Crow. Abundant resident. Breeds.

82. *Dolichonyx oryzivorus* Linnaeus. Bob-o-link. Summer resident. Breeds. Formerly rare or wanting. Becoming more common èvery summer.

83. *Molothrus ater* Bodd. Cow bird. Abundant summer resident.

84. *Agelaius phœniceus* Linnaeus. Red-winged Blackbird. Abundant summer resident breeding in swamps.

85. *Sturnella magna* Linnaeus. Meadow Lark. Common summer resident and often seen in mid-winter. Breeds.

86. *Icterus spurius* Linnaeus. Orchard Oriole. Common summer resident. Breeds.

87. *Icterus galbula* Linnaeus. Baltimore Oriole. Probably more abundant than the last species. Breeds.

88. *Scolecophagus carolinus* Müll. Rusty Blackbird. Rather common migrant.

89. *Quiscalus quiscula æneus* Ridgway. Crow Blackbird. Abundant summer resident, sometimes seen in mid-winter.

90. *Coccothraustes vespertina* Coop. Evening Grosbeak. Two pair were taken just beyond the north county line in Whitley County, one pair of which is in the collection of Mr. M. L. Galbreath, Collamer, Ind.

91. *Carpodacus purpureus* Gmel. Purple Finch. Migrant, not very common.

92. *Loxia curvirostra minor* Brehm. American Crossbill. Two specimens seen September 11, 1894, in the cemetery at Wabash.

93. *Acanthus linaria* Linnæus. Redpoll Linnet. Several flocks were seen during the winter of 1889–90. This is the only time they have been noted in the county except a record of the same date by Mr. D. C. Ridgley, nine miles north of Lagro.

94. *Spinis tristis* Linnæus. American Goldfinch. Abundant resident. Breeds.

95. *Spinus pinus* Wils. Pine Siskin. One shot from a flock of goldfinches which came to feed on the mulleins in our yard January 10, 1892. (Wallace.)

96. *Calcarius lapponicus* Linnæus. Lapland Longspur. This bird was first taken by Mr. Orrin Ridgley in the fall of 1891. At Wabash one was taken in 1892, and during the winter of 1893–94 they were common, coming in September and remaining until March 15. All were in company with Horned Larks.

97. *Poocætes gramineus* Gmel. Bay-winged Bunting. Very abundant summer resident.

98. *Passer domestica* Linnæus. European House Sparrow. "English Sparrow." Very abundant resident. Not so abundant as in 1892. A great many were destroyed during the winter of 1892–93.

99. *Ammodramus sandwichensis savanna* Wils. Savanna Sparrow. Migrant, not common.

100. *Ammodramus savannarum passerinus* Wils. Grasshopper Sparrow. Abundant summer resident. Breeds.

101. *Chondestes grammacus* Say. Lark Sparrow. Not very common summer resident. Breeds. More common during migrations.

102. *Zonotrichia leucophrys* Forst. White-crowned Sparrow. Abundant migrant, occasionally seen as late as June 10.

103. *Zonotrichia albicollis* Gmel. White-throated Sparrow. Much more abundant than the last species. Its peculiar note, once heard, is not readily forgotten.

104. *Spizella monticola* Gmel. Tree Sparrow. Abundant winter resident.

105. *Spizella socialis* Wils. Chipping Sparrow. Very common summer resident. Breeds.

106. *Spizella pusilla* Wils. Field Sparrow. Abundant summer resident. Breeds.

107. *Junco hyemalis* Linnæus. Slate-colored Junco. Snowbird. Common winter resident, but more abundant in fall and spring.

108. *Melospiza fasciata* Gmel.. Song Sparrow. Abundant resident. Breeds.

109. *Melospiza georgiana* Lath. Swamp Sparrow. Migrant, not common.

110. *Passerella iliaca* Merr. Fox Sparrow. Common early migrant.

111. *Pipilo erythrophthalmus* Linnæus. Towhee. Chewink. Common summer resident. Breeds. A few remain over winter.

112. *Cardinalis cardinalis* Linnæus. Cardinal Grosbeak. A common resident, less so than formerly. Breeds.

113. *Habia ludovíciana* Linnæus. Rose-breasted Grosbeak. Summer resident, sometimes abundant and sometimes wanting. Breeds.

114. *Passerina cyanea* Linnæus. Indigo Bunting. Very common summer resident. Breeds.

115. *Spiza americana* Gmel. Black-throated Bunting. Very abundant summer resident. Breeds.

116. *Piranga erythromelas* Vieill. Scarlet Tanager. Common summer resident. Breeds.

117. *Progne subis* Linnæus. Purple Martin. Summer resident, abundant in cities. Breeds.

118. *Petrochelidon lunifrons* Say. Cliff Swallow. Summer resident, breeds, but is not so common as formerly. It has been driven out by the English Sparrow.

119. *Chelidon erythrogaster* Bodd. Barn Swallow. Adundant summer resident. Breeds.

120. *Tachycineta bicolor* Vieillot. Tree Swallow. Not often seen. They were observed in some abundance in the fall of '93.

121. *Clivicola riparia* Linnæus. Bank Swallow. Common along the Wabash River. Breeds.

122. *Stelgidopteryx serripennis* Aud. Rough-winged Swallow. Only two specimens taken.

123. *Ampelis garrulus* Linnæus. Bohemian Waxwing. A specimen was taken near the Wabash County line and is now in the collection of Mr. M. L Galbreath.

124. *Ampelis cedrorum* Vieill.. Cedar Bird. Common resident. Breeds late in summer.

125. *Lanius borealis* Vieill. Northern Shrike. Butcher Bird. Winter resident, not abundant.

126. *Lanius ludovicianus excubitorides* Swainson. White-rumped Shrike. Common summer resident. Breeds. The typical species may also be found here.

127. *Vireo olivaceous* Linnæus. Red-eyed Vireo. Abundant summer resident. Breeds.

128. *Vireo philadelphicus* Cassin. Philadelphia Vireo. Rather rare migrant.

129. *Vireo gilvus* Vieill. Warbling Vireo. Common summer resident. Breeds.

130. *Vireo flavifrons* Vieill. Yellow-throated Vireo. Abundant migrant.

131. *Vireo solitarius* Wils. Blue-headed Vireo. Migrant; not common.

132. *Mniotilta varia* Linnæus. Black and White Warbler. Abundant in woodland during migrations.

133. *Helminthophila pinus* Linnæus. Blue-winged Warbler. Summer resident, never very common. Breeds.

134. *Helminthophila chrysoptera* Linnæus. Golden-winged Warbler. Migrant; not so common as the last.

135. *Helminthophila ruficapilla* Wils. Nashville Warbler. An abundant migrant.

136. *Helminthophila celeta* Say. Orange-crowned Warbler. Rare. One specimen taken May 15, 1892.

137. *Helminthophila perigrina* Wils. Tennessee Warbler. Abundant migrant; most common in fall, when they may be found in great abundance along the rivers.

138. *Compsothlypis americana* Linnæus. Parula Warbler. A rare migrant; two specimens taken.

139. *Dendroica tigrina* Gmel. Cape May Warbler. Migrant; not common.

140. *Dendroica æstiva* Gmel. Yellow Warbler. Very common summer resident. Breeds.

141. *Dendroica cærulescens* Gmel. Black-throated Blue Warbler. Migrant; common. In the fall of 1893 it was probably our commonest warbler. It is fond of the dense woodland.

142. *Dendroica coronata* Linnæus. Yellow-rumped Warbler. The earliest of the warblers to arrive and the last to go in the fall. It is probably our most abundant warbler.

143. *Dendroica maculosa* Gmel. Magnolia Warbler. Not very common. Its habits of seclusion make it seem less common than others of equal abundance.

144. *Dendroica cærulea* Wils. Cerulean Warbler. Rather common. So far it has been found only during the migrating season.

145. *Dendroica pennsylvanica* Linnaeus. Chestnut-sided Warbler. Common migrant.

146. *Dendroica castanea* Wils. Bay-breasted Warbler. Not common; most most frequently seen in the fall.

147. *Dendroica striata* Forst. Black-poll Warbler. Rather rare migrant.

148. *Dendroica blackburniæ* Gmel. Blackburnian Warbler. Abundant migrant.

149. *Dendroica dominica albilora* Baird. Sycamore Warbler. Rather rare migrant.

150. *Dendroica virens.* Gmel. Black-throated Green Warbler. Very abundant migrant.

151. *Dendroica vigorsii* Aud. Pine-creeping Warbler. Only two specimens taken in the county.

152. *Dendroica kirtlandi* Baird. Kirtland's Warbler. The only specimen known in the State was taken May 4, 1892. This is the twenty-second specimen reported from North America. Little is known of its life history. I took it in a thicket. It was alone, there being no other birds in the near vicinity of it. It seemed to be an active fly catcher, not having the motions of the other *Dendroica*, being less active. It would dart off after an insect and then return to the same perch. Another specimen was taken May 7, 1895. Early in the morning I heard a bird singing in the thicket of plum trees near the house. The song was strange to me, and consisted of a loud ringing note repeated three times in quick succession, suggesting that of the Wrens or Maryland Yellow Throat. I did not go to look for it at once, but as it continued singing for some time I finally got my gun and went to look for it. It had flown over into the orchard then, but soon returned to the plum thicket and was constantly uttering that peculiar note. I finally caught sight of it and watched it for some time, not thinking of its being the rare *kirtandi.* It moved with the grace and ease of a vireo or fly-catcher. Wallace. [Proc. Ind. Academy of Science. 1893, pp. 119, 120].

153. *Dendroica discolor* Vieill. Prairie Warbler. One specimen was taken May 2, 1892.

154. *Dendroica palmarum* Gmel. Red poll Warbler. Abundant migrant.

155. *Seiurus aurocapillis* Linnaeus. Oven-bird. Very common summer resident.

156. *Seiurus noveboracensis* Gmel. Short-billed Water Thrush. Rather rare migrant.

157. *Seiurus motacilla* Vieill. Large-billed Water Thrush. Summer resident; more common than the last. Arrives as early as April 3.

158. *Geothlypis agilis* Wils. Connecticut Warbler. Only one specimen taken.

159. *Geothlypis philadelphia* Wils. Mourning Warbler. Found in dense thickets. It was rather common in the spring of 1892, but has not been seen since.

160. *Geothlypis trichas* Linnaeus. Maryland Yellow-throat. Abundant summer resident.

161. *Icteria virens* Linn. Yellow-breasted Chat. Summer resident, not common.

162. *Sylvania mitrata* Gmel. Hooded Warbler. One specimen was taken September 13, 1893.

163. *Sylvania pusilla* Wils. Black-capped Yellow Warbler. Three specimens were seen during the spring of 1892, but it has not been noted since.

164. *Sylvania canidensis* Linnaeus. Canadian Fly-catching Warbler. A common migrant.

165. *Setophiga ruticilla* Linnaeus. American Redstart. Summer resident, but much more common during migrations.

166. *Anthus pennsylvanicus* Lath. American Titlark. A migrant of irregular occurrence, but in some seasons very abundant.

167. *Galeoscoptes carolinensis* Linnaeus. Cat-bird. Abundant summer resident. Breeds.

168. *Harporhynchus rufus* Linnaeus. Brown Thrusher, Brown Thrush. Abundant summer resident.

169. *Thryothorus ludovicianus* Lath. Carolina Wren. Rather rare resident. Some seasons none are seen.

170. *Thryothurus bewickii* Aud. Bewick's Wren. Rather common summer resident.

171. *Troglodytes aedon* Vieill. House Wren. Common summer resident. Breeds.

172. *Troglodytes hyemalis* Vieill. Winter Wren. Common migrant. Probably some remain throughout the winter.

173. *Certhia familiaris americana* Bonap. Brown Creeper. Common migrant. Occasionally seen in midwinter.

174. *Sitta carolinensis* Lath. White-breasted Nuthatch. Common resident.

175. *Sitta canadensis* Linnaeus. Red-breasted Nuthatch. One specimen taken Sept. 15th, 1891.

176. *Parus bicolor* Linnaeus. Tufted Titmouse. Very common resident.

177. *Parus atrocapillis* Linnaeus. Black-capped Chickadee. Abundant winter resident.

178. *Regulus satrapa* Licht. Golden-crowned Kinglet. Common winter resident.

179. *Regulus calendula* Linnaeus. Ruby-crowned Kinglet. Common migrant.

180. *Polioptila cærulea* Linnaeus. Blue-gray Gnatcatcher. Common summer resident.

181. *Turdus mustelinus* Gmel. Wood Thrush. Common summer resident.

182. *Turdus fuscescens* Steph. Wilson's Thrush. Migrant. Not so common as the preceding.

183. *Turdus ustulatus swainsonii* Cab. Olive-backed Thrush. Rather common migrant.

184. *Turdus aonalaschkæ pallasii* Cab. Hermit Thrush. Common migrant. Our most abundant Thrush.

185. *Merula migratoria* Linnaeus. American Robin. Very abundant summer resident. Breeds.

186. *Sialia sialis* Linnaeus. Blue Bird. Abundant summer resident. Breeds.

Notes on a Collection of Fishes of Dubois County, Indiana. W. J. Moenkhaus.

The following list of fishes is offered as a slight addition to our knowledge of the fishes of Indiana. The list is based on a collection made during the second week in September, 1893, in Patoka River and Short Creek near Huntingburg, Dubois County, Indiana. It has been withheld from publication thus long because I have hoped that further work might be done in the same streams, but as each year makes this more improbable, it is perhaps best to publish the list as it is. Very little is known of the fishes of the Patoka River, investigations having been made only near its mouth, at the city of Patoka, by Jordan and Evermann, some years ago. (Jordan, Bull. U. S. Fish Com. VIII, 1890).

The Patoka River flows from east to west across about one-half the width of the State. In its course it passes through the southern part of Orange County and through the middle of Dubois, Pike and Gibson counties, emptying into the Wabash a few miles south of the mouth of the White River. In the vicinity of Huntingburg where it was fished, the channel is from 75 to 100 yards in width. The stream is everywhere obstructed along the banks and ofttimes entirely across by fallen timbers. The water is always more or less muddy, except in the fall, when very low, it approaches clearness. The river was fished for three-quarters of a mile where Hunley Creek empties into it. The water was very low and the fish were mostly collected in the deeper places in the channel. The ripples were repeatedly seined, but were found to be poor in fish. These places seemed ideal for darters, but not a single one was taken here. All that were caught were living together and had collected in the apparently stagnant holes.

Short Creek is a narrow muddy stream about seven miles in length, emptying into Hunley Creek three miles above its mouth. During dry seasons it dries up at many places and presents only pools of yellow, muddy, stagnant water. It was in some of these pools from its mouth to about a mile above that our fishing was done.

Patoka River will be indicated by (*P*) in the descriptions, and Short Creek by (*S*).

All of this collection is in the Indiana University Museum.

The common names given are those by which they are known in this locality:

1. *Ictalurus punctatus* Rafinesque. Channel cat. (P.) Two specimens.
2. *Amiurus melas* Rafinesque. Black cat. (P.) One specimen.
3. *Leptops olivaris* Rafinesque. Flat-head. Mud cat. (P.) One specimen.
4. *Schilbeodes miurus* Jordan. (P.) Sixteen specimens.
5. *Moxostoma aureolum* Le Sueur. Red horse. White sucker. Four specimens from Short Creek and fourteen from the Patoka River.
6. *Hybognathus nuchalis* Agassiz. Thirty-seven specimens from Short Creek and fifty-nine from Patoka River.
7. *Pimephales notatus* Rafinesque. (P.) Seven specimens.
8. *Cliola vigilax* Baird & Girard. (P.) Many specimens.
9. *Notropis microstomus* Rafinesque. (P.) Nineteen specimens.
10. *Notropis whipplei* Girard. (P.) Sixty specimens.
11. *Notropis ardens* Cope. (P.) Twenty specimens.
12. *Notropis umbratilis* Girard. (S.) Fifty-eight specimens.
13. *Notropis atherinoides* Rafinesque. (P.) Thirty-eight specimens.
14. *Opsopoeodus emiliae* Hay. (S.) Two specimens.
15. *Notemigonus chrysoleucus* Mitchell. Golden shiner. (S.) Five specimens.
16. *Dorosoma cepedianum* Le Sueur. Mud shad. Hickory shad. (P.) One specimen.
17. *Tygonectes notatus* Rafinesque. Top minnow. (P. S.) Sixty-one specimens from Patoka River and five from Short Creek.
18. *Lucius vermiculatus* Le Sueur. Pike. Pickerel. (P.) Four specimens.

19. *Labidesthes sicculus* Cope. Silver side. (P.) Five specimens.

20. *Aphredoterus sayanus* Gilliams. (S.) Five specimens.

21. *Pomoxis annularis* Rafinesque. Calico bass. (S.) Twenty specimens. All ages. Six specimens show the following characters: Length, 85, 96, 108, 123, 124, 145; lat. l., 43, 44, 43, 46, 45, 47; dorsal fin, V-15, VI-15, VI-15, VI-14, VI-15, VI-14; anal fin, VI-19, VI-19, VI-18, VI-17, VI-19, VI-17.

22. *Chaenobryttus gulosus* Cuv. & Val. (S.) Four specimens.

23. *Micropterus salmoides* Lacépède. Large-mouthed black bass. (P.) Thirteen specimens. All ages.

24. *Lepomis nugalotis* Rafinesque. (S.) One specimen.

25. *Lepomis pallidus* Mitchell. (P. S.) Six specimens from Short Creek and fifteen from Patoka River.

26. *Etheostoma aspro* Cope & Jordan. Blacksided darter. (P.) Forty-nine specimens. The Table X contains details of counts and measurements of these specimens:

Current Number of Specimens.	Length of Body in mm.	Length of Head in mm.	Scales on Lateral Line.	Anal Fin.	Dorsal Fin.	Current Number of Specimens.	Length of Body in mm.	Length of Head in mm.	Scales in Lateral Line.	Anal Fin.	Dorsal Fin.
1	53	14.5	9-63-11	I-11	XIV-14	26	51	14	9-65- 9	II-10	XIV-14
2	42	11	9 61- 9	I- 9	XIV-13	27	47	12	9-61- 9	II- 9	XV -13
3	54	14	9-67- 9	I- 9	XIV-13	28	43	11	10-60- 9	II- 9	XIV-14
4	35	10	8-66- 9	I-11	YIV-14	29	42	11	9-62- 9	II-10	XIV-13
5				I-10	XIII-13	30	52	13.5	9-66- 9	II-11	XV -13
6	52	13.5	9-63-10	I- 9	XIV-13	31	58	14	10-62- 9	II-10	XIV-13
7	55	13.5	9-67- 9	I-11	XIV-14	32	52	13	9-63-10	II-10	XV -13
8	52	13	9-67- 9	I-10	XIII-14	33	47	12.75	8-62- 9	II-10	XIII-14
9	62	15	9-70- 9	I-10	XIII-13	34	43	11	8-62- 8	II-10	XIV-13
10	44	11+	9-70- 7	I-10	XIII-13	35	43	11	9-66-10	II- 9	XV -13
11	40	10	9-64- 9	I-10	XV -14	86	44	11.5	9-62- 9	II-11	XIII-13
12	58	15	9-63- 9	I-11	XIII-14	37	51	13	10-70-10	II- 9	XIII-14
13	58	15	9-66- 9	I-10	XV -14	38	60	15.25	10-63- 9	II-10	XIV-13
14	58	15	9-69- 9	I- 9	XV -14	39	59	15	9-67- 9	II- 9	XIII-13
15	44	11.5	9-66- 9	I-10	XIV-13	40	43	11	9-67- 9	II-10	XIV-14
16	52	13.5	9-65- 9	I-10	XIII-13	41	55	13.5	9-60- 9	II-10	XVI-13
17	33	8.5	9-59- 9	I- 9	XIII-13	42	43	11	9-63- 9	II- 9	XII -13
18	43	11	9-66-10	I-11	XIII-13	43	37	10	-63-	II-10	XIII-13
19	43	11	8-63- 9	I-10	XV -14	44	47	12	9-68-10	II-11	XIV-14
20	41	10.5	9-63- 9	I-11	XIII-14	45	57	13	11-64- 9	II-10	XIII-14
21	43	11	9-61- 9	I-10	XV -14	46	41	10.5	11-68-10	II-10	XIV-13
22	56	15	9-65- 9	I-10	XIV-13	47	43	11	9-58- 9	II-10	XIV-14
23	43	11	10-63- 9	I-10	XIV-14	48	45	11	[illegible]-58- 9	II-11	XV -13
24	43	11	9-63- 9	I- 9	XIV-12	49	41	10.5	9-57- 9	II- 9	XIII-15
25	51	13	11-69-10	I-11	XIV-13						

27. *Etheostoma phoxocephalum* Nelson. (P.) Six specimens.

28. *Etheostoma nigrum* Rafinesque. Johnny Darter. (P.) Forty-one specimens.

All the specimens had the cheeks, nape and breast naked and the opercles sealed. 20 had the belly naked, 12 partly and 4 completely sealed. Below is the table of counts for their scales along lateral line and the dorsal and anal fins. 36–10–46, for instance, stands for 36 scales with tubes, 10 without and 46 for the total along side:

Current Number of Specimens.	Scales Along Lateral Line.	Anal Fin.	Dorsal Fin.	Current Number of Specimens.	Scales along Lateral Spine.	Anal Fin.	Dorsal Fin.
1	40- 4-44	I-8	VIII-13	22	36-10-46	I- 8	VIII-12
2	39- 9-48	I-9	VIII-11	23	41- 2-43	I- 9	VIII-12
3	42- 6-48	I-8	IX -12	24	45- 1-46	I- 9	X -11
4	43- 6-49	I-8	IX -12	25	39- 6-45	I- 9	IX -12
5	44- 4-48	I-9	IX -13	26	47- 5-52	I-10	IX -13
6	40- 8-48	I-9	IX -12	27	35-13-48	I- 9	IX -13
7	43- 7-50	I-8	VIII-12	28	41- 4-45	I- 9	IX -13
8	44- 5-49	I-9	VIII-12	29	36-12-48	I- 9	VIII-13
9	43- 7-50	I-8	VIII-13	30	42- 7-49	I- 8	VII -13
10	40- 5-45	I-8	IX -12	31	43- 5-48	I- 9	VIII-13
11	44- 1-45	I-9	X -12	32	47- 5-52	I- 8	X -12
12	45- 0-45	I-9	X -14	33	42- 7-49	I- 8	VIII-12
13	33- 9-42	I-9	IX -12	34	43- 6-49	I- 9	VII -12
14	49- 1-50	I-9	IX -13	35	45- 0-45	I-10	VIII-13
15	45- 1-46	I-9	IX -13	36	45- 4-49	I- 9	X -13
16	42- 8-50	I-9	IX -13	37	37-10 47	I- 8	VIII-12
17	40-12-52	I-9	VIII-13	38	39- 5-44	I- 9	X -12
18	33- 9-42	I-8	VIII-12	39	42- 6-48	I- 9	VIII-12
19	45- 5-50	I-8	IX -12	40	43- 4-47	I- 9	X -12
20	45-10-55	I-8	VIII-12	41	44- 6-50	I- 9	IX -13
21	44- 5-49	I-9	X -12				

29. *Etheostoma camurum* (Cope.). (P.) 11 specimens.

Additional Notes on Indiana Birds. By A. W. Butler.

Each year observations on the birds of Indiana bring to notice interesting facts. This year has been no exception. The region covered by the reports of correspondents includes not only this State, but also Michigan and the part of Illinois and Ohio bordering on Indiana; therefore, I am enabled to add some valuable notes from neighboring localities that, while not within our limits, have a bearing upon the study of our birds.

The winter of 1894–5 was mild until after Christmas. From several localities in the State came information regarding the wintering of forms not commonly seen. Meadow Larks, Robins and Bluebirds were reported north of the latitude of Indianapolis. Yellow-rump Warblers and Golden-crowned Kinglets spent the winter about Brookville. After a warm Christmas the weather changed. December 27 and 28, 1894, it became quite cold in this latitude. It remained warm generally over the Southern States. On January 24, 1895, the temperature as far south as South Carolina was near the zero mark. It turned warmer that night, and the next day, January 25, the weather was bright and clear. The day following was Friday. It rained, then snowed, the wind came down from the northwest with great velocity, the temperature fell rapidly, everthing was icebound or snowbound to the Gulf of Mexico, then followed weeks of unusual severity. The cold weather of April was also especially severe over the territory noted. The region affected is the winter home of numbers of our birds. There Robins, Bluebirds, Phœbes, Yellow-rump Warblers and House Wrens spend that season.

At the end of the severe weather in April, we are told, but few Robins and Bluebirds were to be found. The destruction of birds must have been enormous. The Bluebirds seem to have been almost exterminated. An observer living at Mt. Pleasant, S. C., says that when the April cold spell came millions of Robins were congregated in that vicinity and they perished by thousands. The severe weather had lasted so long and food was generally so scarce that they easily succumbed to the last effort of winter. The Yellow-rump Warbler and Hermit Thrush are reported also to have suffered severely. Perhaps other kinds of birds were also caught in that death dealing storm. The following notes on this and other subjects are brought to your attention:

1. *Sialia sialis* (Linn.), Bluebird.

Early in the spring of 1895 accounts of the scarcity of the Bluebirds began to be received. This scarcity was generally observed. Some of the particulars are here given.

At Redkey, Ind., Roy Hathaway says he saw two Bluebirds February 24; next seen April 7. He did not find a single pair breeding and only a few were seen, probably six or seven. He saw four Sunday, August 18; three of them he took to be young. He did not hear of any nests being found near there last spring.

At Greensburg, Ind., Prof. W. P. Shannon reports one seen February 24; next seen March 12. He notes it is becoming less common.

Mr. S. W. Collett, Upland, Ind., says: First seen March 25. Remarkably scarce. Have not seen more than a dozen.

Prof. Glenn Culbertson, Hanover, Ind. First seen February 23, one; next, February 28; next, March 1. Decreasing in numbers.

Angus Gaines, Vincennes, Ind., says they are absent this year.

A. B. Ghere, Frankfort, Ind., reports them extinct.

Jesse Earll, Greencastle, Ind., notes first one seen February 22; next, March 2. Decidedly scarce this summer.

Alexander Black, of the same place, says they have not appeared this year. He has not seen a dozen pairs all told.

Dr. Vernon Gould, Rochester, Ind. One reported March 19. One or two reported later. Have not seen or heard one this summer.

Mrs. Jane L. Hine, Sedan, Ind. First seen were two, March 29; next, April 2. Very rare. The whole country must report a loss of Bluebirds. Once in a great while one is seen. In a ride of twenty miles you may see none, or at best only one or two.

T. S. Palmer, Acting Ornithologist U. S. Department of Agriculture, Washington, D. C., informs me they received many reports of the unusual scarcity of Bluebirds last spring.

L. A. and C. D. Test, Lafayette, Ind., report one, the first, March 9; the next March 10. Strangely uncommon. Seemed very rare after the cold spell during the first half of March.

Clyde L. Hine, Waterloo, Ind. First seen, one, March 3; next, March 29; next, April 14. Very rare this spring.

Prof. A. L. Treadwell, Oxford, Ohio. Two seen January 1; next seen January 3, which was last one noted.

Prof. E. L. Moseley, Sandusky, Ohio. One, the first, seen February 22; next seen March 24. Not common this year.

E. M. Kindle, Franklin, Ind., says: The Bluebird seemed very scarce in Orange, Martin and Dubois counties, Indiana, this summer (1895).

B. T. Gault, Glen Ellyn, Ill., reported seeing but three at that place.

Ruthven Deane, Chicago, Ill., informs me he saw one at English Lake, Ind., but was not near enough to certainly identify it. He says all reports from this section show its extreme scarcity.

E. J. Chansler, Bicknell, Knox County, Ind., in a letter last spring, writes: Has been a resident until this spring, but has disappeared. Have not seen one the entire spring. Saw a dead one during the cold spell last winter. The past autumn he wrote: Have not been seen here since last February until about October 21. I have made numerous inquiries in regard to them, but can not learn of their breeding here this season.

T. L. Hankison, Agricultural College, Michigan: Heard one March 27. I have not seen a Bluebird this year, and know of only one other being seen.

W. De Clarenze, Brant, Saginaw County, Mich.: Two seen April 4; next seen April 10. For some reason Bluebirds are very scarce this season.

In the vicinity of Chicago, Ill., their absence was very noticeable.

Eliot Blackwelder, Morgan Park, Ill., informs me: Bluebirds have been extremely scarce this year. Have seen two single birds—March 28 and May 10; two pairs and one family of six. This makes in all twelve birds. Only one is recorded by the Chicago Academy of Science for Lincoln Park, Chicago. September 11 saw a flock of eleven sitting on a telegraph wire near my home. Last seen October 28.

L. A. and C. D. Test: Last seen (at Lafayette, Ind.) October 18. Usually abundant, but this year strangely rare. Have seen Bluebirds but twice, and am at a loss to account for their absence

At Brookville, Ind., they were as abundant as usual in the fall and almost every nice day through November and December, 1894. After the severe weather last winter none were seen. Only a few were noted in the spring and none through the summer of 1895. I do not know that any bred here. This fall they have been more noticeable, but still are very rare. September 20 saw five in my garden with flock of sparrows. September 22 saw three, one adult, two young. November 2 saw four. November 4, quite a flock. November 23, one, the last.

2. *Turdus migratorius* (Linn.), American Robin.

Noticeably scarcer this year than usual. In some localities almost as few as Bluebirds.

Mrs. Jane L. Hine, Sedan, Ind., reports them not more than one-half to two-thirds as numerous as last year.

L. A. and C. D. Test, the past fall, say: Not as common as usual the past fall.

S. W. Collett, Upland, Ind., writes: Very scarce. A remarkable year for scarcity of Robins and Bluebirds. Have not seen more than a dozen of either kind.

Reported very scarce in and about Chicago, Ill. A daily paper there notes that but one Robin's nest was all that vigilant search revealed in Lincoln Park this year, where formerly there were hundreds of them. A single pair was seen in Oakwood Cemetery and three or four in Washington Park.

O. B. Warren, Palmer, Mich., says they were much scarcer than in 1894.

As to the general scarcity of certain birds, the following specific information will give some idea.

Alexander Black, Greencastle, Ind., says we did not have such numbers of warblers as we usually have. We saw a few Black-throated Green Warblers, a few Yellow-rump Warblers, and one or two Canada Warblers.

Mrs. Jane L. Hine, Sedan, Ind., says Bridge Pewees (Phœbes) were rare. Hermit Thrushes very rare, but Olive-backed and Wood Thrushes were common as ever.

Charles Clickener says Wrens and Catbirds were rare in Parke County this year.

At Palmer, Mich., O. B. Warren reports that many species were noticeably less common than in 1894. Among them were Golden-crowned Thrush, *Seiurus aurocapillus* (Linn.); Chestnut-sided Warbler, *Dendroica pennsylvanica* (Linn.); Black and Yellow Warbler, *Dendroica maculosa* (Gmel.); Yellow-rump Warbler, *Dendroica coronata* (Linn.); Black and White Creeper, *Mniotilta varia* (Linn.); Indigo Bunting, *Passerina cyanea* (Linn.); Junco, *Junco hyemalis* (Linn.); Pine Finch, *Spinus pinus* (Wils.); Red Crossbill, *Loxia curvirostra minor* (Brehm); White-winged Crossbill, *Loxia leucoptera* (Gmel.); Spotted Sandpiper, *Actitis macularia* (Linn.); Yellow-bellied Woodpecker, *Sphyrapicus varius* (Linn.); Flicker, *Colaptes auratus* (Linn.); Night Hawk, *Chordeiles virginianus* (Gmel.); Wood Pewee, *Contopus virens* (Linn.); Least Flycatcher, *Empidonax minimus* (Baird); Rusty Blackbird, *Scolecophagus carolinus* (Müll.). Especially rare were White-throated Sparrow, *Zonotrichia albicollis* (Gmel.); Nashville Warbler, *Helminthophaga ruficapilla* (Wils.); Winter Wren, *Troglodytes hyemalis* (Vieill.). Of the Hermit Thrush, *Turdus aonalaschkæ pallasii* (Cab.), he says there is a marvelous decrease in numbers, more noticeable than the absence of *Sialia sialis*.

E. J. Chansler, Bicknell, Ind., noted Phœbe, *Sayornis phœbe* (Lath.), and Eave Swallow, *Petrochel don lunifrons* (Say), as scarcer than usual.

3. *Catharista atrata* (Bartr.). Black Vulture.

November 24, 1894, three seen at Monrovia, Morgan County, Ind.—Alden M. Hadley.

Large flocks observed at Bicknell, Ind., last fall (1895) feeding on dead hogs. —E. J. Chansler.

4. *Phalacrocorax dilophus floridanus* (Aud.). Florida cormorant.

Prof. Stanley Coulter informs me that there is a specimen in the collection of Purdue University, Lafayette, Ind., bearing the following legend: "Shot March, 1880, from amid a flock of wild ducks on bayou of Wild Cat Creek, Tippecanoe County, Ind., by Daniel Mueller, who donated the same to Purdue University."

5. *Phalacrocorax dilophus* (Sw. and Rich.). Double-crested Cormorant.

One shot November 28, 1895, on Big Walnut Creek, Putnam County, Ind.—Jesse Earll.

6. *Aquila chrysaëtos* (Linn.). Golden Eagle.

One measuring seven feet, two inches in extent was caught in a steel trap by Charles Fry, near Fairfield, Ind., December, 1895. The trap was set for skunks and was baited with rabbit.

7. *Pelecanus erythrorhynchos* (Gmel.). American White Pelican.

One shot in the Wabash River near Lafayette, Ind., about September 29, 1895. —L. A. and C. D. Test.

8. *Chen hyperborea* (Pall.). Lesser Snow Goose.

March 14, 1895, some sportsmen killed eight from a flock of twenty, near Greensburg, Ind. Those killed were immature, and the others seemed to be also. —Prof. W. P. Shannon.

9. *Anas penelope* (Linn.). Widgeon.

Since our last meeting records have been received of two more European Widgeons from Indiana. One, the second noted from the State, a young male, was killed in the Kankakee marshes, near English Lake, Ind. It was shot from a flock of Baldpates by Mr. J. F. Barrell, April 7, 1895. The specimen is now in the collection of Ruthven Deane, Chicago, Ill. Mr. Deane has also reported a specimen in the collection of Dr. Nicholas Rowe, of "The American Field," Chicago, Ill. It was killed at English Lake, Ind., in 1881 or 1882. This is the third record for Indiana, and the fifth for the interior of the United States. (The Auk, Vol. XII, No. 3, p. 292. See also Proc. Ind. Academy of Science, 1894, p. 78.)

10. *Calcarius lapponicus.* (Linn.) Lapland Longspur.

A hundred were seen at Morgan Park, Ill., October, 17, 1895, when it became abundant. Next seen October 26. Most abundant winter resident. —Eliot Blackwelder.

11. *Ammodramus caudacutus nelsoni.* (Allen.) Nelson's Sparrow.

Eliot Blackwelder, Morgan Park, Ill., reports it from that locality September 28, 1895. He says it is not common and breeds there.

12. *Ammodramus lecontei.* (Aud.). LeConte's Sparrow.

Mr. Blackwelder saw six at Morgan Park, Ill., April 21, 1895. He next noted them April 22. One day—the week of April 25—he shot three, and F. M. Woodruff, who was with him, shot another.

13. *Loxia curvirostra minor.* (Brehm.) American Crossbill.

There seemed to be a flock of seven on and near Purdue University campus (Lafayette, Ind.) which were observed on the following dates, 1895: March 30; April 3, 5, 6, 7, 10, 12, 13, 14, 15, 17, 18, 21, 23, 24, 25, 26, 29; May 1, 3, 4, 7, 11, 17, 18, 20, 21, 22. They may have remained later, but the observers were absent after the last date. This fall these birds were seen November 5 (three), and heard November 26. (L. A. and C. D. Test.)

14. *Dendroica kirtlandi.* (Baird.) Kirtland's Warbler.

The second specimen of this rare warbler from Indiana was taken by the same person in the same vicinity as the first. W. O. Wallace obtained it near Wabash, Ind., May 7, 1895. Mr. Wallace writes: "Early in the morning I heard a strange song in the thicket near the house, but I was very busy and did not go to see the singer for some time. It kindly remained until I completed my work, when I located it. Had it not been for its loud and peculiar song I should have pronounced it a Canada Flycatcher. Its song sealed its fate. After watching it catch insects and listening to its song for some time, I backed off and shot it. Imagine my surprise when I held in my hand my second Kirtland's Warbler. The song bears considerable resemblance to that of the Great Carolina Wren and also suggests that of the Maryland Yellow-throat. It is loud and rather musical. I noticed in both specimens movements more like the Flycatchers than the Warblers."

Notes on Parasites Collected in the State in 1895. By A. W. Biting.

I have only a few parasites to report as additions to the list presented last year. Some of these are very common and it now seems strange that they were not collected before.

Gastrophilus hæmorrhoidalis was taken in the mature state during the summer.

