THIRD REPORT

OF THE

MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, MARCH 28, 29 AND 30, 1901

PREPARED UNDER THE DIRECTION OF THE COUNCIL

By JAS. B. POLLOCK, Sc. D., Secretary

BY AUTHORITY

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OF THE

MICHIGAN ACADEMY OF SCIENCE

LETTER OF TRANSMITTAL

To Honorable A. T. Bliss, *Governor of the State of Michigan:*

Sir—I have the honor to submit herewith the Third Annual Report of the Michigan Academy of Science, for publication in accordance with Section 14 of Act No. 44, of the Public Acts of the Legislature of 1899.

Respectfully,

JAS. B. POLLOCK,

Secretary of the Michigan Academy of Science.

Ann Arbor, Mich., March 26, 1902.

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ABSTRACT[1] OF HISTORY OF THE MICHIGAN ACADEMY OF SCIENCE.

The movement which finally resulted in the organization of the Michigan Academy of Science was first started in 1892. In response to a feeling that it was desirable to effect an organization of the men interested in the work in natural science in the State of Michigan, a circular letter was sent to a considerable number of men believed to be interested, asking for their opinions in regard to the organization of a State Society of Naturalists, the scope of the work, and the character of the membership. This letter was sent out by Prof. J. E. Reighard, of the University of Michigan, and was also signed by Profs. V. M. Spalding, W. H. Howell and J. B. Steere, of the same institution, all interested in the biological sciences.

The answers to this letter indicated that an organization was desirable with a membership not very closely restricted.

Nothing further was done until 1894, when another letter was sent out by Profs. J. B. Steere, W. P. Lombard, and F. C. Newcombe, of the University of Michigan, calling a meeting at the University for June 27, to organize a State Natural History Society. About 25 people responded to this call, and a temporary organization was effected. The officers elected at this meeting served until a permanent organization was effected, and acted as an advisory board with the duty of recommending a name for the society, and a constitution and by-laws for adoption by it. The name recommended was the "Michigan Academy of Sciences," and the object of the society was the study of agriculture, archaeology, botany, geography, geology, mineral resources, zoology, etc., of the State of Michigan, and the diffusion of the knowledge thus gained among men.

The permanent organization was finally effected at a meeting held in Lansing, December 26 and 27, 1894, at which a constitution and by-laws were adopted, and sections organized in zoology, botany and sanitary science.

The constitution provides for a summer or field meeting and a winter or annual meeting. At present (1901) the summer meetings have been discontinued by common consent. The winter meetings have been continued with increasing importance and value. At the second field meeting held at the Michigan Agricultural College, June 13, 1896, permission was granted to organize a section of agriculture; so that the academy at the present time consists of four sections, those of zoology, botany, sanitary science, and agriculture.

Important aid was given to the Michigan Academy of Science by the State Legislature in 1899. Section 14 of act No. 44 provides for the

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[1]The history of the Academy will be found in full in the First Annual Report.

publication of a report of the meetings of the academy at the expense of the State. This section reads as follows:

Sec. 14. There shall be printed of the following reports the number of copies herein indicated. Not to exceed one hundred copies of each shall be printed and bound and retained in the office of Secretary of State for future distribution. The number indicated in section 20 shall be printed for the purposes indicated in section 20, and in addition there shall be printed the number of copies, as follows, which shall be distributed by the heads of the departments making the report:

* * * * * * * *

Report of the Michigan Academy of Science, not to exceed one thousand copies of two hundred fifty pages each.

Sec. 20. There shall be printed of all publications, reports and documents as provided in this act, such additional copies for use and exchanges by the State library as the State Librarian may in his discretion deem necessary for such purpose, but not exceeding two hundred copies of any one publication, and it shall be the duty of the Board of State Auditors to advise with the State Librarian, prior to ordering the State printer to print such publications, that the proper number be ordered from the State printer and delivered to the State Librarian:"

The Academy thus receives substantial aid in accomplishing one of the tasks set for itself, namely, the distribution of scientific knowledge. This distribution is not confined to the State of Michigan alone, but through the exchanges of the State Library, and of the Academy itself with other similar organizations, the knowledge contributed by the members of the Academy is made accessible to the scientific world in general.

CONSTITUTION

OF THE

MICHIGAN ACADEMY OF SCIENCE.

ARTICLE I.

This Society shall be known as THE MICHIGAN ACADEMY OF SCIENCE.

ARTICLE II: OBJECTS.

The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science.

ARTICLE III: MEMBERSHIP.

The Academy shall be composed of *Resident Members, Corresponding Members, Honorary Members, and Patrons.*

1. Resident Members shall be persons who are interested in scientific work and resident in the State of Michigan.
2. Corresponding Members shall be persons interested in science, and not resident in the State of Michigan.
3. Honorary Members shall be persons distinguished for their attainments in science, and not resident in the State of Michigan, and shall not exceed twenty-five in number.
4. Patrons shall be persons who have bestowed important favors upon the Academy, as defined in Chapter I, Paragraph 4 of the By-Laws.
5. Resident Members alone shall be entitled to vote and hold office in the Academy.

ARTICLE IV: OFFICERS.

1. The officers of the Academy shall consist of a President, a Vice President of each Section that may be organized, a Secretary, and a Treasurer.

These officers and all past presidents shall constitute an Executive Committee, which shall be called the *Council.*

2. The PRESIDENT shall discharge the usual duties of a presiding officer at all meetings of the Academy, and of the Council. He shall take cognizance of the acts of the Academy and of its officers, and cause the

provisions of the Constitution and By-Laws to be faithfully carried into effect. He shall also give an address to the Academy at the closing meeting of the year for which he is elected.

3. The duties of the President in case of his absence or disability shall be assumed by one of the Vice-Presidents who shall be designated by the Council.

The VICE-PRESIDENTS shall be chairman of their respective Sections. They shall encourage and direct research in the special branches of science included within the Sections over which they preside.

4. The SECRETARY shall keep the records of the proceedings of the Academy, and a complete list of the members, with the dates of their election and disconnection with the Academy. He shall also be the Secretary of the Council.

The SECRETARY shall co-operate with the President in attending to the ordinary affairs of the Society. He shall attend to the preparation, printing and mailing of circulars, blanks, and notifications of elections and meetings. He shall superintend other printing ordered by the Academy, or by the President, and shall have charge of its distribution under the direction of the Council.

The SECRETARY, unless other provision be made, shall also act as *Editor* of the publications of the Academy and as *Librarian* and *Custodian* of property.

5. The TREASURER shall have the custody of all funds of the Academy. He shall keep an account of receipts and disbursements in detail, and this account shall be audited as hereinafter provided.

6. The Academy may elect an *Editor* to supervise all matters connected with the publication of the transactions of the Academy, under the direction of the Council, and to perform the duties of Librarian until such time as the Academy shall make that an independent office.

7. The COUNCIL is clothed with executive authority, and with the legislative powers of the Academy in the intervals between the latter's meetings; but no extraordinary act of the Council shall remain in force beyond the next following stated meeting, without ratification by the Academy. The Council shall have control of the publications of the Academy, under the provisions of the By-Laws and of resolutions from time to time adopted. It shall receive nominations for members, and on approval, shall submit such nominations to the Academy for action. It shall have power to fill vacancies *ad interim*, in any of the offices of the Academy.

8. TERMS OF OFFICE. The *President* and *Treasurer* shall be elected annually, and shall not be eligible to re-election for an interval of three years after retiring from office. The *Vice Presidents*, *Secretary*, and the *Editor* shall be elected annually and be eligible to re-election without limitation. [Section 8 was amended April 1, 1898, to read as follows: The President, Vice Presidents, Secretary, Treasuser, and Editor shall be elected annually, and be eligible to re-election without limitation.]

ARTICLE V: VOTING AND ELECTIONS.

1. All *elections* shall be by ballot. To elect a Resident Member, Corresponding Member, Honorary Member, or Patron, or impose any spe-

cial tax shall require the assent of three-fourths of all Resident Members voting.

2. Any member may be expelled by a vote of nine-tenths of all members voting, providing notice that such a movement is contemplated be given at a meeting of the Academy three months previous to such action.

3. ELECTION OF MEMBERS. Nominations for Resident membership shall be made by two Resident Members, according to a form to be provided by the Council. One of these Resident Members must be personally acquainted with the nominee and his qualifications for membership. The Council shall submit the nominations received by them, if approved, to a vote of the Academy at a regular meeting.

4. ELECTION OF OFFICERS. Nominations for office shall be made by the Council as provided in the By-Laws. The nominations shall be submitted to a vote of the Academy at its winter [Annual] meeting. The officers thus elected shall enter upon duty at the adjournment of the meeting.

5. At the meeting in which this Constitution is adopted the officers for the ensuing year shall be elected in such manner as the Academy may determine.

ARTICLE VI: MEETINGS.

1. The Academy shall hold at least two stated meetings a year—a *Summer [or Field] Meeting*, and a *Winter [or Annual] Meeting*. The date and place of each meeting shall be fixed by the Council, and announced by circular at least three months before the meeting. The programme of each meeting shall be determined by the Council, and announced beforehand, in its general features. The details of the daily sessions shall also be arranged by the Council.

2. All members must forward to the Secretary, if possible before the convening of the Academy, full titles of all papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery and a brief abstract of their contents. From the abstracts thus presented, the Council will determine the fitness of the paper for the programme.

3. This section stricken out April 1, 1898.

4. SPECIAL MEETINGS of the Academy may be called by the Council, and must be called upon the written request of twenty Resident Members.

5. STATED MEETINGS OF THE COUNCIL, shall be held coincidently with the stated meetings of the Academy. Special meetings of the Council may be called by the President at such times as he may deem necessary.

6. QUORUM. At meetings of the Academy a majority of those registered in attendance shall constitute a quorum. Four members shall constitute a quorum of the Council.

ARTICLE VII: PUBLICATIONS.

The publications of the Academy shall be under the immediate control of the Council, but the Council shall accord to each author the right, under proper restrictions, to publish through whatever channel he may choose.

ARTICLE VIII: SECTIONS.

Members not less than eight in number may by special permission of the Academy unite to form a Section for the investigation of any branch of science. Each Section shall bear the name of the science which it represents, thus: The Section of (Agriculture) of the Michigan Academy of Science.

2. Each Section is empowered to perfect its own organization as limited by the Constitution and By-Laws of the Academy.

ARTICLE IX: AMENDMENTS.

This Constitution may be amended at any Winter [Annual] meeting by a three-fourths vote of all the Resident Members present.

BY-LAWS.

CHAPTER I: Membership.

1. No person shall be accepted as a Resident Member unless he pay his initiation fee, and the dues for the year, within three months after notification of his election. The initiation fee shall be one (1) dollar and the annual dues one (1) dollar, the latter payable on or before the annual meeting in advance; but a single pre-payment of twenty-five (25) dollars shall be accepted as commutation for life.

2. The sums paid in commutation of dues shall be invested, and the interest used for the ordinary purposes of the Academy during the payer's life, but after his death the sum shall be covered into the Research Fund.

3. An arrearage in payment of annual dues shall deprive a Resident Member of the privilege of taking part in the management of the Academy and of receiving the publications of the Academy. An arrearage continuing over two (2) years shall be construed as notification of withdrawal.

4. Any person eligible under Article III of the Constitution, may be elected Patron upon the payment of one hundred (100) dollars to the Research Fund of the Academy.

CHAPTER II: Officials.

1. The President shall countersign, if he approves, all duly authorized accounts and orders drawn on the Treasurer for the disbursement of money.

2. The Secretary, until otherwise ordered by the Academy, shall perform the duties of Editor, Librarian, and Custodian of the property of the Society.

3. The Academy may elect an Assistant Secretary.

4. The Treasurer shall give bonds, with two good sureties approved by the Council, in the sum of five hundred dollars, for the faithful and honest performance of his duties, and the safe-keeping of the funds of the Academy. He may deposit the funds in bank at his discretion, but shall not invest them without the authority of the Council. His accounts shall be balanced on the first day of the Annual Meeting of each year.

5. The minutes of the proceedings of the Council shall be subject to call by the Academy.

CHAPTER III: ELECTION OF MEMBERS.