Trichodectes parumpilosus Piaget taken last spring. It is the common biting louse of the horse.

Pulex was taken on *Scalops aquaticus*, Cuv. Only a few specimens of this parasite have ever been collected.

A species of Ixode was taken from *Spermophilustridecum lineatus*.

A species of *Pulex* was taken from the same host.

Strongylus paradoxus was recently obtained from hogs thought to be affected with cholera.

Amœba meleagridis was found in the liver of a turkey on December 25.

Trichocephalus affinis was obtained from the intestines of the sheep.

A Report Upon Certain Collections of Phanerogams Presented to the State Biological Survey. By Stanley Coulter.

During the past year the Survey has come into possession of three collections, embracing nearly one thousand species, which serve as a good foundation for the proposed herbarium. The specimens are unmounted and provision should be made in the near future for their permanent preservation. The collections, while representative, contain but a scant series of duplicates, so that at present the proposed distribution into sets is impossible. Much fuller collections must come into the hands of the Survey before this work can be undertaken.

The material has been derived chiefly from three sources:

1. A collection of about 500 species, selected from the duplicates of the herbarium of Purdue University. This represents for the most part forms of general distribution, although containing such exceptional forms as *Leavenworthia Michauxii*, *Sullivantia Ohionis* and *Brachychaeta cordata*.

2. A collection of 163 species from the Rev. E. J. Hill, of Englewood, Illinois. This collection is of especial value, since it is made up almost entirely of plants of exceptional or limited distribution. A fuller idea of the value of this collection may be gathered from an examination of the paper on *Noteworthy Indiana Phanerogams* (these Proceedings, p. —), to which reference is made.

3. A collection of some 300 species from Mr. H. J. Clements, of Washington, Daviess County. The collection of Mr. Clements was confined to the immediate vicinity of Washington, and the extent of the collection, the accuracy of determination and the completeness of the accompanying data are sufficient proofs of Mr. Clements' ability. As the collection stands for a new region, concerning which it is extremely desirable to have a full knowledge, I have made from the material furnished by Mr. Clements a provisional list of the flora of the vicinity of Washington. Some thirty sheets, chiefly *Asters*, are as yet undetermined. In the work of studying this collection I have been greatly aided by Miss Alida M. Cunningham, to whom the Survey is indebted for much critical work in the examination of Indiana forms.

The sedges and grasses have passed through the hands of Prof. J. Troop, to whom acknowledgment is thus made.

Until such time as the Directors of the Survey have determined the form in which the State flora shall appear it has been thought best to follow the nomenclature of Gray's Manual, sixth edition.

Provisional List of the Phanerogams in the Vicinity of Washington, Daviess County, Indiana. Based upon the collections of Mr. H. J. Clements, during the seasons of 1894 and 1895:

RANUNCULACEÆ.

Clematis Pitcheri Torr and Gray. (104.) "Near Prairie Creek. near B. & O. R. R. July 4, 1894."

Anemone Virginiana L. (99.) Woods south of Oak Grove and B. &. O. R. R. July 4. 1894.

Anemone Pennsylvanica L. (81.) Abundant on north side of B. & O. R. R. west of Oak Grove.

Anemonella thalictroides Spach. (17.) Rare. Woods west of Washington. April 13, 1895.

Thalictrum dioicum L. (54.) Sanford's Woods. May 4. 1895.

Thalictrum purpurascens L. (79.) South bank of railroad track, south of Oak Grove. May 18, 1895.

Ranunculus multifidus Pursh, var. *terrestris* Gray. (87.) First wood south of B. & O. R. R. and west of Oak Grove. May 18, 1895.

Ranunculus abortivus L. (13.) Common in wet places. B. & O. Railroad west of shops. April 5, 1894.

Ranunculus recurvatus Poir. (55.) Sanford's woods. May 14. 1894.

Ranunculus septentrionalis Poir. (27.) Common, hillsides in woods, low places, etc. April 20, 1894.

Ranunculus repens L. (80.) Hyatt's, south of B. &. O. Railroad. May 18, 1895.

Isopyrum biternatum Torr and Gray. (12.) Woods south of B. & O. shops. April 13, 1894. This form was referred by Mr. Clements to *Thalictrum clavatum*, DC., which does not occur in Indiana.

Delphinium tricorne Michx. (39.) Sanford's woods. April 21. 1894.

Actaea alba Bigel. (40.) Woods south of B. & O. Railroad and Oak Grove. April 27, 1894.

Hydrastis Canadensis L. (33.) Hyatt's woods, south of B. & O. shops. April 27. 1894.

MENISPERMACEÆ.

Menispermum Canadense L. (213.) South of Oak Grove. May 18, 1895.

BERBERIDACEÆ.

Podophyllum peltatum L. (34.) All woods. April 27, 1894.

PAPAVERACEÆ.

Sanguinaria Canadensis L. (11.) Common. Sanford's woods. East of Washington. April 5, 1894.

FUMARIACEÆ.

Dicentra Cucullaria DC. (20.) Hyatt's woods, south of B. & O. shops. April 14, 1894.

CRUCIFERÆ.

Dentaria laciniata Muhl. (14.) Woods south of Oak Grove. April 5, 1894.

Cardamine rhomboidea DC. (24.) Bretz's pasture, damp places along branch. Rather common. April 20, 1894.

Cardamine rhomboidea DC., var. *purpurea* Torr. (5.) Woods south of B. & O. Railroad at Oak Grove, two miles west of Washington. April 2, 1894.

Cardamine hirsuta L. (7.) Thin woods along Prairie creek. April 4, 1894. The determination is apparently correct, but the specimen sent the Survey is too immature for absolute certainty.

Draba Caroliniana Walt. (8.) One specimen found along fence row, about 3½ miles north or northwest of Washington. April 4, 1895.

Sisymbrium officinale Scop. (145.) Common everywhere. August 4, 1895.

Brassica nigra Koch. (136.) Escaped about gardens, etc. July 29, 1895.

Lepidium Virginicum L. (124.) Common weed. July 29, 1895.

CAPPARIDACEÆ.

Polanisia graveolens Raf. (177.) Along B. & O. track in West Washington. July 4, 1895.

VIOLACEÆ.

Viola palmata L. (47.) Sanford's woods. Common. May 4, 1894.

Viola palmata L., var. *cucullata* Gray. (19.) Hyatt's woods, south of shops. April 13, 1894.

Viola pubescens Ait. (18.) Hyatt's woods, south of B. & O. shops. April 13, 1895.

CARYOPHYLLACEÆ.

Saponaria officinalis L. (97.) Common along roadsides, etc. July 4, 1895.

Silene stellata Ait. (102.) South of Oak Grove and B. & O. railroad. July 4, 1895.

Silene Virginica L. (71.) Abundant. Woods south of B. & O. Railroad, Oak Grove and west.

Silene antirrhina L. (305.) Along railroad track in shop yard. May 11, 1895.

Lychnis Githago Lam. (214.) Grain fields; B. & O. track at Relay Station. May 18, 1895.

Cerastium arvense L., var. *oblongifolium* Holl. and Brit. (42.) Edge of Hawkin's creek, southwest of B. & O. shops. April 27, 1894.

PORTULACACEÆ.

Claytonia Virginica L. (1.) Common with flower parts multiplied. Abundant later in all woods and meadows. March 30, 1894.

HYPERICACEÆ.

Hypericum maculatum Walt. (135.) Roadside, northeast of Washington. July 10, 1895.

MALVACEÆ.

Malva rotundifolia L. (288.) About dwellings. September 28, 1894.

Sida spinosa L. (208.) Weed about gardens and yards. September 28, 1894.

Hibiscus lasiocarpus Cav. (161.) Roadsides, one or two miles north of Washington. August 5, 1895.

Hibiscus militaris Cav. (162.) Bank of Swan pond. August 5, 1895.

TILIACEÆ.

Tilia Americana L. (82.) Bank of White River, Hyatt's. Not common. May 18, 1895.

GERANIACEÆ.

Geranium maculatum L. (31.) Sandford's woods. April 27, 1894.

Geranium Carolinianum L. (243.) Waste ground, side of streets, etc. May 4, 1895.

Oxalis violacea L. (57.) Bretz' pasture. May 4, 1895.

Oxalis corniculata L., var. *stricta* Sav. (52.) Common everywhere. May 4, 1895.

Impatiens fulva Nutt. (126.) John Hyatt's woods. July 10, 1895.

CELASTRACEÆ.

Euonymus atropurpureus Jacq. (175.) Bank of Prairie Creek on B. & O. Railroad. July 4, 1895.

RHAMNACEÆ.

Ceanothus Americanus L. (103.) Woods south of B. & O. Railroad and Oak Grove. Herbaceous above, but drying down to wood base in winter.

Vitaceæ.

Vitis cordifolia Michx. (77.) Close to White River, near B. & O. bridge. May 18, 1895.

Sapindaceæ.

Negundo aceroides Moench. (83.) Near White River, along or near B. & O. track. May 18, 1895.

Polygalaceæ.

Polygala Senega L. (89.) Hyatt's woods, south of B. & O. Railroad. Also south of Oak Grove. May 18, 1895.

Leguminosæ.

Trifolium arvense L. (110.) About old canal, near B. & O. Railroad. July 4, 1895.

Trifolium pratense L. (237.) Waste places, roadsides, etc.

Petalostemon violaceus Michx. (165.) Roadside, Swan pond road. August 5, 1895.

Robinia Pseudacacia. (56.) Bretz' pasture. May 8, 1895.

Desmodium nudiflorum DC. (142.) Woods south of Oak Grove, and all woods. A nuisance. July 29, 1895. (223.) Fruiting specimen, August 10, 1895.

Desmodium acuminatum DC. (143.) Woods south of B. & O. Railroad and Oak Grove. July 29, 1895.

Desmodium pauciflorum DC. (174.) Woods two miles east of Washington. July 16, 1895.

Cercis Canadensis L. (28.) South of Oak Grove. April 23, 1894.

Cassia Marilandica L. (141.) Woods south of B. & O. Railroad at Oak Grove. July 29, 1895.

Cassia Chamæcrista L. (144.) Woods south of Oak Grove and B. & O. Railroad. July 29, 1895.

Gleditschia triacanthos L. (138.) Near Washington; no special habitat. July 29, 1895.

Rosaceæ.

Prunus serotina Ehrh. (43.) Bretz' pasture. May 4, 1894.

Spiræa tomentosa L. (155.) Woods south of Oak Grove and B. & O. Railroad. July 29, 1895.

Geum album Gmelin. (130.) Very common in moist woods. July 10, 1895.

Fragaria Virginiana Mill., var. *Illinoensis* Gray. Railroad track and woods south of Oak Grove. May 11, 1895.

Potentilla Canadensis L. (44.) Bretz' pasture. May 4, 1894.

Agrimonia Eupatoria L. (149.) Woods south of B. & O. Railroad and Oak Grove. July 29, 1895.

Rosa humilis Marsh. (180.) South of Oak Grove. July 10, 1895.

SAXIFRAGACEÆ.

Hydrangea arborescens L. (128). Sanford's woods. July 10, 1895.

CRASSULACEÆ.

Penthorum sedoides L. (168.) Grassy pond. August 5, 1895.

LYTHRACEÆ.

Lythrum alatum Pursh. (101.) Two miles east of Washington on B. & O. Railroad. July 4, 1895.

ONAGRACEÆ.

Œnothera fruticosa L. (151.) Woods south of Oak Grove. July 29, 1895.

Circæa Lutetiana L. (113.) John Hyatt's woods. July 13, 1895.

CUCURBITACEÆ.

Echinocystis lobata Torr. and Gray. (275.) Along ditch south of B. & O. shops, September 28, 1894.

UMBELLIFERÆ

Daucus Carota L. (93.) Along ditches beside B. & O. track. May 18, 1894. (210.) Along B. & O. track. September 28, 1894.

Zizia aurea Koch. (92.) Along railroad track, edge of woods west of Washington. May 18, 1895.

Erigenia bulbosa Nutt. (2.) Beech woods, Hyatts, just south of B. & O. shops. March 30, 1894.

CORNACEÆ

Cornus florida L. (35.) Rather common. Hyatt's woods, south of shops. Some with pink involucre, April 27, 1894.

CAPRIFOLIACEÆ.

Triosteum angustifolium L. (254.) Hyatt's.

Rubiaceæ.

Cephalanthus occidentalis L. (111.) Bank of Prairie Creek and B. & O. railroad. July 4, 1895.

Spermacoce glabra Michx. (170.) On side of Swan pond road. August 5, 1895.

Galium circæzans Michx. (188.) South of Oak Grove. May 18, 1895.

Galium trifidum L. (120.) Woods south of Oak Grove. Common. July and August.

Galium concinnum Torr and Gray. (181.) South of B. & O. railroad at Oak Grove. June 29, 1895.

Compositæ

Elephantopus Carolinianus Willd. (226.) Woods south of B. & O. railroad at Oak Grove. August 10, 1895.

Vernonia fasciculata Michx. (273.) Fields and roads. September 28, 1895.

Eupatorium purpureum L. (225.) Woods south of Oak Grove and B & O. railroad. Six to eight feet high. August 10, 1895.

Eupatorium perfoliatum L. (221.) Woods south of Oak Grove. August 10, 1895.

Eupatorium ageratoides L. (200.) Woods south of Oak Grove. September 28, 1894.

Eupatorium cœlestinum L. (232.) Near B. & O. shops, and in other places. August 22, 1895.

Solidago cæsia L. (199.) Woods south of Oak Grove. September 28. 1895.

Solidago Canadensis L. (274.) Waste fields, fence rows, etc. September 28, 1894.

Aster lævis L. (199 and 283.) Field west of B. & O. shops. September 28, 1894.

Antennaria plantaginifolia Hook. (25.) Abundant in patches. Bretz's pasture. April 20, 1894.

Gnaphalium polycephalum Michx. (206.) Field west of Washington. September 28, 1894.

Ambrosia artemisiæfolia L. (279.) Fields everywhere. September 28. 1894.

Heliopsis lævis Pers. (191.) Woods south of Oak Grove. September 28, 1894.

Rudbeckia hirta L. (179 and 190.) Woods south of B. & O. Railroad and at Oak Grove. July 4, 1895.

Helianthus divaricatus L. (156.) Woods south of B. & O. Railroad and at Oak Grove. July 29, 1895.

Helianthus hirsutus Raf. (271.) Woods south of Oak Grove. July 29, 1895.

Helianthus decapetalus L. (247.) Woods south of Oak Grove. August 15, 1895.

Bidens connata Muhl. (194.) Woods south of Oak Grove. September 28, 1895.

Helenium autumnale L. (204.) Railroad track near Oak Grove. September 28, 1894.

Achillea Millefolium L. (212.) Along railroad near Oak Grove. Common along roads. August 4, 1895.

Chrysanthemum Leucanthemum L (94.) Railroad bank, west of Oak Grove. Edge of woods. June 8, 1894.

Tanacetum vulgare L. (159.) Roadside, about one mile north of West Washington. August 5, 1895.

Senecio aureus L. (88.) Hyatt's, south of B. & O. Railroad. May 18, 1895.

Cacalia atriplicifolia L. (158.) Woods south of B. & O. Railroad and Oak Grove. July 29, 1895.

Arctium Lappa L. (236.) Waste places. August 16, 1895.

Cnicus lanceolatus Hoffm. (239.) Vacant lots, etc. August 16, 1895.

Cnicus altissimus Willd. (192 and 272.) Railroad track west of shops. September 28, 1894.

Krigia amplexicaulis Nutt. (66.) Woods south of Oak Grove. May 11, 1895.

Lactuca Canadensis L. (281.) Along fence rows, etc. September 28, 1894. No. 137 also in all probability belongs here, although the form is too immature for accurate determination.

Lobeliaceæ.

Lobelia cardinalis L. (163.) Edge of Swan pond. August 5, 1895.

Lobelia syphilitica L. (188a.) On same sheet with No. 188 and probably the same data.

Lobelia puberula Michx. (188 and 205.) Yard, corner E. 6th and Vantrus Sts.; near ditch west of shops. September 28, 1894.

Lobelia inflata L. (148.) Woods, south of Oak Grove. July 29, 1895.

Campanulaceæ.

Specularia perfoliata DC. (219.) Side bank of B. & O. track at Hyatt's. June 15, 1895.

Campanula Americana L. (114.) John Hyatt's woods. July 17, 1895.

Primulaceæ.

Steironema ciliatum Raf. (100.) Hyatt's woods and B & O. tracks. July 4, 1895.

Apocynaceæ.

Amsonia Tabernæmontana Walt. (86.) Abundant along Prairie Creek, south of B. & O. tracks. May 18, 1895.

Apocynum cannabinum L. (176.) Along railroad in wet places. July 4, 1895.

Asclepiadaceæ.

Asclepias tuberosa L. (109.) Common south of Oak Grove, and B. & O. Railroad. July 4, 1895.

Asclepias purpurascens L. (186.) South of Oak Grove and B. & O. Railroad. June 1, 1895.

Asclepias incarnata L. (266.) John Hyatt's woods. July 14, 1895.

Asclepias Cornuti Decaisne. (263.) Along B. & O. Railroad, West Washington.

Asclepias variegata L. (185.) South of Oak Grove and B. & O. Railroad. June 1, 1895.

Polemoniaceæ.

Phlox paniculata L. (115.) John Hyatt's woods. July 13, 1895.

Phlox glaberrima L. (183.) Open woods, one-half mile west of Oak Grove. June.

Phlox pilosa L. (60.) South of Oak Grove. May 11, 1895.

Phlox divaricata L. (15.) Common, woods south of B. & O. shops. April 13, 1894.

Polemonium reptans L. (53.) Bretz' pasture. May 4, 1895.

Hydrophyllaceæ.

Hydrophyllum appendiculatum Michx. (304). Hyatt's woods, south of B. & O. shops. June 1895.

Phacelia bipinnatifida Michx. (32.) Hyatt's woods, just south of B. & O. shops. April 27, 1894.

Borraginaceæ.

Heliotropium Indicum L. (228.) Roadside three miles north of Washington. August 5, 1895.

Cynoglossum Virginicum L. (63.) Woods south of railroad at Oak Grove. May 11, 1895.

Echinospermum Virginicum Lehm. (258.) Woods two miles east of Washington. July 16, 1895.

Lithospermum canescens Lehm. (252.) South of Oak Grove, near railroad track. May 11, 1895.

CONVOLVULACEÆ.

Ipomœa purpurea Lam. (289.) Gardens, etc. September 28, 1894.

SOLANACEÆ.

Solanum nigrum L. (140.) Common about yards. July 29, 1895.

Solanum Carolinense L. (276.) Waste places. September 28, 1895.

Physalis Philadelphica Lam. (91.) Along B. & O. Railroad and in woods south of Oak Grove.

Physalis pubescens L. (139.) About yards. July 29, 1895.

Datura Stramonium L. (230.) Near Washington. September 28, 1895.

Datura Tatula L. (229.) Near Swan Pond. Not so common as No. 230. August 5, 1895. As Mr. Clements confused the two species the inference is that *Tatula* is the abundant form.

SCROPHULARIACEÆ.

Verbascum Blattaria L. (134.) Common in waste places. July 10, 1895.

Linaria vulgaris Mill. (244.) Common weed, lots and streets, September 10, 1895.

Scrophularia nodosa L., var. *Marilandica* Gray. (70.) Oak Grove on railroad track. May 18, 1895.

Pentstemon pubescens Solander. (189.) Railroad track south of Oak Grove.

Pentstemon lævigatus Solander, var. *Digitalis* Gray. (216.) Hyatt's. Wet places. June 6, 1895.

Mimulus alatus Ait. (164.) Prairie Creek bridge, Swan Pond road. August 5, 1895.

Veronica Virginica L. (95.) Along B. & O. railroad, two miles west of Washington. July 4, 1895.

Veronica peregrina L. (22.) Bretz's pasture. April 14, 1894.

Gerardia quercifolia Pursh. (171.) Woods south of B. & O., and Oak Grove. Flowers, lemon-color. Plant, six to eight feet high. August 10, 1895.

Gerardia purpurea L. (193). Woods south of Oak Grove. September 28, 1894.

BIGNONIACEÆ.

Tecoma radicans Juss. (96.) Along B. & O. tracks, west of Washington. July 4, 1895.

ACANTHACEÆ.

Ruellia strepens L. (303.) Abundant along Prairie Creek at Hyatt's. May 18, 1895.

VERBENACEÆ.

Verbena urticæfolia L. (285.) Common weed in waste places. September 28, 1894.

Verbena angustifolia Michx. (119.) Along railroad track east of Washington. July 16, 1894.

Verbena hastata L. (270.) Yard of B. & O. shops. August, 1895. (132.) Wilson's woods; wet places.

Verbena stricta Vent. (133.) Common plant along railroad and in vacant lots. July 10, 1895.

Verbena bracteosa Michx. (125.) Growing along sidewalks, etc. July 31, 1895.

Lippia lanceolata Michx. (122.) Common, growing along grassy fences and in pastures. July and August.

Phryma Leptostachya L. (131.) Sanford's woods. July 10, 1895.

LABIATÆ.

Teucrium Canadense L. (106.) South of B. & O. Railroad and Oak Grove. July 4, 1895.

Mentha piperita L. (150.) Along railroad tracks. July 29, 1895.

Lycopus rubellus Moench. (277 and 291.) Field west of B. & O shops. September 28, 1894.

Pycnanthemum lanceolatum Pursh. (173.) Abundant in waste lands two miles east of Washington. July 16, 1895.

Monarda fistulosa L. (105.) Woods south of Oak Grove. July 4, 1895.

Blephilia hirsuta Benth. (129.) Wilson's woods, along branch east of Washington. July 10, 1895.

Nepeta Glechoma Benth. (64.) West Eighth Street and B. & O. track. May 11, 1894.

Scutellaria lateriflora L. (169) Near Swan Pond. August 5, 1895.

Scutellaria canescens Nutt. (107.) Woods south of Oak Grove. July 4, 1895.

Scutellaria nervosa Pursh. (68.) Woods south of Oak Grove. May 11, 1895.

Brunella vulgaris L. (153.) South of B. & O. at Oak Grove. July 29, 1895.

Marrubium vulgare L. (168.) Swan Pond. August 5, 1895.

Lamium amplexicaule L. (248.) Side of northeast Sixth Street, near Walnut. May 11, 1895.

Illecebraceæ.

Anychia dichotoma Michx. (121.) South of B. & O. railroad at Oak Grove, in edge of woods.

Anychia capillacea DC. (264.) South of Oak Grove, near railroad.

Amarantaceæ.

Amarantus retroflexus L. (234.) Gardens, yards, etc. July.

Amarantus albus L. (211.) Weed about gardens. September 28, 1894.

Amarantus spinosus L. (209.) Weed in all gardens, etc. September 28, 1894.

Chenopodiaceæ.

Chenopodium album L. (290.) Common weed. September 28, 1894.

Phytolaccaceæ.

Phytolacca decandra L. (147.) Common, roadsides, etc. July 29, 1895.

Polygonaceæ.

Rumex Britannica L. (238.) Waste places. August 16, 1895.

Rumex Acetosella L. (69.) Common everywhere in waste places. May 18, 1894.

Polygonum Pennsylvanicum L. (286.) Yards, etc. September 28, 1894.

Polygonum orientale L. (235.) Escaped from yards. August 16, 1895.

Polygonum Virginianum L. (146.) Woods south of Oak Grove and B. & O. Railroad. July 29, 1895.

Polygonum dumetorum L., var. *scandens* Gray. (117.) John Hyatt's woods and E. & I. Railroad. July 13, 1894.

Aristolochiaceæ.

Asarum Canadense L. (85.) South of B. & O. tracks at Hyatt's. Not common. May 18, 1895.

Santalaceæ.

Comandra umbellata Nutt. (249 and 306.) Woods south of Oak Grove, where woods run into a low, grassy place. May 11, 1895.

Euphorbiaceæ.

Euphorbia Preslii Guss. (280.) Weed in waste places. September 28, 1894.

Euphorbia corollata L. (154.) Common along banks of B. & O. Railroad and woods south of Oak Grove. July 29, 1895.

URTICACEÆ.

Laportea Canadensis Gaudichaud. (116.) John Hyatt's woods. July 13, 1895.

Bœhmeria cylindrica Willd. (267.) John Hyatt's woods. July 13, 1895.

Parietaria Pennsylvanica Muhl. (267a.) John Hyatt's woods. July 13, 1895.

IRIDACEÆ.

Iris versicolor L. (72.) First pond beyond Oak Grove, south of B. & O. tracks. May 18, 1894.

Belamcanda Chinensis Adans. (127.) In pasture on Sanford's farm. July 10, 1895.

Sisyrinchium angustifolium Mill. (90.) Prairie Creek, west of Washington. May 18, 1895.

AMARYLLIDACEÆ.

Agave Virginica L. (233.) Near B. & O. Railroad, two miles east of Washington. Six to seven feet high. July 16, 1895.

DIOSCOREACEÆ.

Dioscorea villosa L. (59.) Woods south of B. & O. Railroad and Oak Grove. May 11, 1894.

LILIACEÆ.

Smilax herbacea L. (45.) Sanford's woods. Common in all woods. May 4, 1894.

Smilax Pseudo-China L. (78.) A vine covering a small tree. Bank of White River, north of B. & O. track. May 18, 1894.

Allium Canadense Kalm. (75.) Prairie Creek, south of B. & O. Railroad. May 18, 1894.

Camassia Fraseri Torr. (76.) Prairie Creek, south of Oak Grove. May 18, 1894.

Polygonatum biflorum Ell. (61.) Woods south of Oak Grove. May 11, 1894.

Polygonatum giganteum Dietrich. (253.) Beside railroad track near Oak Grove. May 18, 1895.

Asparagus officinalis L. (160.) About one mile north of West Washington. August 5, 1895.

Smilacina racemosa Desf. (46.) Sanford's woods. May 4, 1894.

Uvularia grandiflora J. E. Smith. (23.) Woods south of Oak Grove. April 21, 1894.

Erythronium Americanum Ker. (19a.) Hyatt's woods, south of B. & O. shops. April 14, 1895.

Erythronium albidum Nutt. (16.) Woods south of B. & O. shops. April 13, 1894.

Trillium sessile L. (74.) Hyatt's, south of B. & O. Railroad. Not common in this vicinity. May 18, 1894.

Trillium recurvatum Beck. (21.) Common in most woods. April 20, 1894.

Trillium erectum L. (30.) East of Washington. April 26, 1894.

Commelinaceæ.

Tradescantia Virginica L. (62.) Common. Railroad bank and woods south of Oak Grove. May 11, 1894.

Araceæ.

Arisæma triphyllum Torr. (38.) Hyatt's woods, south of B. & O. shops. April 27, 1894.

Arisæma Dracontium Schott. (73.) Prairie Creek, south of B. & O. Railroad. May 18, 1895.

Alismaceæ.

Sagittaria variabilis Engelm. (245.) Ditch, south of B. & O. shops. September 10, 1895.

Cyperaceæ.

Cyperus strigosus L. (202.) Along ditch, west of shops. September 28, 1895.

Carex Grayii Carey. (300.) Wet places near B. & O. Railroad at Hyatt's. May 18, 1895.

Carex Shortiana Dewey. (301.) Hyatt's, near B. & O. Railroad. May 18, 1895.

Carex crinita Lam. (217.) Hyatt's. June 6, 1895.

Carex teretiuscula Gooden. (302.) Wet places near Hyatt's. May 18, 1895.

Gramineæ.

Panicum microcarpon Muhl. (308.) Two miles east of Washington. July 4, 1895.

Cenchrus tribuloides L. (201.) Along railroad tracks. September 28, 1895.

Noteworthy Indiana Phanerogams. By Stanley Coulter.

The ruling of the directors of the Survey that no form should be admitted to the catalogue of the flora of the State unless verified by actual specimens has led me as far as possible to secure first exceptional forms of limited range, in the hope that by a publication of the data concerning them the attention of collectors might be directed to them, and our knowledge of their distribution within the State be increased. The most notable collection of these exceptional forms that has come into the possession of the Survey was that received from Rev. E. J. Hill, of Englewood, Ill., embracing 163 species. All of the specimens were of extreme interest, and many of them represented the sole record for the State. The following notes are based very largely upon this collection, and most of the forms represent a southern extension of northern forms. It should be remembered, however, that, until we have a full knowledge of the isotherms of our country, statements as to "southern limit" and "northern limit" are merely terms of convenience, and do not necessarily involve any real extension of range.

A fuller knowledge of natural drainage systems, of prevailing winds at varying seasons and of numerous other physical conditions is necessary before we can properly undertake a definite limitation of the range of any plant form. In a limited area, in which there is a definite organization of work, it is possible to determine many of these conditions and by their record add much to the ease with which some of the problems of geographical distribution may be solved.

Another feature emphasized by this paper is the extreme importance of long-continued collections in the same region. The work of Mr. Hill in Lake County covers a period of twenty years and has resulted not only in the addition of many new forms to the State flora but in a thorough botanical knowledge of that portion of the State. The work of Mr. Van Gorder in Noble County, extending through ten years, has shown similar results. Many problems which present themselves can only be solved by work of this kind. The tendency of collectors in the past work of the State has been to cover large areas, rather than to study closely some definite regions. Closer attention should be given by all collectors throughout the State to mass distribution, as distinguished from the station at which the collection is made, and also to the collection of fruiting specimens.

A somewhat careful study of our State flora leads me to believe that many forms may be added if a more careful study is made of our marsh and lake forms and of those groups which are of difficult discrimination. Special studies should also be made during the coming season of definitely characterized regions, as, for example, of the flora of lime stone cliffs, of clay soils, of sand hills, etc. The work needed is not so much a collection of plants as a collection of *facts* verified by plants.

In the following notes I have not in all cases referred to Mr. Bradner's list of the plants of Steuben County, because I have had no opportunity to examine his collections. The references, save as indicated in the notes, are to material in the possession of the Survey. A large number of interesting forms of *Cyperaceæ* and *Gramineæ* have been omitted, because our knowledge of the distribution of these forms in the State is too scant to justify any conclusions concerning them.

Cardamine pratensis L. This rare Northern plant, which was included in the State catalogue, but of which no specimen had been preserved, is now definitely reported with verifying specimens from two localities. Wet banks of Calumet River, Miller's, Lake Co., June 6, 1893 (E. J. Hill); Section 5, York Tp., Noble Co., May 28, 1894 (W. B. Van Gorder). Mr. Van Gorder sent me specimens of this plant last June, at which time I determined it to be *C. pratensis* L., a determination which was later confirmed by a careful comparison with the material in the Gray Herbarium at Harvard University. Under date of November 6, 1895, Mr. Van Gorder writes as follows:

"*Cardamine pratensis* L. grows plentifully on a tract of wet land, three or four acres, in section 5, York Tp., Noble Co. This tract is a part of the Elkhart River flat. I had seen the plant for several years, and at a distance thought it *C. rhomboidea* DC. This last spring it was dry enough, and passing the place I determined to know for sure. It flowers from May 15 to June 10. The specimen sent you was collected May 28."

The manual range of the plant is, "Wet places and bogs, Vt. to N. J., Wis., and northward; rare."

The following local references which I was able to collate while at the Gray Herbarium during the past summer may serve to show the interest which attaches to this plant as a member of the Indiana flora:

State (Indiana) Catalogue, etc. Lake Co. P. 3.

Flora of Michigan. Wheeler, C. F., and Smith, E. F. "Bogs." Rare S., frequent in C. and common N. P. 14.

Flora of Minnesota. Warren Upham. Lake Superior to sources of Mississippi. North. (Houghton.) P. 24.

Flora of Nebraska. Samuel Aughey. Includes without note. P. 6.

Flora of Iowa. J. C. Arthur. Does not include.

Preliminary Catalogue of Anthophyta and Pteridophyta, etc. Torrey Botanical Club.—Includes without note.

Catalogue of Plants of New Jersey. N. L. Britton.—Cedar swamp at New Durham. Rare. P. 8.

Catalogue of Native and Naturalized Plants of the City of Buffalo and Its Vicinity. David F. Day.—Rare. S. E. portion of Buffalo, near West Seneca. P. 18.

Flora of Cook Co., Ill., and Part of Lake Co., Ind. Higley, Wm. K., and Raddin, Chas. S.—Calumet River, near Miller's, Ind.—Rare. April. (Bastin and Hill.) P. 9. This reference is evidently based upon the collection of Mr. Hill cited *supra*.

Plants of Illinois. H. N. Patterson.—Does not include.

Flora Peoriana (Ill.). Frederick Brendel.—Does not include.

Higher Seed Plants of Minnesota Valley. Conway Macmillan.—Does not include.

Catalogue of Canadian Plants. John Macoun.—"Wet, swampy meadows, Labrador; St. Patrick, Charlotte Co., N. B.; vicinity of Prescott Junction, three miles south of Ottawa; wet meadows and swamps, Hastings Co., Ont.; Whiskey Island; Georgian Bay; Hudson's Bay; throughout Arctic America and Greenland."

Manual and Instructions for Arctic Expedition, 1895. Hooker, on arctic plants, p. 203, says: "The most arctic plants of general distribution that are found *far* north in all the arctic areas are the following; all inhabit the Parry Islands or Spitzbergen or both." A list of fifty-three plants is given, including *Cardamine pratensis* L.

On page 226, the range of this form is given as "from Mackenzie's River to Baffin's Bay. Throughout Arctic Greenland."

In same volume, page 244, the following note concerning this form is given by James Taylor: "*Cardamine pratensis* L. Flowers June-July. East side Disco Island. Altitude, 200 feet. North lat., 69° 10′; W. long., 54° 30′."

In the various catalogues of the New England States it is usually included with the statement, "chiefly found in the northern part."

From these citations it will be seen that the Indiana stations mark the southern-central limit of this true arctic form, which in all probability found its way southward during the glacial period.

Arabis lyrata L. "Dry, sandy ground, Miller's, Ind., June 6, 1893." (E. J. Hill.) Reported also from Laporte County, presumably upon authority of Dr. Barnes, and included in Bradner's flora of Steuben County. The form in general is a northern one in its mass distribution, although extending south along the mountains as far as Kentucky. Its local distribution will probably be found to be limited to the northern portions of the State, and its occurrence there can only be expected in exceptionally favorable localities.

Hudsonia tomentosa Nutt. "Sand hills, Miller's, Ind., June 20, 1893." (E. J. Hill.) This striking form has as yet its only station as indicated. It is so unlike the ordinary phanerogam of Indiana that it could scarcely have escaped notice if it was of any wide distribution. The range of the plant is "sandy shores, Maine to Md., and along the Great Lakes to Minn., rarely on streams inland." It is therefore probable that its distribution in Indiana is extremely restricted.

Lechea thymifolia Michx. "Sandy ground, Tolleston, Ind. Flowers collected Sept. 16, 1882; fruit, Oct. 1, 1881." This is the only record for the species, and if the determination holds good, is a rather peculiar extension of range. The assigned range is "dry grounds near the coast, E. Mass. to Fla." The reference is apparently accurate, but on account of the well-known difficulty of discrimination between the species of this genus, I am unable to feel absolutely certain in the absence of authenticated specimens for comparison. The authority of Mr. Hill, however, is sufficient to retain the plant in the State list until opportunity occurs for comparison with forms from the east.

Arenaria Michauxii Hook. f. "Dry sands, Clark, Ind., June 13, 1893." (E. J. Hill.) There seems to be no special reason why this species should not be found generally distributed throughout the State, although as yet this is the only station recorded. The known range of the plant easily includes Indiana, and it should be looked for throughout the State.

Arenaria lateriflora L. "Dry woods, Miller's, Ind., June 20, 1893." (E. J. Hill.) This species was reported by Dr. A. J. Phinney in his list of plants of the region covering Jay, Delaware, Randolph and Wayne counties. He, however, secured no verifying specimen. The Lake County collection, however, serves under the rules of the State to give the species a place in the flora of Indiana. It is probable that the plant will be found to occur only in the eastern and northern counties of the State, its general range being northward.

Hypericum Kalmianum L. "Wettish sands, Tolleston, Ind. Flowers collected June 29, 1880; fruit, September 3, 1880." (E. J. Hill.) Also collected at Laporte by Dr. C. R. Barnes. This species is evidently limited to the northwestern counties of the State and will probably not be found much beyond the lake region. The assigned range is Niagara Falls and northern lakes.

Linum sulcatum Riddell. "Dry, sandy soil, Pine Station, Ind., July 28, 1875." (E. J. Hill.) So far as I am able to determine, this is the only station in the State for this species. Its general range, "E. Mass. to Minn., and south-westward," would indicate, perhaps, a more general distribution since it has made its appearance within our boundaries.

Nemopanthes fascicularis Raf. "Wet ground, Miller's, Ind. Flowers collected April 29 and May 11, 1882; leaves and fruit July 4, 1882." (E. J. Hill); Steuben County (E. Bradner). Although not included in the lists of Mr. Van Gorder, I have received from him this summer material of this species collected in Noble County. The manual range of the plant was extended upon the collection of Mr. Hill, and from the later reports it is fair to infer that its occurrence is limited to perhaps the northern tier of counties.