1. Nominations for Resident Membership may be proposed at any time on blanks to be supplied by the Secretary.

2. The *form* for the nomination of Resident Members shall be as follows:

In accordance with his desire, we respectfully nominate for Resident Member of the Michigan Academy of Science
(Full name)
(Address)
(Occupation)
(Branch of Science interested in, work already done, and publications if any)
(Signed by at least two Resident Members)

The form when filled is to be transmitted to the Secretary.

3. The Secretary shall bring all nominations before the Council at either the winter [Annual] or summer [Field] meeting of the Academy, and the Council shall signify its approval or disapproval of each.

4. At the same or the next stated meeting of the Academy, the Secretary shall present the list of candidates to the Academy for election.

5. Corresponding Members, Honorary Members, and Patrons shall be nominated by the Council, and shall be elected in the same manner as Resident Members.

CHAPTER IV: ELECTION OF OFFICERS.

Section 1. At the Annual Meeting the election of officers shall take place, and the officers elected shall enter on their duties at the end of the meeting.

Section 2. The Council shall nominate a candidate for each office, but each Section may recommend to the Council a candidate for its Vice President. Additional nominations may be made by any member of the Academy. All elections shall be made by ballot.

CHAPTER V: FINANCIAL METHODS.

1. No pecuniary obligation shall be contracted without express sanction of the Academy or the Council. But it is to be understood that all ordinary, incidental and running expenses have the permanent sanction of the Academy, without special action.

2. The creditor of the Academy must present to the Treasurer a fully *itemized* bill, *certified* by the official ordering it, and *approved* by the President. The Treasurer shall then pay the amount out of any funds not otherwise appropriated, and the receipted bill shall be held as his voucher.

3. At each annual meeting, the President shall call upon the Academy to choose two members, not members of the Council, to whom shall be referred the books of the Treasurer, duly posted and balanced to the first day of the Annual Meeting as specified in the By-Laws, Chapter II, Paragraph 4. These AUDITORS shall examine the accounts and vouchers of the Treasurer, and any member or members of the Council may be present during the examination. The report of the Auditors shall be

rendered to the Academy before the adjournment of the meeting and the Academy shall take appropriate action.

CHAPTER VI: Publications.

1. The publications are in charge of the Council and under their control, limited only as given by Article VII, of the Constitution.
2. One copy of each publication shall be sent to each Resident Member, Corresponding Member, Honorary Member, and Patron, and each author shall receive fifty copies of his memoir. This provision shall not be understood as including publications in journals not controlled by the Academy.

CHAPTER VII: The Research Fund.

1. The Research Fund shall consist of moneys paid by the general public for publications of the Academy, of donations made in aid of research, and of the sums paid in commutation of dues according to the By-Laws, Chapter I, Paragraphs 2 and 4.
2. Donors to this fund, not Members of the Academy, in the sum of twenty-five dollars, shall be entitled without charge, to the publications subsequently appearing.

CHAPTER VIII: Order of Business.

1. The Order of Business at the Winter [Annual] Meetings shall be as follows:

(1) Call to order by the Presiding Officer.
(2) Introductory ceremonies.
(3) Statements by the President.
(4) Report of the Council.
(5) Report of the Treasurer, and appointment of the Auditing Committee.
(6) Election of officers of the next ensuing Administration.
(7) Election of Members.
(8) Announcement of the hour and place for the Address of the retiring President.
(9) Necrological notices.
(10) Miscellaneous announcements.
(11) Business motions and resolutions, and disposal thereof.
(12) Reports of Committees, and disposal thereof.
(13) Miscellaneous motions and resolutions.
(14) Presentation of memoirs.

2. At an *adjourned session*, the order shall be resumed at the place reached on the previous adjournment, but new announcements, motions and resolutions, will be in order before the resumption of the business pending at the adjournment of the last preceding session.
3. At the Summer [Field] Meeting, the items of business under numbers (5), (6), (8), (9), shall be omitted.
4. At any Special Meeting the Order of Business shall be (1), (2), (3), (7), (10), followed by the special business for which the meeting was called.

CHAPTER IX: Amendments.

These By-Laws may be amended by a majority vote of the mebers present at any regular meeting.

SEVENTH ANNUAL MEETING OF THE MICHIGAN ACADEMY OF SCIENCE.

The seventh annual meeting of the Michigan Academy of Science was held at Ann Arbor, March 28, 29, 30, 1901. There appeared on the programme a list of fifty-three papers, a few of which were read by title only. Besides the general sessions and the meetings of the different sections, two lectures to which the general public were invited, were given under the auspices of the Academy, and a joint session was held with the Biological Section of the Schoolmasters' Club. In the joint session two main subjects were considered: first the teaching of the biological sciences in the secondary schools; second, the presentation of some recent discoveries and theories in the biological sciences. It is hoped that these joint meetings may aid the Academy in carrying out one of its aims, namely, the distribution of knowledge, and at the same time afford the teachers in the secondary schools of the State an opportunity to keep in touch with the progress of the sciences in which they are interested.

The most important items of business transacted by the Academy were as follows:

1. Election of Members. The following individuals were elected resident members:

Wilfred A. Brotherton, Rochester.
William S. Cooper, Detroit.
Joseph W. T. Duvel, Ann Arbor.
S. Fred Edwards, Agricultural College.
Samuel J. Holmes, Ann Arbor.
Herbert S. Jennings, Ann Arbor.
Frank Leverett, Ann Arbor.
Frank N. Notestein, Alma.
Raymond Pearl, Ann Arbor.
Howard S. Reed, Ann Arbor.
Daniel C. Schaffner, Ann Arbor.

2. The secretary notified the Academy of the death, since the last meeting of three resident members.

Mrs. Laura E. Burr, Lansing.
Myron T. Dodge, Saginaw.
Percy S. Selous, Greenville.

3. The treasurer's report was accepted after passing through the hands of the auditing committee, and showed the following items:

Balance from previous year	$156 74
Receipts during present year	31 00
Total	$187 74
Bills paid during the year	$44 35
Balance on hand	$143 39

4. The Academy voted to endorse the following bills before the legislature:

The bill on a topographical survey of the State.

The bill for an archaeological survey of the State.

The committee in charge of the bill on the natural history survey were allowed to use their discretion in pushing their bill, provided they did not jeopardize the bill for the topographical survey.

5. On recommendation of the Council the following officers were elected for the ensuing year:

President—Dr. Victor C. Vaughan, Ann Arbor.

Secretary—Dr. James B. Pollock, Ann Arbor.

Treasurer—Prof. Wm. H. Munson, Hillsdale.

Vice Presidents—Botany, Prof. Charles F. Wheeler, Agricultural College; Zoology, Prof. Hubert L. Clark, Olivet; Sanitary Science, Hon. Frank Wells, Lansing; Agriculture, Prof. J. A. Jeffery, Agricultural College.

6. In accordance with a vote of the joint session of the Academy and the Schoolmasters' Club, the Council appointed Prof. J. E. Reighard as a delegate, and Prof. Walter B. Barrows, as alternate, to represent the Academy in the committee which should consider the affiliation of the Scientific Societies of the State with the Academy.

LIST OF PAPERS PRESENTED AT SEVENTH ANNUAL MEETING OF THE MICHIGAN ACADEMY OF SCIENCE.

GENERAL SESSIONS.

PRESIDENT PROF. CHAS. E. BARR, ALBION.

1. Nature Study. Presidential Address, by Professor Charles E. Barr, Albion.
2. The Place of Physics in a Liberal Education. Professor H. S. Carhart, Ann Arbor.
3. The Haunts and Habits of Wild Birds. Professor F. H. Herrick, Cleveland, O. Illustrated with lantern views.
4. An Archaeological Survey of Michigan. Harlan I. Smith, New York, N. Y.
5. Recent Work of the State Geological Survey. Dr. A. C. Lane, Lansing.
6. The Proposed Topographic Maps of Michigan. Dr. Israel C. Russell, Ann Arbor. Paper not sent in for publication.
7. Glacial Investigations in Michigan under the State and Government Surveys. Mr. Frank Leverett, Ann Arbor.

SECTION OF BOTANY.

PROF. C. F. WHEELER, AGRICULTURAL COLLEGE, VICE PRESIDENT.

8. The Perception Zone of Roots. Dr. Frederick C. Newcombe, Ann Arbor. To be published elsewhere.
9. Transition from Stem to Root in *Echinocystis lobata*, Torr & Gray. Dr. James B. Pollock, Ann Arbor.
10. Zygomorphy of *Stylidium adnatum*, R. Br. Dr. George P. Burns, Ann Arbor. Not sent in for publication.
11. Adaptation of *Solanum Dulcamara*, L. to Aquatic Conditions. Theresa G. Williamson, Ann Arbor. To be published elsewhere.
12. Ecological Study of a Glacial Lake near Ann Arbor. Howard S. Reed, Ann Arbor.
13. Aerotropism of Roots. May Ella Bennett, Ann Arbor. Not sent in for publication.
14. A Disease of the White Birch. John Larsen, Ann Arbor.
15. Conditions Influencing the Vitality of Seeds. Joseph W. T. Duvel, Ann Arbor. Not sent in for publication.
16. Interfoliar Scales of Monocotyledonous Aquatics. Minna C. Denton, Ann Arbor. To be published in detail elsewhere.
17. Something concerning the Forests of Northern Michigan; with lantern views. Dr. W. J. Beal, Agricultural College.
18. Notes on the Flora of Eaton County. Prof. Hubert Lyman Clark, Olivet.
19. The Dwarf Mistletoe in Northern Michigan. Prof. Charles F. Wheeler, Agricultural College. Not sent to Secretary.

20. The Relation of Algae to Marl. Prof. Charles A. Davis, Alma. To be published elsewhere.
21. A Noteworthy Occurrence of *Wolffia*. Prof. Charles A. Davis, Alma,
22. Notes on *Utricularia cornuta* Michx. Prof. Charles A. Davis, Alma.
23. Some Corrections in Botanical Nomenclature. O. A. Farwell, Detroit.
24. Contributions to the Flora of Michigan. O. A. Farwell, Detroit.
25. Notes on Michigan Saprophytic Fungi. B. O. Longyear, Agricultural College.
26. New Species of Michigan Fungi. B. O. Longyear, Agricultural College.
27. A Sclerotium Disease of the Huckleberry. B. O. Longyear, Agricultural College.
28. Causes inducing Asparagus to take its Form of Growth. L. Lenore Conover, Detroit.

SECTION OF ZOOLOGY.

BRYANT WALKER, DETROIT, VICE PRESIDENT.

29. Phototaxis in Amphipods. Dr. S. J. Holmes, Ann Arbor. To be published elsewhere.
30. Preliminary Report on the Molluscan Fauna of the Region about Ann Arbor. Mr. H. E. Sargent, Detroit. Paper not sent in.
31. Suggestions for a Method of Studying the Migrations of Birds. Mr. L. J. Cole, Ann Arbor.
32. The Occurrence of *Ammocœtes*, the Larval Form of *Lampetra wilderi*, near Ann Arbor. Mr. D. C. Schaffner.
33. Some Aspects of the Electrotactic Reaction of Lower Organisms. Mr. Raymond Pearl.
34. A Curious Habit of the Slug, *Agriolimax*. Mr. Raymond Pearl.
35. The Effect of very intense Light on Organisms. Mr. Raymond Pearl and L. J. Cole.
36. Certain Reactions of the Common Slug, *Agriolimax campestris*. Mr. Raymond Pearl and Miss Maude M. DeWitt.
37. Some Further Notes on the Breeding Habits of *Amia*. Prof. Jacob Reighard.
38. On the Anterior Head Cavity of the Elasmobranchs. Prof. Jacob Reighard.
39. On the Early History of the Auditory and Lateral Line Organs of *Amia*. Cora J. Beckwith. To be read by Prof. Jacob Reighard. Papers 37-39 are to be published in detail elsewhere.
40. The Classification of Birds. Prof. Hubert L. Clark, Olivet.
41. The Breeding Habits of Holothurians. Prof. Hubert L. Clark, Olivet.
42. The Evolution of Certain Muscles of the Leg. Dr. J. Playfair McMurrich, Ann Arbor. Not sent in for publication.
43. Death from the Bite of the Water Moccasin, *Agkistrodon piscivorus*. Prof. Walter B. Barrows, Agricultural College. Not sent to Secretary.
44. Birds of the Carolinian or Upper Sonoran Zone in Michigan. Prof. Walter B. Barrows, Agricultural College. Not sent to Secretary.

SECTION OF SANITARY SCIENCE.

HON. FRANK WELLS, LANSING, VICE PRESIDENT.

45. A Bacteriological Study of an Epidemic among Guinea Pigs. Louis M. Gelston, Ann Arbor.
46. Fraenkel's Pneumococcus found in a Case of Tonsilitis. W. G. Carhart, Ann Arbor. Not sent to Secretary.
47. The Detection of Boric Acid in Milk. W. H. Veenboer, Ann Arbor.
48. The Detection of Formaldehyde in Milk. A. J. Hood, Ann Arbor.
49. The Toxin of the Colon Bacillus. Dr. V. C. Vaughan, Ann Arbor. Not sent to Secretary.
50. Some Results of Public Health Work. Hon. Frank Wells, Lansing. Not sent to Secretary. Papers 45, 47 and 48 are to be published in detail elsewhere.
51. Biological Problems in the Prevention of Certain Diseases. Dr. Henry B. Baker, Lansing. Not sent to Secretary.

SECTION OF AGRICULTURE.

PROF. J. A. JEFFERY, AGRICULTURAL COLLEGE, VICE PRESIDENT.

52. Some of the Relations of Botany to Agriculture. Dr. W. J. Beal, Agricultural College.
53. Some New Demands upon Agricultural Education. Kenyon L. Butterfield.

JOINT SESSION WITH BIOLOGICAL SECTION OF SCHOOLMASTERS' CLUB.

PROF. F. C. NEWCOMBE, CHAIRMAN.

Papers Contributed by Members of the Academy:

- The Teaching of Meteorology in the Grammar Schools. Lieutenant C. F. Schneider, Lansing.
- How Shall a Young Person Study Botany? Dr. W. J. Beal, Agricultural College.
- Recent Work and Theories on Fertilization of Animals. Dr. S. J. Holmes, Ann Arbor.
- Recent Work and Theories on Fertilization of Higher Plants. Illustrated by Lantern Slides. Dr. J. B. Pollock, Ann Arbor.

Papers Contributed by Members of the Schoolmasters' Club:

- Outline for a Year's Work in Botany. L. Lenore Conover, Central High School, Detroit.
- Suggestion for a Year in Zoology. Miss Andre, Central High School, Detroit.
- Value of Supplementary Experiments. Dr. Lewis Murbach, Central High School, Detroit.
- Science in the High School. Miss Palmer, High School, Lapeer.

PAPERS READ IN GENERAL SESSION OR FOR THE GENERAL PUBLIC.

NATURE STUDY.

CHARLES E. BARR.

(Address of retiring President of the Academy, delivered March 29, 1901.)

As a science teacher I trust I may be pardoned for presenting as a presidential address a subject so largely of pedagogic interest; yet apology is scarcely needed, for the stimulation of right modes of thinking and the cultivation of all the powers of body, mind and soul, afford an aim fundamental to all true progress in science as in life.

It seems scarcely necessary, at this date, to urge the importance of nature study, yet it may be well to recall your attention to some of the reasons why we believe it of great importance in the correct development of the powers of the child.

The educational world is in a state of unrest. New ideas arise from day to day, they float upon the surface for a time, and many sink into the forgotten depths again. We are seeking new gods. The idols we have worshipped have been found with feet of clay and we have been erecting altars to the unknown god.

That the "classical" education of the past few centuries possessed elements of strength it is fruitless to deny. As scientific men we must accept the evidence offered and abide by the plain inference. It expanded the mind, trained it to effectiveness and established an ideal of power and culture that we are all striving to realize. That it was the best means of accomplishing this result may be questioned. That the longest way round will bring us home there is no doubt, but that it is also the shortest is a statement that can only be discussed by those whose ordinary senses are obscured by the little blind god.

That the well trained mind is the ultimate goal in education, is, I think, an accepted premise. Our whole system has been based on this idea and grand results have been achieved. But that there have been errors in our processes he would be indeed bold who denied. "Life is real, life is earnest," and only as life's realities are kept before us can we become truly fitted to cope with them.

Our methods of training the young have been at fault in taking them from the real to an ideal world. As memory serves, in my own first schooling, I was introduced into a representative world where every idea must be gained through the medium of something absolutely foreign to my mode of thought. I found myself among strangers. True there were some friends there, but they were seen as in a maze and like captives forbidden to converse we journeyed through a strange land.

Our children, trained in nature's school, come to us for aid. Their interests have been in the concrete and they have already learned much of the proper method of approach. How does our education affect them?

There come to me, year by year, sixty or more freshmen for a laboratory course in biology. They have forgotten the first and greatest gift nature ever gave them—how to observe. It is pitiful to contemplate their almost helplessness when given some thing to study. Their thought has been wrapped up in books—their school thoughts—and that they can actually see for themselves, that their own eyes can show them truths has become so strange to them that I actually have to hide books that treat of the objects they are studying, they have come to lean so heavily on them. It is a long task to reawaken their confidence in themselves. Despite the absolute evidence of their bodily senses they will deny what they see, and fortify themselves by reference to an author who has perchance been led astray through like error. This is a harsh arraignment of our educational methods, but every teacher of nature at first hand will bear me out. A method that can produce such effects as this deserves no other name than that of a crime against our children.

It has been my custom for some years to submit certain of my classes to tests of their observing powers. From a series of data not complete enough to warrant entire confidence, there yet stand out certain accordant facts that are highly suggestive. These tests were such as could be performed without apparatus and were designed to try a number of faculties. I have found that pupils fail more in accuracy in estimating short intervals of time than in anything else on which I have experimented. The average error is 75 per cent. Ordinary, casual perception comes next with an error of 53 per cent. Let us now turn to pure memory and the difference is very striking. In pure memory the error is only 28 per cent, while that of size is 20 per cent and form only 13 per cent.

It has been interesting to note the variations that occur in individuals and to correlate these with their educational experience. The following is a typical illustration. In a class of thirty-seven students eleven objects were placed upon the desk. Particular attention was directed to them, and they were then lifted, one by one, placed in a basket and removed from the room. The pupils were then asked to make a list of them and the replies were grouped in two classes: the first of those who had had one years training in a laboratory course in biology: the other of those who had had no such training. The difference in the classes was marked. Of the first group eight out of fourteen could name them all and the average number recalled was 10.50. Of the second group the average was 9.52 and only four out of twenty-three could give the entire list. The number seen and sufficiently observed to recall them was as follows: Of those who had had the training in observation one saw nine, five saw ten and eight saw them all. Of the others; one saw but five, one seven, one eight, five saw nine, eleven saw ten and only four out of the twenty-three listed all; and this difference with only one year of six hours per week to overcome the results of previous training.

These experiments give some measure of the results of our primary and secondary education and the results are not assuring. There is a radical defect in any method that so atrophies the natural powers instead of increasing their efficiency. A natural method preserves its foundations for upon them must rest the whole superstructure.

Education should be a continuous process, beginning with the child's entrance into the world and proceeding by well ordered steps from that which is known to the unknown. There should be no break in the life, but the entrance into school should, just as perfectly as possible, simulate the normal life of the child and stimulate, to even fuller extent, the factors that have thus far given him power.

He should be advanced with such gradual steps that he scarce realizes that he is led into new fields of thought and activity. All knowledge is a unit and it should be taught as such. It is often difficult for us, narrowed in, each in his own little cell, to see relations, but some day a giant mind will grapple with the problem and a science of teaching will result.

I welcome the kindergarten—I thoroughly believe in it. The sympathetic co-operation with the child, leading him on, never driving, correcting his faults by suggesting the proper acts, entering into his joys and sorrows, his interests and his plays, in short becoming again a child with him, plus the experience and leadership of maturer age offers untold help in setting him right at the outset of his life's career.

But the kindergarten stops all too soon and the change to later school life is like a transition to a new stage of existence. How shall we remedy this evil? The obvious method lies in the child taking his interests with him.

The objects of nature study are manifold and to enumerate them all would seem to many of you to present an extravagant claim. In brief, they are these: To link the school life of the child to his previous experience; to develop and perfect his powers of observation; to lead him to question intelligently from the thing he sees to the causes that produced it, and which he cannot see; to realize the interdependence of natural phenomena and hence their essential oneness; to bring him to place himself in proper relation to his environment and to recognize himself as but one small part of a great and closely knit whole; from this to lead him to an appreciation of mutual helpfulness and to regard his own interest not an end to be advanced but the common interest as paramount, his own to be secured only as he subordinates his place; to lead him to altruism, to morality and thence on to God. This is a lofty aim and, as I said, the claim may seem o'er bold. Let us see.

That the physical nature first manifests itself in sensation and later in motion, and develops to a point of efficiency, to be in turn succeeded by a thinking and a reasoning nature is of common knowledge. The linking of these into a perfect chain, strong in all its parts, is our task. The little child lives in a realm of sensations. So far as we can tell, he has no thoughts. His whole existence is bounded by feelings but through these feelings he by and by begins to know. In his first five years, he learns perhaps as much as in all the remainder of his life. He learns to use his body fairly well, to run, to walk, to see and hear, to talk, to think, to coördinate sense impressions with experience, and to hear and see with the understanding as well as with the bodily organs of the senses. His means of learning are: first, his own observations; second, inductions from them; third, the testing of these by experience; fourth, deductions from approved inductions; fifth, queries from others—and well do we know his insatiable curiosity. From him nothing is hid and nothing is too high, nothing too deep for his search. It is always "How?" and "Why?" The "What?" he usually answers for himself.

Observation is a means of education that is insufficiently appreciated. The tendency of our educational methods has been to discount it and to put the premium upon verbal reproduction. I do not refer to memoriter work. That is happily becoming extinct, but the reproduction of ideas not our own, though in our own language, is but a step removed. Only as we learn to see and to interpret the impressions borne in upon us by our senses do we really best gain in power of thought. Observation is in itself good, but when to this is added (rather not taken away) the inquiring mind, its value becomes many times multiplied.

Careful observation and careful development of the power of observation affords a tool of priceless worth. This it is that stimulates rapid thought, that trains one to meet the unexpected emergency, that relates the whole to its parts and its parts to the whole. It is said that Robert Houdin had so trained himself that after a single sweeping glance he could name all the articles in a shop window. This power it is that enables the wily antagonist to foresee and meet the attack of his opponent on the football field.

How many of us "see" the letters in a printed word? Yet the trained proof reader will detect a misplaced letter in the most cursory scanning of a word. The days of "a, b, c," as intellectual food for babes seems to have passed, yet the substitution of the present fad, the "word method" presents the same difficulties, many of them in an aggravated form, and though progress may be apparently faster, as by absorbing more highly concentrated foods, the mental digestion is not thereby strengthened. It has been a source of amazement and of sorrow to me that so many students come up to college unable to spell. Many pronounce words without any adequate idea of their parts, and in this we see the defects of the system, if system it may be called. It is wrongly based, as it demands a more complex observation and that without an adequate and necessary training.

With observation and as an aid and test should go representation of the thing observed. Careful study attended by careful drawing weld the idea and the form together. Let no one be discouraged at fancied inability to draw. The trouble is not with the hand, but the eye. One can draw anything that he can accurately see. A thing half seen is a thing virtually unseen. A thing observed in its entirety and in its relations is of abiding worth. The whole in parts and the parts in relation to the whole is the key to accurate knowledge. Improve the observation and the manual dexterity will follow fast. Slipshod observation and slipshod reproduction lead inevitably to slipshod modes of thought and slack modes of thought to deteriorated mentality and perverted morality.