Lathyrus maritimus Bigel. "Shores of Lake Michigan, Whiting, Ind., July 15, 1875." (E. J. Hill.) A species inhabiting the seashore from Oregon and New Jersey to the Arctic Ocean, and also found on the Great Lakes. The range in Indiana can evidently be but slightly extended, if at all.

Rosa Englemanni Watson. "Flowers collected, East Chicago, Ind., June 5, 1890; fruit collected in damp thickets at Pine Station, Ind., Aug. 25, 1891. Four feet to eight feet high." (E. J. Hill). The specimen furnished the survey seems clearly referable to this species, though showing a decided increase in size. The plant is normally from "three to four feet high, or less." Its range is given as "Whisky Island, Lake Huron, shores of Lake Sŭperior, and west to the Red River valley, and in the mountains from N. Montana and N. Idaho to Colorado." Its appearance in Indiana is of extreme interest and adds a new station for the species.

Heuchera hispida Pursh. "Sandy, open grounds, Tolleston, Ind., June 20, 1893." (E. J. Hill.) This is an additional station for this species which was formerly reported only from Vigo County by W. S. Blatchley. It may be assumed that the form will be found in favored localities throughout the State. (Saxifrageæ in Indiana, Proc. Ind. Acad. of Sci. 1894, p. 105.)

Sambucus racemosa L. "Open woods, Porter, Ind., May 17, 1890; fruit, Otis, Ind., May 21, 1881" (E. J. Hill); "common at least in eastern part of Noble County" (Van Gorder); Steuben County (Bradner); Putnam County (MacDougal); Jefferson County (J. M. Coulter); Clarke County (Baird and Taylor). This species is northern in its mass distribution and is more rarely found southward. In leaf, fruit and bark characters, it at times runs perilously close to *S. Canadensis* L. I have found the color of the pith to be by far the most satisfactory means of discrimination between the two forms. Although the assigned range includes Indiana, my own experience leads me, in the absence of verifying specimens from other localities, to limit the distribution of the species to the northern portion of the State.

Linnaea borealis Gronov. "Moist, pine woods, Pine Station, Ind., June 7, 1884." (E. J. Hill.) This is the recorded southern limit for this definitely northern form. Its occurrence so far south is worthy of note. It must be remembered, however, in this extension of ranges that limits are marked by parallels of latitude, when the proper method would be a consideration of isothermal lines.

Galium boreale L. "Sandy prairies, Sheffield, Ind., July 6, 1875" (E. J. Hill); "rather common, Noble County" (W. B. Van Gorder). The distribution of this species seems fairly well made out for Indiana, being confined to the northern counties which represent in a general way its southern limits. It is a form that can not be readily mistaken for any other members of the genus, being definitely marked by its bright white flowers.

Liatris cylindracea Michx. "Dry sands. Lake County, Ind., September 4, 1893. (E. J. Hill.) The Indiana stations for this plant, so far as reported, in addition to that in Lake County, are St. Joseph County (C. R. Barnes); Gibson and Posey counties (J. Schneck). These widely separated stations indicate at least the probability of its occurrence throughout the State in favorable localities. The manual range reads: "Dry, open places, Niagara Falls to Minn. and Mo." The St. Joseph County record is verified by specimens in the Purdue Herbarium. The inclusion of the Gibson and Posey County station is upon the authority of Dr. J. Schneck, of Mt. Carmel, Ill.

Solidago humilis Pursh. "Sand hills, near Lake Michigan, Miller's, Ind., September 12, 1893. Sometimes 3 feet high." (E. J. Hill.) This is a distinctly northern form, and one which shows in its very considerable increase in size the effect of its new range. In its normal range, "Rocky banks, W. Vt., along the Great Lakes, and northward," it is a low plant from 6 to 12 inches high. At the base of the White Mountains a form is reported, by Gray, as occurring, having a "stout stem, 1–2 feet high." Variety *Gillmanni* Gray, is larger (2 feet high), but in addition to differences in inflorescence, is sharply separated from the species by its "laciniately toothed leaves." The species is undoubtedly a member of the State flora, and the Lake County station is to be added to the other exceptional stations recorded, "islands in the Susquehanna, near Lancaster, and at the Falls of the Potomac."

Solidago uliginosa Nutt. "Peat bogs. Pine Station, Ind., Sept. 11, 1890." (E. J. Hill.) This plant, which is northern in its mass distribution, has its southern limit, so far as reported, in the northern tier of counties of Indiana. Additional stations are, St. Joseph County (C. R. Barnes) and Noble County (W.

B. Van Gorder). Specimens have been examined from all three localities. The recorded range of the plant is "Peat bogs, Maine to Penn., Minn., and northward."

Brachychæta cordata Torr. and Gray. Among the forms that have come into the Indiana flora from the South the above is one of the most interesting. Its station is in Jefferson County, especially at Clifty Falls. The station is one of the remarkable ones in the State, because of the number of rare forms there found, *Sullivantia Ohionis* Torr. and Gray, being perhaps the most noteworthy if we except *Brachychæta*.

The manual range of the plant is as follows: "Wooded hills, S. Ind. and E. Ky. to N. Ga." In the Synoptical Flora, p. 161, the range is given as follows: "Open woods, etc., W. North Car. and E. Ky. to upper part of Ga." The plant was apparently first collected by Rafinesque, by whom it was described as *Solidago sphacelata*, Raf. Ann. Nat. (1820), p. 14.

In Short's Supplement to the Catalogue of the Plants of Kentucky it is described as *Solidago cordata* Short.

In DeCandolle's Prodromus, V. 313, it appears as *Brachyris ovatifolia* DC., with the range "*in agro Kentuckensi ad ripas fluminum legit*, el. Rafinesque. * * Species, *distinctissima*."

Additional localities are as follows:

Flora of West Virginia. C. F. Millspaugh. P. 382.—"Fayette County, near Nuttalsburg, plentiful."

Flora of Southern United States. A. W. Chapman, 2d edition. P. 213, entered as *Solidago cordata* Short. "Mountains of Georgia and North Carolina and northward."

Botany of Southern States. John Darby. P. 370—"North Carolina and Northern Georgia."

A Sketch of Botany of South Carolina and Georgia. Stephen Elliott. Vol. II (1824), which includes Solidago, does not distinguish the form.

Tennessee Flora. August Gattinger (1887). P. 51—Records as occurring over the whole State.

The specimens in the Gray Herbarium only include four sheets, all being from the South. They are as follows:

Solidago cordata (n. sp.) Short. Cliffs of Kentucky River. C. W. Short, M. D., Lexington, Ky. This is the type specimen of *Brachychæta cordata* Torr. and Gray.

Solidago cordata Short, Wilkes County, North Carolina, M. A. Curtis; Table Mountain, North Carolina, M. A. Curtis. Both of these have received the label *Brachychæta cordata* in the handwriting of Dr. Gray.

Solidago cordata Short. French Broad River, 1843. No collector's name.

Brachychæta cordata Torr. and Gray. Curtiss, North American Plants, No. 1298; Bluffs of Cumberland River, near Nashville, Tenn. Legit A. Gattinger.

An examination of the above data shows that this form can be reasonably expected in the southwestern counties of the State. It is easily mistaken for a Solidago, which genus it resembles closely in head and flower, except in the pappus. It perhaps should be looked for in collections among the Solidagos.

Aster polyphyllus Willd. "Grassy borders of low thickets, Whiting, Ind. September 29, 1892." (E. J. Hill.) The range of this species being "northern Vermont to Wisconsin, and southward," it is a little remarkable that this is its only record for the State. It is possible that it has been mistaken for *A. ericoides* L., which it resembles in many particulars. The extreme variability of this latter form renders such an error a natural one. It is probable that *A. polyphyllus* is more widely distributed throughout the State than the single recorded station would indicate.

Aster umbellatus Mill. "Moist grounds, Pine Station, Ind. September 4, 1893." (E. J. Hill.) This form, "common, especially northward," is only recorded from four counties of the State. Additional stations are as follows: Jefferson County (C. R. Barnes); Clark County (Baird and Taylor); Jay County (Dr. Phinney). The Jefferson County reference has its authentication in specimens in the Purdue Herbarium; the Clark and Jay County stations rest upon the authority of the collectors. The plant may be confidently looked for in the northern counties of the State, and many new stations should be added as a result of the work of the ensuing season.

Aster ptarmicoides Torr. and Gray. "Dry sands, Pine Station, Ind." (E. J. Hill.) This form, occurring on "dry rocks, western New England to Minnesota, along the Great Lakes, and northward," is another species that has entered the State from the north. The Lake County station is the natural one for the State. In the fall of 1894, Messrs. Conner and Laben collected this species at Happy Hollow, Tippecanoe County. I withheld judgment upon the determination, until I was able to examine the type specimens in the Gray Herbarium. There is no question that *A. ptarmicoides* occurs in Tippecanoe. The station in which it is found is so secluded as to preclude the probability of its recent introduction. The range of the species must therefore be extended somewhat.

Echinacea angustifolia DC. "By Michigan Southern and Lake Shore Railroad, Durham, Ind. In a prairie. July 4, 1892." (E. J. Hill.) So far as I am able to find, this is the only record for this species in the State. The form has evidently entered our flora from the west, its recorded range being "Plains from Ill. and Wisc. southwestward." It is easily distinguishable from *E. purpurea* Moench. and should be looked for carefully in the western counties of the State.

Artemisia Canadensis Michx. "Shores of Lake Michigan, Lake Co., Sept. 4, 1893." (E. J. Hill.) This northern form has its only recorded station for Indiana in the above reference. Its range is "Northern New Eng. to the great lakes, Minn., and northward." It is closely allied to *A. caudata* Michx., which also has its sole Indiana station in Lake Co. No specimen of this latter form, however, has as yet been obtained by the Survey. *A. caudata* having a range "Mich. to Minn., and southward," should be found, at least, in the northern counties of the State. Both species are separated from the other Artemisias by their *dissected leaves* and should be readily recognized.

Cnicus Pitcheri Torr. "Sandy shores of Lake Michigan, Pine Station, Ind., June 21, 1891." (E. J. Hill.) This well-marked species has this as its only station in the State, so far as the records indicate. Its range, "Sandy shores of Lakes Michigan, Huron and Superior," would indicate but a slight probability of any material increase in its distribution. It would probably be found in Laporte County in the region of Michigan City, if careful search were made. With its cream-colored flowers and white woolly covering it is an extremely attractive form and could scarcely be mistaken for any other species of the genus.

Cnicus pumilus Torr. "Pine barrens. Lake County, Ind., July 4, 1891." (E. J. Hill.) This form is labeled *Cnicus Hillii* W. M. Canby. I am unable, however, to see any reason why the form should not be referred to *C. pumilus* Torr., and in the absence of Mr. Canby's original description I have so referred the specimen sent to the Survey. Certain variations from the type seem to me easily referable to geographical causes, and not of sufficient importance to necessitate the establishment of a new species. The range of the plant, "Dry fields, N. Eng., near the coast, to Penn.", seems to me to furnish the only argument against the reference. It is possible that more abundant material may lead to a different conclusion. The reported occurrence of *Cnicus pumilus* in Dearborn County (S. H. Collins) is not authenticated by specimens, and is in all probability an error in determination. The extension of the range of a coast plant to the Great Lakes could be easily accounted for, but its extension to Dearborn County without intervening stations would be difficult of explanation.

Prenanthes racemosa Michx. "Open, grassy land, East Chicago, Ind., Oct. 5, 1892." (E. J. Hill.) Noble County (W. B. Van Gorder). The range of this species in Indiana seems to be limited to the northern tier of counties. The form is found in "plains, N. Maine to N. J. and northward," though extending also into Missouri. It is easily distinguished from the other species of the genus found in the State by its heads being in crowded clusters, and could scarcely have escaped the attention of collectors had it been of any general distribution.

Pyrola chlorantha Swartz. "Sandy woods, Whiting, Ind., May 25, 1878." (E. J. Hill.) A northern form, ranging from Labrador to Minnesota, northward and westward, with the single record from Indiana as indicated. The specimens in the possession of the Survey are, so far as known, the only ones from the Indiana station in the herbaria of the State.

Trientalis Americana Pursh. "Damp woods, Miller's, Ind., May 11, 1878." (E. J. Hill.) "In tamarack marshes in moss near the roots of trees. Very common in some places. Noble County." (W. B. Van Gorder.) The mass distribution of this species is decidedly northern, its southern limit being the northern tier of counties in Indiana, save where it extends southward along the mountains. It will probably be found in all of the northern counties. but need scarcely be expected farther south.

Menyanthes trifoliata L. "Bogs and peat marshes, Pine Station, Ind. May 13, 1876." (E. J. Hill.) "Moist shores of lakes—very common at Pleasant Lake, Noble Tp., Noble Co." (W. B. Van Gorder.) While the sixth edition of Gray's Manual includes Indiana in the range of this species, its authenticated distribution is confined to the stations mentioned. It probably occurs throughout the northern portion of the State in favorable localities.

Convolvulus arvensis L. "By railroad, Pine Station, Ind. July 28, 1875. Rare." (E. J. Hill.) Also reported from Jay, Delaware, Wayne and Randolph Counties (Phinney), and Dearborn Co. (Collins). This adventive species, heretofore restricted to North Atlantic States, has evidently made lodgment in Indiana. I am inclined to think the Dearborn County reference somewhat doubtful, judging from the general range of the plant and taking into consideration the means of distribution to which the presence of this intruder is evidently due. I believe its range in the State will be found limited to the northern and central counties.

Stachys hyssopifolia Michx. "Wet, sandy banks, Laporte, Ind. July 22, 1875." (E. J. Hill.) Also collected at Laporte by C. R. Barnes. The State catalogue notes the plant as occurring from "Marion Co. and northward." The Marion County reference was doubtless based upon the authority of the late Dr. H. E. Copeland, who was an exceedingly keen observer, but who, unfortunately, left no verifying specimens. It is scarcely possible that this can be the only station for the plant, since its range fairly covers the State.

Utricularia resupinata B. D. Greene. "Sandy margins of ponds, Whiting, Lake County, Ind., Aug. 16, 1883." (E. J. Hill.) This collection, upon which is based the extension of the range of this form in the 6th Edition of Gray's Manual (p. 735 c.), is only one of the many evidences of the critical work done by Rev. E. J. Hill and proof of the value of a long continued study of a single area. This same form was sent me last summer by W. B. Van Gorder from north shore of Bear Lake, Noble County, thus extending its local distribution.

Utricularia purpurea Walt. "Shallow ponds, Pine Station, Lake County, Sept. 13, 1879." (E. J. Hill.) This is another form shown by Mr. Hill to be a member of the State flora. This station for the plant is somewhat remarkable because it is so far *inland*. While the range is "ponds, Maine to Florida," it is limited by the additional statement, *usually near the coast*.

Utricularia gibba L. "Sandy, wet margins of ponds, Pine Station, Lake County, Sept. 13, 1879." (E. J. Hill.) While this plant would be naturally expected within our range, it has been but rarely collected in the State. The specimens furnished by Mr. Hill being the only ones I have seen from Indiana. It is especially desirable that close observations should be made in favorable localities in order that the distribution of these forms within the State may be determined.

Corispermum hyssopifolium L. "Dry, sandy ground, Pine Station, Ind., Sept. 4, 1893" (E. J. Hill.) The only reported station for this species. No great extension of its range throughout the State need be expected, since in our range it seems confined to the beaches of the Great Lakes, although farther west and south it is not so restricted. The form is presumably from the west, judging from available data.

Salsola Kali L., var. *Tragus*. This plant has undoubtedly obtained a sufficient foothold in the State to be included in its flora. It is, however, very doubtful if its spread will be sufficiently rapid to give it rank among our worst weeds. The plant is definitely reported from Clarke, Lake County, by E. J. Hill, and from Avilla, Noble County, by W. B. Van Gorder. Both collections are labelled "along railroad," indicating very clearly the method of introduction into our State flora. An examination of both specimens leads me to question the reference of the Lake County specimen. It does not agree in many particulars with the Noble County specimen, which latter is very plainly the typical variety *Tragus*, and so far as I am able to judge agrees more nearly with *Salsola Kali*. The extension of the range—"sandy seashore, New England to Georgia"—by the addition of "and along shores of Great Lakes" is a very natural one, but is apparently incorrect because of the label, "along railroad." So far as I am able to learn, the plant has not spread with the rapidity to be expected from the variety *Tragus*. In view of the accuracy of Mr. Hill in all of his determinations, the Lake County station is admitted, with the suggestion that the plant in that particular locality needs a much closer study.

The Noble County plant is unmistakable, not only in its characters, but in its habits of growth. From facts ascertained through the work of Supt. Van Gorder, it is safe to say that if the Russian thistle spreads throughout Indiana it will be from the Noble County station as a center. The plant has been carefully watched since its first appearance in 1893, and efforts made to prevent its spread, though with no very great success, as the following letter indicates:

Brimfield, Ind., Nov. 3, 1895.

Mr. W. B. Van Gorder, Knightstown, Ind.:

Dear Sir—In reply to yours of some time ago, will say that the Russian thistle came up again this year worse than last year. It was not cut soon enough, which, of course, scattered the seeds. I have not heard of it any place else yet. * * * *

J. E. Niswander.

In the last map issued by the United States Department of Agriculture, showing the distribution of the Russian Thistle, a location is given in south-central Indiana. The map is, however, so small that I have not been able to locate the station, nor have I been able to discover upon what authority it was added.

In my opinion there are not more than two stations for the Russian Thistle in the State. Of these, that in Noble County alone seems to threaten any great spread of the pest. While the plant should be carefully watched, its general character as to periods of flowering and maturation of seed, taken in connection with the fact that though known to exist in Indiana since 1892, it has yet made no marked advance, would indicate that the danger from its introduction has been overestimated.

Polygonum tenue Michx. "Sand hills, Pine Station, Ind., July 28, 1875." (E. J. Hill.) Tippecanoe County, 1893. (Stanley Coulter.) This species has perhaps a more general distribution throughout the State than the references would indicate. Its normal range easily includes our territory, yet so far as I know no other stations are recorded. In a study of the genus *Polygonum* made recently I examined all of the collections in the State, and it is certainly not found in them from any other localities. The species is sufficiently characteristic to be easily separated from the more common forms, and could scarcely be confused with any other species, if we except *P. ramosissimum* Michx., from which it is readily distinguished by the character of the achenes.

Polygonella articulata Meissn. "Sand hills, Miller's, Ind., October 1, 1881. Flowers white or rose-colored." (E. J. Hill.) This seems to be the only authenticated station for this species. Mr. Van Gorder includes it in his list of plants of Noble County, published in pamphlet form in 1884, but excludes it from list published in 1887 in Eighteenth Report of the State Geologist. I infer from this that its inclusion in the first list was an error. Baird and Taylor also include it in their "Flora of Clark County," but as they made no collections the record is necessarily a doubtful one, with the probability against the accuracy of the determination. The assigned range is: "Dry, sandy soil; on the coast from Maine to New Jersey, and along the Great Lakes." It can be readily seen that its distribution in Indiana is in all probability limited to the northwestern counties.

Shepherdia Canadensis Nutt. "Sand ridges, usually near sloughs. Pine Station, Lake County, May 13 and 27, 1876." (E. J. Hill.) This attractive shrub has perhaps its southern station in this record. Its reported range is from "Vermont and New York to Michigan, Minnesota and north and westward." It is worthy of notice, perhaps, that in Indiana it occurs "near sloughs," while in other regions it is found chiefly on rocky or gravelly banks.

Euphorbia polygonifolia L. "Sandy shores of Lake Michigan, Lake County, Indiana, September 4, 1893." (E. J. Hill.) The range of this species is probably limited to the shores of Lake Michigan, at least so far as Indiana is concerned. While in general appearance it might be easily confused with other species, it is characterized by having seeds larger than those of any other species in section *Anisophyllum.*

Myrica asplenifolia Endl. "Sand hills, Miller's, Indiana. Flowers collected April 29 and May 30, 1882; fruit, July 4." (E. J. Hill.) This is the only locality for the State and it was upon this collection that the range of the species was extended in the sixth edition of Gray's Manual to include Indiana.

Betula papyrifera Marshall. "Sandy soil, Pine Station, Ind. Flowers collected May 13, 1876; fruit, September 3, 1876. Trees ten to thirty feet high." (E. J. Hill.) The material furnished the Survey was somewhat scant, but seemed sufficient to verify the determination. The petioles were shorter, perhaps, than in the normal form, but this seemed the only deviation from type in the leaf characters. The reduction in size from a tree fifty to seventy-five feet high in the normal range, to that indicated above, is the most marked feature in this extension of range. The form also occurs in northern Illinois, but I have no data at hand which indicate whether or not a similar reduction in size occurs. The species, as is well known, is northern in its general range.

Pinus Banksiana Lambert. "Sand barrens, Lake County, Ind., May 13, 1876." (E. J. Hill.) This is the only record for the gray or northern scrub pine in the State. The specimens sent the Survey establish the species as a member of the State flora beyond question. The inclusion is an extension of the reported range from Southern Michigan to Northern Indiana. It is a fact that in all probability more new forms will be added to the State flora by a careful study of our forest trees than from any other group of plants, if we except, perhaps, the water plants. For various reasons forest forms have received less attention and are more poorly represented in existing herbaria than any other. It is especially urged that during the ensuing season specimens of all forest trees be furnished the Survey by those interested in the work.

Orchidaceæ. Our knowledge of the occurrence and distribution of the various orchids of the State has been very greatly increased during the past year, a fact due largely to the labors of Messrs. Hill and Van Gorder. Both of these gentlemen have studied definite regions for years and have placed the Survey under many obligations for their careful and courteous responses to the many requests for information. I have asked Miss Alida M. Cunningham to collate the facts at hand, which she has done under the title "*Distribution of Orchidaceæ in Indiana*," and reference is hereby made to that article (These Proc., p. —). I wish also, in this connection, to express the thanks of the botanical division of the Biological Survey to Miss Cunningham for the patient and efficient work she has done in the study and comparison of critical forms, which has done much to expedite the work of the division and has added greatly to the value of its final report.

Tofieldia glutinosa Willd. "Moist sands. Pine Station, Ind., July 28, 1875. (E. J. Hill.) The State Catalogue refers this species to the "northern tier of counties." This, however, is the only station in the state from which I have been able to secure herbarium specimens. It is included in the Flora of Noble County by W. B. Van Gorder (18th report of State Geologist, p. 66,) as growing in "moist grounds along the Elkhart river in Orange township, and is represented in Mr. Van Gorder's private herbarium. I know of no other stations in which the species occurs. The recorded range of the plant is "moist grounds, Maine to Minnesota, and northward; also south in the Alleghanies.

Triglochin maritima L. "Wet sands, border of slough, East Chicago, June 13, 1893." (E. J. Hill.) This species has been added to the state flora through the close work of Mr. Hill, who has recorded the only station for Indiana. The species is easily distinguished from the other members of the genus by its fruit of six carpels. The assigned range of the plant is, "salt marshes along the coast, Labrador to N. J., and in saline, boggy or wet places across the continent."

Potamogeton. Any systematist who has undertaken a study of this genus, will at once appreciate the fact that the value of specific determinations is largely increased if they have received the sanction of a specialist in the group. Mr. Hill's forms of this genus have undergone the scrutiny of the late Dr. Thomas Morong and may be added with confidence to the state flora. It is therefore with very great diffidence that I venture to question the determination of one or two of the sheets sent the Survey. The question is not of the original determination, but the suggestion is made that in the distribution there has been a confusion of forms. The most noteworthy species of this genus are the following:

P. pulcher Tuckerm. "Shallow ponds, Pine Station, Lake Co., June 21, 1884." (E. J. Hill.) From an examination of many specimens, I am led to believe that this form as received by the Survey should be referred to *P. amplifolius* Tuckerm, because of leaf and fruit characters. The range of the two forms is practically the same and it is possible that they may be found associated, and become mixed in distribution. The size of the fruit is perhaps the most apparent distinction between the two forms. In addition to *P. pulcher* Tuckerm, *P. amplifolius* Tuckerm is also without doubt a member of the state flora.

P. prælongus Wulf. Cedar Lake, Lake Co., Ind., Feb. 27, 1882. (E. J. Hill.) This well marked form should be more generally found in the northern counties of the State. The region is fairly within the range of the plant and the conditions for its occurrence are good. It has, however, been reported from no other locality, so far as I have knowledge.

P. Robbinsii Oakes. "Cedar Lake, Lake Co., Ind., June 30, 1886." (E. J. Hill.) This is another interesting northern form added to the Indiana flora as a result of Mr. Hill's indefatigable work. (Man. 6th edn. 735c.)

In the specimen sent the Survey by Mr. Hill, both fruit and flowers are absent. From this specimen standing alone, I would refer the form to *P. marinus* L., since the leaf and stem characters do not conform to the description of *P. Robbinsii.* My very high appreciation, however, of the skill and acuteness of Mr. Hill lead me to include the form *P. Robbinsii* Oakes, and also to add the species *P. marinus* L.

I am inclined to believe that a more careful study of the plants of our marsh and lake regions would result in the extension of the range of many forms in this and allied groups.

Eriocaulon septangulare Withering. "Sandy borders of ponds, Laporte, Ind., July 22, 1875. Scapes 6-8 striate." (E. J. Hill.) The addition of Indiana to the assigned range of this plant in the 6th edition of Gray's Manual was based upon the collection of Mr. Hill. During the last summer Mr. Van Gorder collected it in Noble County, and Mr. Bradner includes in catalogue of the Flora of Steuben County (17th Report of State Geologist, p. 156), with the statement, "badly named, as the scape frequently has eight striae." The Hill collection is of the normal size from 2-6 inches high, while that of Van Gorder shows specimens from 1-2 feet high, having been submersed.

Distribution of the Orchidaceæ in Indiana. By Alida M. Cunningham.

The family of Orchidaceæ, as shown by the reports and specimens examined, is represented in the State by twelve genera and thirty-seven species.

Microstylis monophyllos Lindl., according to the 6th edition of Gray's Manual, s found growing in cold swamps in northern Indiana. It is also reported from the "Knob" region by Dr. J. M. Coulter. No specimen was examined.

Microstylis ophioglossoides Nutt., has been reported from Monroe by W. S. Blatchley, whose determination is verified by specimens in the DePauw Herbarium. One specimen of this species has been reported from Noble by W. B. Van Gorder and has been examined.

Liparis liliifolia Richard, occurs in the southern and central portions of the State. It is reported as rare in Franklin by O. M. Meyneke, but common in rich, shady woods in Gibson and Posey by Dr. Schneck. No specimens of this form have been examined.

Liparis Loeselii Richard, grows in extreme northern counties. Specimens from Lake by E. J. Hill and from Noble by W. B. Van Gorder were studied. Mr. Van Gorder states that it is very rare in that region and grows in tamarack marshes.

Aplectrum hiemale Nutt., is reported from the following counties: Clark, Jefferson and Franklin in the southeast; Gibson and Posey in the southwest; Putnam in the central; Noble and Steuben in the north. The State catalogue includes the species, referring it to Tippecanoe, but gives no authority for its inclusion. Specimens from Clark and Noble were the only ones studied.

Corallorhiza is represented in the State by three species—*innata*, *odontorhiza* and *multiflora*.

C. innata R. Brown. No Indiana specimen of this species was examined. It is reported, however, from the "knob" region by Dr. Clapp.

C. odontorhiza Nutt., is reported from Gibson and Posey by Dr. Schneck as rare, and found growing in shady woods in rich soil; from Franklin, by O. M. Meyncke; from Steuben, by E. Bradner, and from Noble, by W. B. Van Gorder, whose specimens were examined.

C. multiflora Nutt., is reported from Union by W. S. Blatchley, whose determination is verified by specimens in the DePauw Herbarium. From Noble, by W. B. Van Gorder, who states that it is rare in that county and grows in dry woods; and also from Steuben, by E. Bradner. The State catalogue includes this species, referring it to Jefferson, but gives no authority for its inclusion. No specimens were examined.

Spiranthes is said to be represented by four species: *latifolia*, *cernua*, *præcox* and *gracilis*.

S. latifolia Torr., is very limited in its range, at least as far as we have knowledge of its distribution. It is reported from Noble by Mr. Van Gorder, who states that only a few specimens were found. It is reported also from Tippecanoe by John Hussey, and his determination is verified by a specimen in the Purdue Herbarium.

S. cernua Richard, occurs chiefly in southern and western counties. It is reported also from Noble, where it grows with cranberry vines on the low shores of lakes.

S. præcox Watson, has been reported from Clark by Messrs. Baird and Taylor, and from Steuben by E. Bradner. The 6th edition of the Manual does not include Indiana in the range of this species, which reads: "Wet, grassy places. Mass. to N. J. and Fla."

S. gracilis Bigelow, is fairly well distributed, being reported from southeastern, northern and central counties, but is not found abundantly. Specimens from Noble, Lake and Jefferson were examined.

Goodyera repens R. Br., is reported from Steuben by E. Bradner. No specimens were studied, but the habit and range of the plant renders the determination doubtful.

Goodyera pubescens R. Br., has been collected in Noble by Mr. Van Gorder, whose specimen was examined. It is also reported from Warren and Vigo Counties.

Arethusa bulbosa L., is referred, in the State catalogue, to Lake Co. Dr. J. M. Coulter also reports it in the region of "Barrens." This would make it a true northern form and indicate that it grew in a cool climate and in both dry, sandy soil and low ground. No specimens were examined.

Calopogon pulchellus R. Br., is a northern species, being reported from St. Joseph by Dr. Barnes, whose specimen is in the Purdue Herbarium; from Steuben by E. Bradner, and from Noble by Mr. Van Gorder, who states that it is very abundant in that county and found growing in the same locality with *Pogonia ophioglossoides*.

Pogonia is represented by three species: *ophioglossoides*, *pendula* and *verticillata*.

P. ophioglossoides Nutt., is another true northern form. It is reported from Lake by E. J. Hill, from Noble by W. B. Van Gorder, who reports it to be very abundant and growing in cranberry marshes and low ground along the Elkhart River, and from Steuben by E. Bradner.

P. pendula Lindl., is reported from the extreme northern and extreme southern portions of the State. From Lake, by E. J. Hill, as very rare; Noble, by W. B. Van Gorder, as rare and growing in rich woods; Steuben, by E. Bradner; Gibson and Posey, by Dr. Schneck, as rare, growing in damp, rich woods, and from Jefferson, by Dr. J. M. Coulter.

P. verticillata Nutt., has been reported from three counties. From Monroe by W. S. Blatchley, Jefferson by Dr. Barnes, and from Noble by W. B. Van Gorder. Specimens from Noble and Jefferson were examined.

Orchis spectabile L., is the most widely distributed species in the family, being represented in twelve counties. It has been reported from the following: Jay, Delaware, Randolph and Wayne in the east; Jefferson, Clark and Monroe in the south; Noble and Steuben in the north; Putnam in the central; Franklin and Dearborn in the southeast.

Habenaria is represented by twelve species.

H. tridentata Hook., is reported from Lake by E. J. Hill whose specimen was examined.

H. virescens Spreng., is reported from Steuben by E. Bradner. No specimen of this species was examined, but its range would include it in the State list.

H. bracteata R. Br. Mr. Van Gorder reports three specimens of this species from Noble. Dr. Stanley Coulter says that it is fairly abundant in Tippecanoe, being reported by almost every class. Specimens from both counties were studied.

H. hyperborea R. Br., is referred to Lake in the State Catalogue, but no authority is given for its inclusion. It is probably, however, based upon the collection of E. J. Hill.

H. Hookeri Torr., is a northern form. Mr. Van Gorder reports it from Noble. A specimen from Lake by E. J. Hill was the only one studied.

H. orbiculata Torr., is also a northern species, being reported only from Noble, where it is very rare and grows in rich woods. A specimen from this county was examined.

H. ciliaris R. Br., is reported from St. Joseph by Dr. Barnes, from Noble by W. B. Van Gorder and from Steuben by E. Bradner.

H. leucophæa Gray, is reported from Noble by W. B. Van Gorder, from Steuben by E. Bradner and from White by J. Hussey.

H. lacera R. Br., is reported from Noble, where it grows in tamarack marshes.

H. psycodes Gray, is limited to the eastern half of the State, being reported from Jay, Delaware and Randolph by Dr. Phinney; Clark by Baird and Taylor; Jefferson by Dr. J. M. Coulter; Noble by W. B. Van Gorder and Steuben by E. Bradner.

H. fimbriata R. Br., has been reported only from Clark by Messrs. Baird and Taylor.

H. peramœna Gray, is a southern and western species. A specimen from Jefferson was the only one studied.

Cypripedium is represented by five species.

C. candidum Muhl, has been reported from Steuben by E. Bradner, and also from Gibson and Posey by Dr. Schneck, who states that it was at one time very common in that locality, but is rapidly disappearing.

C. parviflorum Salisb., is reported from Lake and Noble in the north; Dearborn in the southeast; Gibson and Posey in the southwest. In Noble it is rare and grows in birch marshes. It was at one time common in Gibson and Posey, but is becoming rare.

C. pubescens Willd., grows in northern and central counties. It was, at one time, common in Franklin, but is becoming rare. Mr. Van Gorder states that it is very common in dry woods in Noble

C. spectabile Salisb., is another extreme northern species. It is found in Noble growing in moist, shady places of tamarack swamps and bogs. It is reported also from Steuben by E. Bradner.

C. acaule Ait., has been collected in Noble by W. B. Van Gorder whose specimen was examined. It is also reported from Lake.

Out of the thirty-seven species named in this paper twenty-seven have been verified by herbarium specimens. Most of the others doubtless occur in the State, as they have been reported by good authorities.

From these facts we find that the following species are found only in the region north of an imaginary line drawn east and west through Indianapolis:

Liparis Loeselii, Spiranthes latifolia, Goodyera repens, Arethusa bulbosa, Calopogon pulchellus, Pogonia ophioglossoides, Habenaria tridentata, H. virescens, H. bracteata, H. Hookeri, H. orbiculata, H. ciliaris, H. leucophæa, H. lacera, Cypripedium spectabile and C. acaule. Of these the following are confined exclusively to the northern tier of counties: Goodyera repens, Arethusa bulbosa, Habenaria tridentata, H. virescens and H. hyperborea.

The following are reported only in the region south of the above named line: Microstylis ophioglossoides, Liparis liliifolia, Corallorhiza innata, Habenaria fimbriata and H. peramœna. Habenaria fimbriata is confined exclusively to counties bordering on the Ohio river.

Habenaria virescens and Goodyera repens are reported only from Steuben County, and need verifying specimens to support the reference.

Three species, viz., Arethusa bulbosa, Habenaria tridentata and H. hyperborea, are reported exclusively from the western portion of the State, yet it is a noteworthy fact that all three come from Lake County, and are doubtless exclusively northern species. In all probability a careful study of the flora of the northeastern counties would show no division between the eastern and western species.

FIRST REPORT OF THE BIOLOGICAL STATION.

TURKEY LAKE* AS A UNIT OF ENVIRONMENT, AND THE VARIATION OF ITS INHABITANTS.

First Report of the Indiana University Biological Station. By C. H. Eigenmann.†

Introductory.—At the last meeting of the Academy I outlined a plan for the future work of the zoölogical section of the biological survey of Indiana. It was, in brief, to study some lake as a unit of environment and the variation of its inhabitants. This plan has materialized, and I present this as the Biological Station's first report.

To select a suitable site I visited, in February, 1895, lakes Maxinkuckee, Eagle and Turkey. The lakes were frozen over, and I had a good long walk over Maxinkuckee and a sleigh ride over Turkey Lake. Turkey Lake seemed well suited for a starting point for the work in hand. In March I again visited this lake to look for a suitable laboratory and quarters. A laboratory was found in a large boat-house belonging to Mr. T. J. Vawter, the owner of Vawter Park. The boat-house is directly on the water's edge, in about 86° 18′ east longitude and 41° 23.5′ north latitude. In March the lake was still frozen over with but a narrow rim of free water near the shore. When I again visited the lake, to make the final arrangements, on the 30th of May, and captured snakes, turtles, frogs, and two species of spawning fishes, all within a hundred feet of the laboratory door, I was convinced that no mistake had been made in the selection of a locality. Deep water near the laboratory, a spring at the laboratory door, the situation of the laboratory nearly equidistant from either end of the lake, high land all about the laboratory, the nearness of such large bodies of water as Lake Tippecanoe of another river system, and a large number of smaller lakelets within a mile of Turkey Lake, all contributed to make the location selected as near perfect as could be expected

*The only recorded name of this lake seems to be Turkey. It appears so in the government surveys of 1838, and on all the maps published since that time. I am told that it received that name from the fancied resemblance of the general outline of the lake to a Thanksgiving turkey. During the last few years the lake has been known to those personally acquainted with it as Lake Wawasee, and there seems to be a laudable ambition that this latter name should supplant the homlier, but more significant, name of Turkey. The lower lake is locally known as Syracuse Lake.

The following letter was received from the Director of the Bureau of American Ethnology: In response to your letter of December 6th last, I beg leave to inform you that the word "wa-wá-see," "wa-wá-si" or "wa-wá-sing," signifies "at the bend of a river."

Yours with respect, J. W. Powell.

†Contributions from the Zoölogical Laboratory of the Indiana University, No. 14.

A twelve-room cottage was rented, in which fifteen of the members of the Station besides my family were quartered. While a summer cottage, thus peopled, is not a good place for consecutive thinking, this experience will also be remembered with pleasure. Most of the students rented a large dining tent and hired a cook. Others tented and boarded themselves. Their expenses ranged from $1.25 to $3 per week.

The laboratory was open from June 25 to September 1.

ACKNOWLEDGMENTS.—Mr. T. J. Vawter, besides placing the boat house at our disposal, gave us camping ground just back of the laboratory, and assisted us in various ways, both in fitting up the Station and during the entire summer.

I am under many obligations to the officers of the Baltimore & Ohio, the Vandalia and the Michigan Division of the Big Four for transportation over their lines leading to Vawter Park, and for other favors.

During our stay at Tippecanoe Mr. W. S. Standish assisted us very materially. He took the whole party on a tour of general inspection about the lake from end to end, and placed himself and his steamer at our disposal during our entire stay.

The Pottawatomie Club granted us the use of their reception room, where some of the lectures were delivered.

Professors Birge, Kellicott and Call have prepared accounts of material collected during the summer.

I must especially thank Dr. J. C. Arthur, Dr. G. Baur and Geologist Willis Blatchley, who visited the Station to deliver lectures before the members.

Lastly, I am indebted to Mr. J. P. Dolan, superintendent of the Syracuse schools. He first directly, and through Mr. Eli Lilly, of Indianapolis, called my attention to Turkey Lake, met me at Warsaw, and guided me to the lake and over and around it on my first visit. During the summer he furnished the Station with a splendid row-boat, and by his knowledge of the lake and its surroundings and personal acquaintance with the natives contributed much to the success of the undertaking.

EQUIPMENT.—The equipment of the Station consisted of a room 18x30 feet, with six windows on a side. In this space the twenty-two members of the Station were provided with tables. Continuous with this available laboratory space was a space 18x20, opening by very wide doors to the lake front. This space was utilized for storing apparatus. The apparatus, nearly all furnished by the Indiana University, was as follows: Compound microscopes (Zeiss), 21; dissecting microscopes, 3; microtome, 1; dredge, 1; plankton net, 1; Birge net, 1; dipnets; reagents, about 200 bottles; working library, about 200 volumes; Wilder's protected thermometer, 1; lamps, glassware, etc., the usual equipment of a laboratory table; two boats; one sounding machine. The plankton net and sounding apparatus and the method of using them may be described here.

PLANKTON NET.—An idea of our plankton apparatus and its modus operandi can be gathered from one of the illustrations. The sounding boat was fitted in the stern with a swinging derrick. Through the end of this was attached a pulley, through which the rope supporting the net passed. The derrick was high enough to allow the net to swing clear of the sides of the boat, so that when a haul had been made, the net could be swung forward over a tray of tubes, ready to receive the condensed plankton. The depth through which hauls were made could be ascertained either by means of the sounding apparatus or by the direct measurement of the plankton rope. The plankton net was built essentially as devised by Hensen and Apstein, except that the straining net of No. 20 silk bolting cloth, Dufour's, was permanently attached to the truncated cone of canvas. The bucket which receives the plankton was from necessity greatly simplified, but as no measurements were made with it, and further improvement, both in efficiency and simplicity, have been devised, I will describe this instrument as it will be made for next summer.

The diameter of the bucket will be made one and one-half inches. Its bottom will be of a sheet of brass or copper, hammered so that it will be slightly concave or cup-shaped. A hole will be punched from the inside and provided with a nipple soldered on the outside. The sides of the bucket will be made of one piece of wire net of the same caliber as the No. 20 bolting cloth of Dufour.* The upper part of the bucket will consist of a flat brass or copper ring soldered to the wire sides, and provided with openings through which the binding screws, fastening the whole bucket to the net, may pass. Three legs of narrow strips of copper passing from the upper ring along the sides of the bucket, being also fastened to the bottom, will give rigidity to the sides and form a support for the bucket when it is being emptied. To the nipple at the bottom of the bucket will be attached a short rubber tube. The opening in the bottom will be closed with a tight-fitting rubber stopper, manipulated from above by a glass rod passing through its middle. The whole cost of the bucket need not exceed $3.50. The estimate received on one of Hensen's pattern was $25.

* Only part of the sides were made of the wire netting during the past summer. A piece of new bolting cloth was found to have 83 per cent. of its surface solid, 17 per cent. being open for the passage of water. The wire cloth used during the past summer had 77 per cent. of its surface solid, 23 per cent. being open for the passage of water. Repeated trials of forcing water thick with plankton through the bolting cloth and through the wire showed that the wire was under such conditions a more effective strainer than the cloth.

Sounding Apparatus and Method of Using it.—A flat-bottomed boat capable of running into shore at all points was manned by three persons. One who was an expert and steady oarsman at the oars, one in the stern to take notes and steer, and one in the bow to make the soundings. The sounding apparatus consisted of a wheel two inches wide with a circumference at the bottom of a flat marginal groove of one foot ten inches. (It had been ordered with a circumference of two feet.) On the drum was wound 175 feet of fine annealed wire. This, when wound, formed less than two layers over all parts of the drum. The weight consisted of a round pebble as large as a fist and was tied in a piece of cheese cloth. This was a very simple and efficient piece of apparatus. The weight, if lost, could easily be replaced by one of several others carried along, and the wire was found sufficient for the whole summer's work. The original cost plus the cost incident to its operation did not exceed $1.50. The wheel was provided with a crank and being of a definite circumference the depth was measured by the number of turns it took to raise the weight from the bottom to the surface. This apparatus would be efficient in any lake of moderate depth. To run a line of soundings the bearing to the objective point on the distant shore were taken from the starting point with a compass. The oarsman pulled thirty strokes, backed water and held the boat. A sounding was made in the bow and the depth recorded by the man in the stern. It was found that with the boat always used for the purpose, manned as above in calm weather, when all the sounding was done, 30 strokes moved the boat 300 feet. This method proved entirely satisfactory in short lines a mile and a half in length. In long lines it proved unsatisfactory.

Additions to the Equipment. A new laboratory 18x55 feet, two stories high, will be ready for occupation by June 1 of 1896.

A partial description of new apparatus devised for next summer's work may be given.

One flat-bottomed boat similar to sounding boat, 12 feet, 2 oars.

One flat-bottomed boat 15 feet, four oars. Plankton apparatus.

Three glass-bottomed galvanized iron boats about 12 inches in diameter to explore bottom.

One galvanized iron tube 2 inches by 20 feet, glass ends and funnels for filling or emptying, to determine color of water.

Automatic recording apparatus to observe seiches.

Plan of Work.—It must be understood that the undertaking was quite expensive both in time and in money. The Indiana University endorsed the plans and lent apparatus from the zoölogical laboratory with the provision that the Station be of no expense to the University. At the end of the season the University paid for some of the apparatus specially designed for the Station, which thus became the permanent property of the University. In order to defray expenses, a series of courses in elementary and advanced instruction were offered and given. Each one of the advanced students and the instructors took charge of some particular work of the survey. The preliminary reports of some of these, form part of this first report. The work was distributed as follows:

C. H. Eigenmann, Director.

W. J. Moenkhaus, Variations in Etheostoma.

F. M. Chamberlain, Variations in Lepomis.

J. H. Voris, Variations in Pimephales

D. C. Ridgley, Physical Survey and Variations in Micropterus.

Bessie C. Ridgley, Variations in Labidesthes.

Thom. Large. Physical Survey and Variations in Fundulus.

Chancy Juday. Physical Survey and Planktonist.

Curtis Atkinson, Variations in Batrachians.

H. G. Reddick, Variations in Reptiles.

O. M. Meincke, Botanist.

J. P. Dolan. Meteorologist.

The work of but few has progressed far enough to justify even "forläufige" notices. We have but just begun our work, and the Station will remain at least three years longer at the same place. Excursions were made to lakes Tippecanoe, Webster, and Shoe in the Mississippi basins.

While much of this report is taken up with the physical features of the lake, and the enumeration of the inhabitants, it must be borne in mind that the physical studies are merely a means to an end. That however interesting in themselves, to us they are only interesting as far as they form part of the environment of the highest creatures making the lake their permanent home. It may even be that some of the things considered or to be considered, form in reality no part of the environment of the vertebrates, *i. e.*, that they in no way affect them, but this is a matter that must be determined, and for the present we must consider as many things as *may* influence them. The things probably most directly influencing the higher forms to be found in a lake are light, temperature and food. The last item is again conditioned as the highest forms are, so that nothing short of a complete understanding of the conditions will be sufficient. A lake seemed to me the ideal place because here the changes due to light, temperature, change of water or surface are reduced to the minimum to be found in this latitude. A small lake is better than a large lake, because the unknown elements can be reduced to a smaller number.

We have attempted to collect specimens of the higher creatures in such numbers and sizes, that had we collected all the specimens in the lake, our results would not be different. How far we have succeeded in this remains to be seen.

The main object of the Station is the study of the variation of the non-migratory inhabitants. I may be permitted to quote here the plan as stated in the circular issued by the Station last spring.

The main object of the Station will be the study of variation. For this purpose a small lake will present a limited, well circumscribed locality, within which the difference of environmental influences will be reduced to a minimum. The study will consist in the determination of the extent of variation in the non-migratory vertebrates, the kind of variation, whether continuous or discontinuous, the quantitative variation, and the direction of variation. In this way it is hoped to survey a base line which can be utilized in studying the variation of the same species throughout their distribution. This study should be carried on for a series of years, or at least be repeated at definite intervals to determine the annual or periodic variation from the mean. A comparison of this variation in the same animals in other similarly limited and well circumscribed areas, and the correlation of the variation of a number of species in these areas will demonstrate the influence of the changed environment, and will be a simple, inexpensive substitute for much expensive experimental work.

For this work the situation of Lake Wawasee, surrounded as it is by other lakes, some of them belonging to other river basins will be admirably adapted.

In connection with this study of the developed forms, the variation in the development itself will receive attention. For instance the variation in segmentation, the frequency of such variation, and the relation of such variation in the development to the variation in the adult, and the mechanical causes affecting variation.

This plan will be modified as our knowledge grows and our experiences dictate.

PART I. THE LAKE AS A UNIT OF ENVIRONMENT.

INTRODUCTORY.—A lake is a depression in the ground filled with water more or less stagnant.

A glance at a good map of North America will show the following peculiarities in the distribution of lakes:

I. A large number of lakes are found in Florida.

II. A host of them are distributed in northern United States and Canada, including the greatest collection of fresh waters on the globe.

III. A good number in the Sierra Nevada and the Rocky Mountains.

The remainder of the country from the southern boundary of Georgia to the northern boundary of Pennsylvania west to the Rockies is practically free from lakes, except

IV. along either side of the lower Mississippi and Red Rivers.

These four groups of lakes are due to four different methods of lake formation, but all four are indicative of the fact that the lake-rich areas have undergone recent change.

The first series is due to the comparatively recent elevation of an irregular ocean floor. The second series is due to the action of ice in the irregular gouging and irregular dumping of debris. These are all of recent date, probably none of them being over 10,000 years old. The third series is due to the exigencies of mountain formations, including in this plication and plication hollows, craters and lava flows and the settling of small areas. The fourth is due to the change of channel on the part of the Mississippi and to the debris brought down by the Red River which it has deposited at the mouths of its tributaries.*

Of course the lakes of one of these regions need not be all of the same origin. Small lakelets around Lake Tahoe in the Sierra Nevada are certainly due to the gouging action of glaciers coming from a steep incline onto a comparatively level plain. Generally speaking, mountain regions, unless, as in the case of the Appalachian, they have outgrown their lake stage, contain lakes of the greatest diversity of origin.

Lakes are of interest to the geologist to determine the particular way in which a general cause has been modified to produce a particular effect at any particular lake; to the physicist to account for the various colors, temperatures, pressures, reflections, refractions, etc.; to the chemist to determine the degree of concentration of minerals and gases in solution; they are of interest to the naturalist to determine the organic inhabitants, their quantity and kind and their life histories; to the oecologist and evolutionist to determine the geological, physical and chemical characters in their effect on the organic inhabitants and these on each other.

Lakes may therefore be studied for other than purely economic interests, such as water supplies and highways for commerce or location of summer resorts.

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*The facts for the foregoing have largely been drawn from Russell's American Lakes. Ginn & Co., 1895.

ORIENTATION.—A hight of land (morain) extends from the northeastern corner of Indiana directly southwest to south of Albion in Noble County, and from here westward between Turkey Lake and Tippecanoe Lake, then northwest through Nappanee in Elkhart County to near South Bend. In its range from the northeastern corner to south of Albion this ridge separates the Lake Michigan from the Lake Erie basin. West of this it separates Lake Michigan basin from the Ohio basin, and still farther west from the Mississippi basin proper. In the eastern half of Indiana this ridge is exceedingly rich in lakes. Most of these lie on the northern side of the divide, but about the headwaters of the Tippecanoe and Blue rivers many are also found on the south side of the divide. A glance at the map leaves the impression that this region is low and swampy, while in reality this whole region forms one of the highlands of Indiana, a considerable part being over 1,000 feet high.

Turkey Lake is the most western lake of this series lying north of the divide. It lies in Turkey Creek Township, in the northeastern corner of Kosciusko County. South of the ridge separating the Mississippi and St. Lawrence basins at this point lie Webster and Tippecanoe lakes, and south of these the Barber lakes and Shoe Lake. Between the crest of the ridge and Turkey Lake the country is pitted and grooved. Many of the pits are filled with water, forming ponds of various sizes. One of these has recently been drained. Many more lakelets are found about the head of Turkey Lake, but the topography of this region will be dealt with in one of the following reports. This whole region gives one the impression that it has changed but little since the ice left it.

GENERAL FEATURES.—The lake has a general trend from southeast to northwest. It is divided by a wide stretch of very shallow water, which is fast being reclaimed by various water plants. A deeper channel extends through this swampy region, connecting the upper and lower portions.

The greatest length from the head of Turkey Lake to the end of Syracuse Lake is five and one-half miles. The width, measured at right angles to such a line, rarely exceeds a mile. The greatest width is just east of Ogden Point, where it measures one and a half miles. The length of Turkey Lake from Mineral Point to Conkling Hill is about four miles. The total shore line is between twenty and twenty-one miles.

The excellent map prepared by Messrs. Juday and Ridgley, based as it is on numerous soundings, shows the lake bottom to be of the same rolling character as the surrounding region. A lowering of the surface of the lake ten feet would make the long stretch of territory between Syracuse and Turkey lakes dry land, and make the lake entirely landlocked.

The similarity of the lake bottom to the surrounding country, which seems to have been little changed by erosion, makes it quite certain that the lake basin is due to the irregular dumping in a terminal moraine, parts of it containing deeper kettle holes.

The lake was never much more extensive than now. There are evidences that the surface was a few feet higher. These will be considered in a later report. The lake is surrounded by extensive swamps on the east, north, and west; these would practically all be covered by water should the surface of the lake be raised five feet. The hydrographic basin is so small that at present but seven inches of water are removed from the surface by outflow, while thirty are removed by evaporation. The lake having a surface of 5.6 square miles, an increase of this surface by $\frac{7}{30}$, or about one and a third square miles, would be sufficient to allow all the water coming into the lake to be lost by evaporation except in wet seasons. The surface of the lake, therefore, can not have been very much higher than at present if the present precipitation and evaporation have been constant since the ice left this region. The lake has been about six or seven feet lower, having been raised to its present height by the building of a dam across its outlet. The changes due to this dam and to the encroachment of plants will be considered in another report.

SIZE.—The total area now under water is 5.659722 square miles. This area was obtained by weighing a sheet of paper of uniform thickness and of the shape of the whole area to be calculated, and comparing this weight with the weight of a square of the same paper covering a square mile. This method is much more expeditious than calculating such an irregular body as these lakes in the absence of a planimeter, and quite as exact. The same method was used in determining the areas below which there is a certain depth of water, with the following results:

Depth of Water.	Area in Square Miles.	Amount of Water in Cubic Miles.
1–10 feet	3.27777	.00310395
10–20 feet	.59027	.00167690
20–30 feet	.62500	.00314867
30–40 feet	.45833	.00303817
40–50 feet	.39583	.00337165
50–60 feet	.22918	.00231162
60–70 feet	.0694	.00082026
	5.64576	.0174712
Error to be distributed	.1396	
	5.65972	

Forel (Faune profonde des lacs Suisses, p. 5) proposed to estimate the volume of a lake by comparing it with a cone whose height is the maximum depth, and whose base is the surface of the lake. Estimated in this way he found the cone gave but .67 of the actual volume of Lake Geneva. A similar estimate for Turkey Lake will give us .024654 cubic miles, or considerably more than the actual value. The average depth obtained by dividing the cubic contents by the surface gives us 16.6 feet. All these measurements were made during the summer of 1895 when the lake was below the average height, so that 17 feet will probably be nearer the average depth. It will be found that by another method Mr. Ridgley obtained 21 feet as the average depth.

Over half the area contains water less than 10 feet deep. A reduction of thirty feet below the present level would reduce the lake to a Y-shaped figure extending nearly from end to end of the present lake. One of the horns of the Y would extend to Crow's Bay, the other to Mineral Point. The base of the figure would lie to the west of Black Stump Point. Between the horns of the Y we should have a peninsula continuous with Morrison's Island, which is the last of a series of islands left in the lake. During the ancient history of the lake the land about Buttermilk Point was an island, and ridges of land east and west of this formed the islands. One of these is seen in the illustration. The detailed description of the hydrography of the lake will be given in the map and Mr. Ridgley's report.

Relation of Water to Outflow and Evaporation.—Without any addition to the water of the lake the quantity now in the lake would be sufficient to supply the present outlet for 26 years.*

In other words, every cubic foot of water entering the lake will remain in it on an average of twenty-six years, unless removed by evaporation. Ridgley estimates that the inflow from springs equals the outflow, yet the lake was observed to fall on an average of one-quarter inch per day, rising of course during rains. That the outflow will not account for the fall of the lake is sufficiently shown by the fact that the calculated fall due to the outflow is but .0016 inches per day. (See Ridgley's report). The remainder of the fall must be due to evaporation and seepage, very largely to the former. Attempts were made to estimate the amount of evaporation from the surface, but they proved failures. It is self-evident that simply exposing water in an open dish will not answer the purpose of estimating the amount of evaporation in the lake for the reason that water in a shallow dish is heated to very different degrees from the water of the lake. An

*Based on Ridgley's and Juday's estimate of the outflow, and my estimate of the lake's contents.

apparatus which promised to measure the evaporation accurately and at the same time do several other things was devised, but it proved a failure because it could not be well protected in rough weather and still maintain natural conditions. The apparatus which we hope we shall be able to perfect is as follows:

A glass jar 9 inches in diameter and 12 inches high with a small hole near the bottom and open at the top is sunk into the lake to within two inches of its top. When the water in the jar has reached the level of the lake water a tight rubber stopper is inserted in the small opening from without. The column of water in such a jar would be as near as possible under the same conditions as the surrounding water, and the fall of the water in the jar, plus the amount of rainfall for the period, would very closely approximate the amount of evaporation. This apparatus would also enable one to get at the amount of water received from springs and other sources aside from rain falling directly into the lake. The amount of reduction due to outflow from the lake can readily be calculated by observing the outlet. Mr. Ridgley has estimated it at .0017 inches per day. If at the end of thirty days there was a difference between the water in the jar and the water in the lake, less the calculated reduction of the lake due to outflow, the difference would represent the inflow from springs and other tributaries during thirty days.

The lake is frozen over about four months in a year. During the remaining eight months evaporation is going on at a maximum rate of one-fourth inch per day and a minimun of 0. Taking one-eighth inch per day as the average, we obtain about thirty inches as the amount of the annual evaporation. At this rate the lake, if without income, would become dry in twenty-eight years. Four years would reduce the lake to half its present size.

Outflow and evaporation operating together would reduce the level at the following rate:

Time in Years.	Reduction by Outflow.	Reduction by Evaporation.	Total Reduction
3	1 ft. 9 in.	7 ft. 6 in.	9 ft. 3 in.
3	4	7 6	11 6
2	3 2	5	8 2
2	4 8	5	9 8
2	6 8	5	11 8
1	5 2	2 6	7 6
1 about	17 7	2 6	10 1
14	33 2	35	68

These figures do not claim any great degree of accuracy; they simply help to form an estimate of the length of time it would take both the outflow and evaporation together to empty the lake. But while it would take both the outflow and the evaporation fourteen years to empty the lake, one-fourteenth does not express the per cent. of the water of the lake changed annually under present conditions. Since the vertical reduction is the same whether the surface is large or small, it is evident that a much larger amount would be evaporated while the surface is large. In reality, if a bulk were to be taken from the lake equal to the outflow, plus the evaporation over the present area, about six years would be sufficient to empty the lake, or, to put it in other words, during average years every cubic foot of water entering the lake remains on an average six years. During very wet seasons the amount of loss may reach a much larger proportion of the whole contents.

Constancy of Turkey Lake as a Unit of Environment.—From the preceding chapter it must be evident that the conditions in the lake, from month to month and from year to year are but little changed, that the conditions, as far as the water is concerned, are remarkably constant, especially if we compare these conditions to those obtaining in the lower courses of such rivers as the Wabash or the Illinois.

In the early part of this century a dam was built across the mouth of the outlet forming an effective barrier to the ingress of fishes from below. The lakes being at the headwaters, nothing has entered it from above. A few forms were planted in recent years by Col. Lilly of Indianapolis.

The level of the lake was changed by the building of the dam, and as late as 1840 trees were standing in water six to seven feet deep. Many of the stumps still remain. Their location and the effect of the dam upon the lake will be discussed elsewhere.

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A Preliminary Report on the Physical Features of Turkey Lake. By D. C. Ridgley.*

ACKNOWLEDGMENTS.

Most of the data on which this preliminary report is based were collected during the summer of 1895 at the Indiana University Biological Station at Vawter Park, Koscinsko County, Indiana, under the direction of Dr. Carl H. Eigenmann. I wish to acknowledge the aid of his valuable suggestions, both in the collection of the data and the preparation of the report. I wish to acknowledge also the

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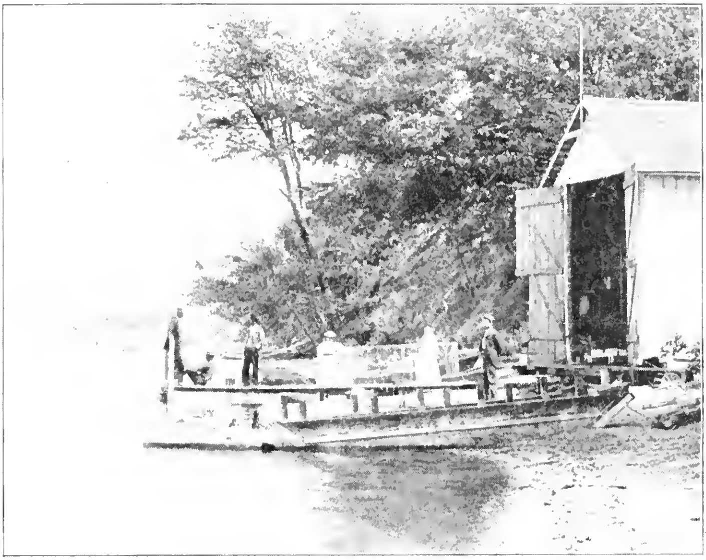
*Contributions from the Zoölogical Laboratory of the Indiana University, No. 15a.

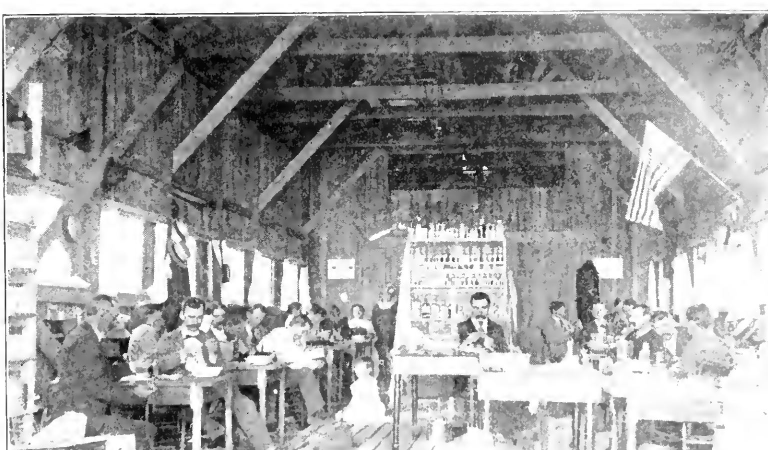
PLATE I.

No. 1.



Indiana University Biological Station.

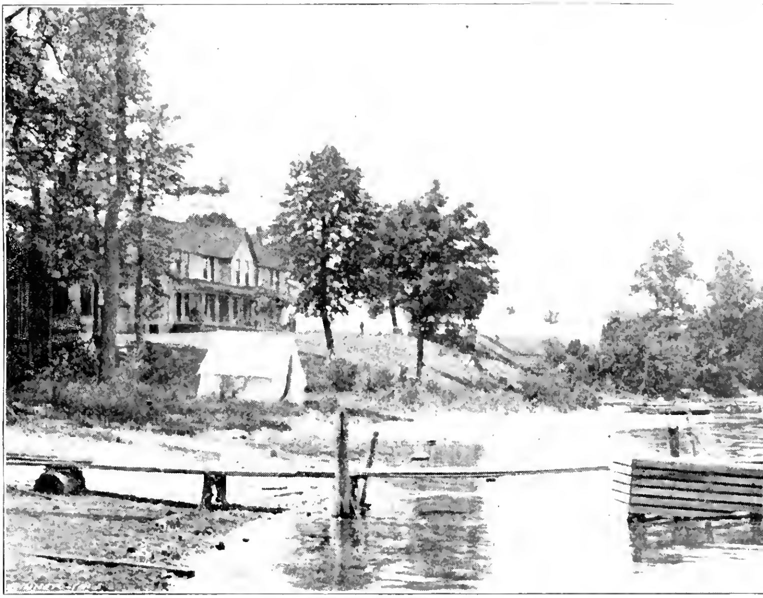
No. 2.



Interior of the Laboratory.

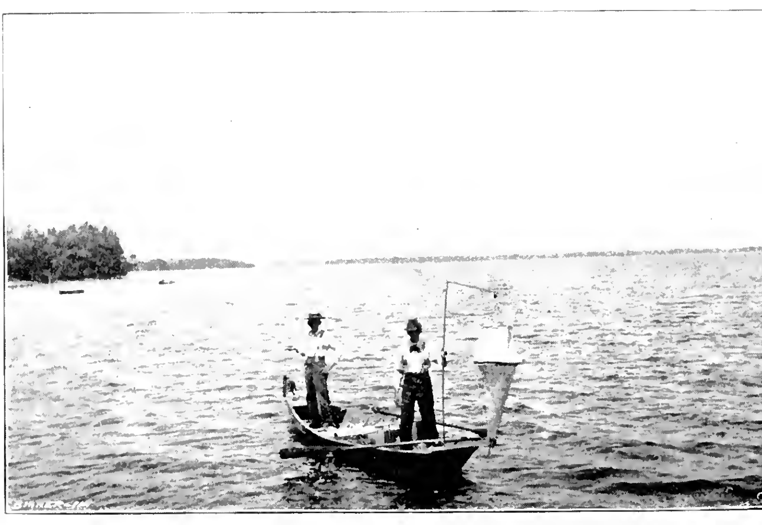
PLATE II.

No 3.



Vawter Park Hotel from the Laboratory.

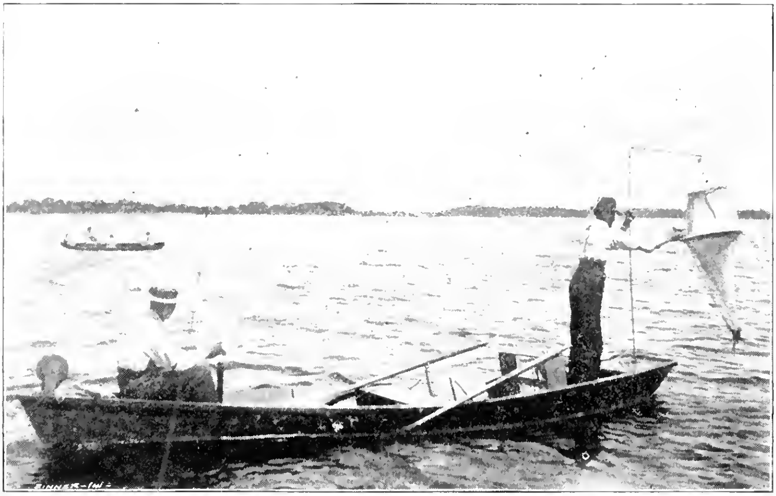
No. 4.



Black Stump Point from the Laboratory. Plankton Boat.

PLATE III.

No. 5.



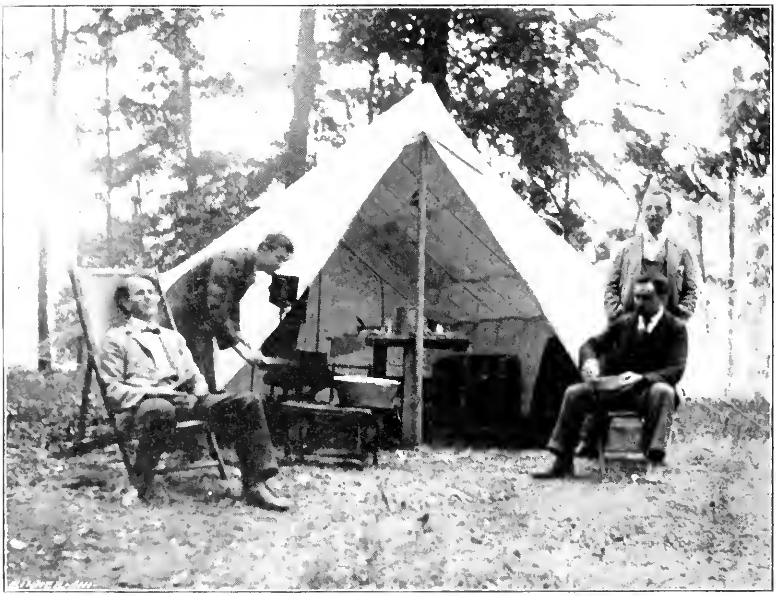
Looking Toward Ogden Point from the Laboratory. Plankton-Boat in Forewater.

No. 6.

Ogden Point from Near the Pottawatomie Club-House.

PLATE IV.

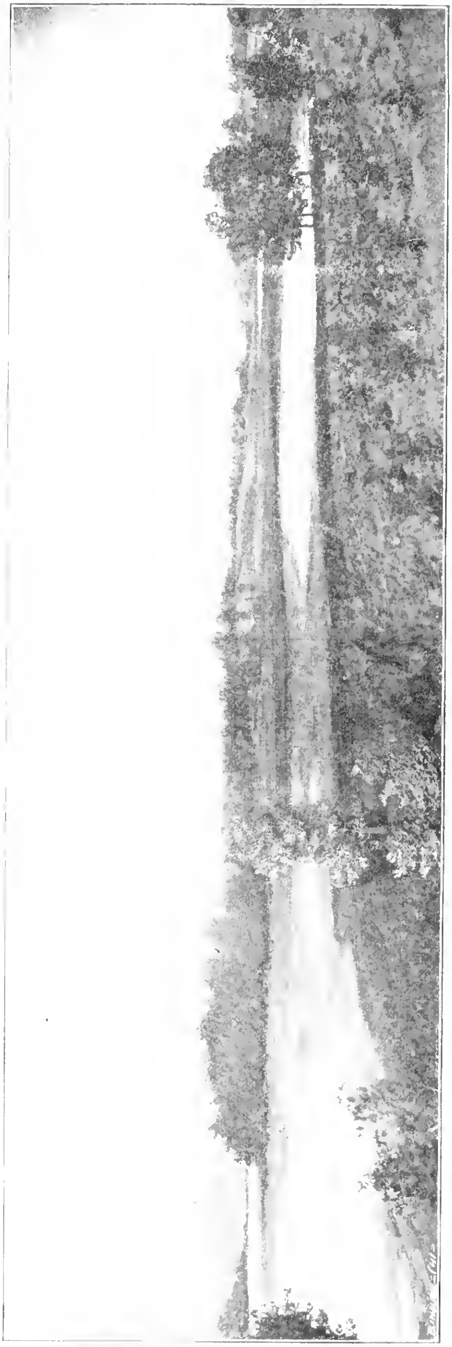
No. 7.



STUDENTS' CAMP IN VAWTER PARK.

PLATE V.

No. 8.



GANS' LAKE.
HOOPER'S LAKE.
HARTZELL'S LAKE, I.

OLD ISLAND.

TURKEY LAKE.
HARTZELL'S LAKE, II.
HARTZELL'S LAKE, III.

GENERAL VIEW FROM MORAINE AT HEAD OF TURKEY LAKE.

PLATE VI.

No 9.

West Beach of Morrison's Island.

No. 10.

Crow's Bay Showing Ice Beaches.

PLATE VII.

No. 11.

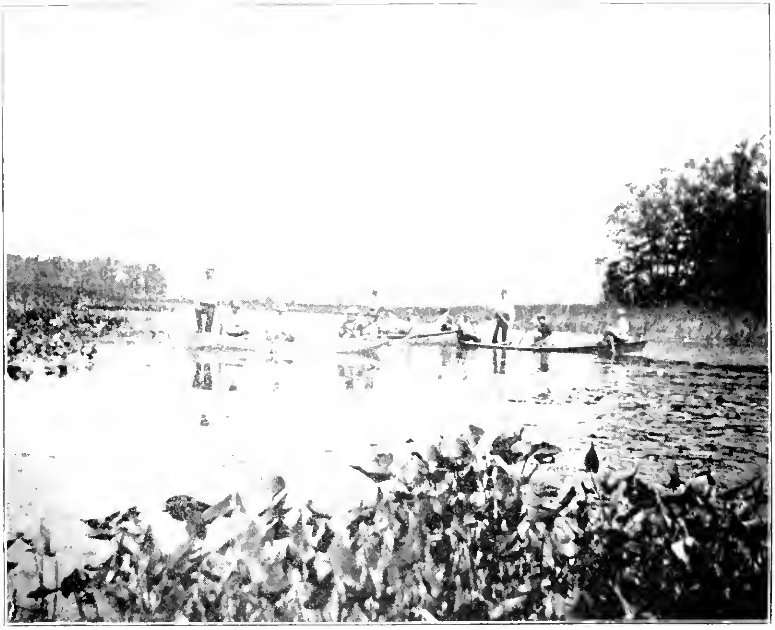
Cedar Point.

No. 12.

Beach West of Cedar Point.

PLATE VIII.

No. 13.



In the Channel Between Turkey and Syracuse Lakes.

No. 14

At the Head of Syracuse Lake.

assistance of Mr. Chauncey Juday, Mr. Thomas Large and others in taking the soundings of the lake; of Mr. Juday, in making a survey of the shore and for copies of the accompanying map with which he has furnished me and from which the report on the topography of the bottom is largely drawn; of Mr. J. P. Dolan for records of daily observations of lake phenomena and for the history of the lake in years past; of the officials of the Baltimore & Ohio Railroad who furnished data with reference to elevations and whose generosity has made it possible for me to make frequent visits to the lake during the winter.

GENERAL FEATURES OF THE LAKE.

Turkey Lake is made up of two parts, connected by a channel. The channel is three-quarters of a mile in length and from one hundred feet to a half mile in width. Its depth varies from one to five feet. The part of the Lake north of the channel is known as Syracuse Lake. It includes an area of three-quarters of a square mile, which is approximately one-eighth of the area of the entire Lake. The larger part of the Lake, to the south and east of the channel, may be known as the main lake.

The general direction of the lake is from southeast to northwest. Its greatest length is five and a half miles, and its greatest width at a right angle to its length is one and a half miles. The entire shore line is between twenty and twenty-one miles in length, and the area of the lake is a little more than five and a half square miles. No very prominent irregularities occur around Syracuse Lake, while in the main lake a number of evident indentations are to be found. The east end of the main lake is made up of three bays. Johnson's Bay, extending to the north, is one mile long and three-eighths of a mile wide. Ogden Point lies to the west of the entrance of this bay and Cedar Point to the east. The east end of the main lake is Crow's Bay, with Cedar Point on its north and Morrison's Island on its south. Jarrett's Bay extends to the southeast, with Morrison's Island to the east of its entrance and Clark's Point to the west. In the west end of the main lake is Conkling Bay, circular in form and with the surrounding marsh a half mile in diameter. It lies south of Conkling Hill. These are the most prominent indentations. Between the channel and Ogden Point, which are two and a quarter miles apart, the shore line curves gently northward three-quarters of a mile, forming Sunset Bay. Between Clark's Point and Black Stump Point, one and three-quarters miles to the northwest, the shore line bends southward one-third of a mile.