Thus it is that in our laboratories we continually dwell on representation of the object which is studied. Not that our pupils may learn to draw, but that they may surely see. Only as definite observations are made do representations become possible; and further, only as drawings are made can we detect and remedy deficient seeing. Only as one has experienced the delight of personal investigation can he realize the sense of power that it confers. "This thing I know." No amount of description, no figures in a book can ever take the place of personal contact with the thing studied. Books may teach us what we shall believe, but those things our hands have handled and our eyes have seen, have passed beyond the phase of simple belief and have become a part of ourselves.

So strongly has this principle commended itself as affording the real elements of power that the most vigorous opponents of the growing claims of science education have been forced to employ its methods in their everyday work.

But why nature study? Are not or cannot the same results be attained by other methods already in use? I would say decidedly, no. Nature is the environment of us all. Many of us have regarded it as "un fait accomplie," but to the child it is the most absorbing interest in life. It is things that hold him, not thoughts; objects and not ideas. He has been forced to study his surroundings and has found the study pay. He no longer cries for the moon, for he has found it to be unattainable. He shuns the fire, not because he has been told it is dangerous but because he has felt it burn. Leaves, trees, grass, birds, flowers and insects are to him of absorbing worth, for of these he knows and would fain learn more and interest is one of the foundation stones of pedagogical success.

Study not to know things alone, but to know them as part of a great whole. Link each new fact to the storehouse within. Coordinate knowledge. A thing assimilated is like a jackstraw in a pile. Touch it and you disturb the whole. Things do not exist alone, they exist for other things as well. This is as true of man as of the grass of the field. It should be our constant aim to relate, *relate*, RELATE things! Start at any point and were we wise enough we could bind together the universe as in a chain. To illustrate: Rocks, soil, plants, trees, leaves, soil, rocks. Soil, water, sand, rocks, houses, men, agriculture, soil. Trees, fruits, seeds, grain, meadows, forests, trees. And not things alone, but activities are a part of our real world. The child should know his environment and that the relations between it and himself are mutual. This knowledge carries with it obligation and consideration for his environment as contributing toward himself. Love of nature is truly love toward man.

A slight suggestion along this line sometimes bears rich fruit. Set a child to searching for relations and the world is full of them. Nymphs inhabit the fountains, dryads the trees, and every flower is a fairy bower. Aesop lives again and in a truer sense than in olden tales the beasts of the field talk together.

This study of relations is a study of the "whys." By it not only is the actual perception quickened but the reasoning powers as well. Induction and deduction become a part of life and the child learns to stand alone. It has been the fault of our education that it cultivated dependence. I often hear, even yet, that horrid phrase "the book says so." Books should be aids, not masters. Dependence on books is dependence on the past, while we live only in the eternal present. Only as we see and feel, only as we can use the fact acquired to lead on to another to be gained can we win that independence of thought and reason that make us truly the children of God.

But one must strive to learn not merely the truth and nothing but the truth, but best of all, the whole truth. And the whole truth that a simple flower may present is not alone its parts, their number, their arrangement and the function of its seeds; it must include, to be complete, the plant itself, its provisions for growth and nurture, its relations to soil and atmosphere, to the bee that sips its nectar, to other plants that struggle with it for its place and to the whole animate world that it may affect or that may be affected by it. The physics and chemistry of its growth and other life processes are as much a part of the flower as its petals themselves. The story of the flower is indeed long. We may not hope to know it all, but we may at least learn to glimpse its meaning and its multitudinous relations to the universe of which it forms a small, though never an insignificant part.

"Flower in the crannied wall,
I pluck you out of the crannies;
Hold you here, root and all, in my hand,
Little flower—but if I could understand
What you are, root and all, and all in all,
I should know what God and man is."

It became evident early in the history of the race, that a knowledge of things apart was of little worth. The man who knew by name and by structure a thousand plants would never become a botanist but as he grouped them. This truth applies to all records of data, be they in the mind or on the printed page. This idea may be brought very close to the child and he may be easily led to look for likenesses and thus to classify his knowledge. Classified knowledge leads to scientific insight, but our task is yet incomplete.

It is the lot of the many to toil. Day by day they accumulate data, year by year they add to them, generations devote themselves to the task, and it is a worthy one. But some day, marked great in the calendar of time, a genius is born and a Darwin delves and stirs the accumulations of the centuries, throws them into form, and Truth, so long obscured, leaps into view and their final cause is achieved. That such men have lived is profound cause for thankfulness to God and ours the task to train from the very outset in the path that leads to these noble ends. Not to many is such power given, for few indeed know the patience, the careful tests from which these world ideas have sprung. Few Newtons have arisen in the history of the world, but we can at least save those who otherwise would die with their powers all unknown to others or to themselves.

The object of nature study is often misconceived and its result therefore far different from that to be desired. Let me say at once, then, that its highest aim is not to teach science. This is an end undoubtedly valuable in itself, but the true purpose of nature study is broader and deeper. Nature study is a study in correct methods of thought.

Let me not be misunderstood. I am not advocating the introduction of science into the grades. Nothing could be further from my purpose. The science that is taught in these hours with nature should be, as I conceive it, an incident, the method the end. These children are not ready for the study of botany, but they may know and love flowers; geology is beyond their ken, but rocks, soils, and water are of their daily lives; zoology presents problems that they cannot know, but animals are their playmates, and they should be taught that these are of the same stuff as they and that as they consider them they should themselves be treated. In other words, we may and must employ with them the materials of science that they may be taught the method of scientific thought. The teacher must ever be on the guard lest these, the means, become to him the absorbing end. Of course to the child they are the end, but the teacher must ever place before himself the development not of science but of the child. And much true science may be taught. The foundation of much that he will meet in later years may be made a part of himself that when that day comes, he may still be on sure ground and know whereof he speaks.

Science embraces all knowledge and the scientific method applies to all. It is characteristic of higher education that scientific method dominates all its fields; not to the extent that it should and will, but the leaven is working and day by day we are nearing the goal. More and more is the value of things lessened in our vision, as educators, and they become but the stepping stones, as it were, that lead across the river of knowledge to the heights where wisdom reigns. Knowledge is not power. It may be, it is the means by which power comes, but only as it is subordinated and the lessons it teaches strike deep in our hearts.

The greatest value of the scientific method is that it leads us to use to the full our powers; to weigh, to analyse and to combine; to frame hypotheses and test them by our knowledge, by experiment and experience; to lean upon them only as they prove themselves strong. And the strife toward finality in knowledge is as the light that shineth more and more unto the perfect day. As one learns more and more to use his reason, more perfectly to apply it to all problems of school and life as they come before him, to view the world as one great whole, in which we are merely atoms in a cosmos, to govern himself by that which is approved from the all round view, so does he come into that greatest of all possessions, which cannot be taken away, though all else should fail, the true and perfect enjoyment of the cultured, the intellectual life.

If I may be permitted to say a few words about methods I would say, first, study nature in her home. Reading about nature or talking about her never made a naturalist. The method is vicious. We might with equal profit discuss our expected dinner and end with discussion. We demand the substance and the pupil must have a first hand acquaintance with nature herself. The easiest way is to bring the materials to the schoolroom, though it should always be the pupil, not the teacher that finds and brings them. The best method, however, is to find things where they grow, in their natural environment for only thus can we answer many of the questions that they suggest and only thus may we avoid error by the instant appeal to fact.

I realize the difficulties attendant on field excursions by school children, and would not minimize them. This work calls for mental alertness and tact to the very highest degree. My first suggestion would be that every excursion should start with a definite object. Mere general observation has rarely solved a difficulty. It is only as the attention is concentrated on some particular point that observation is of real advantage. Further it relieves at once of much aimless questioning, which leads to distraction and consequent loss of precious time.

If for any reason it be impracticable to journey afield with the class much valuable work may be accomplished by asking some judicious questions that will set the pupil at work outside the school hours. In physiography for example it is a most excellent plan for the teacher to select a locality and then, on the spot, to study it, take notes, make sketches and perhaps formulate a few questions with which the pupils may be sent to the place, there to seek and find the answers.

And I do not suggest merely questions on what the eye can see. Children in the grades have a really marvellous capacity for drawing inferences. Give their imagination play. It will grow by what it feeds on.

Above all don't be discouraged by any apparent lack of opportunity. Every year I provide each member of my class in nature study with a two foot string, tell him to tie the ends together and then find some comfortable spot, stretch it out in a circle and spend the hour studying what lies within. One who has never tried it cannot conceive the interesting things he will find, wherever it lies, nor the questions suggested and some of them answered within its eight-inch circle. It is an interesting fact that in all the years I have taught this class in spring, summer or fall, but two students have as yet failed to find ants either as residents or explorers.

After such an experience as this none can complain that their field is too small, that the locality does not afford opportunities. Some work may, and to be successful must be done by this intensive study of a small area, other work requires the birdseye view of broad reaches of surface. Some things demand keen and discriminating work with almost microscopical sight, others may be best perceived with eyes half closed that detail may be blurred out and only the broadest effects realized. Wherever we go, there nature is, and in her moods new joys are ours if we attune ourselves to hear her myriad voices.

"To him who, in the love of Nature, holds
Communion with her visible forms, she speaks
A various language; for his gayer hours
She has a voice of gladness, and a smile
And eloquence of beauty; and she glides
Into his darker musings with a mild
And healing sympathy, that steals away
Their sharpness, ere he is aware.

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Go forth under the open sky, and list
To Nature's teachings."

THE PLACE OF PHYSICS IN A LIBERAL EDUCATION.

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The latter half of the century, which has just closed, has witnessed profound and significant changes in the materials which are used to impart a liberal education. The object aimed at remains, however, the same from age to age. The training of the intellectual powers so that the educated man may employ them with the highest efficiency in all positions calling for the exercise of his intellect, constitutes the chief object to be attained by study directed to purely mental ends. I do not wish to be understood as implying that moral training should be divorced from intellectual culture; but my theme deals chiefly with the intellectual rather than the ethical aspects of education.

The narrow curriculum of the college half a century ago has given place to the varied and differentiated university courses of the present. The sciences, though at first rather unwelcome guests, are now acknowledged members of the family circle. The modern languages have reached a position of higher esteem than formerly, and the study of them has become a necessary and essential part of a liberal education. The philosophy of history and the study of contemporary events have supplanted the old array of dusty facts and sanguinary battle records. Even in the primary schools the inspiring practice of waving the revolutionary "bloody shirt" in the faces of our British friends across the sea is happily becoming obsolete. The English language and English literature are now considered as worthy of study as are the languages and literatures of peoples that long since ceased to be. Political economy and sociology are subjects of recognized standing and are attracting large numbers of students. Even philosophy, by a process of peaceful acquisition, has allied itself to science by including experimental psychology within its colonial domain; and the storm center of heated controversy has shifted from it to the modern subject of sociology. This shift typifies the change in the topic absorbing public attention.

Not only has the past half century witnessed an enlargement of the subject-matter of a liberal education, but a revolution has taken place in the methods of using educational material. Secondhand knowledge has taken a secondary place as compared with information gained at first hand. The sovereignty of the text-book has yielded to the sovereignty of nature. Knowledge by authority is giving place to knowledge by conviction. Museums with locked cabinets of natural history or of antiquities may be very laudable enterprises to meet the demands of public curiosity, but they become educational appliances only when the student has access to their treasures and can study them by actual contact.

A significant change has taken place also in pedagogical practice. The method of investigation as compared with mere memoriter acquisition has been introduced with the serious study of science into our American universities. The experimental method adopted by science and its practice of original investigation have compelled other departments of learning to become its imitators. Archaeology now has its workroom; language its photographs and lantern, its casts and reproductions of ancient life and times; while psychology has appropriated the apparatus of the physicist along with his methods.

Fifty years ago the laboratory method of teaching chemistry even was a novelty. It was not till a later date that physics adopted the same method and founded physical laboratories. The remarkable investigations of Regnault near the middle of this century were made possible at first by the appliances furnished by the Royal Porcelain Works at Sevres, of which he was the director, and later by the gift of English money. In England science was advanced by the enthusiastic labors of gentlemen of fortune, who devoted their time and money to this purpose. A fortunate combination of talent and talents secured for England much scientific renown. Now every scientific department in a university the world over is a constant contributor to the advancement of science. The scientific method and the scientific spirit have become general. In such an environment the place of physics in a liberal education is more readily ascertained than under the old conditions prevailing at the middle of the last century.