The following places are located for convenience in referring to different parts of the shore line and lake: The town of Syracuse lies on the west side of Syracuse Lake near Turkey Creek, the outlet of the lake. Pickwick Park is on the north shore of the main lake a half mile east of the channel. Eppert's is 1,000 feet east of Pickwick Park, and nearly a half mile further east is Jones' Landing. Three-fourths of a mile east of Jones' Landing is Wawasee. Jarrett's Landing is at the middle of the southern extremity of Jarrett's Bay. Vawter Park is a half mile west of Clark's Point and directly south of Wawasee. The laboratory of the Indiana University Biological Station is located on the shore of the lake near the west end of Vawter Park.

TOPOGRAPHY OF THE BOTTOM.

The data from which the topography of the bottom has been determined consist of numerous soundings taken throughout the lake between June 29 and August 21, 1895. The water was very low during this period. For our purpose we may consider all soundings taken when the lake had the level of July 6, 1895. This level has been marked and is used for a bench line from which to read the fluctuations in level On August 21 the lake had receded 5 inches from this level. Soundings were taken along 28 lines in the main lake and 4 lines in Syracuse Lake. These soundings were taken about 300 feet apart along all lines. Where water deeper than 60 feet was found, numerous soundings were made to determine the extent of such areas. Below is given the number and location of each line along which soundings were taken, except No. 3 and No. 9 in the main lake, neither of which was used in drawing contour lines or in computing average depth.

IN MAIN LAKE.

No. of Line.	Location.
1	From Biological Station to Ogden Point, North 37° East.
2	From Ogden Point to east end of Crow's Bay, South 53° East.
4	From Biological Station to Wawasee, North.
5	From Wawasee to Black Stump Point, South 52° West.
6	From Biological Station to Cedar Point, North 64° East.
7	From Cedar Point to Morrison's Island, South.
8	From Morrison's Island to northeast corner of Crow's Bay, North 8° East.
10	From south end of Jarrett's Bay to mouth of Bay, North 7° West.
11	From east margin of Ogden Point to north end of Johnson's Bay, North 1° West.
12	From north end of Johnson's Bay to mouth of Bay, South 10° East.
13	From east side of Ogden Point across Johnson's Bay, North 60° East.
14	From middle of east side of Johnson's Bay, across the Bay, North 79° West.
15	From Clark's Point to Morrison's Island, East.
16	From mouth of Turkey Creek across Jarrett's Bay, West.
17	From a point ¾ of a mile west of Biological Station across the lake, North.
18	From Clark's Point to east side of Ogden Point, North 5½° East.
19	From point a half mile east of Biological Station, North.
20	From Ogden Point to Black Stump Point, North 83° West.
21	From west side of Jarrett's Bay to Mineral Point, East.
22	From Clark's Point to east side of Johnson's Bay, North 30° East.
23	From north end of No. 22 to Ogden Point, South 85° West,
24	From point one-half mile west of Wawasee across lake, South.
25	From Black Stump Point, North.
26	From Eppert's South.
27	One-quarter of a mile west of No. 26 and parallel with it.
28	One-quarter of a mile west of No. 27 and parallel with it.

IN SYRACUSE LAKE.

No. of Line.	Location.
1	From middle of east end of Syracuse Lake, South 80° West.
2	From point 700 feet southeast of west extremity of Lake, North 70° East.
3	From a point on north shore one-half mile east of west extremity of lake, South 10° West.
4	From west extremity of lake, South 80° East.

In the accompanying map, constructed by Mr. Juday, the hypothetical contour lines of the bottom of the lake were drawn from the soundings along the above mentioned lines, and numerous other soundings taken to determine the extent of certain depths of water. The contour lines indicate intervals of ten feet in depth. From the same data were constructed ten vertical sections of the bottom. In constructing the vertical sections a base line was drawn from Pickwick Park to Mineral Point, and seven of the vertical sections, from "A" to "G" inclusive, were made at right angles to this line at intervals varying from one-quarter of a mile to two-thirds of a mile. Vertical section "H" is a short distance east of No. 18, "I" is along No. 4. and "J" along No. 25 of the lines of soundings in the main lake. The remarks on the topography of the bottom are drawn largely from a study of these contour lines and vertical sections.

The average depth of the lake, found by taking the average for the soundings at regular intervals of 300 feet along the lines of soundings is 21 feet 6 inches in the main lake, 13 feet 6 inches in Syracuse Lake, and 20 feet 5 inches for the entire lake. By a different method, as explained in his report, Dr. Eigenmann has computed the average depth at a little more than 17 feet. The maximum depth found in the main lake is 68 feet 7 inches, one-quarter of a mile from the southern extremity of Jarrett's Bay; 1,000 feet northeast of the Biological Station a depth of 66 feet 5 inches was found; three-quarters of a mile north and one-quarter of a mile west of the Station the water is 60 feet deep; and a half mile northwest of Black Stump Point it is 63 feet 3 inches deep. The deepest water found by us in Syracuse Lake is 28 feet 10 inches. A depth of 35 feet is recorded for this lake in the State Geologist's Report for 1875.

An examination of the contour lines of the map shows that if we consider water having a depth of 30 feet or more as deep water, we have in the main lake four areas of deep water varying greatly in size, and connected with each other by channels.

In Crow's Bay the greatest depth found was 49 feet 9 inches. These waters enter the main body of the lake through a channel deeper than 30 feet, and 200 feet wide at its narrowest point. This channel flows across the mouth of Johnson's Bay, meeting a short arm deeper than 30 feet from that bay, and comes within 600 feet of the southeast extremity of Ogden Point. This channel continues less than 400 feet wide to a point two-thirds of a mile west of Ogden Point where it joins the channel deeper than 30 feet from Jarrett's Bay. The deepest water in Jarrett's Bay is 68 feet 7 inches, and the area deeper than 30 feet is one-fourth of a mile wide, extending north beyond the mouth of the bay and to within 700 feet of its southern shore. This 30-foot depth joins the main body of the lake a half mile north of Clark's Point where the channel 30 feet deep is only 100 feet wide. Turning to the west, 1,000 feet northeast of the Biological Station this channel deepens to 66 feet 5 inches, and widens to a half mile directly north of the Station. Here it meets the narrow channel 30 feet deep from Crow's Bay.

The two channels merge into one and form an area of water from 30 feet to 66 feet in depth, one mile in length and with a maximum width of three-quarters of a mile. This area of deep water lies nearer the south shore, its center being one-third the distance from the south shore to the north shore. Near Black Stump Point the deep water narrows abruptly from the north, and 500 feet out from Black Stump Point its width is but 200 feet. West of Black Stump Point the deep water widens abruptly to the north to a width of one-quarter of a mile and deepens to 63 feet 3 inches. West of this the area of deep water narrows again and the water having a depth of 30 feet ends one-quarter of a mile southeast of the entrance to the channel between the main lake and Syracuse Lake.

Between the deep channels from Crow's Bay and Jarrett's Bay the area having a depth less than 30 feet is one and one-quarter miles long, 1,300 feet wide, and contains an area one mile long and 500 feet wide over which the water is less than 10 feet deep.

If the level of the lake were lowered 30 feet there would remain four bodies of water connected by channels from 100 feet to 200 feet wide and less than 10 feet deep. These four bodies of water would be: (1) a small area in Crow's Bay with a maximum depth of 19 feet; (2) about one-half of Jarrett's Bay with a maximum depth of 38 feet; (3) the main body of the lake, its width decreased almost one-half, and its maximum depth being 36 feet; (4) a small area northwest of Black Stump Point with a maximum depth of 33 feet. Lower the level of the lake 10 feet more, that is, 40 feet below its present level and these four bodies of water would remain as separate lakes, the connecting channels now being dry.

Great changes in the shore line will take place if the level of the lake be lowered to a much less extent. By observing the map it will be seen that a lowering of the level of the lake to the amount of 10 feet would move the shore line to the first contour line. This would leave one-half the bottom of Johnson's Bay dry land; it would move the shore line along Crow's and Jarrett's Bays from 400 feet to 1,000 feet into the lake. Clark's Point would extend 2,000 feet further north, and the distance between Clark's Point and Ogden Point would be reduced from 4,000 feet to 1,800 feet. The south shore line from Clark's to Conkling Bay would be moved northward distances varying from 250 feet at Iron Spring Point to 1,000 feet along the shore west of Black Stump Point. The north shore line from Ogden Point to the Channel would be moved southward from 900 feet to 2,000 feet, and at one place—between Jones' Landing and Black Stump Point—4,000 feet, reducing the width of the lake at this place from 1 mile to 500 feet. The Channel between the main lake and Syracuse Lake would be drained, and the greater part of Syracuse Lake would become dry land.

Judging from the contour of the land, the level of the lake has probably never been more than 5 feet below its present level.

TOPOGRAPHY OF THE SHORE.

The shore of 20 miles is about equally divided between dry shores and marshy shores. The shores of Syracuse Lake and of the west end of the main lake were not carefully surveyed, but accurate measurements and notes were taken of the shore line of the east end of the main lake from a point on the north shore three-eighths of a mile to the northwest of Wawasee, around the east end of the lake to a point directly south of the starting-point. These data were used in mapping a ten-foot elevation line around this part of the lake. For this reason the shores of the east end of the lake are treated more in detail than the others.

The dry shores are composed of sand and gravel. Some are less than 5 feet high, but more often they are abrupt bluffs from 10 to 30 feet high, or hills which ascend rapidly to a height of 40 feet. The west, north and northeast shores of Syracuse Lake are bluffs or hills. The east shore is marshy. The shore south of Turkey Creek, the outlet, is also marshy, and these marshes extend along both sides of the Channel between Syracuse Lake and the main lake. Pickwick Park is located on a gravelly shore less than 10 feet above the level of the lake. Between Pickwick Park and Eppert's is the Gordoniere Marsh extending northwest to the Channel. Pickwick Park and the land to the west of it is surrounded by the main lake, the Channel and the Gordoniere Marsh and is known as British Island. The shore between Eppert's and Jones' is mainly marsh. From Jones' one-quarter of a mile east the shore is a bluff from 10 feet to 15 feet high. From this point almost to Wawasee the land near the shore is at present a dry marsh. The bluff at Wawasee is 15 feet high and extends along the shore 1,700 feet. This bluff extends back from shore 500 feet where it joins the marsh which stretches along the shore to Ogden Island, and also to the east to Johnson's Bay. Ogden Island, which is surrounded by the lake only on the southwest side and on all other sides by marshes, extends a half mile to the northwest of Ogden Point and is from 300 feet to 1,000 feet wide. Its greater part is from 3 feet to 6 feet above the level of the lake. About one-half of that part of the island which touches the lake is a bluff from 10 feet to 18 feet high. The area higher than 10 feet is 1,100 feet long and from 175 feet to 400 feet wide. The marsh around Johnson's Bay is known as the Johnson Marsh. It skirts the southeast and east sides of Ogden Island, surrounds a piece of timbered land 700 feet in diameter north of Ogden Island known as Oak Island, borders the bay on the north, sending off a broad marsh across the country to the northeast, and continuing along the east side of the bay with a width of a half mile, joins a narrow marsh extending to the southeast. On the east side of Johnson's Bay are two bluffs, one reaching a height of 23 feet and extending from Cedar Point northwest one-quarter of a mile along the shore and having 500 feet for its greatest width; the other is 1,000 feet further to the northwest, and is between 10 feet and 15 feet high, 700 feet long and 150 feet wide. Lying to the northeast of these bluffs and extending between them is an arm of the Johnson Marsh from 50 feet to 800 feet in width, which joins Crow's Bay just east of Cedar Point. From the northeast corner of Crow's Bay the bluffs extend south along the east end of the lake for a half mile. They are from 10 feet to 27 feet in height. The 10-foot elevation line then leaves the shore and extends almost south to Turkey Creek, leaving an area of well timbered dry land along the lake with an elevation of from 3 feet to 10 feet and attaining a width of 1,000 feet.

The land on both sides of Turkey Creek, the inlet of the lake, is marshy. Lying to the north of the mouth of the creek this marsh is 400 feet wide and extends one-quarter of a mile north along the lake. This marsh is separated from the marsh along the east margin of Morrison's Island by a shallow channel of water. The west side of Morrison's Island is a bluff reaching a height of 21 feet. From Turkey Creek to Buttermilk Point the shore is skirted with marsh from 200 feet to 400 feet wide. Mineral Point is 200 feet from the lake and ascends abruptly from the marsh to a height of 25 feet. A half mile south of Turkey Creek the lake is entered by Jarrett's Creek which is the outlet of a chain of small lakes lying southeast of Jarrett's Bay. This stream flows through a marsh 400 feet wide, and all the small lakes are bordered by marsh land. The marsh along the lake ends at Buttermilk Point, and for a quarter of a mile the shore is dry and sandy. The land along this shore is not a perpendicular bluff, but rises rapidly from the lake to the south and reaches a height of 40 feet at a distance of 400 feet from the shore. The west side of Jarrett's Bay is skirted by a marsh from 150 feet to 1,000 feet wide. West of the marsh is a bluff from 10 feet to 15 feet high continuous with the land south of the bluffs of Vawter Park. West from Clark's the south shore of the lake is a perpendicular bluff reaching a height of 29 feet in Vawter Park and extending west beyond the point where our survey of the summer ended. This bluff is cut by a ravine 50 feet wide at the Biological Laboratory and by a small stream entering the lake a quarter of a mile west of Vawter Park. The shore extending west to and around Black Stump Point is from 5 feet to 15 feet above the level of the lake. The high bluffs from Clark's Point to Black

Stump Point is by far the longest stretch of highland along the shore, being nearly two miles in length. Conkling Bay during the summer months contained an area of water about 300 feet in diameter and 20 feet deep, bordered by wide stretches of marsh containing a few small pools of very shallow water. To the north of Conkling Bay, Conkling Hill ascends rapidly to a height of 40 feet or more. This hill is conical in shape and slopes to the water on the south and east, and to marsh and lowland on the north and west.

It will be noticed that the perpendicular bluffs of the main lake face to the south at Jones' Landing; to the southwest at Wawasee, Ogden Island and Cedar Point; to the west along Crow's Bay and Morrison's Island; and to the north along Vawter Park. The high hills at Jarrett's and Conkling's are without precipitous shores. All of these bluffs are bordered by wide areas of shallow water, and it will be noticed that the 10-foot contour line of the bottom does not approach the shore much nearer than 400 feet, and is usually much further from shore. As a rule, the bluffs facing to the south and southwest have a much wider margin of shallow water than those facing to the west or north.

Wherever there is a long stretch of shore, bordered by marsh, there is no beach formed, but the muddy bottom of the lake merges into the mud of the marsh along the shore line. Along all the dry shores, and along the marshes of small extent lying between bluffs, the beach is composed of gravel and sand. This gives a gravelly or sandy beach around Syracuse Lake, except on the east and southwest; along the north shore of the main lake, from the Channel to Ogden Point; along the east shore of Johnson's Bay, from Cedar Point northwest to the extremity of the dry shores; from the northeast corner of Crow's Bay to a point east of the north end of Morrison's Island; along the south end of Jarrett's Bay; from Clark's Point along the south shore for a short distance beyond Black Stump Point. These beaches along the bluffs are formed by erosion and deposit along the base of the bluffs. The sandy and gravelly beaches along marshes are found where the adjoining bottom of the lake is composed of sand and gravel. These beaches have most probably been formed by the action of ice.

Around the main lake a number of beach formations of this kind are found. From Wawasee a half mile west the beach is composed of sand and gravel. It is about three feet above the water's level, and is higher than the land back of it. From the east end of the bluffs of Wawasee to the dry land of Ogden Island is a distance of a half mile, and the marsh along the shore is very little, if any, higher than the level of the lake. Between the marsh and lake is a beach composed of sand and gravel. This beach is two feet or more above the level of the water, and 30 feet wide. The beach along the bluff of Ogden Island is of the usual formation, but this beach continues along the shore for one-fourth of a mile beyond the bluff as a very sandy beach a foot or more above the water's level and 50 feet wide; then the beach grows narrower and is on the level of the water, the sand becomes less plentiful, and the beach is composed of a small amount of coarse gravel and then merges into the marsh, where the shore line of Ogden Point turns north. The same formation is found running a short distance north of the bluffs on the east side of Johnson's Bay.

Between the two bluffs on the east side of Johnson's Bay is a beach 1,000 feet in length, with the lake on one side and a marsh containing pond lilies on the other. This beach is from 20 feet to 80 feet wide, 3 feet above the water's level, and composed of sand and coarse gravel. The margin of the beach further from the lake is the higher, and is covered with a growth of willows, cedar and other small trees. Along the lowlands of Crow's Bay is a broad beach composed of coarse gravel about three feet high and on a level with the land back of it. Along the south end of the west side of Morrison's Island, which is lowland, the beach is from 15 feet to 25 feet wide, three feet high, and composed of coarse gravel. The beaches along marshes and lowland are broader and higher, and contain much more material than those along bluffs.

The action of the ice is an important factor in the formation of these beaches. For the explanation of the action of ice on beaches as well as the formation of ice cracks, I am indebted to I. C. Russell's excellent book, "Lakes of North America." The lake freezes over and by expansion the ice is pushed up along the shore carrying sand, gravel and stones with it. Numerous ice cracks form during the winter and fill with water. This water freezes and pushes the ice still further up the shore carrying the beach forming material still higher. These ice cracks are very numerous and may be as much as three inches wide. The amount of lateral pressure brought to bear on the shores by this means is very great, and beach ridges are begun and added to each year. The action of the ice in forming beaches along marshes is very great, while along bluffs it is small. In the first case no great resistance is met with in expansion, and the material for building the beach will be carried up to the full extent of the expansion of the ice, while along the bluffs the ice crowds against the shore and is itself broken at every expansion. A recent ice formation is evident at the northwest end of the Gordoniere Marsh, between the marsh and the Channel. In 1891 this marsh was under water, but since that time the water of the lake has receded and left the marsh dry. Separating the marsh from the Channel is a ridge of earth more than one foot high running parallel with the water's edge. This ridge can be accounted for by the action of the ice subsequent to the time when the marsh was left without water. Some of the most striking examples of ice action in the formation of beaches are found along the east side of Johnson's Bay; along Crow's Bay; at Morrison's Island, where two ice beaches, separated by a few feet, are now covered by trees; at Clark's Point, where an old beach extending as much as 200 feet from shore is found, and at Black Stump Point.

CHARACTER OF BOTTOM.

In the shallower parts of the lake the bottom is composed of sand, gravel, and small boulders, except along the low marshy shores, where it is composed of mud. At several places, both in Syracuse Lake and in the main lake, dredgings were taken at depths from 25 feet to 60 feet. Here the bottom was covered with a deposit of marl in which were found many diatoms and shells.

Further investigations will be carried on to determine more fully the character of bottom at different depths.

ICE.

For information concerning the freezing of the lake I am indebted to Mr. J. P. Dolan, who has given me the history of ice formations as he has observed them during years past, and he has furnished me with records of careful observations made since the first formation of ice in October, 1895. These observations, unless otherwise indicated, are for Syracuse Lake. Ice forms on the main lake at the same time, but it does not freeze entirely over so soon as Syracuse Lake.

The lake begins to freeze along the edge, except where strong springs enter near the margin. Information has been obtained concerning the influence of springs only at Crow's Bay and Vawter Park. Springs are numerous along Crow's Bay for a half mile and the water along the edge is kept open after the lake is frozen over, but I have not yet learned to what extent these springs influence the freezing of the edge of the lake in this locality. From Mr. Smith Vawter, who has observed the springs at Vawter Park for a number of years, I learned that the spring, which is near the margin of the lake and 200 feet east of the Biological Laboratory, keeps the edge of the lake open throughout the winter. If the weather is not severe, ice does not form for 25 feet along the shore, and from 12 feet to 15 feet from shore. In the severest weather the lake is kept open for 2 or 3 feet from the margin.

The ice spreads rapidly from the shore towards the center. The lake freezes over quite rapidly when the general temperature remains below 32° Fahrenheit and there is no accompanying wind. All parts of the lake freeze, except where it is kept open by springs, but the last place to freeze is a narrow strip from 20 feet to 30 feet wide, extending from the north end of the Channel to Turkey Creek, the outlet of the lake. Ice sometimes forms to a thickness of 6 or 8 inches along the margins of this channel before it freezes over. This is due to a current along this narrow channel towards the outlet. The ice is always thinner here than elsewhere.

Accurate information could not be obtained concerning the exact date of freezing in 1894, but from Mr. Dolan's observations we can give an accurate account of ice-formation during the fall and winter of 1895.

The first ice of the season was observed on October 20. The temperature of the air at 7 A. M. was 28°. A thin layer of ice 4 or 5 feet wide had formed along the edge of the lake. It melted during the day. At 7 A. M. October 30, the temperature of the air was 26°, and about one-fourth of Syracuse Lake was frozen over. Not quite all the ice melted, but it all disappeared on the following day. At 7 A. M. November 2, the temperature of the air was 22°. The mill race was covered with ice three-eighths of an inch thick. Only the edge of the lake was frozen, as the wind blew during the night. On November 21, the temperature of the air at 7 A. M. was 13°, and ice had formed from shore to shore on Syracuse Lake; at 12 M. the ice was nearly all melted, and at 5 P. M. the lake was free of ice. This was the first date on which the ice extended entirely across the lake. On November 23, at 7 A. M., the temperature of the air was 30°. Ice had formed on the mill race, but no ice formed on the lake, owing to a slight wind. On November 27, the temperature of the air at 7 A. M. was 16°, and a wide belt of ice had formed around the lake, but it disappeared on the following day. On December 2, the night was clear and calm. There was no ice at 4 P. M., but at 7:30 P. M. a thin sheet of ice had formed and extended apparently from shore to shore. On December 3, Syracuse Lake was completely covered with ice. The temperature of the air during the day was 6° at 7 A. M., 16° at 12 M. and 12° at 5 P. M. On December 5, the ice was 2 inches thick near shore. On December 7, the ice near shore was 3¾ inches thick, and 500 feet out from shore 1¼ inches thick. I visited the main lake on December 7, and the ice appeared to extend over the entire lake. Warren Colwell had skated over the lake during the forenoon as far east as Ogden Point. The only place where he found the lake open was a space about 20 feet square, half way between Ogden Point and Black Stump Point. Three dozen ducks and mud-hens had congregated in this open space.

The increase and decrease in the thickness of the ice from December 9, to December 20, are shown in the following table. The measurements were taken 50 feet or more from shore.

Day of Month.	Thickness of Ice in Inches.	Temperature of Air at 5 P. M.	Condition of Weather.
9	4	18°	North wind; cloudy.
10	4½	26°	Wind, southwest to south.
11	5	36°	Snow and rain.
12	5¼	20°	Clear.
13	5½	24°	East wind; clear.
14	6¼	36°	Wind, south to southwest.
15	6¼	26°	Clear.
16	5½	39°	East wind.
17	5	46°	Southwest wind; rain.
18	4¼	52°	South wind; rain.
19	2¼	54°	South wind; rain.
20	0	52°	South wind.

On December 13, ice cutting for commercial purposes was begun, with the ice 5½ inches thick. Last winter no ice was cut until January 1, 1895, when the ice had reached a thickness of 6 inches. On December 15, the ice had reached a thickness of 6¼ inches, after which it grew thinner, owing to the rise in temperature and the heavy rains. By December 20, the ice had melted so that only slush ice remained. On the morning of December 21, this ice had drifted to the north and northeast parts of the lake and at 5 P. M. of the same day the ice had all melted.

Mr. Dolan has given me accurate information concerning the ice on the lake from January 1, 1895, to March 25, when the ice left the lake. On January 1 the ice was 6 inches thick and kept increasing in thickness for more than a month. The maximum thickness, observed by persons engaged in fishing through the ice, was noted in the early part of February and found to be from 24 inches to 28 inches. The greatest thickness is found where the ice has been kept clear of snow by the wind. In January and February the snow lay about nine inches on the level, but it was drifted in many places on the lake while other areas were without snow.

In the spring the ice sometimes wears into holes out in the open lake, and breaks up in the center of the lake first, the last ice to break being along the shores. This is the case when the ice goes off in cloudy weather and with heavy rains. Usually the ice begins to melt along the shore, with some holes further out. A heavy wind then breaks the ice and carries it ashore. For the past ten years the ice has gone off with a west or southwest wind and has been piled up on the east or northeast shores.

In the spring of 1895, the ice went off the lake in an unusually short time. The lake had remained completely frozen over until March 24. During this day the ice began to melt along the shores. On the morning of March 25, the ice had melted to a distance of 20 feet from shore. At noon the ice had receded 400 feet from shore. A heavy west wind was blowing all day, and the cracking of the ice could be heard. At 3 p. m. the noise caused by the crushing of the ice became very loud and could be heard for a quarter of a mile. The ice was broken into huge cakes. The wind now began to lift the ice and drive it eastward. At 4 P. M. all the ice was piled along the east shore. The height to which the ice is piled depends on the character of the shore and the strength of the wind. The piles are not so high along a low marshy shore as along an inclined or abrupt shore. Occasionally a great sheet of ice is pushed up a smooth inclined surface 6 or 7 feet without breaking the ice to any great extent. An instance of this kind was observed by Mr. Dolan on the northeast shore of Syracuse Lake last March. No ice formed on the lake after March 25.

Ice cracks are very numerous from the time the ice forms entirely across the lake and has attained sufficient stability. They form before the ice has reached the thickness of one inch. When the first cracks formed in December the ice was so thin that it sagged slightly along the crack. The water came through the crack and spread over the surface of the ice sufficiently to melt the small amount of snow covering the ice. to a distance of 5 or 6 feet on each side of the crack.

The explanation of ice cracks as quoted from Gilbert by Russell in his "Lakes of North America" is so applicable to the case in hand that I reproduce the quotation here:

"The ice on the surface of a lake expands while forming, so as to crowd its edge against the shore. A further lowering of the temperature produces contraction. and this ordinarily results in the opening of vertical fissures. These admit the water from below, and, by the freezing of that water. are filled. so that when expansion follows a subsequent rise of temperature the ice can not assume its original position. It consequently increases its total area, and exerts a second thrust upon the shore. When the shore is abrupt, the ice itself yields, either by crushing at the margin or by the formation of anticlinals (upward folds) elsewhere; but if the shore is gently shelving, the margin of the ice is forced up the acclivity and carries with it any boulders or other loose material about which it may have frozen. A second lowering of temperature does not withdraw the protruded ice margin, but initiates other cracks and leads to a repetition of the shoreward thrust. The process is repeated from time to time during the winter, but ceases with the melting of the ice in the spring."

The formation of these cracks is accompanied with noise, and, when the ice has reached the thickness of four or five inches, the noise resembles the distant booming of cannon. These cracks may be mere seams in the ice, or they may be several inches wide. On December 7, I measured a crack three-eighths of an inch wide in ice one and three-fourths inches thick. On December 9, Mr. Dolan measured one two and three-fourths inches wide in ice four inches thick. On the same day he counted eleven loud reports caused by the formation of ice cracks in five minutes. They form during all parts of the day and night. They cross the lake in every direction, and, while the cracks are slightly zig-zag, their general courses are in straight lines.

The ice is very clear and pure, especially out from the shore, where there is no vegetation near the surface. Is is used very largely for commercial purposes, the ice being cut from about one-fourth of the surface of Syracuse Lake each year.

INLET.

The only stream flowing into the lake and containing water throughout the year is Upper Turkey Creek, which enters the lake on the east side of Jarrett's Bay. During the summer months it was filled with an abundant growth of water vegetation, and was without any perceptible current. When the water is high the chain of small lakes lying to the southeast is drained into the large lake through Jarrett's Creek, entering Jarrett's Bay a half mile south of Turkey Creek. During the past summer no water entered the lake from this source. A small stream one-fourth of a mile west of Vawter Park, and another from the east side of Johnson's Bay, contribute water to the lake when the water is high, but not during the dry summer months. There are no springs around Syracuse Lake, but springs are found along the margin of the main lake wherever the shore rises fifteen feet or more and extends across the country as elevated territory. These springs usually enter the lake near high water mark. This gives springs along Crow's Bay, Mineral Point, the south and west sides of Jarrett's Bay, and along the south shore from Vawter Park one mile west. No springs are found along the bluffs at Jones', Wawasee, Cedar Point, Morrison's Island, or Conkling Hill, but in each case these highlands are narrow and surrounded by marsh or lowland. For a half mile along Crow's Bay the bluff is more than twenty feet high. All along the foo of the bluff the water percolates from the gravel, and at places it flows from quite strong springs. At Mineral Point there are a number of strong springs. At Buttermilk Point and along the base of the bluffs west of Jarrett's Bay are a number of springs. The margin of the lake from Vawter Park one mile west is very springy, but the flow of water is not so strong as along Crow's Bay. The waters from all these springs show traces of iron more or less strongly.

OUTLET.

The waters of the lake flow into Lower Turkey Creek through which they enter the Elkhart River near Goshen, Indiana; then through the Elkhart and St. Joseph rivers they reach Lake Michigan.

Near the outlet of the lake the creek, during the summer, was about 20 feet wide and had an average depth of less than 6 inches. The volume of water discharged through the outlet was computed from measurements taken in the creek and the overflow of the mill race July 18, 1895. The outflow through the creek was 103 cubic feet, or 772½ gallons, per minute; through the mill race, 41 cubic feet, or 307½ gallons, per minute, making a total of 144 cubic feet, or 1,080 gallons, per minute. At the same time the volume of the creek a half mile below was computed at 137½ cubic feet, or 1,031 gallons, per minute.

By taking the outflow of the lake at 144 cubic feet per minute, finding the amount discharged in twenty-four hours, and computing the amount the level of the lake, with an area of 5½ square miles, would be lowered by such an outflow with no inflow, we find it to be .016 of an inch. At this rate it would require 62½ days to lower the lake one inch. In one year of 365 days, at the same rate, the level would be lowered 5.84 inches. The inflow, during the summer months, is almost entirely due to springs, and probably equals the outflow. The lowering of the level of the lake, during the summer months, seems to be due almost entirely to evaporation.

ELEVATION.

The elevation of the lake above the sea and above Lake Michigan is shown in the following list of stations and their respective elevations. The list of stations with their respective elevations above mean tide at Sandy Hook, New York, was furnished by the General Superintendent of the Baltimore & Ohio Railroad. The elevation of each station above Lake Michigan was found by subtracting 582 feet, the elevation of the surface of Lake Michigan above the sea, from the elevation of the station above the sea:

ELEVATIONS OF STATIONS ON BALTIMORE & OHIO RAILROAD FROM SOUTH CHICAGO, ILL., TO PATTON SIDING, IND., THE MOST EASTERN STATION IN INDIANA.

NAME OF STATION.	No. Miles from Grand Central Station, Chicago.	Elevat'n Above Mean Tide at Sandy Hook, New York, in Feet.	Elevat'n Above Lake Michigan, in Feet.
STATIONS IN ILLINOIS.			
South Chicago	19	593.0	11.0
Rock Island Junction	....	593.5	11.5
STATIONS IN INDIANA.			
Whitings	....	598.5	16.5
Edgemoor	....	596.5	14.5
Wilsons	....	604.5	22.5
Millers	37	617.0	35.0
Dock Siding	....	621.5	39.5
Willow Creek	....	640.3	58.3
McCools	....	640.5	58.5
Babcock	....	652.0	70.0
Woodville	....	687.8	105.8
Suman	....	748.6	166.6
Coburg	....	786.0	204.0
Alida	57	788.8	206.8
Wellsboro	64	760.0	178.0
Union Centre	71	718.5	136.5
Walkerton	79	716.0	134.0
Teegarden	85	800.7	218.7
La Paz	....	859.0	277.0
La Paz Junction	88	856.0	274.0
Bremen	96	819.0	237.0
Berlinton	....	853.0	271.0
Napanee	104	880.0	298.0
Milford Junction	112	840.2	258.2
Syracuse	116	869.2	287.2
Wawasee	120	882.2	300.2
Cromwell	125	935.2	353.2
Kimmell	....	923.2	341.2
York	....	901.6	319.6
Albion	135	926.2	344.2
Ripley	....	970.2	388.2
Avilla	145	961.2	379.2
Garrett	150	890.0	308.0
Auburn Junction	153	871.7	289.7
Inverness	....	864.2	282.2
St. Joe	163	812.2	230.2
Patton Siding	....	849.7	267.7

Syracuse is the station having most nearly the elevation of the surface of Turkey Lake. The mean level of the lake is about 5 feet below the station at Syracuse. This gives the lake an elevation of 864 feet above the sea, and 282 feet above the surface of Lake Michigan.

CHANGES IN LEVEL.

Changes in the level of the lake have been due to three causes: erosion, the dam which is built across Turkey Creek just below the outlet of the lake, and climatic conditions.

Old beach formations give evidence that the level of the lake was formerly 5 or 6 feet higher than at present. By erosion the channel at the outlet was cut 10 feet below this ancient level, and the dam has raised the level of the lake 5 feet to its present level.

The history of the dam as given by an old settler is as follows:

A small dam was built in 1828, to which additions were made in 1831. This dam washed out in 1833, and the present dam and mill race were begun in the same year. This raised the level of the lake so that timber stood in water 5 feet deep. Much of this timber remained uncut in 1840, and some was still standing as late as 1865.

The vertical distance between the level of the water in the creek below the dam and the top of the waste gate, December 7, 1895, was five feet. This would be the amount the dam, when in working order, would raise the level of the lake. The dam is not in use at present and a small portion has been removed, which allows the water to pass into the creek at a level 16 inches below the top of the waste gate. This present condition of the dam holds the water of the lake 3 feet 8 inches above the level of the water in the creek below.

The submerged stumps in many parts of the margin of the lake is the best evidence that the dam had the effect of increasing the area of the lake. These stumps stand at present in water from a few inches to two feet or three feet deep. Along the margin of Syracuse Lake the stumps are most abundant at the point of the lake extending furthest west, and on the east shore along the edge of the marsh. Turkey Creek, from the lake to the dam, is sixty feet wide, and only twenty feet along the middle is clear of stumps. This was the channel of the creek before the dam was built, and the stumps now standing in water are the remains of the timber which grew along the banks of the creek. On the north and south sides of Buck Island, at the south end of Syracuse Lake, areas of submerged stumps indicate that this island was formerly one hundred feet wider in each direction. On the east side of the entrance of the main lake to the channel are many submerged stumps. Along Johnson's Bay much timber stood in water, especially on the east side of Ogden Point and on the east side of the bay just north of the bluffs. In these localities the stumps are very numerous, and among the largest in the lake. There are a few stumps along the marsh just east of Cedar Point. Others are found in the vicinity of Morrison's Island and go to indicate that this island, before the building of the dam, was a part of the mainland. It is so represented in the government survey of 1838. On the west side of Jarrett's Bay submerged stumps are numerous, especially along the southeast corner, where much small timber is still lying in the marsh at the margin of the lake, and at Clark's Point where many large stumps are found in the water. Submerged stumps are also found west of Black Stump Point. The elevation of the lake by the dam, not only increased its area but must have rendered much of the low level land in the vicinity of the lake marshy, which would have been tillable. It is claimed by persons living in the vicinity of the lake that the dam rendered four thousand acres of land untillable.

The fluctuations in the level of the lake are caused by climatic conditions, and vary with the inflow and outflow, rainfall and evaporation. In Mr. J. P. Dolan's report will be found the record of changes of level as observed during the past few months. Annual fluctuations are estimated to be about two and one-half feet. The level of the lake is usually highest about May 1, after the heavy spring rains, and lowest in August, although this year it kept lowering until November 2, owing to the very light rains up to that time. It was then ten and one-half inches lower than on July 6. The lake was lower on November 2, than at any time since 1871, when the marshes around the lake were drier than in 1895. Since November 2, the lake has been rising until, on December 25, it was fifteen and three-quarters inches higher than on November 2.

In May, 1891, the lake was higher than at any time during the past twenty years. The difference between well-remembered high water marks of that time and the level of November 2, 1895, is four and one-half feet, which is the maximum fluctuation during recent years. Each spring since 1891, has found the level of the lake lower than during the preceding spring. This gradual lowering of the level of the lake has decreased its area and has shown marked changes in the marsh land along the margin of the lake. Four years ago the water in Conkling Bay covered an area a half-mile in diameter, now it is reduced to three hundred feet in diameter; a small shallow lake just west of Conkling Bay contained water throughout the year, now it is dry and growing good crops; fields lying west of the channel were almost marsh land, the crops being greatly damaged by water, but during the past two years no difficulty has been experienced in tilling them; two or three feet of water flowed over the Gordoniere Marsh, which is now dry with beach lines forming along its margin; and boats were rowed over all parts of the Johnson Marsh, while at present hardly any of its surface is submerged.

CONSULT HYDROGRAPHIC MAP NEXT TO FRONT COVER.

TEMPERATURE OF TURKEY LAKE. BY J. P. DOLAN.*

In making these observations a Charles Wilder standard, protected, thermometer was employed. They were begun the 13th of July, during which month four soundings were taken in the deepest parts of the lake from the surface to the bottom at every five feet. Then on October 5 two records were made at about the same points, and again on November 2.

September 17 a rain guage was set up and from that day to the present a regular record of temperature, precipitation, direction of wind and rise and fall of lake has been kept, but the observations have been confined to the northwest part of the lake; properly, Syracuse Lake.

I. TEMPERATURES OF TURKEY LAKE, 1895.

	JULY.				OCT. 5.		NOV. 2.	DEC. 14.	DEC. 24.
	INDIANA UNIVERSITY BIOLOGICAL STATION.				I. U. BIO. STAT'N.	JARRETT'S BAY.	I. U. BIO. STAT'N.	BLACK STUMP POINT.	
	13th, 10 A. M.	16th, 8:45 A. M.	17th, 9:30 A. M.	23d, 8:45 A. M.	11 A. M.	1:45 P. M.	11:10 A. M.	10 A. M.	
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	
Air	81½	83½	78½	72	65	......	50	28	......
Surface	74	75	75	76½	60½	61½	43	34½	......
5 feet	......	......	......	......	60	60¼	......	34½	......
10 "	73	74	75	71	60	59	43	24½	......
15 "	72½	74	74½	70	59	59	......	......	......
20 "	71	71	73½	67½	58½	58½	43	......	......
25 "	68	65	68½	61½	58½	58½	43½	35	......
30 "	65	63	68½	......	58½	58½	......	......	......
35 "	60	62	......	58½	58½	58½	......	35½	......
40 "	60	60	......	......	58½	58	......	......	......
45 "	59	57	......	58	58½	58	......	35½	......
50 "	59	......	......	58	58½	58	......	......	......
55 "	58	......	......	......	58½	58	......	......	......
60 "	58	......	......	58	58¼	57½	......	......	......
65 "	58	......	......	58	58	56¼	......	......	......
67½ "	......	......	......	......	......	53¼	......	......	......

*Contributions from the Zoölogical Laboratory of the Indiana University, No. 15.

VI. SUMMARY OF SOUNDINGS OF TURKEY LAKE.

	Difference in Degrees First 20 ft.	20 to 25 ft.	25 to 30 ft.	30 to 35 ft.	35 to 40 ft.	40 to 45 ft.	45 to 50 ft.	50 to 55 ft.	55 to 60 ft.	60 to 65 ft.	Total.	Maximum.	Minimum.	Mean.	Average.
	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg
I. U. Bio. Station	3	3	3	5	2	2	2	2	2	2	16	74	5 8	66	71.9
July 13	......	......	......	......	......	*3	......	......	......	......	......	......	......	......	......
July 16	4	4	2	1	2	3	......	......	......	......	16	75	57	69	$66\frac{7}{9}$
July 23	6½	2½	6	......	3	......	......	......	......	......	18½	76½	58	67¼	65.06
Oct. 5	2	......	......	......	......	......	......	......	¼	¼	2½	60½	58	59¼	58.84
Nov. 2, A. M.	0	½	0	0	0	½	......	......	......	......	......	......	......	......	......
Nov. 2, P. M.	0	0	0	0	0	0	0	0	0	0	0	43	43	......	......
Dec. 14		......	......	......	......	......	......	......	......	......	......	......	......	......	......
Dec. 24	7	......	......	......	......	......	..	......	......	......	......	......	......	......	......

* Bottom.

II. TURKEY LAKE TEMPERATURES, 1895.

September	22	23	24	25	26	27	28	29	30							
Air	86	45	37	......	....	55	......	......	......							
Surface	73	68	65	68	68	......	......	......	56							
Bottom	69	69	68	67	67	....	......	......	57							
Precipitation	......	.01	......	1.40	......	......	.03	.09	......	Total inches 1.53						
October	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Air	56	58	68	68	65	62	64	45	38	45	49	45	40	54	48	46
Surface	54	.....	63	60½	60½	57½	......	56	55	53	.....	52	51½	......	53	52
Bottom	55	......	58	56	58½	56	......	56½	56	53½	.....	52½	51	......	53	52½
Near shore	......	.	....	.....	......	......	......	48	...	......	......	45	47	.....	......	50
Precipitation	......	......	......	......	. . .	......	......	......	......	......	......	......	......	......	......	......
October	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	
Air	45	49	26	28	28	......	.. ...	......	69	60	48	40	38	34	34	
Surface	51	......	......	46	46½	......	......	......	......	45	44	43	......	.....	39	
Bottom	51½	....	......	48	47	......	......	......	......	46½	46	44	...	......	39	
Near shore	....	......	.....	40	45	......	......	......	......	40	......	...	......	......	......	
Precipitation	.....	.....	......	. ....	......	......	......	......	......	......	.....	......	......	......	......	
November	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Air	30	22	54	60	61	60	69	45	32	32	28	26		......	......	.....
Surface, 25 ft	38	43	43	41½	42	43	43	43	42	......	42½	..	......	......	......	......
Bottom, 25 ft	43	43	43	42	41	45	43	43	44	43	......	43	......	.....	......	......
Surface near shore	.....	36	.....	......	42	.....	50	......	38	.....	....	......	.....	.....	......	......
Precipitation	......	......	......	......	......	.02	.78	1.10	.....	....	......	......	.02	......	.07	......

November.....	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
Air	......	52	34	22	20	35	33	35	35	22	16	35	36	32		
Surface	......	43½	41	39	.....	......	39	*	*	*	......	......	......	34		
Bottom	......	43	42	39	......	......	39	*	*	*	38†	......	......	35		
Surface near shore	......	46	38	34	......	.....	.....	*	*	36†	36‡	.....	......	......		
Precipitation	......	......	......	......	......	......	....	.....	....	....	.....	.....	.....	......		
December.....	1	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18
Air 7:30 A.M.	......	6	......	12	36	28	24	28	32	18	2	28	32	24	40	45
Air 5:00 P.M.	.....	12	......	26	33	24	18	26	36	20	24	36	26	39	43	52
Surface	......	......	.....	34	33	33	33	33	34	33½	.....	34½	34	......	-33½	33½
Bottom	......	......	......	35	36	35	35	36	36	35½	......	35½	35	......	35	35
Near shore ...	......	34	......	......	32	33	33	......	......	......	......	......	......	......	......	......
Precipitation	.56	......	.07	......	......	......	......	......	.11	......	......	......	.07	......	.13	1.15
December	19	20	21	23												
Air 7:30 A.M.	52	52	40	......												
Air 5:00 P.M.	54	52	39	......												
Surface	33½	35½	37	......												
Bottom	35	37½	37	......												
Near shore ...	......	43	......	38												
Precipitation	1.87	.96	.12	.58												

* Broken thermometer. † Under ice. ‡ Common thermometer.

SUMMARY OF TEMPERATURES.

		September.		October.		November.		December.	
		Date.	Deg.	Date.	Deg.	Date.	Deg.	Date.	Deg.
Maximum.	Air	22	86	3	68	5	61	19	54
	Surface, 25 ft	22	73	3	63	18	43½	21	37
	Bottom.........	22	69	8	56½	26	45	20	37½
Minimum.	Air	24	37	19	26	27	16	6 13	12 2
	Surface, 25 ft	30	56	31	39	30	34	7, 8, 9, 10	33
	Bottom, 25 ft	30	57	31	39	26	36	6, 8, 9, 15, 17, 18, 19	35
Averages.	Air	....	56	....	47.8	....	36.7	....	$31\frac{2}{3}$
	Surface	....	$66\frac{2}{3}$	....	51.7	....	41.2	....	$33\frac{13}{14}$
	Bottom	....	$66\frac{1}{3}$	....	51.57	....	41.93	....	$35\frac{19}{28}$

N. B.—Water general average for three months higher than air.

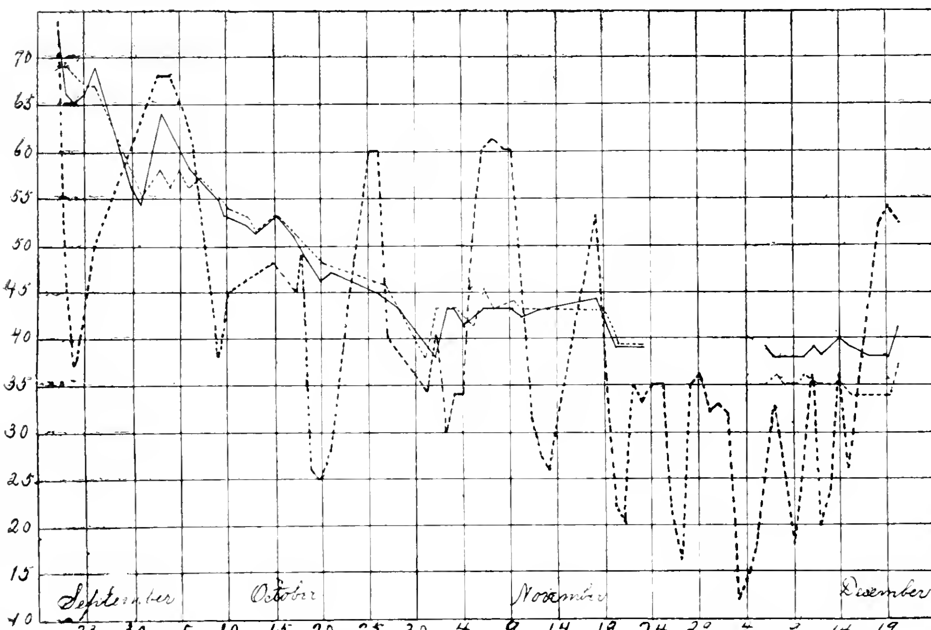
	AIR.	SURFACE.	BOTTOM.
Grand average for four months......................................	42.94	48.37	48.87

From December 3 to noon of the 20th the lake was covered with ice. During this period the surface temperature varied from 33° to 34½° and the bottom from 35° to 36°.

At 5:00 P. M. of the 20th, ten hours after the ice started to move in a body from the lake, the surface showed 35½°, a gain of 2½°; the bottom 37½°, another gain of 2½°, and in the shallow water, fifty feet from south shore, where it had been 32°, 33°, 33° on the 7, 8 and 9th respectively, it was now 43°, a gain of 10°.

The next day surface and bottom both registered 37° degrees at the twenty-five-foot station.

The results of these observations are embodied in the accompanying profile chart, in which it has been attempted to show the absolute and relative movements of the air, surface, and bottom of lake at a depth of twenty-five feet.



Temperatures from September 23 to December 23. Broken line, temperature of air; dotted line, temperature of water 25 feet below surface on the bottom; continuous line, temperature of water at the surface at the same place.

(*a*) A few well-known facts are emphasized, the variableness of the atmosphere and the persistence of the water; that water is a poor (*b*) radiator and an indifferent conductor of heat, and responds slowly to atmospheric changes.

(*d*) It shows also that the great volume of Syracuse lake at no time has been stagnant, but that a condition of activity has obtained throughout the entire period of observation.

(*e*) For the four months in which a large number of observations were made the general average of the water, both surface and bottom, is higher than that of the air.

A difference of 10° between the water one foot deep near the shore and the surface mid-lake during a rain the day the ice left the lake, shows that the surface drainage is no small factor in winter and spring in raising the temperature of the whole body.

PART II. THE INHABITANTS OF TURKEY LAKE.*

Plankton.

By plankton, Hensen, the author of the word, means everything floating in the sea and passively driven about by the waves and currents. Haeckel includes under plankton all organisms swimming in the sea. Haeckel says: "The totality of the swimming and floating population of the fresh water may be called limnoplankton." Limnoplanktonic studies have been made whenever a collector scooped for protozoa, diatoms or other minute organisms. Planktonic studies of this sort have been carried on for a long time. Recently plankton has been studied in a new way, first in the ocean and more recently in fresh water. This more recent study has been the quantitative and qualitative estimation of the plankton in a given volume of water. There seem to have developed in a remarkably short time two schools of planktonists, the one headed by Hensen asserting that planktonic organisms are uniformly distributed, the other, headed by Haeckel, being equally sure that planktonic creatures are to be found in clouds or schools. We are interested in plankton only in so far as it is part of the environment of the vertebrates inhabiting the lake. That it is not an unimportant element of the environment is due to the fact that it forms the primitive food of most of the fishes and that at the most plastic period in the life of the individual. The amount of plankton, as well as its composition from year

*Contributions from the Zoölogical Laboratory of the Indiana University, No. 16.

to year, is therefore of prime importance in the search for the causes of the differences in the same fish in two contiguous lakes or in two successive years in the same lake.

Our plankton apparatus was completed too late to enable us to make any systematic measurements, especially as our planktonist was actively engaged in the physical survey of the lake. But plankton was collected and some of its different constituents will be reported upon.

A good historical account of planktonic studies, as well as exact definitions, are to be found in the Planktonic Studies of Haeckel, translated by G. W. Field, and published in Commissioners' Report, 1889-91, U. S. Com. Fish and Fisheries, pp. 565-641.

In the following sketch several groups of animals are not at all considereds and others but briefly. The only groups found in the lake of which we approximate a complete list are the fishes, batrachians and reptiles. Deficiencies will be removed in subsequent reports when a classification of the material into *littoral*, *bathybial* and *pelagic* will also be attempted.

PROTOZOA.

The *Protozoa* were not represented by a large array of species during the summer. No detailed work has been done on them as yet, but I want to mention two characteristic forms.

The most striking *Protozoan* is *Ophridium*. It is found in clumps varying from microscopic minuteness to the size of walnuts, and in different parts of the lake the pebbles and exposed parts of clam shells are covered with these colonies to such an extent as to suggest young lettuce beds.

Ceratium hirudinella is as striking and abundant in the *pelagic* regions as *Ophridium* is in the *littoral*.

In this connection two plants may also be noticed.

Rivularia is very abundant during the whole summer. It is conspicuous in calm weather, when it rises to the surface. Toward the end of August and in early September it collects in such numbers as to form large patches and streaks, forming a true *Wasserblüthe*.

Various forms of *Palmella* are abundant during the whole summer, and in October, when *Rivularia* has disappeared, it forms large patches on the surface forming the *Wasserblüthe* of the late fall.

PORIFERA.

Sponges are not abundant in the lake. They are found in small patches on boards, sticks and other things near the margins of the lake. They grow much more luxuriantly in the outlet of the lake where they sometimes form patches several square feet in extent.

CNIDARIA.

Hydra viridis L. Specimens of *hydra* were exceedingly rare. On one occasion a few were taken on a submerged stick near Black Stump Point.

PLATHELMINTHES.

Flat worms were not systematically collected and none of these collections have been identified. Of *Turbellarians* there were several species. *Amia calva* is infested by a tape worm and by a *Distomum*.

NEMATHELMIA.

No attempt was made to collect thread worms. *Gordius* is exceedingly abundant on the margins during the latter part of summer. I counted as many as twelve in the area of one foot square.

ANNELIDA. BY BESSIE C. RIDGLY.

No *Chaetopoda* were collected.

No systematic attempt was made to get large numbers of leeches, but specimens were preserved whenever found. In the classification I have followed Verrill.

Nephelis quadristriata Grube. Thirteen specimens from Turkey Lake.

Nephelis fervida Verrill. Fourteen specimens.

Clepsine parasitica Diesing. Three specimens.

Clepsine ornata stellata Verrill. This species was not found in Turkey Lake. Two specimens were taken in Tippecanoe Lake.

Clepsine ornata rugosa Verrill. Four specimens.

Clepsine ornata variety d Verrill. Ten large specimens corresponding with the second specimen described by Verrill were found, most of them on turtles.

Clepsine papillifera Verrill. One specimen.

Clepsine papillifera carinata Verrill. Three specimens. One of these, one-half inch long, was found under a stone in front of the laboratory. A number of young were attached to it.

Clepsine pallida Verrill. One specimen.

Clepsine pallida variety b Verrill. One specimen.

Clepsine elegans Verrill. Five specimens.

ROTIFERA. D. S. KELLICOTT.

I received in September three vials of plankton, from Mr. Chancey Juday with the request to report upon the *Rotifera* found therein. The vials were marked and described as follows: "I. Contains plankton caught at the surface of the water of Wawasee Lake, Indiana, by using a plankton net; taken August 28, 1895; killed in picro-sulphuric acid; washed in 35 per cent. and 50 per cent. alcohol and preserved in 85 per cent. alcohol." "II. Depth of haul, 60 feet (Wawasee); depth of water, 65 feet; taken July 20, 1895; killed in Flemming's Fluid; washed in 35 per cent. and 50 per cent. alcohol, and preserved in 85 per cent. alcohol." "III. From Tippecanoe Lake; depth of haul, 110 feet; depth of water, 117 feet; taken August 7, 1895; killed in Flemmings's Fluid; washed in 35 per cent. and 50 per cent. alcohol, and preserved in 85 per cent. alcohol."

I find that the *Rotifera* were much better preserved in II and III than in the first. The illoricate species in I were. scarcely recognizable; in fact three species found in this vial I have not been able to place more nearly than the probable genus. Those in II and III have all been satisfactorily identified. While the whole number recognized in these collections is not large some interesting facts are brought to light. Three species not hitherto reported from this country are among the number, and others rarely. It is certain that the *rotiferal* fauna of these lakes is rich and will yield many unique forms as a reward to any student who may be able to work in the region, to take and study them in the fresh state, and in all their varied relations and situations of residence.

I shall enumerate, with remarks, the species found in each haul separately, although it will cause some repetition, and in the order of Hudson and Gosse's *Rotifera*, without citing the bibliography farther than a description where the partial bibliography, however, will usually be found.

I.

1. *Floscularia mutabilis* Bolton. Not infrequent. It is quite unexpected that a floscule should occur among pelagic species, and yet there are four known species of these *Rhizota* that cut loose and become sailors. Mr. H. S. Jennings has found three of them in St. Clair and lakes of Michigan. Of this one he says: "Very common in towings from Lake St. Clair, either at the surface or near the bottom. Hudson and Gosse, I, 56.

2. *Œcistes brachiatus* Hudson. A large number were found, but it was impossible to identify them surely. The tube conforms to the figures and descriptions of that of *Brachiatus;* it is cylindrical, smooth, compact, perfectly hyaline,

often containing a slight amount of adhering matter, often containing several eggs, which, however, are not so elongate as the figures represent those of *Brachiatus;* the long narrow foot and the long non-retractile antennæ agree well with the type. I am pretty confident that it is *Brachiatus*, yet I am surprised to find so many of them, or any of them, in a surface tow, as it is evidently normally anchored; perhaps they were attached to floating algæ which apparently are not uncommon in the lake. H. and G., I, 83.

3. *Philodina megalotrocha* Ehrenberg. Numerous. I have often taken it at a distance from land, particularly in shallow lakes or among floating algæ. H. & G., I, 101.

More than one species of *Rotifer* which could not by any means be identified were present.

4. *Sacculus viridis* Gosse. Rare. H. and G., I, 124.

5. *Polyarthra platyptera* Ehrenberg. Many seen. The serrations on the edges of the broad plates are coarse and more distant than in the type. H. and G., II, 3.

6. *Dinocharis pocillum* Ehrenberg. One individual. It is a bottom feeding species and rarely occurs in a surface tow. H. and G., II, 71.

7. *Dinocharis collinsii* Gosse. One. Bottom feeding species. It has not been observed in this country before. No species exceeds it in beauty. I could not make out the pair of spines on the foot and the edge of the lorica appears to be set with a row of small spines, rather than being serrate as described and figured. H. and G., II, 72.

8. *Anuræa cochlearis* Gosse. Exceedingly abundant. Our form differs slightly from Gosse's figure since the mesal ridge of the lorica does not extend straight from end to end, but has a decided angle at each pair of facets, the anterior median one is not divided. H. and G., II, 124.

9. *Notholca longispina* Kellicott. Not rare. This rotiferon was first known in the water supplies of cities along the Great Lakes. Soon after it was described in 1879, it was found in Olton Reservoir, Eng., and then by Imhof in the Swiss Lakes. More recently it has been found in lakes of America. Mr. Levic reports finding the eye spot double, or so far separated as to be regarded as two eyes. I have seen several in these collections with the same peculiarity.

II.

1. *Polyarthra platyptera* Ehrenberg. Few.

2. *Triarthra longiseta* Ehrenberg. Comparatively few in this vial. H. and G., II, 6.

3. *Ploesoma lenticulare* Herrick. Very many. It occurs in the lakes of Europe. In this country it has been reported only from Lake St. Clair, both in bottom and surface tows (Jennings). Zoöl. Anz., Bd. 10, 577.

4. *Brachionus militaris* Ehrenberg. Rare. I have found this an abundant species in ponds of western New York; it is a good sailor, preferring small seas, however. Authors have recorded the fact that the posterior spines are not in the same horizontal plane. This seems to be in relation to the habit of always turning on its long axis as it swims; they appear to bore their way through the water. H. and G., Sup. 82.

5. *Anuraea cochlearis* Gosse. Many, but far less numerous than in I.

6. *Notholca longispina* Kellicott. More abundant than in I.

III.

1. *Asplanchna priodonta* Gosse. Quite numerous. Jennings reports this fine species as abundant in Lake St. Clair, both at the surface and in deep water. H. and G., I, 123.

2. *Polyarthra platyptera* Ehrenberg. Several found.

3. *Triarthra longiseta* Ehrenberg. Numerous.

4. *Diaschiza valga* Gosse. Only one seen. It appears to agree well with the figure and description. H. and G., II, 77.

5. *Anuraea cochlearis* Gosse. Not common.

6. *Notholca longispeia* Kellicott.

CLADOCERA. A. BIRGE.

The following letter on the *Cladocera* of Turkey Lake has been received:

I enclose list of *Cladocera* in your bottles.

1. *Holopedium gibberum Zad.*, few; *Daphnia hyalina and retrocurva* Forbes. Much *algal* material, chiefly *Clathrocystis*.

2. *Holopedium gibberum D. retrocurva Sida. crystallina O. F. M.*, *Diaphanosoma brachyurum* Liev.

3. *D. retrocurva*, extreme form of hemlet, like that of Lake Mendota, *Diaph. brachyurum*. Material looks as if it had been dried.

4. *D. retrocurva Diaph. brachyurum Ceriodaphnia lacustris* Birge. *Leptodora hyalina Lillj.*, *Holopedium gibberum*, one specimen.

5. *Diaph. brachyurum*, *Sida crystallina*, *Cer. lacustris.*

6. *Holo. gibberum*, *Diaph. brachyurum*, *D. retrocurva*, *Algae* like No. 1.

7. *Diaph. brachyurum*, *D. retrocurva*, *Cer. lacustris*, *Leptodora hyalina.*

Great number of *Epischura lacustris*, far more than I ever saw before.

8. *D. retrocurva*, *Sida crystallina*, *Diaph., brachyurum.*

9. *Diaph. brachyurum*, *D. retrocurva*, not an extreme form, *Daphnia longiremis* Sars, *Sida crystallina*, very few.

Most of these species are predictable, that is, they would be found in almost any pelagic collection from this general region. I do not think that *H. gibberum* has been found so far south as this collection shows it. *Cer. lacustris* has not been found outside of Wisconsin before. The specimens are much more thin-shelled than those which I have seen before. It is remarkable that *D. retrocurva* is far more numerous than is *D. hyalina.* The reverse has been true in all lakes which I have studied, except Pine Lake, Wisconsin. In most of the bottles examined it was difficult to find *D. hyalina*, while the other species was quite plenty. It is to be noted that this species of Forbes is really a variety of *D. kahlbergiensis* Sch, but as the form is well marked and the full name intolerably long, I have quoted it by the varietal name only.

D. longiremis has been found before only in Lake Geneva, Wisconsin. In size, form and shape of head it exactly agrees with my figures and description in Trans. Wis. Acad.; Vol. IX, p. 299, pl. XI, figs. 4-10.

In all bottles there were many *Cyclops* and *Diaptomus*, and in one, as already noted, large numbers of *Epischura.*

I should gladly write more, but have been too busy for a longer report. Will send bottles to Marsh for Copepods and try to get up a full account later.

Very truly,

E. A. Birge.

Data of the lots of specimens numbered in the above letter:

I. Taken Aug. 28, 1895, between 1 and 2 p. m., from surface of water. Killed in picro-sulphuric acid. Preserved in 70 per cent. alcohol.

II. Taken June 27, 1895, at 8 a. m. Skimmed from surface of water, using No. 2 Bolting Cloth. Killed in picro-sulphuric acid. Preserved in 70 per cent. alcohol.

III. Taken Aug. 14, 1895, at 5 p. m. Depth of haul, 60 ft. Killed in picro-sulphuric acid. Preserved in 70 per cent. alcohol.

IV. Taken July 27, 1895. Skimmed from surface of water, using No. 2 Bolting Cloth. Killed and preserved in 10 per cent. formalin.

V. Taken June 27, 1895, at 8 a. m. Skimmed from the surface with a No. 2 Bolting Cloth net. Killed and preserved in 10 per cent. formalin.

VI. Taken July 29, 1895. Depth of haul, 25 ft. Killed and preserved in formalin.

VII. Taken July 12, at night. Surface skimming, using a No. 2 Bolting Cloth net. Killed and preserved in 10 per cent. formalin.

VIII. Taken Aug. 1, 1895, at 9 A. M. Depth of haul, 10 ft. Killed in Flemming's fluid. Preserved in 70 per cent. alcohol.

IX. Taken Aug. 7, 1895, at 4 P. M. Depth of haul, 110 ft. Killed in Flemming's fluid. Preserved in 70 per cent. alcohol.

I, II, III, IV, V, VI, VII, VIII are from Turkey Lake or Lake Wawasee; IX is from Tippecanoe Lake.

Decapoda.

The following crayfishes from Turkey Lake were identified by Mr. W. P. Hay, of Washington, D. C.:

Cambarus blandingii acutus Girard.

Cambarus propinquus Girard.

Cambarus virilis Hagen.

On a Small Collection of Mollusks from Northern Indiana. By R. Ellsworth Call, M. D., Ph. D.

The mollusks herewith reported on were collected by the members of the Indiana University Biological Station during the past summer. The region is sufficiently well characterized in the report of Dr. Eigenmann, the Director of the Station, and it is necessary here only to allude to its salient features.

The locality is on the divide separating the drainage areas of the Great Lakes and the Wabash River. In certain places the two drainages are practically identical and thus afford opportunity for the intermingling of the two faunas. The lakes and streams are all well within the limit of glaciation in former ages and their beds and shores are boulder-covered or lined. The bottoms of shallower portions of the lakes are gravelly or muddy, while the deeper portions are either muddy or sandy. Corresponding with these physical factors are certain features of molluscan distribution and modification, which it is the object of these notes to adduce and emphasize.

Unionidæ.

Anodonta decora Lea. Two specimens of this form were found, both of which were obtained in Syracuse Lake. The specimens were very much more fragile and far thinner than is usual for this species, even when secured from lakes and ponds. The epidermis is quite pale, the lines of growth crowded, and the nacreous deposit very white. Forms from sluggishly flowing streams in southern Indiana and elsewhere in the Ohio basin are very highly colored, both interiorly and without. As in other members of this family from these lakes the optimum habitat does not appear to be here. Many of the shells are coated with heavy deposits of calcareous matter, indicating a chemic condition of the water that is unfavorable to the normal development of the several species.

Anodonta ferussaciana Lea. One specimen from Turkey Creek; three specimens from Syracuse Lake.

The resemblance of these shells to the *Anodonta subcylindracea* is very marked indeed. The lake form is lighter both in texture and color than the one specimen from the creek.

Anodonta footiana Lea. Three specimens from Syracuse Lake; one specimen from Turkey Creek.

The shells submitted are very characteristic of this form, which may not, ultimately, be separated from *Anodonta lacustris* Lea. Like its congeners from the same locality the lake form is very pale in color and unusually thin and fragile. A very interesting fact is illustrated in the littoral distribution of this species and *Sphaerium* from the same lake. Those which occur in comparatively deep water are very much thinner and lighter in color than the shore forms. Also, those which are found on the northern shores are thinner and more fragile than those on the southern beach. The reason possibly may lie in the prevailing winds, which are from the northeast. The southern beach is also more gravelly than the northern. The conditions of environment then, in this case, favor thicker development of the shell in the forms living on the southern beach; they need greater powers of resistance, are subjected to rougher conditions of habitat and this finds expression in heavier secretion of nacreous material. The shells which live at the lake's bottom are also beyond the disturbing influence of waves and being deeply imbedded in mud develop to greater size, but with thinner shells.

Margaritana calceola Lea. A single dead specimen, from Turkey Creek.

This specimen is a very characteristic one, the deposit of calcareous matter on the inner surfaces of the valves being marked; this is a pathologic feature, well marked in the type specimens which Dr. Lea studied. This form and *Margaritana deltoidea* Lea are synonyms.

Margaritana rugosa Barnes. Represented by eight specimens from Turkey Creek, all of which are characteristic.

Unio coccineus Lea. One specimen, dead, from Turkey Creek.

The nacre of this shell is quite white, a fact true of the majority of shells which fall under this form, though the type-form was beautifully pink. It is often found in collections labelled *Unio rubiginosus* Lea, but is easily separated by the characters of the cardinal teeth and the rounded, nonangulate character of the posterior slope. In *Unio rubiginosus* there is a well marked ridge extending quite to the posterior margin. The flat and white nacred form also may occasionally be seen in collections as *Unio gouldianus* Lea, now a well recognized synonym.

Unio fabalis Lea. Twelve specimens from Tippecanoe Lake.

This is one of the smallest of our *Unios*. The shells submitted do not present any variant features other than the very light coloration so characteristic of all the lake shells which we have seen. *Unio lapillus* Say is a synonym.

Unio gibbosus Barnes. This form is represented by three specimens from Turkey Creek. These are all much thinner and lighter than the same species from the Ohio and Wabash rivers, in both of which it is a common shell. It seems to be very abundant in certain of the lakes of northern Indiana, notably Lake Maxinkuckee. The nacre of these three individuals is very dark purple. Similar shells to these probably have led to the reference of *Unio complanatus* Solander to the western fauna.

Unio iris Lea. Two characteristic specimens from Turkey Creek. Like its near relative—which is probably also a synonym—*Unio noviboraci* Lea, this shell occurs most commonly and abundantly in creeks and other small streams. It most affects soft muddy bottoms in rather still waters.

Unio luteolus Lamarck. Ten specimens from Syracuse Lake; seven specimens from Turkey Creek.

This species is the most widely distributed shell of the family. It occurs in every stream, lake and pond in Indiana in which shell life of any sort occurs at all. It is also the most abundant *Unio*, and, correlated with abundance and wide distribution, is a range of variations that are of the greatest import in evolutionary processes. All the shells submitted, particularly those from Syracuse Lake, are well covered, posteriorly, with carbonate of lime in heavy masses. The lake specimens also have beautifully marked green rays widely separated over a polished disk, thus constituting them the form to which Anthony gave the name of *Unio distans*. The epidermis usually has the peculiar coloration of forms which live in muddy bottoms, though in the lake specimens the epidermis is, for some hidden chemical reason, quite red posteriorly. This peculiar coloration has often been noticed in shells submitted to us from the lake region of Northern Indiana.

Unio occidens Lea. Nine characteristic specimens from Turkey Creek. None present features different from shells found elsewhere in the State.

Unio pressus Lea. One specimen from Turkey Creek.

A great many shells of this species have been seen from time to time from various places in Indiana. Very many of them, as this one well does, present a peculiar diseased or pathologic condition of the cardinal teeth not altogether unlike the condition exhibited by the interior surface of *Margaritana calceola*. In this instance the cardinal teeth are nearly destroyed and are represented by distorted and imperfect vestiges. It would be interesting indeed if the Station, during the next season, could investigate this phenomenon as a study in the physiology of *Unio*, a field yet uncultivated.

Unio rubiginosus Lea. Two specimens from Turkey Creek, one of which is pathologic

These shells are intermediate between *Unio trigonus* Lea and typical *Unio rubiginosus* Lea. They are somewhat more trigonal than the latter shells are commonly found, and, on the other hand, are less heavy and trigonal than the ponderous river form. The whole group is sadly confused and needs painstaking revision.

CORBICULADÆ.

Sphærium rhomboideum Prime. A single specimen only was taken, from Turkey Lake, in muddy bottom and in comparatively deep water. The specimen is very much thinner than usual.

Sphærium solidulum Prime. Ten specimens from Turkey Lake. These are all smaller than common and quite heavy; they came from the beach at Vawter Park.

FRESH-WATER UNIVALVES.

Amnicola porata Say. Eight specimens of this small univalve were obtained in Tippecanoe Lake. Neither it nor others of the univalves found present any characters different from shells found in streams throughout the State.

Campeloma decisum Say. Five dead specimens from Turkey Lake.

Campeloma integrum Dekay. One dead specimen from Turkey Creek.

Campeloma rufum Haldeman. About twenty specimens from Tippecanoe Lake; thirteen, one of which was reversed or sinistral, from Turkey Creek.

There is no difficulty in recognizing these several forms, though tyros annually make the discovery that there are no valid species but one. *Campeloma rufum* differs from both the others constantly by the outlines of the whorls, the shape and color of the aperture, the pink character of the apical whorls, a feature which is best illustrated in the very young and which is a constant character, and in the polished epidermis, which presents a character seen in no other member of the genus. Reversed forms are not uncommon, but yet may be justly considered rare. The type of the genus is a reversed specimen of *Campeloma ponderosum* from the Ohio River, taken by Rafinesque near Louisville, Ky.

Planorbella campanulata Say. Very abundant in all parts of Tippecanoe Lake.

Helisoma trivolvis Say. Two specimens from Turkey Lake; three specimens from Turkey Creek. The form submitted from Turkey Creek is a very large one, and is rather heavy in texture. The species must be very abundant in favorable localities.

Limnophysa humilis Say. Five specimens of this small limnæid were obtained along the shores of Turkey Lake.

Limnophysa caperata Müller. A single specimen of this common form only was secured. It came from Turkey Lake.

Physa ancillaria Say. Four specimens taken alive, entirely white, from Turkey Lake. This shell is usually honey yellow in coloration, but these specimens were a snow white.

Physa gyrina Say. Only two specimens of the "tadpole" physa appear in the collections, and these came from Tippecanoe Lake. It is one of the most widely distributed and most abundant of the Limnæidæ.

Goniobasis pulchella Anthony. Nine specimens from Turkey Lake; very abundant in Tippecanoe Lake, from which many dead specimens were submitted. This form is widely distributed throughout Indiana. Sometimes associated with it is *Goniobasis livescens* Menke, a form decidedly characteristic of the lake drainage.

Pleurocera subulare Lea. Very abundant in Lake Tippecanoe, from which many dead examples were seen.

Valvata tricarinata Say. A single specimen from Tippecanoe Lake.

LAND MOLLUSCA.

Limax campestris Binney. Four specimens of this widely distributed form were obtained from Vawter Park.

Succinea obliqua Say. This species is represented by ten alcoholic specimens. All taken at Vawter Park.

Zonites arboreus Say. Three alcoholic specimens from Vawter Park.

None of the univalves present features worthy of special mention. The whole collection is rather the result of incidental work than of careful collecting, and is to be taken as somewhat indicative of the wealth of molluscan life in favored localities in Indiana. It is submitted as a local contribution, in the form of a special report, that may help to a general knowledge of Indiana mollusks. Cincinnati, Ohio, November 3, 1895.

THE ODONATA. BY D. S. KELLICOTT.

I received for identification last fall two small collections of Dragonflies from Professor Eigenmann. They have been studied and compared with a determined collection; the following species were included:

1. *Calopteryx maculata* Beauv. It occurs throughout the Eastern United States and is usually abundant wherever it is found, preferring shady streams or rivulets of spring water.

2. *Hetærina americana* Fabr. Several examples of both sexes. This species extends over a wide eastern range and is represented in the Gulf States by a well marked form known in the lists as *H. basalis*, and on the Pacific Slope by another, *H. Californica*. Flies late, often until the middle of October, in Ohio. The scarlet patches at the base of the wings of the male make it a beautiful and conspicuous insect.

3. *Enallagma hageni* Walsh. This appears to be a rare species, but has now appeared in Illinois, Indiana and Ohio.

4. *Enallagma signatum* Hagen. Extends from the Gulf to Maine.

5. *Æschna clepsydra* Say. Two males and one female (?) were sent. All the *æschnas* fly late in the season. The three species *constricta*, *clepsydra* and *verticalis* resemble one another so closely that they are often regarded as one species; the females can not be separated by any one as yet.

6. *Anax junius* Drury.

7. *Tramea lacerata* Hagen.

8. *Libellula basalis* Say.

9. *Libellula pulchella* Drury.

10. *Plathemis trimaculata* DeGeer.

11. *Celithemis eponina* Drury.

12. *Diplax vicina* Hagen. This is doubtless the last odonat on the wing in our latitude. In central Ohio it has been taken pairing and ovipositing as late as November 8.