The first proposition which I wish to establish appears to be almost or quite self-evident. An education can not at this period of the world be broad, comprehensive, free from narrow limitations, inclusive of the best things that go toward the making of a man, unless it comprises more than the time-honored humanities. It is unnecessary at this point to dilate on the humanistic element in science, those features that connect it indissolubly with human interests, nor to depreciate linguistic and philosophical studies. For if a study of the highest types of ancient literature gives an insight into the thoughts and feelings of the cultured past; and if it makes the student feel that he is allied to all that is most glorious in ancient history; so also does the study of history in the mother tongue have an equally emancipating effect on the mind. No one group of related subjects possesses the exclusive control of culture. If today the humanities should form a trust in their exclusive product of liberal culture, they could not control the output. The range of liberalizing studies has been greatly extended within fifty years. It is at the present time no less illiberal to contend that a liberal education is the exclusive function of the traditional subjects than to claim that it is the exclusive product of scientific study. The well-trained, evenly-cultured man is one who has laid a broad foundation for his specialized superstructure. Intellectual power is the prime object of education; but the power imparted by a single subject is usually specific and not general. Any study may have a tendency to fit one for special activities, but it rarely fits for activities in every direction. Hence the student whose intellectual diet is limited to the traditional menu may or may not acquire an easy, graceful and discriminating use of his mother tongue. It is of the highest importance that he should do so, but the study of mathematics and the classics chiefly or alone can never give mastery in dealing with the many sided activities of life in which language is not the most important factor. If to the traditional subjects are added science, civics, history and commerce, then more intelligent interest will be awakened, and power will be cultivated in other directions than those leading to the legal and clerical professions. The young man who has completed his general training with such a scheme of study, finds himself in harmony with his environment when he enters active life, where he must make his own way if it be made at all. The student who gives almost exclusive attention to the strictly classical studies may succeed in getting in touch with the distant past; and if he does, he will probaly find himself out of touch with the present. Even a culture course should be broad enough to take in living human interests.

One of the decisive tests to be applied to determine the educational value of any study is the interest which it excites in the mind of the student. Judged by this criterion physics claims a prominent place in every curriculum. He must be a dull boy indeed whose interest is not awakened by the explanation of the most glorious and the most curious phenomena of nature. His enthusiasm is excited when he learns for himself that the events of the natural world are not fortuitous and incomprehensible, but are reducible to natural causes and are subject to the reign of law. This interest and enthusiasm are heightened by the knowledge that man has utilized natural forces and laws so as to produce the most beneficent results for the human race. He soon learns that invention follows discovery, and that the real pioneer is he who wrests from nature her secrets, and discovers the causes and relations of things. We are only just beginning to comprehend that Faraday in his laboratory in the Royal Institution in London wrought a social and economic revolution by his discoveries of greater importance and more enduring than the political revolution of Napoleon, which only temporarily changed the face of Europe. Napoleon made and unmade kings as if they were puppets to do his bidding; but the slate of Europe which he made has long since been wiped off. On the other hand, the discoveries of Faraday have changed the civilization of the world within the past thirty years. And every decade only adds new applications of his discoveries, for they underlie every electric generator, motor and transformer. Electric lighting, electric railways, and the transmission of power, as at Niagara, are some of the beneficent results of Faraday's immortal discoveries. And yet there are some who tell us that the study of physics does not touch the secret spring of human interest and human activity with the same certainty as does the study of the humanities; that physics does not offer the persuasive attractiveness that inheres in the classical languages and literatures. Grant that physics appeals to the immature mind in a different way from the study of language; nevertheless, it appeals strongly in the hands of a live teacher imbued with the dignity and interest of his subject. Testimony of parents is not lacking that the first notable intellectual stimulus received by their children came through the study of physics. The taste for science is as natural as the taste for language, and both are necessary elements in a healthful intellectual diet.

Another element which should weigh in an estimate of the educational value of physics is the kind of training which physics furnishes. Its pursuit contributes to exactness of reasoning, of thinking, and of expression. It is an admirable training preparatory to other important subjects. Physics includes a great body of laws and relations which admit of precise quantitative statement. The student of physics finds a subject which busies itself with the reason of things. Its business is to account for natural phenomena in the simplest possible manner. Causal relations are among the most prominent of those studied. An earnest study of physics, especially by the laboratory method, disinclines the student to rest on the authority of a text-book. He learns to try all things and to hold fast that which is good. Without losing respect for the opinions of others, he learns to discriminate for himself. In the laboratory he has ample opportunity to form independent judgments. His work contributes to the making of a man who not only knows but who does. The student in practical physics "must acquire a certain technique, a deftness and certainty of touch, an ability to handle and adjust apparatus, which, however small it may seem to be in itself, forms one of the characteristic differences between the civilized man and the savage." There is a close but almost indefinable relationship between manual and mental training. Manual dexterity begets mental agility. The refinement of the mind expresses itself in the refinement of manipulative skill. Trained fingers and a trained mind give the possessor a double claim on public appreciation. The artistic instinct and artistic appreciation do not make an artist. To these must be added dexterity with the brush, the pliable fingers, the mallet and chisel. Musical feeling expresses itself at the very finger tips. The hand is often as good an index of character as the face. The combined mental and manual skill cultivated in physical manipulation is no mean reward for the time devoted to it.

Physics has also other and perhaps higher motives. It considers not only the things which are seen, but still more the things that are not seen. If it has to do with many-sided matter, it has also to do with multiform energy. The most important and most facinating phenomena of physics are not the things one can see, but the invisible things that one apprehends only by the use of the imaginative faculty. It thus happens that the serious study of physics cultivates in no small degree the power of imagination. Force is invisible, though matter is its medium; energy is invisible, and so difficult is its apprehension that even cultivated men fail to distinguish between it and force. An electromagnet is a simple electric device; but when we contemplate its attendant magnetic field with its invisible magnetic lines in the invisible ether, and try to picture to ourselves how energy is transmitted and transmuted through the agency of this invisible magnetic halo of gossamer threads, the imagination is taxed to its utmost capacity. Consider further the fairy land of light, the audience hall of sound, the seething caldron of solar heat, or the appalling chill of liquid air, of interstellar space, or of the deathlike immobility of the absolute zero of temperature. Follow if you can the flow of radiant energy with the speed of light through boundless space, and tell us whether the Almighty, who let it fly, corrals it again and holds it in leash in some unknown rendezvous on the boundary of the infinite. The discoveries of physics outrun even the imaginations of men. When the first report of Roentgen rays was bruited abroad we received it with incredulity. That an exhausted glass tube, excited with electricity, should render visible the bones of a living man, and should enable one to see the pulsating heart, was a unique fact lying beyond the realm of fancy even. Not less extraordinary was the discovery and measurement of Hertzian waves excited by the electric spark, and followed by the marvellous application to space telegraphy. Discoveries often require the suggestion and stimulus of the imagination. Without doubt there is still worth unrecognized in the material things about us which need the touch of genius, aflame with the fire of imagination, to reveal. We need only call to mind "the ages during which men saw the kettle boil and the lightning flash without learning the worth there is in steam and electricity."

One more reason only do I need to give for the serious, contemplative pursuit of physics. By no means the least among educational values is the ethical aspect of a subject. The making of a man is seriously compromised by the lack of moral tone. Education that may cover the whole range of the intellect, and yet fail to produce seasoned moral fiber, is not entitled to be called liberal. Intellectuality divorced from morals is a misfortune to the individual and a menace to society. Judged by the ethical standard, physics is entitled to respect, not because it teaches formal morality, but because of the indirect yet powerful influence it brings to bear on the serious student. If it teaches anything, it emphasizes the reign of law. No shifting or pretense relieves him who sins against nature's laws.

Moreover, there is every motive of personal interest to honesty in the physical laboratory. The only object of the work is to find out the truth, and there can be no possible reason for preferring an incorrect result to a reliable one. Indifference as to what the result is to be, unflinching honesty in dealing with determinations, and patient revision and verification of values, are the ideals which are impressed on the student in the laboratory. When the law of the Conservation of Energy has been assimilated by the student, he will know that it is impossible in nature to get something for nothing. Wherever energy is concerned, an equivalent must be given for all we get. The physics student is always engaged in verifying old truths or in the discovery of new ones. Professor Rowland says: "I value in a scientific mind most of all that love of truth, that care in its pursuit, more than any other quality. This is the mind which has built up modern science to its present perfection, which has laid one stone upon the other with such care that it today offers to the world the most complete monument to human reason."

I have briefly sketched some of the beneficial results to be expected from the serious study of physics. Have I drawn the outlines of an ideal pupil in an ideal school, and does the reality fall short of the ideal? Undoubtedly in many cases it does. Whether physics yields much or little depends first of all upon the qualifications of the teacher. The solution of the whole problem rests with him. But this condition is not peculiar to physics. The same may be said of any subject of study. The classics and mathematics have had the training of teachers for centuries, and even these subjects often suffer at the hands of their friends. Until a very recent time it has been assumed that the classical graduate was competent to teach "any of the minor branches," as one of them expressed it, and that no special preparation for the important profession of teaching science was necessary. But all that is changed now. It is a matter of congratulation that in many localities at least normal graduates are adding university study to their preparation, and graduates with a Bachelor's degree are returning to the graduate school to fit themselves for effective work as science teachers in secondary schools.

In certain university circles too much stress has of late been laid on the ability to investigate to the disparagement of the teaching ability. It is assuredly of vital importance to the teacher's influence that he should lead the way by his contributions to the science which he cultivates. On the other hand, it is no mean accomplishment to be a teacher of the best type. The teaching ability is as rare as the capacity for research. The good teacher lives in the hearts and lives of his pupils, while his researches may lie in the unwakened slumber of unread scientific transactions. Every teacher, even in a secondary school, should contribute something to this chosen science by way of device or invention or discovery; but he should first of all see to it that he does not neglect his preparation as an instructor. Joseph Henry in the Albany Academy made discoveries in electricity that attracted the attention of the scientific world and established his fame. Read his own account of his experiments carried out during the summer vacation because he could not neglect his duties as a teacher in term time. So careful was Faraday in his preparation for his lectures that he invariably tried every glass stopper in advance to assure himself that none were stuck in the bottles; and Faraday was a prince of experimenters and eminent in research.

The inspiring teacher is a treasure-trove. Like Topsy he is not made; he grows. But symmetrical growth requires cultivation and nourishment. The teacher of genuine power is not one who turns to the profession as a temporary expedient. He prepares himself for his profession with conscientious fidelity. He must have a broad and catholic intellectual outlook, and should see other subjects than his own in proper perspective and dimensions. He must have the zeal of youth, the insight of maturity, and the wisdom of age. He must be enthusiastic himself if he would arouse enthusiasm in others. He must first see clearly all around any topic before he tries to make it clear to his pupils. He must have warm human sympathies and be tolerant of mediocrity even, but he has no call to condone sloth. Devotion and diligence are the price of success. Continuous, persistent work conquers more difficulties than genius does. If the noblest prizes are for the great, many great rewards remain for the noble. If the pecuniary returns are not large, there are many compensating satisfactions. To help the deserving on the threshold of active life and to see one's pupils grow into places of power and public esteem are compensations for many personal losses.

No profession requires greater watchfulness as the years advance than the profession of teacher. Most of all the teacher must see to it that he does not forget his own youth and so grow out of sympathy with the young. He needs to lay his course with care and to check it by frequent observations, lest he suddenly find himself far out of the intended path. To age it is permitted not merely to simulate youth but to retain youthful feeling. The fir tree yields not its living, lustrous green to summer's sun nor winter's cold. When one reaches the period of the "sere and yellow leaf" he should retire. He will never survive the "winter of his discontent" and revive with new bloom.