13. *Mesothemis simplicollis* Say.

14. *Pachydiplax longipennis* Burm.

I am surprised at the absence of all Gomphines and that so few Agrionines are present. Collecting in the early summer would doubtless disclose several species of both groups.

FISHES. BY C. H. EIGENMANN.

Fishes were collected in much larger numbers than any of the other vertebrates. They will form the subject of our most extented study of variation. I present here simply a few dates on the spawning time and the distribution of the various species in the localities examined. Half of these localities are on the St. Lawrence side of the divide; the other half on the Mississippi side. To show the relation of the fauna to that of the State I present a complete list of Indiana fishes.

SPAWNING SEASONS.

Most of the fishes spawn in the spring before the Station opened. This was true of all the larger species except a few stragglers of *Lepomis pallidus*.

Noturus flavus. This species is common under boards and logs in Turkey Creek, at Syracuse. Eggs were found in all stages of development the latter half of June. They are laid in little depressions in the gravel under boards, and are apparently watched by the adult. The eggs adhere to each other in masses large enough to fill the hollow of the hand. The eggs are very flabby, the membrane being not tense, as usual in fish eggs. After hatching the young remain together in the nest, and if they are uncovered by raising the board they quickly scatter to hide under another object or under the board again if this has been turned over. The blastoderm forms a narrow nodule well separated from the yolk by a deep constriction.

Pimephales notatus. The eggs of this species are laid on the under surface of various objects submerged in the margin of the lake to a depth of one or two feet. The fish is usually found with the nest, and the immediate neighborhood of the nest is kept clean of weeds and mud. The eggs were found during the whole of June and the greater part of July. The young swim near the surface and are very abundant the latter half of June.

Fundulus diaphanus menona. On June 24 eggs of this species were dragged up by the seine from the grass of the bottom. They are bound together by filaments.

Zygonectes notatus. Many taken on June 27 in Turkey Creek were with ripe eggs.

Etheostoma caprodes. This species was spawning on May 30, a single ripe female was taken about June 25.

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake.	Turkey Creek (Upper).	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe Lake.	Tippecanoe River (Above Dam).	Tippecanoe River (Below Dam).	Shoe Lake.
Ammocoetes branchialis L. Brook Lamprey						†						
Ichthyomyzon concolor Kirkland												
Polyodon spathula Walbaum. Spoon-bill Cat									†			
Scaphirhynchus platyrhynchus Raf. Shovel-nosed Sturgeon												
Acipenser rubicundus Le Sueur. Lake Sturgeon												
Lepisosteus osseus L. Common Gar Pike			†		†				†			
Lepisosteus platystomus Rafinesque. Short-nosed Gar-pike			†									
Lepisosteus tristœchus Bloch and Schneider. Alligator Gar												
Amia calva L. Bow-fin, Mud-fish, Dog-fish		†	†	†	†				†			
Ictalurus furcatus Le Sueur. Chuckle-headed Cat												
Ictalurus punctatus Rafinesque. Channel Cat												
Ameiurus lacustris Walbaum. Great Cat-fish												
Ameiurus natalis Le Sueur. Yellow Cat	†		†			†	†	†	†	†	†	
Ameiurus nebulosus Le Sueur. Common Bull-head, Horned Pout									†			
Ameiurus melas Rafinesque												
Leptops olivaris Rafinesque. Mud Cat												
Noturus flavus Rafinesque						†						
Schilbeodes exilis Nelson												
Schilbeodes miurus Jordan												
Schilbeodes eleutherus Jordan												
Schildeodes gyrinus Mitchill	†		†	†		†						
Schilbeodes nocturnus Jordan and Gilbert												
Ictiobus cyprinella Cuv. and Val. Common Buffalo Fish												
Ictiobus urus Agassiz. Razor-backed Buffalo												
Ictiobus bubalus Rafinesque. Sucker-mouthed Buffalo												
Carpiodes carpio Rafinesque												
Carpiodes difformis Cope												
Carpiodes velifer Rafinesque. Quill-back												
Cycleptus elongatus Le Sueur. Black Horse												
Catostomus catostomus Foster. Northern Sucker												
Catostomus commersoni Lacépède. Common Sucker, White Sucker		†				†						

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake Creek.	Turkey Creek (Upper).	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe Lake.	Tippecanoe River (Above Dam).	Tippecanoe River (Below Dam).	Shoe Lake.
Catostomus nigricans Le Sueur. Hog Sucker						†						
Erimyzon sucetta oblongus Mitchill. Ch		†	†	†		†	†	†	†	†	†	
Minytrema melanops Rafinesque. Striped Sucker						†						
Moxostoma anisurum Rafinesque. White-nose Sucker												
Moxostoma aureolum Le Sueur												
Moxostoma breviceps Cope.												
Placopharynx duquesnii Le Sueur												
Lagochila lacera Jordan and Brayton. Hare-lip Sucker												
Compostoma anomalum Rafinesque. Stone Roller						†						
Chrosomus erythrogaster Rafinesque. Red-bellied Minnow												
Hybognathus nuchalis Agassiz												
Pimephales promelas Rafinesque												
Pimephales notatus Rafinesque			†			†		†	†			†
Cliola vigilax Baird and Girard. Bull-head Minnow												
Notropis anogenus Forbes			†									
Notropis bifrenatus Cope.			†			†						
Notropis heterodon Cope			†	†		†	†	†	†			
Notropis microstomus Rafinesque			†									
Notropis cayuga Meek												
Notropis boops Gilbert												
Notropis hudsonius Clinton. Spawn-eater									†			
Notropis whipplei Girard. Silver-Fin.												
Notropis megalops Rafinesque. Common Shiner		†	†			†	†	†	†	†	†	
Notropis jejunus Forbes												
Notropis ariommus Cope												
Notropis ardens Cope. Red-fin												
Notropis atherinoides Rafinesque												
Notropis arge Cope												
Notropis dilectus Girard												
Notropis rubrifrons Cope												
Ericymba buccata Cope												
Rhinichthys atronasus Mitchill												
Hybopsis dissimilis Kirtland												
Hybopsis amblops Rafinesque												
Hybopsis storerianus Kirtland												

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake.	Turkey Creek (Upper).	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe Lake.	Tippecanoe River (Above Dam).	Tippecanoe River (Below Dam).	Shoe Lake.
Hybopsis watauga Jordan and Evermann												
Hybopsis kentuckiensis Rafinesque. Horny Head, River Chub, Jerker		†				†		†		†		
Hybopsis hyostom Gilbert												
Semotilus atromaculatus Mitchill. Horned Dace, Creek Chub		†				†		†				
Phoxinus elongatus Kirtland												
Opsopœodus emiliæ Hay												
Notemigonus chrysoleucus Mitchill			†	†			‡	†	†			
Hiodon alosoides Rafinesque												
Hiodon tergisus Le Sueur. Moon-eye												
Clupea chrysochloris Rafinesque. Skip-jack												
Dorosoma cepedianum Le Sueur. Gizzard Shad												
Coregonus quadrilateralis Richardson												
Coregonus clupeiformis Mitchill												
Coregonus labradoricus Richardson												
Coregonus hoyi Gill												
Coregonus artedi Le Sueur												
Coregonus artedi sisco Jordan									†			
Salvelinus namaycush Walbaum. Trout												
Percopsis guttatus Agassiz. Trout Perch												
Amblyopsis spelæus De Kay. Blind Fish												
Typhlichthys subterraneus Girard												
Fundulus diaphanus menona Jordan and Copeland			†									
Zygonectes notatus Rafinesque. Top Minnow		†				†					†	
Zygonectes dispar Agassiz								†	†		†	
Gambusia patruelis Baird and Girard. Top Minnow												
Umbra limi Kirtland. Mud-minnow, Dog-fish	†						†	†		†		
Lucius vermiculatus Le Sueur. Little Pickerel	†	†	†	†	†	†	†	†	†	†	†	†
Lucius lucius L. Pike, Northern Pickerel												
Lucius masquinongy Mitchill. Muskallunge												
Anguilla anguilla rostrata Le Sueur. Eel												
Pygosteus pungitius L. Nine-spined Stickleback												
Eucalia inconstans Kirtland. Brook Stickleback												
Labidesthes sicculus Cope. Brook Silverside			†	†	†	†			†			
Aphredoderus sayanus Gilliams. Pirate Perch	†					†						

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake.	Turkey Creek (Upper).	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe River.	Tippecanoe River (Above Dam).	Tippecanoe River (Below Dam).	Shoe Lake.
Centrarchus macropterus Lacépède												
Pomoxis sparoides Lacépède. Calico Bass			†									
Pomoxis annularis Rafinesque. Crappie												
Ambloplites rupestris Rafinesque. Rock Bass, Red Eye			†	†		†		†	†			
Chaenobryttus gulosus Cuv. and Val. War Mouth			†	†			†		†	†		†
Lepomis cyanellus Rafinesque. Green Sunfish			†			†		†			†	
Lepomis macrochirus Rafinesque												
Lepomis humilis Girard												
Lepomis pallidus Mitchill. Blue Sunfish			†					†	†	†	†	†
Lepomis megalotis Rafinesque												
Lepomis garmani Forbes												
Lepomis euryorus McKay												
Lepomis heros B. and G. McKay												
Lepomis notatus Agass. McKay												
Lepomis gibbosus L. Common Sunfish			†	†				†	†	‡	†	†
Micropterus dolomieu Lacépède. Small-mouthed Black Bass			†			†			†	†		
Micropterus salmoides Lacépède. Large-mouthed Black Bass		†	†			†		†	†	†	†	†
Etheostoma pellucidum Baird. Sand Darter												
Etheostoma asprellus Jordan												
Etheostoma nigrum Rafinesque. "Johnny"			†			†		†	†	†		†
Etheostoma chlorosoma Hay												
Etheostoma blennioides Rafinesque. Green-sided Darter												
Etheostoma coplandi Jordan												
Etheostoma histrio Jordan and Gilbert												
Etheostoma shumardi Girard												
Etheostoma uranidea Jordan and Gilbert												
Etheostoma caprodes Rafinesque. Log Perch, Hog-fish			†			†	†	†	†			
Etheostoma macrocephalum Cope												
Etheostoma ouachitae Jordan and Gilbert												
Etheostoma aspro Cope and Jordan						†		†	†			
Etheostoma phoxocephalum Nelson												
Etheostoma sciera Swain												
Etheostoma evides Jordan and Copeland												
Etheostoma variatum Kirtland												

	St. Lawrence Basin.						Mississippi Basin.					
	String Lake.	Turkey Creek (Upper.)	Turkey Lake.	Channel.	Syracuse Lake.	Turkey Creek (Below Dam).	Webster Lake.	Webster Lake (Below Dam).	Tippecanoe Lake.	Tippecanoe River (Above Dam).	Tippecanoe River (Below Dam).	Shoe Lake.
Etheostoma zonale Cope												
Etheostoma camurum Cope												
Etheostoma maculatum Kirtland												
Etheostoma flabellare Rafinesque								†				
Etheostoma squamiceps Jordan												
Etheostoma tippecanoe Jordan and Evermann												
Etheostoma iowæ Jordan and Meek			†			†	†	†	†			†
Etheostoma cæruleum Storer. Rainbow Darter						†		†		†		
Etheostoma cæruleum spectabile Agassiz												
Etheostoma jessiæ Jordan and Brayton												
Etheostoma fusiforme Girard												
Etheostoma eos Jordan and Copeland												
Etheostoma microperca Jordan and Gilbert			†							†	†	
Perca flavescens Mitchill. Yellow Perch		†	†	†	†	†	†	†	†	†	†	†
Stizostedion vitreum Mitchill. Wall-eye												
Stizostedion canadense C. H. Smith. Sauger, Sand Pike												
Roccus lineatus Bloch. Striped Bass												
Roccus chrysops Rafinesque. White Bass									†			
Morone interrupta Gill. Yellow Bass												
Aplodinotus grunniens Rafinesque. Fresh Water Drum												
Cottus ricei Nelson												
Cottus bairdi Girard. Miller's Thumb											†	
Cottus pollicaris J. and G												
Cottus hoyi Putnam												
Lota lota maculosa Le Sueur. Burbot												

Batrachia. By Curtis Atkinson.

Siren lacertina Linnaeus. A single specimen of this species was taken in the seine in the channel. Mr. Dolan secured another late in September, and afterwards, through his students, secured a nest of eleven, which were uncovered while cleaning a lot near Syracuse. These had evidently gone into winter quarters. Five of them are still alive. Turkey Lake is the most northern locality so far recorded for the siren.

Necturus maculatus Rafinesque. Three specimens of this species were secured. It is said to be abundant, but no other specimens were noted. On June 28, a number of eggs were found fastened to the lower surface of a board, which was well imbedded in the mud of the bank of Turkey Creek. The young were already quite active in the loose, flabby bags forming their covering.

Amblystoma jeffersonianum Green? A single specimen under a log near the lake.

Bufo lentiginosus Shaw. The ubiquitous toad was present, but not in great numbers at Syracuse, Turkey and Tippecanoe lakes.

Acris gryllus crepitans Baird. Abundant along the shallow margins of the lake among rushes and lillypads. Detailed localities where it was taken are outlet of String Lakes, Turkey Lake, Syracuse Lake, Turkey Creek, Webster and Tippecanoe Lakes and Tippecanoe River.

Rana virescens Kalm. Very abundant and variable. I am not at all certain that the varieties described by Cope and Hay are to be found among our material, but it seems quite certain that there is no correlation in the variations of different parts of the body. If varieties are to be distinguished it must be by separating them on single characters.

I have made measurements of a number of characters to determine whether the 120 specimens collected could be grouped according to any of these.

The relation of the tibia in the length of the body gave the length of the tibia .55 that of the body as the most common relation between the parts.

From this there is a gradual reduction to a length of .49 on the one hand and an increase to .70 on the other. But .20 of the specimens had the tibia with the most common length. This character is then perfectly useless in separating varieties in my specimens.

The same may be said of the length of the head in the length of the body, .33 is the relation occurring oftenest and from this there is a variation to .20 on one hand and .27 on the other; .20 of all the specimens have the length of the head .33 of the length of the body.

The relation of the fifth toe to the length of the third toe gave a very jagged curve with the length of the fifth toe .95 of the length of the third as the condition occurring in .20 of the specimens. From this a very irregular curve extends to .89 on one side and to 1.00 on the other.

The relation of the diameter of the tympanum to the diameter of the eye gave the most irregular curve. Thirty-five per cent. of all the specimens had a tympanum with a diameter equal to .60 of that of the eye. From this we have a saw-toothed curve to .48 on one side and .70 on the other. A comparatively large per cent.—15 per cent.—have a relation of .50. Attempts to get system out of this curve by breaking it up into age curves did not succeed entirely. But these separate curves for the different ages show that in the young the tympanum is comparatively small, and that the peak noted at the .50 mark is due to the young included in the general curve.

The whole study emphasized the fact that there is little or no coördination in the variation in this frog. No two characters, in fact, seem to vary together and all the specimens may be referred to but one variety.

I have in the following grouping, in the shape of the conventional key, separated the specimens according to their color patterns. All but one or two of the combination of patterns contains individuals which have the vomerine patches of teeth forming a straight line, and others with these patches inclined to each other at a more or less distinct angle. They clearly show that there is no coördination in the different parts of the color pattern. Each region varies apparently independently of the others.

KEY TO THE COLOR PATTERNS.

a. A spot on the nose.
  b. Two complete series of spots on the back.
    c. Two cross bars on the femur.
      d. Tibia with a mixture of spots and bars. 5 specimens.
  bb. Two complete series of spots on the back, with a third broken series between.
    e. Two cross bars on the femur.
      f. Tibia, with a mixture of spots and bars. 16 specimens.
      ff. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 1 specimen.
    ee. Three cross bars on the femur.
      g. Tibia, with a mixture of spots and bars.
        h. Spots on back, many and small. 21 specimens.
        hh. Spots on back, few and large. 13 specimens.

gg. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 9 specimens.

eee. Four or five cross bars on femur.

i. Tibia, with a mixture of spots and bars. 16 specimens.

ii. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 2 specimens.

aa. No spot on the nose.

j. Two series of spots on the back.

k. Two cross bars on femur. Tibia, with a mixture of spots and bars. 4 specimens.

kk. Three cross bars on the femur. Tibia, with a mixture of spots and bars. 4 specimens.

kkk. Irregular number of cross bars on femur, always more than three.

l. Tibia, with a mixture of spots and bars. 2 specimens.

ll. Tibia, with a row of spots on the anterior and posterior edge, upper surface unspotted. 2 specimens.

jj. Two complete series of spots on the back, with a third broken series between them.

m. Two cross bars on the femur. Tibia, with a mixture of spots and bars. 4 specimens.

mm. Three cross bars on the femur.

n. Tibia, with a mixture of spots and bars. 11 specimens.

nn. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 4 specimens.

mmm. Four or five cross bars on the femur.

o. Tibia, with a mixture of spots and bars. 1 specimen.

oo. Tibia, with a row of spots on the anterior and another on the posterior edge, upper surface unspotted. 4 specimens.

String Lakes, Upper and Lower Turkey Creeks, Turkey, Webster and Tippecanoe Lakes.

Rana palustris LeConte. One at the String Lakes, one at Turkey Lake, five at Tippecanoe Lake.

Rana sylvatica LeConte. A single specimen at Turkey Lake.

Rana clamata Daudin. Abundant at Upper and Lower Turkey Creek, Turkey and Tippecanoe Lakes.

Rana catesbiana Shaw. Abundant among lily pads, especially in parts of the lake not frequently visited. Turkey and Tippecanoe Lakes.

Snakes of Turkey Lake. By G. Reddick.

The number of specimens of snakes taken amount to about 225. They belong to five genera and eight species.

Bascanion constrictor Linn. is common around Turkey Lake and is the largest of the snakes found here. This snake is of course no part of the lake fauna. This snake was also taken at Lake Tippecanoe.

Eutainia sirtalis Linn. is very abundant along the margin of the lake, feeding on frogs and fish. One specimen was secured with a cat-fish spine sticking through the body wall of the snake.

Young taken from this snake July 17 averaged a slight fraction over seven inches in length and were almost grown, only a very small amount of the yolk being left. These young as soon as they were liberated would try to crawl away, and upon provocation and some without provocation would open their little mouths and flatten their heads and strike as viciously as old snakes.

As high as seventy-two young were taken from one snake, and often from thirty to forty. The average appearing to be between thirty and forty. This snake was also secured from Tippecanoe Lake.

Eutainia saurita Linn. is not nearly so abundant nor is it nearly so prolific. Eggs were taken from only three or four specimens, six being the highest number taken from any one. Specimens of this snake were also taken from the margins of Lake Tippecanoe.

Eutainia butlerii Cope. Only one specimen of this was taken. It was fourteen and one-half inches long. This snake is short and chubby and its movement is very characteristic of it. It does not have the gliding movement of *E. saurita* nor the swift but yet very active movement of *N. sipedon*, but seems rather to exert a large amount of force to do little crawling. The movement is so characteristic that I believe any one, having once seen the peculiar way in which it tries to hurry itself away, would ever after be able to recognize it at a distance. No specimen was taken from Lake Tippecanoe.

Natrix leberis Linn. is rare in Turkey Lake, but common in Lake Tippecanoe. Twelve is the highest number of embryos taken from any one specimen.

Embryos taken August 5 contained a considerable amount of yolk; probably enough to nourish the embryo for a month or more.

Natrix sipedon Linn. is the most abundant of snakes found in this region, but not the most prolific, *E. sirtalis* standing ahead of it. Thirty-four was the highest number of eggs taken from any one specimen. One snake which was kept in confinement gave birth to fourteen young the third week of September.

Among the bullrushes is a favorite abode for this snake, and also under anything whatever that happens to be lying along the margin of the lake, especially if it happens to be lying partly in the water.

Sistrurus catinatus Raf. This snake is very common around Turkey Lake and also around Lake Tippecanoe. Several specimens were secured and others killed. It lives chiefly in the swamps.

A specimen taken August 6 contained five eggs and the embryos were seven inches long.

Storeria dekayi Holb. Only one specimen of this was secured. It was taken along a highway running by the side of a swamp.

TESTUDINATA. BY C. H. EIGENMANN.

Turtles are at all times and everywhere abundant. They frequent especially the shallower portions of the lake. Many specimens of all ages were preserved. The number of variations in the shields is large. I present here simply a list with notes on their abundance and breeding habits.

Chelydra serpentina Linnaeus. This species is abundant in Turkey Lake, and reaches a larger size than any of the others. It is caught for the markets. It is much shyer than the other species of turtles and is not frequently seen. It inhabits the shallower muddy parts of the lake, being abundant in the kettle and about Morrison's Island. No eggs were found.

Trionyx spiniferus LeSueur. The soft-shelled turtle is very abundant. It is the second in size and is caught for the markets. Its round eggs are laid in the sand and gravel near the water's edge during June and July. On June 26 one was seen digging a nest in the gravel banks at Syracuse, and on the 27th we obtained eggs from five nests about Ogden Point and other places about the kettle. Other fresh nests were found July 9. The time of hatching was not determined.

Several empty nests were found in July, but some eggs, examined as late as September 1, contained young which would have been ready to hatch about a month later. The number of eggs found in several nests was as follows: 9; 12; 17; 18; 27; 32.

Aromochelys odorata Bosc. This species is abundant, but not conspicuous. Individuals were oftenest seen the latter part of June and first part of July while laying their eggs. The eggs are laid in the rotten wood in the tops of stumps standing in the margin of the lake. The turtles were frequently found in the tops of these stumps, and some of their eggs wedged as far into the rotten wood as a finger could bore. Rotten logs removed some distance from the water are also favorable places for egg laying, and in a mucky place of small area at the edge of the lake 362 eggs were taken at one time. The number of eggs laid by one individual varies from 4 to 7, this number being usually in a cluster. At this rate about sixty turtles must have contributed to the nest of 362. While passing along a wheat field some turtles were seen coming from it, and on inspection it was found that they had deposited their eggs in the ground in depressions made by a cow while walking over the ground when it was soft. Still other eggs were found in bundles of rushes drifted together. An interesting change of habit seems to have taken place among these turtles during the last fifty years. Before that time the number of stumps standing in the margin of the lake must have been exceedingly small. The present large number is due to the rising of the lake after the building of the dam and the subsequent cutting down of the trees whose boles had become submerged. The habit of laying eggs in stumps can not be of much more than fifty years' duration.

The time of laying must be scattered over considerable time, for many eggs were found hatched in August, while some obtained about then hatched at various times from September 15 to November 1. These were, however, kept in a box in a room and therefore removed from normal conditions. The age of this, as of all other hard-shelled turtles, can be estimated by the lines of growth on the horny cuticle. The originally exposed part of the plate occupies the mediocephalic corner of the plate and additions occur as smooth strips along the outer and posterior margins. The strips are quite distinct in early years, but become more or less obscure with age.

Chrysemys marginata Agassiz. This appears to be the most abundant turtle of the lake. How far its apparent abundance may be due to its habits I am unable to say. It is found floating or quietly paddling along, its head out of the water, but on nearer approach it always turns tail and seeks refuge in the abundant chara fields or in other hiding places. The chara fields are traversed by narrow paths and tunnels made by this turtle. The eggs are laid later in the summer and farther from the water than those of the other species. Many were leaving the water in late August; the eggs were found but once.

Malaclemmys geographica LeSueur. Next to Chrysemys the most abundant of the turtles. It goes by the appropriate name of Housetop.

Emys blandingii Holbrook. Found in moderate numbers in the lake and along the banks of Turkey Creek.

Clemmys guttata Schneider. But two specimens were seen.

Cistudo carolina Linnaeus. One specimen of this species was taken. It, however, in no sense forms a part of the fauna of the lake.

Water Birds of Turkey Lake. By F. M. Chamberlain.

The following birds were taken between July 1 and September 1, on or near Turkey Lake. Only those of more or less aquatic habits are listed:

1. *Hydrochelidon nigra* L.
2. *Botaurus lentiginosus* Montaga.
3. *Botaurus exilis* Gmelin.
4. *Ardea virescens* L.
5. *Rallus elegans* Audubon.
6. *Rallus virginianus* L.
7. *Gallinula galeata* Lichtenstein.
8. *Fulica americana* Gmelin.
9. *Actitis macularia* L.
10. *Aegilites vocifera* L.
11. *Ceryle alcyon* L.
12. *Agelaius phoeniceus* L.
13. *Clivicola riparia* L.
14. *Cistothorus palustris* Wilson.

PART III—VARIATION.

THE STUDY OF VARIATION.* BY C. H. EIGENMANN.

VARIATION AND ITS IMPORTANCE. No two individuals are exactly alike. The differences of whatever sort, whether in structure or habit, between the individuals of a species, whether these individuals are related to each other as parent and child, or belong to the same brood, are termed variation.

The whole basis of the Darwinian idea of evolution is this individual variation. At present we have two estimates of the importance of individual variation.

I. The individual variations are of the utmost importance, and all species are the result of natural selection working on the varying individuals of any species.

II. Individual "variation offers us little hope of learning the real facts of evolution," "species are not the result of the selection of a few favorable variations out of a large number of haphazard changes," but to "the orderly advance (of the mean specific form) towards the final goal, deviating very little from the direct line."†

We subscribe to neither of these views, wishing to view the facts as they are presented by the conditions of the environment at Turkey Lake and the lakes in the neighborhood, in a perfectly impartial way.

The causes of variation are still unknown, though several explanations have been attempted. This is not surprising since the variations in no species are sufficiently known to formulate any satisfactory explanation, in fact little has been attempted but to determine the extent of variation in comparatively few cases where the variation is great, resulting in the naming of new varieties and in the recording of abnormalities. The statistical method of studying variation is of the most recent date, but much promises to be done with this method.

DISTRIBUTION OF VARIATIONS. Variations are to be found at all times and at all places where organisms exist. They are found under conditions where the environment is in a state of stability. The conditions under which the greatest variability is found (in fishes) are:

1. Wide distribution. A large territory is, usually, though not necessarily, inhabited by more or less stable varieties.

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*Contributions from the Zoölogical Laboratory of the Indiana University, No. 17.

†This wording is from Scott, but since the paragraphs are selected from isolated parts of his paper, I do not wish to convey the idea that they state his views as he would like to have them stated. The paragraphs state an extreme view.

2. Great physical and climatic differences, even in comparatively narrow limits. No more striking illustration can be imagined than is offered by the streams of the Pacific slope of North America, which are inhabited by extraordinary variable species, without stable varieties

3. Amphimyxis has been suggested by Ayres as a condition favoring the display of great variation.

These are simply statements under which variation seems to find its optimum condition and do not approach any explanation of its causes.

Classifications of Variations.—Students of variation have found it advantageous to analyze the phenomena, and the result of this analysis has given us the following classifications:

Continuous variation, including all gradual modifications and transitions.

Discontinuous variation; any sudden and wide modifications or saltations.

Using other features as the basis of classification, we have:

Meristic variations dealing with the change in the number of successive parts.

Substantative dealing with the chemical modifications of parts.

Another classification gives us:

Indeterminate, or fortuitous and aimless variation. This is largely individual and pertains to series of variations either geographically or geologically.

Determinate and adaptive, leading to definite end.

The most essential and at the same time the most difficult to define is the distinction between—

Ontogenetic variation including all those deviations appearing at any time, from any cause, during the life cycle of an individual;

Phylogenetic variations change from the specific characters appearing at some time in the life cycle of an individual, or better still, a large number of individuals, reappearing in the next generation, finally becoming hereditarily fixed.

I have in the following directions omitted the use of the terms ontogenetic and phylogenetic. Recently (Osborn, 1894), the distinction between ontogenetic and phylogenetic variation in the study of evolution has been strenuously insisted upon as the only possible way of determining the value of any given variation in the process of evolution. However, it is certainly impossible in many cases to determine whether a given variation is ontogenetic or phylogenetic as defined by Osborn. To give a concrete case. The ancon sheep of evolutionary classics was born with short legs. Were they ontogenetic or phylogenetic? Subsequent events proved that they were phylogenetic, but certainly the short legs in themselves enabled no one to make the distinction; the hereditary transmission decided the matter. Sports, therefore, of which the ancon sheep was certainly one, may be phylogenetic. Scott, however, has recently shown, Am. J. Science, 369, 1894, that many if not most saltatory variations are of an entirely different nature from the variations that in the past have given rise to phylogenetic series. In a deviation much less marked, such for instance as the presence of one more than the normal number of spines in a fin, this ultimate criterion of transmission might fail us even were it practicable to put it to the test. A surer way of determining phylogenetic variation is to measure variation in the bulk by means of curves. If, say one thousand individuals of a definite time and place, show in the aggregate a character different from that normal to the species, it is phylogenetic. Such variations may occur in successive years or at isolated places. The phylogenetic character is in such a case really made up of a large number of ontogenetic variations which must also be capable of reappearing; that is, they must also be phylogenetic. A better way of stating the problem would seem to me to be that:

All variations are ontogenetic, some are at the same time immediately phylogenetic and many if not all may become so—a phyletic series. This leaves open the question of the conditions under which ontogenetic variation becomes phylogenetic and ignores the unchanged germplasm theory which from purely embryological grounds is untenable.

The paragraphs pertaining to this subject in the following direction are: 7, 8, 13, 15, 16.

Nearly synonymous terms with ontogenetic and phylogenetic are the terms variation and mutation as used by Newmayr, Waagen, and Scott. Variation is here applied to locally different forms, while mutation is applied to the chronological changes or "steady advance (of the mean) along certain definite lines" The latter term may for our purpose be still further restricted by applying it not only to the changes of the mean in successive geologic periods, but to the changes in the mean which may occur in two successive years or broods.

To quote Newmayr, pp. 60-61 (from Scott, p. 372), "Weil ein Theil der Merkmale gleichmässig nach einer Richtung im Laufe der Zeit mutirt, zeigen andere Charactere regellose Abänderungen und jede Mutation entwickelt denselben Varietätenkreis." Scott illustrates this process by comparing the mutation to the progress of a cyclone center and the continual circlet of variations to the circulating winds.

DETAILED DIRECTIONS FOR COLLECTING AND STUDYING SPECIMENS.

The following directions and explanations have been prepared for the students at the Biological Station for the study of the variation of the inhabitants of lakes Turkey and Tippecanoe and the small lakelets in the neighborhood.

1. Collect at random all available specimens, to the number of several hundred, the last week in June, in both Turkey and Tippecanoe lakes, keeping the exact location where each lot of specimens was collected.

It is necessary to collect at random or the personal element of the collector may become a disturbing factor in determining the variation. The date, which is not necessarily fixed for any particular week, has been selected because at this time many very young specimens, but a few weeks old, can be secured. It is necessary to collect in both lakes at approximately the same date in order to secure corresponding ages.

2. Collect in the same manner and an equal number of specimens in each lake near the end of August.

From this second collection the rate of growth and any elimination taking place early in life may be determined.

3. Arrange the material of each date according to the size, to determine whether the broods of successive years can be separated.

If specimens have been collected at random and include all sizes this can usually be done for the preceding few years. Among the older individuals the gradation in size is usually too perfect to permit any grouping according to age.

4. Determine the variation in two or more prominent characters in each brood of specimens, keeping the record and labeling the specimens in such a way that the specimen for any record can at any time be re-examined. Determine at the same time the sex.

This is by far the most laborious and time killing operation, but absolutely essential to determine anything further. The characters measured in fishes can always be the number of rays in the dorsal and anal fins, and the number of scales in the lateral line. Other characters will vary with the species, as one species has one, another a different character that lends itself especially to the study of variation. In reptiles deviations in the number and characters of plates are available characters for the study of variation. Of course any character can be taken, but one in which the variation can be numerically expressed and the number be determined by a simple count instead of a measurement, is vastly superior, since nothing can be left to the judgment, and the personal element is therefore much less important.

5. Are there external sexual differences, and is the amount and extent of variation different in the sexes?

This determination can usually be left till later; it is introduced here so as not to mar the sequence of the following points.

6. Is there a successive modification in going from younger to older specimens indicating a structural modification with age?

It may be possible with some species, for instance, that the number of rays increases directly with the age. Should such a case exist it might give rise to entirely erroneous notions as to the influence or effect of selective destruction.

7. Is the variation of each year grouped about a mean common to all the specimens, or is each year's variation grouped about a center of its own?

While the idea of the annual variation or the reaction of each brood to a slightly varying environment was supposed to be a possible element, and suggested as such in my first announcement of the station, I was entirely unprepared for the startling annual variation in such a prominent character as the number of dorsal spines which has been discovered by Mr. Moenkhaus and reported upon in another paper.

The neglect of the consideration of the environment during the early period of development in modifying successive broods in different ways may lead to entirely erroneous ideas of the structural modifications of growth on the one hand, or the entirely erroneous ideas of the action of selective destruction on the other. To determine the latter it is absolutely necessary to take individuals of the same year's broods at successive periods or successive years. Whether as great an annual fluctuation is present in crabs as has been observed in Etheostoma I can not presume to say. But the entire neglect of this element vitiates the results of Prof. Weldon, of the committee of the royal society for "Conducting statistical inquiries into the measurable characteristics of plants and animals," which Mr. Thistelton-Dyer (Nature, Mch., 1895) considers to be "among the most remarkable achievements in connection with the theory of evolution."

I quote from Prof. Weldon to show his methods and results. (Nature, Mch. 7, 1895, p. 449.) "In order to estimate the effect of small variations upon the chance of survival, in a given species, it is necessary to measure, *first*, the percentage of young animals exhibiting this variation; *secondly*, the percentage of adults in which it is present. If the percentage of adults exhibiting the variation is less than the percentage of young, then a certain percentage of young animals has either lost the character during growth, or has been destroyed. The law of growth having been ascertained, the rate of destruction may be measured, and in this way an estimate of the advantage or disadvantage of a variation may be obtained.

In order to estimate the effect of deviations of one organ upon the rest of the body, it is necessary to measure the average character of the rest of the body in individuals with varying magnitude of the given organ."

Conclusions reached by an application of these principles to a study of the shore crab gave as a result that—*a*. There is a period of growth during which the frequency of deviations increases. *b*. That in one case the preliminary increase is followed by a decrease in the frequency of given magnitude, in the other case it was not. *c*. Assuming a particular law of growth the observations show a selective destruction in the one case and not in the other.

8. What is the relation of the annual fluctuation (mutation) in variation to the annual fluctuation in the different elements of the environments?

9. What is the difference in the variation of the youngest brood early in the season and late in the season, and what is the difference in the variation in succeeding years of the same brood? Is this difference, if any exists, due to modifications with age or to selective destruction, *i. e.*, has a larger percentage of individuals with one characteristic been eliminated than of individuals with this characteristic slightly different? In what part of the curve of variation have the greatest changes been produced?

10. If certain individuals with definite characters seem to survive, can it be determined in what way this variation brings about the survival?

11. At what age or stage of growth are variations greatest?

12. Can variations arising with age be referred to habits or environment?

13. What is the relation of sports or saltatory variations to the continuous variation numerically?

By saltatory variations are meant all those variations not connected with the mean by intermediate steps.

14. Are saltatory characters always bilateral? If not, to what degree are they bilateral?

The fact that a saltatory variation is confined to one side or is found on both sides, may enable us to determine whether the deviation began in the germ before the appearance of bilaterality or is of later origin.

15. In how far is the repetition of a character due to the repetition of the environment as shown in the correlation of annual fluctuations in environment with annual variations? See under 8.

Whitman Biological Lectures, 1894, p. 4: "An epidemic of metaphysical physics seems to be in progress—a sort of *neo-epigenesis*. In place of the *vis essentialis* of the old epigenesis, the new epigenesis sets up as its fetich the *vis impressa*. The new god is preferred because it works from the outside instead of the inside. It represents the sum of external conditions and influences at the present moment, and is proclaimed all-sufficient for building up organisms out of isotropic corpuscles. Previous conditions are not, indeed, quite ignored, for they have resulted in special molecular constitutions called germs, and these display molecular activities known as metabolism, growth and division. The long past can bring forth only a molecular basis; a few hours of the present can supply all, or nearly all, the determinations of the most complex organism. Impotent past; prepotent present. We have no longer any use for the 'Ahnengallerie' of phylogeny. Heredity does not explain itself or anything else, and it detracts from the omnipotence and universality of molecular epigenetics. We are no better off for knowing that we have eyes because our ancestors had eyes. If our eyes resemble theirs it is not on account of geneological connection, but because the molecular germinal basis is developed under similar conditions. The reason this basis becomes an eye rather than an ear or some other organ is wholly due to its position and surroundings, not to any inherent predeterminations. If the material for the eye and the ear could be interchanged in the molecular germ, that which in one place would become eye would in the other place become ear, and *vice versa*."

16. In what characters does the same species in the neighboring lakes differ, and in what respects does the variation differ in the different lakes?

17. Are variations in one part of the body correlated with variations in another part of the body?

In many cases this can only be determined by converting the variations in part into the terms of the variation of another part. The method for doing this has been suggested by Galton, whose method is discussed at the end of this paper.

18. What correlation is there in the variation of different species under the same environment?

As far as I am aware, no systematic studies of this description have been made. With us this study resolves itself into the determination of whether the fishes in Turkey Lake all differ from those in Tippecanoe along definite, determined ways, so that given the characters of a species for Turkey Lake the characters for the same species in Tippecanoe could be predicted.

Similar but exotic instances are the absence of ventral fins in some of the fishes inhabiting even widely separated mountain lakes, and the presence of enlarged scales along the base of the anal in the Cyprinidæ inhabiting mountain streams of India; or, to come nearer home, the peculiar color patterns of the fishes in some regions of upper Georgia.

METHOD OF PRESENTING RESULTS. Results of statistical inquiries into variation can best be presented by frequency of error curves, and these will be used wherever possible. The abscissa will in all cases be made to represent the size of the organ, the ordinate the percentum of individuals having the particular size.

To convert variations in one organ into the terms of another organ the scheme of distribution will be used with the formula given by Galton for comparing one such curve with another. The process of comparing any curve "a" with any curve "b," multiply each of "a's" height by $\frac{\text{Q of "a"}}{\text{Q of "b"}}$

The Q of any scheme of distribution is one-half the difference between any two grades. The same grades in the two curves to be compared being used to determine their Q for this purpose, 25 per cent. and 75 per cent. are suggested as most convenient by Galton.

Ideally the variations occurring in a single organ expressed by a frequency of error curve, when a large number of individuals have been examined, will form a symmetrical curve which is called a "normal." Such a curve may always be expected when the material under consideration is of a single origin and has developed under the same environment. Unfortunately for non-mathematical evolutionists, the converse does not seem to be the case, for a symmetric curve may be made up of two symmetric curves with axes not far apart, a fact that can only be determined mathematically. Says Pearson, "There will always be the problem: Is the material homogeneous and a true evolution going on, or is the material a mixture? To throw the solution on the eye in examining the graphical results is, I feel certain, quite futile."

It is not hoped that the data can be treated with the mathematical refinement suggested by Pearson, nor is it probable that such treatment of our material will become absolutely necessary, since there can be but little question of the unity of origin of the material in any given small lake.

While usually, as stated above, the curve resulting from the study of a large number of specimens will be symmetric, it will frequently be asymmetric. Samples of the different sort of curves actually observed are given.

Asymmetric curves may be the result.

1. Of the selective influence working on one side of a symmetric curve and be then found in more or less mature specimens.

2. Of the reaction to a change in the environment and indicative of a mutation or change in the mean specific form.

3. Of the double origin of the material under consideration, and may then have a great variety of forms, from slightly asymmetric curve to one with a broad top or with many peaks.

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VARIATION OF NORTH AMERICAN FISHES. II.

The Variation of Etheostoma Caprodes Rafinesque in Turkey Lake and Tippecanoe Lake.* By W. J. Moenkhaus.

Introduction.—In a former paper on the "Variation of *Etheostoma caprodes* Rafinesque" (Am. Nat., Aug., 1894), I determined the geographical distribution of this fish and the geographical variation of its color-pattern and fins.

It was found that this species inhabits practically all the fresh waters of the Atlantic slope east of the 100th meridian and west of the Alleghany Mountains. Its northern and eastern limits are the Great Lakes and Lake Champlain; its southwestern, the Rio Grande in the extreme southern part of Texas.

The following conclusions were reached among others:

1. Each river system from which specimens were examined possesses a peculiar variety. This peculiarity is most striking in the color-pattern.

2. All the variations are continuous.

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*Contributions from the Zoölogical Laboratory of the Indiana University under the direction of C. H. Eigenmann, No. 18.

3. The variation in the anal rays and dorsal spines are determinate with the latitude, the southern specimens having a slightly larger number of rays and spines.

4. The color-pattern variations are determinate, varying through definite stages from a simple to more complex pattern.

In Table A and B are given the data on the anal rays and dorsal spines. The localities are arranged in the order of their latitude from north to south. From these we see that there is both an increase in the average number of rays and spines and in the number that prevails in each case from north to south. In the anal fin 10 is the prevailing number north, and 11 and 12 south, of the Ohio River. Fourteen and fifteen are the prevailing number of dorsal spines in the north and 15, 16 and 17 in the south.

TABLE A.

LOCALITY.	Number of Specimens.	Average Number of Anal Rays.	Number of Specimens with 10 Rays.	Number of Specimens with 11 Rays.	Number of Specimens with 12 Rays.
Torch Lake, Mich	7	$10\frac{1}{7}$	6	1	......
Cedar Rapids, Iowa	1	12	......	......	1
White River, at Indianapolis	1	10	1	......	......
Gosport, Ind	5	10	5	......	......
Bean Blossom, Ind	17	$10\frac{9}{17}$	8	9	......
Rushville, Ind	1	10	1	......	......
Wild Cat Creek, Ind	1	11	......	1	......
Pike Creek, Ind	2	11	......	2	......
Illinois	1	10	1	......	......
Nipisink Lake, Ill	2	$10\frac{1}{2}$	1	1	......
Monongahela River	1	10	1	......	......
Hartford, Ky	4	$10\frac{1}{4}$	3	1	......
Green River, Greensburg, Ky	3	$10\frac{2}{3}$	1	2	......
Little Barren River, Osceola, Ky	4	11	......	4	......
Little South Fork Cumberland River, Wayne County, Ky	1	11	......	1	......
Eagle Creek, Olympus, Tenn	2	11	......	2	......
Obeys River, Elizabethtown, Tenn	13	$11\frac{6}{13}$	1	5	7
Watauga River, Elizabethtown, Tenn	2	$10\frac{1}{2}$	1	1	......
North Fork Holston River, Saltville, Va	1	12	......	......	1
Eureka Springs, Ark	1	......	......	......	......
Chocola Creek, Oxford, Ala	4	$11\frac{1}{4}$	......	3	1
San Marcos Springs, Tex	2	11	......	2	......

TABLE B.

LOCALITY.	Number of Specimens.	Average Number of Dorsal Spines.	Number of Specimens with 13 Rays.	Number of Specimens with 14 Rays.	Number of Specimens with 15 Rays.	Number of Specimens with 16 Rays.	Number of Specimens with 17 Rays.
Torch Lake, Mich	7	$14\frac{4}{7}$	....	3	4	....	....
Cedar Rapids, Iowa	1	14	....	1	....	....	....
White River, at Indianapolis	1	14	....	1	....	....	....
Gosport, Ind	5	$14\frac{4}{5}$	....	1	4	....	....
Bean Blossom, Ind	17	$14\frac{6}{17}$	1	9	7	....	....
Rushville, Ind	1	14	....	1	....	....	....
Wild Cat Creek, Ind	1	15	....	....	1	....	....
Pike Creek, Ind	2	$14\frac{1}{2}$	....	1	1	....	....
Illinois	1	15	....	....	1	....	....
Nipinsik Lake, Ill	2	$14\frac{1}{2}$	....	1	1	....	....
Monongahela River	1	15	....	....	1	....	....
Hartford, Ky	4	15	....	1	2	1	....
Green River, Greensburg, Ky	3	15	....	....	3	....	....
Little Barren River, Osceola, Ky	4	15	....	1	2	1	....
Little South Fork Cumberland River, Wayne County, Ky	1	16	....	....	....	1	....
Eagle Creek, Olympus, Tenn	2	$16\frac{1}{2}$	....	....	....	1	1
Obeys River, Elizabethtown, Tenn	13	$16\frac{6}{13}$	....	....	2	3	8
Watauga River, Elizabethtown, Tenn	2	$15\frac{1}{2}$	....	....	1	1	....
North Fork Holsten River, Saltville, Va	1	16	....	....	....	1	....
Eureka Springs, Ark	1	16	....	....	....	1	....
Chocola Creek, Oxford, Ala	4	$15\frac{1}{2}$	....	....	2	2	....
San Marcos Springs, Tex	2	$13\frac{1}{2}$	1	1	....	....	....

The color-pattern varies from a probably primitive, simple pattern consisting of alternate whole and half cross-bars distributed along the entire length of the body through the pattern consisting of whole, half and quarter bars, having an incomplete longitudinal series of lateral spots to a pattern having a very prominent longitudinal series of dark lateral blotches with fine reticulations on the back. Between these different patterns all stages exist, so that they can be connected by regular steps. Those specimens inhabiting the lakes were found to possess a peculiar color-pattern. This was derived from the primitive, simple pattern by supposing the lower part of the whole bars to have become much broader than the upper part, and then to have shifted backwards slightly.

This lake variety (*maniton*, Jordan) is one of the most abundant of the fishes in Turkey and Tippecanoe Lakes, and upon it the results given in the following pages are based.

Six hundred specimens, all that were collected from Turkey Lake, and three hundred of those collected from Tippecanoe Lake, have been examined with a view, first, of making a comparison of this species in the two lakes, and second, of determining the range and character of its variation within Turkey Lake itself. The number of species collected from Tippecanoe Lake is much greater than 300, but this number was thought sufficient to give fairly good results. The effect of natural selection will be taken up at a later time.

Etheostoma caprodes has two dorsal fins, the first, a spinous one, well separated from the second, which is composed of soft rays. The anal fin is composed of two rather strong spines followed by a number of soft rays. The scales are very regularly arranged, so that they can be definitely counted along the complete lateral lines. The number of spines and rays in these fins, and the number of scales in the lateral line of both sides of the body have been determined. Besides these characters the presence or absence of scales on the nape has been determined. These structures have been taken because, with the exception of the last, they present definite, countable elements, so that in the results the personal factor is entirely eliminated.

Curves have been constructed to represent the variation in these structures. In all the curves the horizontal distances represent the countable elements, and the vertical distances the per cent. of specimens possessing these varying elements.

COMPARISON OF TURKEY LAKE AND TIPPECANOE SPECIMENS.

COLORATION.—The coloration of these fishes in the two lakes will be taken up in detail later. The color-pattern of Turkey Lake specimens is, on the whole, of a more blotched character than that of Tippecanoe Lake specimens, and shows a slighter affinity to the simple, primitive coloration characteristic of the Wabash River forms. The connection of Tippecanoe Lake with the Wabash River may account for this greater affinity.

SQUAMATION OF NAPE.—In Turkey Lake the nape is as a rule naked, while in Tippecanoe Lake it is usually scaled. Table I will bring out the difference.

TABLE I.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having no scales on nape	88.00	19.32
Per cent of specimens having few scales on nape.............	8.00	23.87
Per cent. of specimens having several scales on nape	4.00	28.32
Per cent. of specimens having nape thinly sealed.............	0.20	16.67
Per cent. of specimens having nape closely scaled	0.00	11.74

LATERAL LINE.—The specimens of Turkey Lake have on an average two more scales in the lateral line. The average number for Turkey Lake is 89.46 for the left side, 89.74 for the right side; for Tippecanoe Lake, 87.69 for the left side, 87.45 for the right side. Fig. 1 represents the curves for the scales of the right side. The continuous line represents the conditions in Turkey Lake, and the broken line those of Tippecanoe Lake. It should be noticed that the entire curve for Turkey Lake is two units to the right of that of Tippecanoe Lake, showing that practically all the Turkey Lake specimens have a greater number of scales. Table II contains the summary of the counts for the scales in the lateral line.

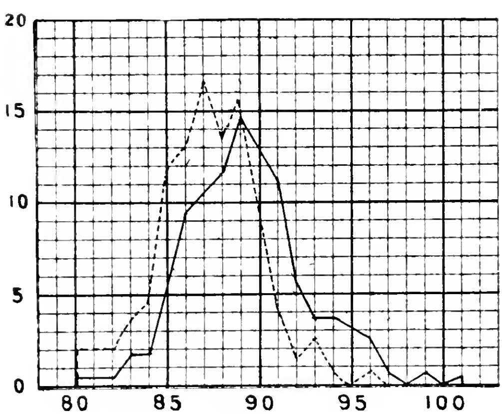

FIG. 1.

TABLE II.

	Turkey Lake.		Tipp'canoe Lake	
	Left Side.	Right Side.	Left Side.	Right Side.
Per cent. of specimens having 78 scales....	0.17	....	....	....
Per cent. of specimens having 79 scales....	....	....	....	....
Per cent. of specimens having 80 scales....	0.17	0.34	....	....
Per cent. of specimens having 81 scales....	....	0.34	0.50	....
Per cent. of specimens having 82 scales....	0.17	0.34	1.00	2.00
Per cent. of specimens having 83 scales....	1.37	1.55	2.50	3.50
Per cent. of specimens having 84 scales....	3.44	1.89	7.00	4.50
Per cent. of specimens having 85 scales....	3.78	5.17	8.50	11.50
Per cent. of specimens having 86 scales....	6.88	9.30	11.50	13.00
Per cent. of specimens having 87 scales....	11.02	10.68	15.00	16.50
Per cent. of specimens having 88 scales....	12.56	11.55	15.00	13.50
Per cent. of specimens having 89 scales....	17.72	14.82	16.00	16.00
Per cent. of specimens having 90 scales....	12.39	12.93	11.50	10.50
Per cent. of specimens having 91 scales....	8.08	11.03	7.50	4.00
Per cent. of specimens having 92 scales....	6.53	5.67	1.50	1.50
Per cent. of specimens having 93 scales....	5.16	3.62	1.00	2.50
Per cent. of specimens having 94 scales....	3.61	3.78	0.50	0.50
Per cent. of specimens having 95 scales....	2.58	3.27	0.50	....
Per cent. of specimens having 96 scales....	1.37	2.41	0.50	0.50
Per cent. of specimens having 97 scales....	1.03	0.51	....	....
Per cent. of specimens having 98 scales....	0.17	....	....	....
Per cent. of specimens having 99 scales....	0.34	0.34	....	....
Per cent. of specimens having 100 scales....	....	....	....	....
Per cent. of specimens having 101 scales....	0.17	0.17	....	....
Per cent. of specimens having 102 scales....	0.17	....	....	....
Per cent. of specimens having 103 scales....	0.17	....	....	....

Anal fin.—The number of spines in the anal fin varies from the normal in only nine specimens from Turkey Lake and in six from Tippecanoe Lake. This variation is always toward a lower number, and extends only through one spine.

Turkey Lake specimens have on an average fewer rays in the anal than Tippecanoe Lake specimens. The averages are 10.87 for the former, 11.15 for the latter. Fig. 2 represents the curves for the anal rays. Here again, and also in the succeeding curves for the comparison of the two lakes, the continuous line represents Turkey Lake and the broken line Tippecanoe Lake. Table III gives the summary of the anal rays for both lakes.

The prevailing number of rays in both lakes is 11; 53 per cent. from Turkey lake, and 56 per cent. from Tippecanoe Lake having that number. The number of rays in the next highest per cent. is 10 for Turkey Lake and 12 for Tippecanoe Lake, about 27 per cent. in each case.

The range of variation is two greater in Turkey Lake. This may be due t the greater number of specimens from this lake.

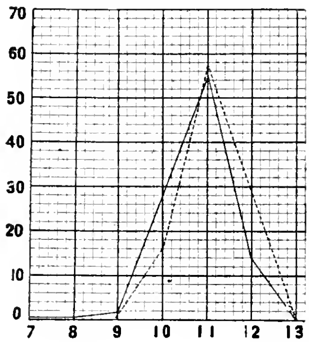

Fig. 2.

TABLE III.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 7 anal rays	0.16	....
Per cent. of specimens having 8 anal rays	0.16	....
Per cent. of specimens having 9 anal rays	1.48	0.77
Per cent. of specimens having 10 anal rays	26.80	15.50
Per cent. of specimens having 11 anal rays	53.43	56.21
Per cent. of specimens having 12 anal rays	14.13	27.13
Per cent. of specimens having 13 anal rays	0.49	0.35

Dorsal Spines.—Turkey Lake has on an average more dorsal spines, the average being 14.52 for Turkey Lake and 14.23 for Tippecanoe Lakes. Fig. 3 represents the curves for this structure. The range of variation is the same, from 12 to 17. Although the average number of spines differs but slightly in the two lakes, the preferences shown for a given number of spines are quite different. In the Tippecanoe Lake specimens the preference is decidedly for 14. In the Turkey Lake specimens the preference is for 15, although not so decided. From Table IV and the curves, it will be seen that the number of individuals in Turkey Lake having 14 spines and 15 spines are about the same, 41 per cent. having 14 and 44 per cent., 15, while in Tippecanoe Lake this is not the case, 60 per cent. having 14, and only 25 per cent. having 15.

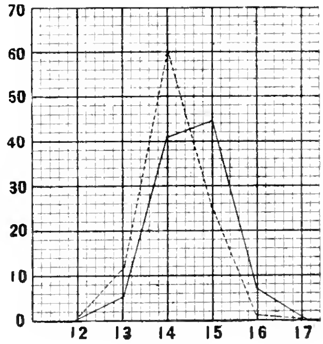

Fig. 3.

TABLE IV.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 12 dorsal spines................	0.32	0.38
Per cent. of specimens having 13 dorsal spines................	5.09	11.24
Per cent. of specimens having 14 dorsal spines................	41.26	60.85
Per cent. of specimens having 15 dorsal spines................	44.22	25.96
Per cent. of specimens having 16 dorsal spines................	6.90	1.16
Per cent. of specimens having 17 dorsal spines................	0.65	0.38

Dorsal Rays.—The average number of dorsal rays for Turkey Lake is 14.87, for Tippecanoe Lake, 16.40, the latter having on an average almost two more. The curves are given in Fig. 4. From this and Table V it will be seen that Turkey Lake specimens show a decided preference for 15 rays, while the Tippecanoe Lake specimens show just as decided a preference for 16 rays, 52 per cent. of the specimens having these numbers in both lakes. The range of variation is two greater in Turkey Lake, from 12 to 18 as compared from 14 to 18 in Tippecanoe Lake. This again may be due to the greater number of specimens.

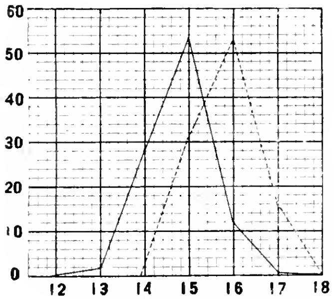

FIG. 4.

TABLE V.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 12 dorsal rays	0.32	....
Per cent. of specimens having 13 dorsal rays	1.48	....
Per cent. of specimens having 14 dorsal rays	28.77	3.48
Per cent. of specimens having 15 dorsal rays	52.26	31.78
Per cent. of specimens having 16 dorsal rays	12.16	52.32
Per cent. of specimens having 17 dorsal rays	1.64	15.11
Per cent. of specimens having 18 dorsal rays	0.16	0.77

Table VI presents all the combinations of dorsal spines and dorsal rays from both lakes. The spines are represented by Roman numbers and the rays by Arabic numbers. The commonest combination in Turkey Lake is XIV-15 and XV-15; XIV, XV, occurring most frequently in the spinous dorsal, and 15 most frequently in the soft dorsal. The per cent. of specimens having these combinations is 22.46 and 24.49 respectively. In Tippecanoe Lake, XIV-16 is the commonest combination, XIV being the prevailing number in the spinous dorsal and 16 in the soft dorsal. 32.11 per cent. of the specimens have this combination.

TABLE VI.

		From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having the combination	XII–14.....	0.16	....
Per cent. of specimens having the combination	XII–15.....	0.16	....
Per cent. of specimens having the combination	XII–16.....	....	0.37
Per cent. of specimens having the combination	XIII–14.....	0.84	0.37
Per cent. of specimens having the combination	XIII–15.....	3.71	2.22
Per cent. of specimens having the combination	XIII–16.....	0.67	5.92
Per cent. of specimens having the combination	XIII–17.....	....	2.59
Per cent. of specimens having the combination	XIV–12.....	0.16	....
Per cent. of specimens having the combination	XIV–13.....	1.01	....
Per cent. of specimens having the combination	XIV–14.....	11.99	1.48
Per cent. of specimens having the combination	XIV–15.....	**22.46**	20.37
Per cent. of specimens having the combination	XIV–16.....	5.74	**32.11**
Per cent. of specimens having the combination	XIV–17.....	0.33	6.66
Per cent. of specimens having the combination	XIV–18.....	....	1.11
Per cent. of specimens having the combination	XV–13.....	0.67	....
Per cent. of specimens having the combination	XV–14.....	13.51	1.85
Per cent. of specimens having the combination	XV–15.....	**24.49**	8.14
Per cent. of specimens having the combination	XV–16.....	5.40	14.44
Per cent. of specimens having the combination	XV–17.....	0.84	1.48
Per cent. of specimens having the combination	XV–18.....	0.16	....
Per cent. of specimens having the combination	XVI–12.....	0.16	....
Per cent. of specimens having the combination	XVI–13.....	0.16	....
Per cent. of specimens having the combination	XVI–14.....	2.36	....
Per cent. of specimens having the combination	XVI–15.....	3.04	1.11
Per cent. of specimens having the combination	XVI–16.....	0.84	0.37
Per cent. of specimens having the combination	XVI–17.....	0.33	....
Per cent. of specimens having the combination	XVII–14.....	0.50	....
Per cent. of specimens having the combination	XVII–15.....	....	0.37
Per cent. of specimens having the combination	XVII–16.....	0.16	....
Per cent. of specimens having the combination	XVIII–14.....	0.16	....

In Table VII is given the variation in the two dorsal fins taken together. The average number for the two fins is 29.21 for Turkey Lake and 30 for Tippecanoe Lake. In Turkey Lake 36.82 per cent. have the average number; in Tippecanoe Lake, 41.8 per cent. The range of variation in the fins separately is six for the spinous dorsal and five for the soft dorsal in Tippecanoe Lake, and seven in each dorsal fin in Turkey Lake. With an exception in the spinous dorsal in Tippecanoe Lake the range of variation is, in each case, one greater for the two fins taken together, than for the fins separately. Although the extent of variation is only one greater for the two fins together, the per cent. of specimens having the average number is much smaller than the per cent. of specimens having the average number in the fins separately. In Turkey Lake nearly 37 per cent. have the average number of the fins taken together, while 44 per cent. and 52 per cent. have the average number in the spinous and soft dorsal respectively. In Tippecanoe Lake 41 per cent. have the average number for both fins, while 52 per cent. and 61 per cent. have the average number in the spinous and soft dorsals respectively.

TABLE VII.

	From Turkey Lake.	From Tippecanoe Lake.
Per cent. of specimens having 26 rays in the dorsals	0.33	....
Per cent. of specimens having 27 rays in the dorsals	2.02	0.37
Per cent. of specimens having 28 rays in the dorsals	16.38	4.07
Per cent. of specimens having 29 rays in the dorsals	36.82	28.15
Per cent. of specimens having 30 rays in the dorsals	32.59	41.80
Per cent. of specimens having 31 rays in the dorsals	9.28	22.22
Per cent. of specimens having 32 rays in the dorsals	1.85	3.33
Per cent. of specimens having 33 rays in the dorsals	0.67	....

SUMMARY.

1. This species is equally abundant in the two lakes.

2. The color pattern of Tippecanoe Lake specimens shows a greater affinity for the primitive, simple Wabash River pattern than does that of Turkey Lake specimens.

3. In Turkey Lake the nape is usually naked; in Tippecanoe Lake the nape is usually scaled.

4. Tippecanoe Lake specimens have a smaller number of scales in the lateral line.

5. The anal spines vary but little, and show the same variation in the two lakes.

6. The anal fin is somewhat larger in the Tippecanoe Lake specimens.

7. Turkey Lake specimens have one more dorsal spine.

8. Tippecanoe Lake specimens have one more dorsal ray, 16 rays is the mean in Tippecanoe Lake and 15 in Turkey Lake.

9. The combinations of the dorsal spines and rays are determined by the numbers that prevail in the fins separately.

10. The range of variation in the total number of dorsal spines and rays combined is one greater than the variation in the fins separately.

11. The number occurring most frequently is 29 in Turkey Lake and 30 in Tippecanoe Lake.

12. The preference shown for a given number is less decided for the two dorsal fins taken together than for the dorsal fins taken separately.

13. The variation is in all cases continuous.

THE VARIATION IN TURKEY LAKE.

Many of the facts on the extent and character of the variation of the 600 specimens from Turkey Lake, taken as a whole, have been given in the preceeding.

The lengths of the 660 specimens from Turkey Lake were measured and upon comparison were found to fall into three quite distinct groups. Fig. 5 represents the curve for all. Each of the smaller horizontal distances represents one mm. and each of the larger verticle distances one per cent. The sizes ranged from 27 mm. to 102 mm. The first group ranges from 27 mm. to 60 mm.; the second from 60 mm. to 80 mm., and the third from 79 mm. to 103 mm. The three curves of Fig. 5 represent these three groups. I have watched the growth during the first summer, and know the first curve to represent the first summer's fish. The second curve in all probability represents the second year's fish, and the third curve, those three years old and over. The growth, thus, is most rapid during the first summer, the rate of growth decreasing each year after. The fish reaches practically its full size the third year, though the more gradual slope to the right of the last curve shows that it does not cease growing entirely.

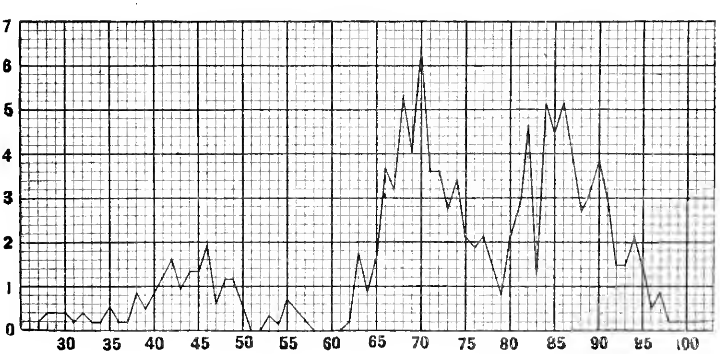

FIG. 5.

Having grouped them into three definite ages, a summary of the characters for each was made, and curves constructed. Figs. 6, 7, 8 and 9 represent the curves for these characters. In all the curves constructed for these ages, the continuous line is for the third year specimens, the broken line for the second year specimens and the dotted line for the first year specimens.

Lateral Line.—Below is the table of the average number of scales in the lateral line of the three ages.

	1st year.	*2d year.*	*3d year.*
Right side	87.84	90.80	88.39
Left side.	88.00	89.80	88.78

From this it is seen that the first and third year specimens are most nearly alike. The second year specimens have about two scales more. By reference to the curves, Fig. 6, and Table VIII below, it will be seen that the great bulk of the specimens of all three ages have from 85 to 92 scales. The increased average in the second year is due to a larger per cent. having 93, 94, 95 and 96 scales than in the first and second years.

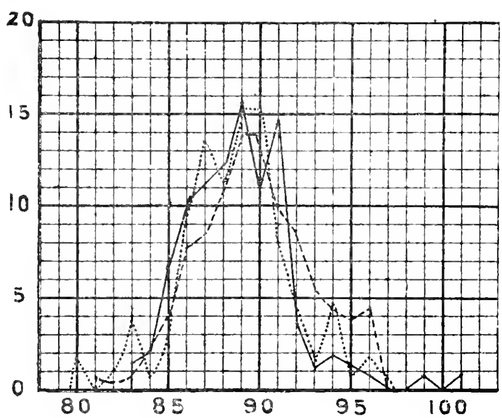

Fig. 6.

TABLE VIII.

	Per Cent. of Specimens Having 80 Scales.	Per Cent. of Specimens Having 81 Scales.	Per Cent. of Specimens Having 82 Scales.	Per Cent. of Specimens Having 83 Scales.	Per Cent. of Specimens Having 84 Scales.	Per Cent. of Specimens Having 85 Scales.	Per Cent. of Specimens Having 86 Scales.	Per Cent. of Specimens Having 87 Scales.	Per Cent. of Specimens Having 88 Scales.	Per Cent. of Specimens Having 89 Scales.	Per Cent. of Specimens Having 90 Scales.	Per Cent. of Specimens Having 91 Scales.	Per Cent. of Specimens Having 92 Scales.	Per Cent. of Specimens Having 93 Scales.	Per Cent. of Specimens Having 94 Scales.	Per Cent. of Specimens Having 95 Scales.	Per Cent. of Specimens Having 96 Scales.	Per Cent. of Specimens Having 97 Scales.	Per Cent. of Specimens Having 98 Scales.	Per Cent. of Specimens Having 99 Scales.	Per Cent. of Specimens Having 100 Scales.	Per Cent. of Specimens Having 101 Scales.
First year specimens	1.99	....	.96	3.84	.46	3.84	9.97	13.45	11.52	15.38	15.38	5.69	4.50	1.99	4.50	.96	1.92	.96	......	......	......	......
Second year specimens	....	.85	.42	.85	2.14	4.29	7.72	8.58	10.73	13.73	13.73	9.87	8.58	5.57	4.29	3.86	4.29	4.29	......	......	......	......
Third year specimens	....	....	....	1.22	2.04	7.35	10.24	11.47	12.28	15.57	11.06	14.34	3.67	2.47	2.86	3.68	.81	.40	......	.81	......	.40

ANAL FIN. Five out of 116 first year specimens have one anal spine; 6 out of 236 of the second year, and 3 out of 246 of the oldest specimens.

The average number of anal rays are 10.56 for the first year, 10.74 for the second year and 11.00 for the third year specimens.

The curves in Fig. 7 and Table IX, below, show that the anal fins of the first and second year specimens more nearly resemble each other. All three ages show a preference for 11.00 rays. The per cent. of specimens having this number are 51.69, 52.53 and 61.60 for the first, second and third year specimens respectively. The per cent. of specimens having 10 rays is reduced from 36.43 in the first year to 20.57 in the third year, and the per cent. of those having 12 rays is increased from 5.09 in the first year to 20.16 in the third year. There is a very evident increase in the number of spines with the age.

The extent of variation of the second and third year specimens is the same. The first year specimens, although only half as many, exceed the other ages two rays in the extent of variation.

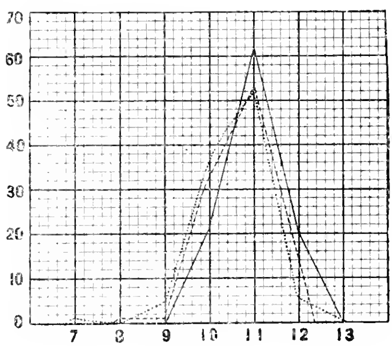

FIG. 7.

TABLE IX.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 7 anal rays	0.84	....	....
Per cent. of specimens having 8 anal rays	....	0.42	....
Per cent. of specimens having 9 anal rays	5.09	1.69	0.82
Per cent. of specimens having 10 anal rays	36.43	32.19	20.57
Per cent. of specimens having 11 anal rays	51.69	52.53	61.60
Per cent. of specimens having 12 anal says	5.09	13.12	20.16
Per cent. of specimens having 13 anal rays	0.84	....	0.82

Several important facts brought out by the preceding comparison are worth consideration.

1. No two of the ages here compared are alike in all the characters.

2. In the anal fin and soft dorsal there is a definite increase in the number of rays with the age.

3. Variation of this nature is not present in the other structures.

4. The extent of variation in the different ages is about the same.

Dorsal Rays.—The average number of dorsal rays are 14.57, 14.76 and 14.98 for the first, second and third year specimens, respectively. There is a slight increase with age. The summaries for this structure are given below in Table XI, and the curves in Fig. 8. The prevailing number of rays is 15 for all three ages, the per cents. being 53.39, 52.53 and 55.69 for the first, second and third year specimens, respectively. The per cent. of specimens having 14 rays decreases from 40.72 in the first year to 22.35 in the third year specimens, while the per cent. of specimens having 16 rays increases from 3.38 in the first year specimens to 16.73 in the third year specimens. The extent of variation is from 12 to 16 in the first year, from 12 to 17 in the second year and from 13 to 18 in the third year specimens. As in the anal fin there is a tendency toward a greater number of rays as the fish grows older.

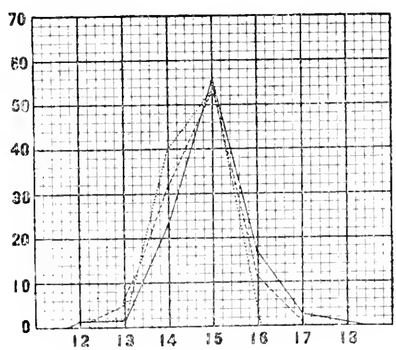

Fig. 8.

TABLE XI.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 12 dorsal rays	0.84	0.42	....
Per cent. of specimens having 13 dorsal rays	1.69	2.96	1.21
Per cent. of specimens having 14 dorsal rays	40.72	30.50	22.35
Per cent. of specimens having 15 dorsal rays	53.39	52.53	55.69
Per cent. of specimens having 16 dorsal rays	3.38	11.48	16.73
Per cent. of specimens having 17 dorsal rays	....	0.84	3.25
Per cent. of specimens having 18 dorsal rays	....	....	0.40

Dorsal Spines.—The averages for this structure are 14.69 for the first year, 14.39 for the second and 14.65 for the third year, the first and third years being almost identical, and the second year having a fewer number. Fig. 9 represents the curves for this structure. The curves of the first and third years are almost identical, both showing a preference for 15, with about 35 per cent. for 14. The second year shows as decided a preference for 14, about 35 per cent. for 15. This structure varies from 13 to 16 in the first year specimens, from 12 to 17 in the second year specimens and from 13 to 17 in the third year specimens. Table X contains the summaries for this structure.

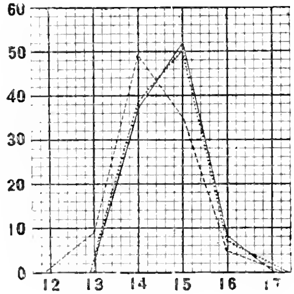

Fig. 9.

TABLE X.

	First Year.	Second Year.	Third Year.
Per cent. of specimens having 12 dorsal spines....	....	0.84	....
Per cent. of specimens having 13 dorsal spines....	1.69	8.47	3.65
Per cent. of specimens having 14 dorsal spines....	38.98	49.14	36.17
Per cent. of specimens having 15 dorsal spines....	50.00	35.16	51.62
Per cent. of specimens having 16 dorsal spines....	7.62	5.50	8.13
Per cent. of specimens having 17 dorsal spines....	....	0.42	0.40

The first and third year specimens resemble each other very closely in regard to the scales in the lateral line and the dorsal spines. In these characters the second year specimens show a decided difference. These have on an average two more scales in the lateral line, and have 14 as the prevailing number of dorsal spines instead of 15, the number in the first and third year specimens.

Several explanations might be suggested to account for a part or all of these differences.

The explanation suggesting itself most readily is that an additional spine and ray are added during the life of the individual. I have gone over all the specimens carefully with this point in view, but find no evidence either of the splitting of a ray or spine, or of the new growth of these, except at the anterior of the dorsal fins. Here may be found numerous instances of shorter spines and rays from two-thirds to one-fourth the normal length. But among so many specimens it is entirely probable that these spines and rays would be found in every possible stage of growth. But this is not the case. The spines and rays, although sometimes only one-fourth the full length, are always strong and suggest aborted rather than immature structures. Besides, if this were the case, we would expect to find the tendency toward a lower number of spines, and rays very decided in the first year specimens. While this condition is true in the dorsal and anal rays, it is decidedly not true in the dorsal spines, where the characters in the first years are almost identical with those of the third year.

Natural Selection.—The principle of natural selection, the influence of which upon this species I hoped in the onset of this work to find, can not be applied in explanation of the difference in the number of scales and dorsal spines without serious objections. If natural selection were the determining factor in producing these differences, we should expect all the variations graduated with the age. We would expect to have a narrower range of variation as the specimens grow older. Neither of these conditions obtain. There are neither 18 dorsal rays nor 13 anal rays represented in the second year specimens; and in the first year specimens 17 dorsal rays are not represented. In the dorsal spines where the difference is most pronounced we have in the first year specimens the exact duplicate of that of the third year specimens, while the second year specimens are quite different. The scales in the lateral line present the same difficulty.

ANNUAL VARIATION.—The explanation that seems to meet all the conditions most satisfactory is that the species varies with the varying conditions of successive years.

The difference in the dorsal spines of the different ages accounts thus for the abnormality of the curve for the dorsal spines of all the Turkey Lake specimens, Fig. 4. The 600 specimens for which the curve is constructed is a composite lot of three age varieties.

This conclusion, however, should be held with some reservation. It will be noticed that nearly all the curves of Figs. 7, 8 and 9 are abnormal curves, which may possibly be due to the presence of local races in the lake. While this may possibly be the case, it is not at all probable, because, in the first place, the curve constructed for the dorsal spines of 100 specimens of three year olds, taken within a distance of 100 yards along the shores where the conditions were undoubtedly uniform, gave a curve identical with that for all the three year olds. In the second place, the second and third year specimens are found in about equal abundance together, and since these were promiscuously preserved it is altogether probable that from any given locality, an equal number of each age was taken.

The sex has been determined in all, and a summary shows that the sexes do not differ in the characters entering into the above considerations.

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