The teacher must also guard against over-confidence. He is exposed to peculiar temptations. He has to deal constantly with those who are not his equals in years and attainments. Hence the tendency to assume an air of authority and of confidence instead of the humility of mind that should characterize the teacher of science. It were better if he found himself frequently face to face with his peers. The stimulus of criticism from one's equals or superiors is a healthful tonic. Competition with mature minds favors sturdy growth. A large university has certain advantages over a small one in this respect. The number on the teaching staff is large enough to give room for the spur of competition and emulation among instructors. It is a mistake to assume that a poor teacher is more easily hidden in a large institution of learning than in a small one. The larger one is likely to make the larger demands. Where there are so many efficient teachers it is more difficult for a poor one to maintain himself. Then too a large corps of instructors creates an atmosphere of work, an environment favorable to production. One must keep in the swim or sink. The modern American university is no cloister, no refuge for the incompetent of other professions. It is a new world, a microcosm in itself. It is alive with ideas, enthusiasms, inventions, discoveries, emulations, awakenings to the higher intellectual life, the vivid foresight of brighter fields of thought, excursions into the boundlessness of space, or descents into the infinite underworld of the microscopically minute. It is in touch with the realm of thought the wide world round.

And what mighty movements have come forth from its doors in power during the past century! Scarcely a great invention of world-wide interest to humanity that has not seen its birth within walls devoted to education. Since the time when an undue respect for the learning of the past ceased to dominate the present, institutions of learning have become the sources of the most significant advances in ideas. Just at the opening of the last century, Volta presented to the world the voltaic cell, and Davy produced the first electric light. A little later Oersted in the University of Copenhagen uncovered the relation between magnetism and the electric current, and so became the pioneer in electromagnetism. Then came Faraday with his mighty insight and his revelation of electromagnetic induction. Henry and Morse made the electric telegraph before the middle of the century, and Helmholtz exposed to view the law of the conservation of energy, which now dominates all science, pure and applied. Then Lord Kelvin taught masters of finance and promoters of international commerce how to use a submarine cable, and invented the instruments for it. Bunsen and Kirchhoff discovered the laws of spectroscopy, and set astronomers to investigate the composition of the stars; while Hoffmann evolved new colors out of coal tar and revolutionized the industry of dyeing. Hertz discovered electric waves for future Marconis to utilize, Ferraris in Sunny Italy invented the rotating magnetic field; and lastly Roentgen applied photography to a new and marvelous art, the value of which is not yet fully appreciated.

Finally, the teacher of science should strive to maintain serenity of mind. The modern university or secondary school is no longer a wooden bench with the pupils on one end and Mark Hopkins on the other. Teachers of great personality are as much a desideratum now as formerly, and as much in science as in the humanities. But science makes the more complex demands upon the teacher. The intellectual and culture elements should be no less strongly developed than in other branches, while the mechanical sense and the cultivation of the fingers are essentials to success in experimentation and investigation. To the science teacher the library is as great a necessity as to the linguist or the historian; besides, he must always have his hand on the lever, ready to speed away on fresh excursions into new fields. To keep abreast of the present he is always reaching out into world-wide fields of information; to press forward into the unknown, he must catch time for thought and absorbing contemplation. All this makes a draft upon his nervous energy but little appreciated by those whose daily round of monotonous duty does not open their eyes to the nature of such absorbing activities.

To be serene amid it all, to maintain one's health and composure, to expend the requisite energy and to retain enough for continued effectiveness and longevity, to grow old gracefully without losing touch with youth, to keep open the lines of communication, and to change one's point of view as the science silently changes with wider knowledge and clearer perceptions, is the problem confronting us who love our work and are devoted to the advance of our favorite subject. Is it too much to ask that governing boards consider these demands in determining schedules of work, and that they leave a little time for the teacher to cultivate moderation, composure and serenity? Then may he appear

> "Like some tall cliff that rears its awful form,
> Swells from the vale and midway leaves the storm,
> Though round its base the rolling clouds are spread,
> Eternal sunshine settles on its head."

AN ARCHÆOLOGICAL SURVEY OF MICHIGAN.

HARLAN I. SMITH.

Beginning the second semester in the college year 1891-92, due to the desire on the part of students for such study and to the support of Prof. Francis W. Kelsey, of the Latin Department, a full course in museum work in American Archæology was offered at the University of Michigan[1] under his general direction. Two students availed themselves of this opportunity and some of the laboratory work was done on Michigan material. Regular university credits were given both that year and the one following, but the course is no longer offered.

In 1893 and 1894, as a direct outgrowth of the interest in the course and the co-operation with the University, of the Detroit Branch of the Archæological Institute of America, several surveys were made of the prehistoric earthworks known as "garden beds" near Kalamazoo. From this data one of the groups was modeled and copies were taken by the Peabody Museum and the American Museum of Natural History.

The Michigan Academy of Science was organized in the fall of 1894 and at the first meeting, December 26, the anthropology of the State was represented by a single paper on "The Data and Development of Michigan Archæology." This paper was published in two parts, that referring to the data together with a note predicting a future activity on the part of the State in the preservation and study of its archæological resources, appeared in the American Antiquarian, May, 1896. The second part referring to the development of Michigan archæology was published simultaneously at the University in The Inlander. This paper not only plead for the subject but suggested a general plan of action particularly that the work be systematic and directed from some such public institution as the State University where the results could be assembled for study and permanent free public exhibition, and that the antiquities of the State should be photographed, surveyed and plotted on a map.

Later a plea for enclosing mounds in public parks, cemeteries, etc., was published in the local papers.

In 1900 the Detroit Branch of the Archæological Institute of America appointed a committee composed of James E. Scripps, owner of the Detroit News-Tribune, Prof. Francis W. Kelsey, of the University of Michigan, George W. Bates, president of the Detroit Branch, Hon. Wm. C. Quinby, owner of the Detroit Free Press, and Levi L. Barbour, to prepare and have passed by the State Legislature a bill to establish a survey of the antiquities of Michigan and make appropriations therefor. This bill was prepared after careful consideration with members of the American Museum of Natural History, Bureau of American Ethnology and Smithsonian Institution, as well as those

[1]See Anthropological Work at the University of Michigan, Memoirs of the International Congress of Anthropology, Schulte Pub. Co., Chicago, 1894. Also University Record, Feb. 1894.

who conducted the archaeological exploration for the New York State University and the Ohio Historical Society.

At the winter meeting of the Anthropologists of the American Association for the Advancement of Science at Johns Hopkins University, December 28, 1900, a committee was appointed to transmit a suitable memorial to the people of Michigan in expression of its approval of the establishment of the survey and tendering its co-operation.[1]

The following memorial was prepared and transmitted:

To the Senate and House of Representatives of the General Assembly, of the State of Michigan:

Resolved: By Section H of the American Association for the Advancement of Science, at its meeting held at Baltimore, December 28-9, 1900, that the proposed archaeological survey of the State of Michigan is highly desirable; that we approve the same, and hope it will soon be pushed to completion. We recommend that the work be placed in charge of an experienced archaeologist, with an advisory board of archæologists the members of which shall serve without pay, the results of which inquisition to be preserved by publication.

THOMAS WILSON, Chairman.
Curator of Anthropology, Smithsonian Institution, Washington.
GEO. A. DORSEY,
Curator of Anthropology, Field Columbian Museum, Chicago.
FRANK RUSSELL,
Instructor in Anthropology, Harvard University, Cambridge.
Members of Committee.

The bill which was presented early this year read as follows:

A bill establishing a Survey of the Antiquities of Michigan and making appropriations by fiscal years therefor.

The People of the State of Michigan enact:

Section 1. That a survey of the antiquities of Michigan be and the same is hereby established.

Sec. 2. That the survey shall be in charge of a commission comprising the Governor of the State ex-officio, the President of the University of Michigan, the *President of the Michigan Academy of Science*, the President of the Pioneer and Historical Society, and the President of the Detroit Archaeological Society, this commission to serve without compensation, but to be reimbursed for their actual and necessary expenses.

The commission shall have the power to employ an archæologist and one or more assistants and to make such incidental expenditures as the nature of the work may require. The accounts for salaries and other expenses provided herein shall be paid upon the warrant of the Auditor General monthly upon the approval of the Governor. At the

[1]Science p. 140—1901 and American Anthropologist, Vol. 2, No. 4, p. 768.

end of each fiscal year the commission shall cause to be made an annual report, the copy for which, as soon as completed, shall be forwarded to the clerk of the Board of State Auditors for publication by the State printer, the expense of such publication to be paid from the general fund of the State upon the allowance of the Board of State Auditors.

Sec. 3. For the purpose of carrying out the provisions of this act, exclusive of the cost of publishing the annual reports, there is hereby appropriated from the general fund of the State for the fiscal year ending June 30, 1902, and each fiscal year thereafter, the sum of $2,500.

Should the bill pass it will be necessary to secure an archæologist to direct the survey who not only has field experience and will avoid the pitfalls so often fatal to such undertakings, but who also can secure the re-establishment of anthropologic work on the University curriculum. The renewal of the course could be easily secured by offering a few lectures the first year, supplemented the second by laboratory work on the results of the survey. This plan would not only furnish material for the students to study, but would also further the interests of the survey by their preparation of its material. These students could later conduct special pieces of research in the field during the summer months and in the laboratory prepare the material and work up the matter for theses. The director should also give popular lectures throughout the State in order to develop a respect among the citizens for the subject which has now become a science and to give them instruction in it.

Should the bill fail to pass it is still significant that the matter should have reached this climax. With the large number of influential and thoughtful people now striving for this survey as part of a permanent anthropological institution in the State and the increased public interest which they have aroused, the subject has now a larger constituency in the State than ever before and with or without the survey the whole movement is one in advance.

[Note.—This paper, with slight changes, was published in the American Anthropologist (N. S.), Vol. 3, January-March, 1901. The bill failed to pass but, beginning in the American Anthropologist (N. S.), Vol. 3, April-June, 1901, the writer has begun a summary of the existing knowledge of the archæology of the State which, had the survey been established, would have been its first task.]

RECENT WORK OF THE GEOLOGICAL SURVEY.

BY ALFRED C. LANE.

Since the last meeting of the Academy we have issued volume 7 of our reports which contains reports on Monroe, Huron and Sanilac counties. Taking these three counties together, one can form a very fair conception of the course of events in the retirement of the ice from the southeast part of Michigan. Considerable progress has been made in delineating the topography of the bed rock surface, and it is worth noticing that there does not seem to be a very close harmony between the bed rock topography and the direction of the ice motion. In the Huron county report I have called attention to the wasting away of the eastern shore of Huron county and am led to an estimate of the age of the Great Lakes which is considerably less than 10,000 years.

This is a point where the various local members of the Academy may be of great assistance in calling our attention to geological action now going on which may enable us to compute the length of the post-glacial time. Prof. Davis' work on the peculiar botanical distribution in Huron county has already been called to your attention and Prof. Sherzer's work on the glass sand of Monroe county has already proved of great practical value. I expect to see the glass industry grow in Michigan. But I will not dwell long upon volume 7, for it can speak for itself, except to call your attention to the fact that in the Sanilac county report by Dr. Gordon is an account of the famous stone wall near Cass City which has been widely heralded in the daily press as a relic of the pre-historic race, but is in reality nothing more than an ice push wall.

Passing to matter which has not yet been put in press officially, I would call your special attention to the brilliant work of Prof. Davis on our marl deposits tending to show that among many of the various possible or true factors in marl formation the efficient one is the work of Algae[1] in producing the beds of great value. He will bring it before you here in another section. Mr. Taylor has published a study of the glacial and surface geology of Lapeer county in the Lapeer County Clarion, and through the work of Mr. Taylor and Mr. Leverett for the United States Geological Survey we shall soon have a mass of detailed facts for surface geology.

In June, 1900, I published a short article in the American Journal of Science giving results of the tests of increase of temperature at Bay City. It proved to be 1° in 67′ for 3,500′. Recently an opportunity offered to get the same gradient at Cheboygan and we found that from a mean annual temperature of 41.6° at the surface, the temperature rose to 61.6° F. at about 1,360′ below. It gives nearly the same gradient,

[1] Journal of Geology, 8: No. 6, Sept.-Oct., 1900.

one degree in 68 feet. We ought to have a few more observations because variation of the thermal gradient of Michigan is a matter of more than local interest. The deepest mines of the world are in this State and in them the gradient is 1 degree in not less than 107 feet I hope to be able to get a few more thermometric observations.

The workers of the Upper Peninsula are still engaged in the correlation of the copper bearing lodes and the acquisition for science of the abundant data offered by the new explorations. This is of practical as well as scientific value, while Dr. Hubbard tells me that in one case of which he knows, in estimating the value of land as containing the Baltic lode, the supervisors were more than a mile off.

Our Railroad Commissioner, Mr. Chase S. Osborn, has invited me to visit with him some large caves in the Niagara limestone of the Upper Peninsula, and I should be glad to have all who are interested in cave life, visit the place.

The work just now in hand in the Lower Peninsula is largely concerned in the study of marl and the correlation of the various coal seams. The new explorations for coal are bringing to light a fauna and flora little by little, which has been sent to Washington for identification, and shows an equivalence with the Pottsville formation, i. e., what was formerly known as the Millstone Grit.

PAPERS READ IN THE SECTION OF BOTANY.

THE RELATION OF THE FIBRO-VASCULAR BUNDLES IN THE ROOT AND HYPOCOTYL IN ECHINOCYSTIS LOBATA TORR. & GRAY.

JAS. B. POLLOCK, SC. D.

In the common wild cucumber, Echinocystis lobata, Torr. & Gray, the writer has observed some facts concerning the transition of the fibro-vascular bundes from the root to the hypocotyl, that seem not to have been described or observed by previous writers on the subject of this transition. The new facts concern the change in number of bundles, which is four in the root and six in the upper part of the hypocotyl, as Lamounette[1] found in Cucurbita maxima and Cucumis melo. The seedling of Echinocystis differs in several particulars from those of most of the other Cucurbitaceæ examined by the writer. First it does not develop a special organ for holding the seed coats in germination as most of the Cucurbitaceæ do. Second, two whorls of vigorous secondary roots, with four roots in each whorl, are developed very early in germination. These whorls are usually 2-4 mm. apart, and situated at the top of the primary root, the upper whorl marking the point where apparently the root leaves off and the hypocotyl begins.

A study of cross sections shows that only below the second whorl of secondary roots does the primary root show the typical root structure, with four sets of xylem bundles alternating with four sets of phloem bundles. The secondary roots of the lower whorl are opposite the xylem bundles of the primary root. Between the two whorls of secondary roots the rearrangement of the xylem bundles takes place just as described by Lamounette in Cucurbita maxima. Each xylem bundle of the primary root separates into two parts, each of which, for some distance takes a secant position, then unites with a similar part from a neighboring xylem bundle, the two finally forming a single xylem bundle lying internal to the corresponding phloem bundle. In Echinocystis this change is completed at the level of the upper whorl of secondary roots, so that at this point there are four collateral bundles, with the secondary roots lying opposite the spaces between them and directly over the roots of the lower whorl. So far then as the relative position of xylem and phloem are concerned, the change from root bundles to stem bundles is completed at the level of the upper secondary roots, and here the number of bundles is the same

[1] Lamounette,—Recherches sur l'origine morphologique du liber interne. Ann. d. sci. nat. Ser. 7, 11: 193-278, 1890.

as that in the primary root. (Fig. 1.) The bundles in the hypocotyl later become bi-collateral by the development of phloem internal to the xylem.

Above the upper whorl of secondary roots at a distance varying from 1 to 16 mm. each of the four collateral (or bi-collateral) bundles separates into two equal parts, making eight in all which take up positions at approximately equal distances from each other, except that there are two groups of four (Fig. 2). Then higher still in the hypocotyl, at opposite points in the circle of eight bundles, two adjacent pairs again unite to form one bundle each (Figs. 3 and 4), making only six in the circle, and this number continues up to the cotyledons. The two bundles formed by the fusion of two pairs are so situated that they would be cut by a plane between the cotyledons splitting the hypocotyl into halves. They correspond therefore to the edges of the hypocotyls of those of the Cucurbitaceae whose hypocotyls are much more flattened, as Cucurbita pepo and C. maxima.

The individual bundles that unite in pairs when the number is reduced from eight to six, have not originated from the same original bundle of the four immediately above the upper roots, but from adjacent bundles of those four as will appear by following through the changes as indicated in figures 1, 2, 3, 4. These figures are diagrams made from actual sections, and represent dimensions fairly accurately. Fig 1 shows a section above the upper whorl of roots, where two of the four bundles first show indications of separating into two each. Fig. 2 shows the eight bundles, which are grouped distinctly into two groups, having a definite relation to the longest diameter of the section, which is not exactly circular in outline. Fig. 3 shows two pairs of the eight bundles almost fused, and Fig. 4 shows the bundles as they are found in the upper part of the hypocotyl, and through the greater part of its length.

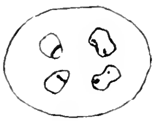
Fig. 1.

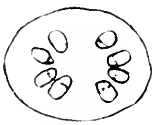
Fig. 2.

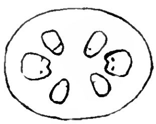
Fig. 3.

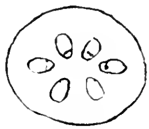
Fig. 4.

SUMMARY.

1. Echinocystis lobata has no special organ at the base of the hypocotyl to hold the seed coats in germination, but it develops very early in germination two whorls of secondary roots near the top of the primary root.

2. Only below the second whorl of lateral roots does the primary root show the typical root structure.

3. The transition from root to hypocotyl so far as it involves the relative position of xylem and phloem takes place between the two whorls of lateral roots.

4. Roots of the upper whorl lie opposite the spaces between the bundles and not opposite the bundles, but they are directly over the roots of the next lower whorl.

5. Just above the upper whorl of secondary roots the number of fibro-vascular bundles is four. Each of these separates into two approximately equal parts, and two pairs of these eight unite so as to leave only six in all. This number continues up to the cotyledons.

6. The point above the upper whorl of secondary roots at which the four bundles begin to separate into eight varies in different individuals from 1 to 16 mm. The whole change from four to eight, then to six bundles may take place within 8 mm. in length of the hypocotyl, though in one case examined it extended through a length of 30 mm. The smaller numbers are more common.

THE ECOLOGY OF A GLACIAL LAKE.

HOWARD S. REED.

About three miles west of Ann Arbor there is a group of small lakes and ponds which, on account of their richness of life, are favorite collecting grounds for biological students. In the autumn of 1900 I undertook a study of the ecological relations of the flora around one of these lakes, of which study a preliminary report is here furnished. The lake which I studied is the remnant of a lake which in recent geological times had four or five times the area of the present lake, and in its deepest portions was forty or fifty feet deep; at that time it probably had an outlet to the southwest. The lake extended ten or fifteen rods farther east than it does at present; from the southeast a wide cape extended into the lake; west and southwest of this cape the lake extended back twenty or twenty-five rods farther than it does now, covering several acres of ground. the former western shore was approximately parallel to the present one, but two or three rods farther back. A shallow bay or arm extended off to the northwest which is still traceable by the extension of zones in that direction. The northern shore was steep and the water probably extended only a few feet back of the present zone of willows.

This former extension of the lake has had an important influence upon the character of the present vegetation. While it prevailed, it of course drowned out all terrestrial plants, then, as the surface of the lake was gradually lowered, the aquatic and semi-aquatic forms had the first chance to get a foothold and become established on the land which was thus uncovered. This was especially the case on the east, west, and southwest shores of the lake, where, on account of the gentle slope of the bottom, there was always a wide strip of shallow water in which aquatic and semi-aquatic plants could get a strong foothold long before it was suitable for terrestrial forms to occupy.

At a certain stage in the recent geological history of the region, as the surface of the lake fell, the large lake was divided into two,— the present lake and another similar, smaller lake four or five rods south of it, which has now almost disappeared.

At the present lake there are six fairly well defined, concentric zones of vegetation.

I. A zone of *Characeae* occupying the central, deeper portion of the lake. The characteristic plant of this zone is *Chara.* sp.

II. A zone of *Potamogetons* characterized by *Potamogeton lucens*, L.

III. A zone of *Nymphea* from ten to thirty feet wide just outside of the shore line in water varying from six inches to two feet in depth, its characteristic plants are *Nuphar advena*, Ait. f., *Potamogeton natans*, L., and Chara.

IV. A zone of *Carex* and *Sphagnum* from six to twenty-five feet wide and extending around nearly the entire circumference of the lake, its characteristic plants are *Carex filiformis*, L., *Sphagnum*, and *Potentilla palustris*, Scop. The outer edge of this zone is two or three inches below water level, the inner edge is five or six inches above water; lying so close to the actual water level, this zone is of course saturated with water and the tough mat of sedges is little better than a floating island.

V. A zone of *Salix* and *Populus* from ten to forty feet wide extends entirely around the lake and stands from three to twenty-four inches above the preceding zone. Some of its characteristic plants are *Salix alba*, L., *S. lucida*, Muhl., *S. myrtilloides*, L., *Populus tremuloides*, Michx. and *Ulmus americana*, L.

VI. A zone of *Gramineæ* and *Compositæ* lies just outside of the last zone and is from six to thirty inches above it. Its most characteristic plants are *Spiræa salicifolia*, L., *Eupatorium perfoliatum*, L., and *Rumex obtusifolius*, L.

The greatest admixture of terrestrial plants occurs on the north and southeast shores where the struggle between plants has been greatest for some time. The list of plants now contains representatives of thirty-two orders.

A study of the different zones shows that their positions are not permanent, but that they are slowly encroaching upon the lake and filling it. The Nymphea zone is a more active land-forming agent than either the Chara or Potamogeton zone. The leaves and petioles of Nuphar projecting above the surface of the water catch and hold most of the twigs, plants and leaves which are blown into the edge of the lake, until they become water-logged and sink. The debris resulting from the decay of the plants added to those which they have captured all goes to build up the bottom. Whenever in any place the bottom is not more than four or five inches below the surface of the water, the sedges begin to move out and occupy the territory thus prepared for them. Perhaps at first they only send out a few skirmishers which occupy the top of a muskrat's mound; generally, however, they advance in an unbroken, solid line and cover the soft muck with a tough, quaking mat of vegetation. As the Carex zone crowds upon the Nymphea zone, so is it in turn crowded upon by the Salix zone.

On steep gravelly banks and places where conditions are unfavorable for the growth of Nuphar, this process of filling does not occur, because the preliminary process of filling by decay cannot take place, the result is that the shore line in such places is quite well marked and permanent.

A few rods south of the lake is the site of the "dead lake," mentioned above, which may throw some light on the life history of the present lake. There is an elliptical depression, in the center of which is a group of sedges and ferns surrounded by a wide belt of willows, outside of these again, a zone of grasses and terrestrial plants. It appears as if this had been the site of a former lake which had been steadily encroached upon by the sedges, in the manner previously described, followed in turn by the willows as soon as the sedges had formed a more or less firm soil. The sedges have exterminated the water lilies and now the willows have in turn all but exterminated the sedges.

My study as far as it has been carried shows at this lake the following facts.

1. The comparative scarcity of terrestrial plants, already explained.

2. A striking predominance of northern forms, undoubtedly the result of the glacial invasion of recent geological time which forced northern forms far to the southward.

3. An interaction of organic and inorganic agencies that has caused and is now causing an unmistakable advance of plants into the water.

4. A struggle in each zone, severer on the landward side than on the lakeward side of that zone.

5. A marked tendency for plants that are engaged in this severe struggle to mass themselves together in solid ranks.

Botanical Laboratory, University of Michigan.

A DISEASE OF THE WHITE BIRCH.

BY JOHN LARSEN.

The beetle Agrilus anxius, one of the Buprestidae, is causing great ravages among our shade birches, both the white and also the cut-leaved variety.

A tree that has been attacked does not die the first season but seems to live during several seasons, the beetle doing its work each season. Infected trees very often have last year's leaves remaining upon branches that have suffered severely. The death of the trees begins at the top and proceeds downwards. In trees that are nearly dead only a few of the lowest branches bear leaves tardily in the spring only to wither soon. The burrowing of the larvae weakens the limbs to such an extent that many of them break from their own weight. Trees may be found where nearly all the limbs hang down broken.

The trees are usually first attacked towards the top where the limbs are from three-fourths to one and one-half inches in diameter and usually only in badly affected trees are the burrows found towards the base in the trunk of the tree.

Aside from the appearance spoken of the presence of the beetle is shown by narrow swollen ridges on the bark which often on the smaller limbs run spirally for some distance. Cutting through these a burrow is always found just beneath the surface. The burrows follow no definite direction in the limbs but may be found running zigzag in any direction, sometimes running upwards, then doubling to again run downwards; sometimes near the bark, then turning inwards even running straight through the center of the limb to the opposite side. The smaller the limb the straighter usually is the course upwards or downwards of the burrows.

The burrows are sometimes found in twigs only one-fourth inch in diameter where they run straight in the center. In the trunk they do not penetrate deeply but twist around among and through each other making it impossible to trace them for any distance as they often form a complete network. In the trunk they do not form regular ridges but irregular swellings; in the smaller limbs and twigs no external sign is shown. The smallest limb upon which ridges were found was one-half inch in diameter. No ridges are found except where the burrow has cut the cambium.

During the early period of the investigation leading to this paper in the early spring of 1899, "Bulletin No. 19, New Series," of the Agricultural Department at Washington came to hand. This furnished the identity of the beetle and data of its distribution. The bulletin speaks of the birches in Buffalo, N. Y., and in Detroit, Mich., as having suffered very severely. Aside from this the observer has found most of the trees here in Ann Arbor suffering more or less severely and many of them dead. The same was found to be the case in various parts of Chicago, Ill., particularly in Humboldt Park where many have died and others were in a precarious condition. Upon inquiry it was found that nursery stock had been brought from Rochester, N. Y., and that some of these were infected. Some specimens were brought here from Rochester for experimenting and planted upon the campus. Upon one of these were found the ridges mentioned above.

The life history of the beetle as far as observed is this: The eggs are deposited in crevices in the bark in the early summer. Insects confined in a glass jar were found to be depositing eggs on June 8, and for a week or more afterwards. Pieces of fresh limbs were supplied, but the insects did not deposit their eggs upon these, but moved about feeling for crevices with their long prehensile ovipositor and having found a place such as between the glass and the lower part of the cork or under a piece of wood, from five to ten or more eggs were put in one place. Copulation had gone on for some time before this. Great activity was exhibited during the copulation and egg-laying. No observations were made of the development of the eggs. Fully formed larvæ were found early in the winter. They remain torpid until spring.

Larvæ that were still in the winter stage were found until April 12. Shortly after this the pupa stage began to appear and development went on rapidly until May 1, when a few adult insects were taken coming out from the burrows. At this date, however, most were still in the pupa stage. Then came a spell of cold weather and not until more than a week later did the insects come out in numbers, many being taken from the burrows as late as May 15.

That the weather, or rather the temperature, decides the time of development is indicated by the above facts. And it was further demonstrated by material kept in the laboratory. Parts of branches containing larvæ were taken into the laboratory in March and development began immediately and an adult insect obtained in the middle of April.

The mode of escape of the beetles from the burrows and places in which the larvæ spend the winter is interesting. The larva burrows out near the bark, then turning into the wood at a slight angle an enlarged oblong chamber is formed in which the larva rests and undergoes further development in the spring. The burrow has been carried outwards in a rather sharp curve which brings its end to just beneath the bark beyond the chamber. When the beetle is ready to escape it makes its way to this and, eating through the bark, escapes. The larva is often found doubled up in the chamber. Normally it lies with its ventral side turned outwards and the beetles are found in this position. Some were found reversed and could not escape. The escape is rather laborious as the insect must squeeze its way to the bark and then eating a small hole again squeeze its way through. Beetles are found with the forward parts of their bodies protruding for hours making long rests between efforts to free themselves. There seems to be no rule governing the direction, whether upwards or downwards, in which the head of the insect is turned during development.

The extent of the burrows is not an easy matter to determine, nor precisely where they take their origin. They are compressed in shape to suit the flattened shape of the larvæ. In one place in a slight swelling on the bark were several small openings, less in diameter than a pin. From these openings burrows were traced. The burrows are at first very small and lie close under the bark and are filled with dark granules, probably colored by tannin. As they become larger and begin to run deeper, they are filled with a whitish dust shown by the microscope to be parts and groups of wood cells.

As to extent one was followed through its winding course a distance of 1 foot 7 inches in a length of branch of 4 inches, now near the bark, now deep down in the wood; now running upwards in the branch, now running downwards. Neither the beginning nor the end of this burrow was found. The branch was somewhat less than an inch in diameter. As mentioned above in small branches the course becomes straight. One burrow was traced upwards in a branch of about a half inch in diameter a distance of about eighteen inches, then doubling upon itself ran downwards parallel to the upward course. When the branch becomes a fourth of an inch or so in diameter no doubling is possible and chambers are often found hollowed out in such twigs. The wood for some distance around a burrow is often found discolored and decaying thus weakening the branch and producing the breaking mentioned above. This breaking often takes place at a chamber, exposing the larvæ to cold and to birds. Woodpeckers are in the habit of burrowing down to the chambers and extracting the larvæ.

When the beetles leave the trees they leave a hole which in outline has one straight side and one curved. The back of the insect in coming out is turned towards the curved side. Either side may be upwards or downwards on the tree, but always one or the other. These holes may be very numerous on one tree. Eleven were counted, in one instance, on a circular space of two and one-half inches in diameter.

Although the beetles may be coming out in numbers, few are found upon the tree. They seem to crawl about for a short time and then taking flight leave the tree.

Methods of destruction were thought of but are hard to apply, on account of this habit of leaving the tree, and besides it was found that they do not feed upon the leaves of the birch. This was demonstrated by keeping a number in a large glass jar in the laboratory and supplying them with fresh leaves. When only birch leaves were supplied they fed but very sparingly. Some elm leaves were then put in with the birch and they fed greedily upon these. This led to further experiment and various sorts of leaves were used. They fed upon almost any leaf of a soft texture. But their favorite food was willow, poplar, and aspen leaves with preference strongly marked in the order given.

It seems from this that the beetles upon leaving the birch feed on other trees until the time for reproduction.

Peculiar growths in the tree itself are caused by the burrows, or rather by some stimulus furnished by the burrows or by the larvæ. It was stated that wherever the burrows were near the cambium corresponding ridges were to be found on the outer surface of the bark. This is due to a growth of sclerotic cells which is formed as an arch over the burrow on the side towards the bark. When the burrow is entirely below the cambium no such growth occurs. It appears that the cambium must be injured before this growth takes place. Between the burrow and the sclerotic tissue a secondary cambium is formed which gives off cork cells towards the burrow tending to fill it up. In some cases this cambium could be connected with the cork cambium of the tree and may take its origin from this. But it was not demonstrated that this was always the case. It may to some extent take its origin from the parenchyma. In any case it seems to give off cells both to form the corky layer mentioned and also in the opposite direction to form the sclerotic tissue.

The cambium of the tree after a time bridges over the burrow and its covering of sclerotic tissue, forming an arch and performing its normal function covers the whole with wood, and while preserving the external ridges buries the burrow deeper and deeper. Burrows, buried in this way, were found with three annual rings above them showing that the trees would overcome the injuries were it not for renewed attacks by numerous beetles. The forming of sclerotic tissue and secondary cambium is probably a means to this end.

That this is true and that the growth mentioned is due to mechanical injury, at least to a large extent, was demonstrated by driving nails through the cambium, leaving wounds which showed the same growth of sclerotic tissue as in the case of the burrows.

In many cases the holes left by the escape of beetles were filled up by the cork cambium growing down and filling them with cork, even to beyond the chambers. Holes left by the falling of dead twigs are filled in the same way. That the tissues mentioned as cork were really such was shown by testing with strong sulphuric acid.

Agrilus anxius has been found upon the willows and it may be that the birch is a new host. In that event, it is not so strange that they should thrive; it may take some time before they are followed by their natural enemies.

THE INTERFOLIAR SCALES OF MONOCOTYLEDONOUS AQUATICS.

MINNA C. DENTON.

(Abstract.)

The squamulæ intrafoliaceæ are transparent scales which are found in the axils of leaves of certain water plants. They occur in all genera and species of certain large groups; these are the Naiadaceæ the Potamogetonaceæ, the Scheuchzeriaceæ, the Alismaceæ, and the Vallisneriaceæ.

The squamulæ are trichomatic in nature, but they differ from most trichomes in several respects. One of these is the absolute regularity of their occurrence; each and every leaf of the plant is provided with them. Another point is the constancy in the number of squamulæ borne in each leaf axil, which the species always shows. In Elodea Canadensis, for example, there are two spuamulæ to each leaf, never more, never fewer. In many plants, however, the number varies within larger or smaller limits. The squamulæ arise in pairs, not simultaneously, but successively. They are often so numerous as to form a crowded circle which passes entirely around the stem in a line just above the leaf insertion.

The squamula is ordinarily composed of non-chlorophyll parenchymatous cells; it has a core or midrib which consists of two or several layers of cells, but its margins and apical portion are only one cell thick. The shape of the scale varies with different plants; perhaps the commonest form is lanceolate ovate, often with a very much elongated tip.

The size varies greatly in different species. In Elodea Canadensis the length is about .3 mm.; in most Potamogetons, .5 mm.; in Zostera marina, 3 mm.; in Scheuchzeria palustris, more than one centimeter.

The squamula is only a transitory organ. It arises when the leaf to which it belongs is a mere rudiment; soon outstrips the leaf in rapidity of development, and perishes by the time the leaf has reached its maturity, or perhaps much sooner. From this fact, it is evident that the squamulæ must in some way be connected with the nourishment or protection of the young embryonic tissues.

A number of the marginal and apical cells of most squamulæ are engaged in the formation of some sort of slime or mucilage. This fact Schilling* interprets as supplying the chief function of these organs. But the number of cells thus engaged is very small when compared with the total number of cells in the squamulæ, being only 1:200, or in a ratio many times smaller.

Lastly, the squamula is an organ not incapable of varying its function to suit the conditions in which it finds itself. Such a variation we find in the chlorophyll squamulæ of Naias, which differ widely in cell contents, size of cells, and in the size and shape of the whole structure, from the ordinary Naias squamula.

* Flora, 1894, Untersuchungen über die Schleimbildung der Wasserpflanzen.

NOTES ON THE FLORA OF EATON COUNTY.

HUBERT LYMAN CLARK.

The country around Olivet is such as to afford attractive hunting grounds to the botanist and during the few weeks in the spring of 1900, when I was able to devote some time to the examination of it, it yielded a number of plants that were of interest to me and some that were of sufficient interest to warrant their being recorded. From a list of more than 70 plants which specially interested me, I have selected the following as being the most notable. In the selection of these forms and indeed in the identification of many species which puzzled me especially among the sedges, I am under great obligations to Prof. C. F. Wheeler.

There are four particular spots near Olivet, which have proved especially interesting and a few words in regard to these will make my notes more intelligible. First of all there is the *Lake Region*, as I shall call it, an area of low land, much of it in tamarack, lying southwest of the college and extending several miles. It includes Pine Lake, Garfield Lake and Kenyon Lake, the latter two being close together. In some parts of this region the ground is higher and is cultivated or supports a growth of oak or beech woods. In the drier soil, such plants occur as the purple cudweed (*Gnaphalium purpureum*), the cream-colored wild pea (*Lathyrus ochroleucus*), the rough alum-root (*Heuchera hispida*), the hoary puccoon (*Lithospermum canescens*) and the spiderwort (*Tradescantia virginica*), while in the swampy ground are found the wild rosemary (*Andromeda polifolia*), the low birch (*Betula pumila*) the yellow birch (*Betula lutea*) and the showy lady's slipper (*Cypripedium spectabile*). This region was beyond question the most interesting of any which I visited and repaid every visit.—Next in interest is a partially cleared, tamarack swamp directly west from the village cemetery, and which I will call the *West Swamp*. Beyond it the ground is slightly raised and rolling and is covered with woods, chiefly oak. In the swampy ground are found the cuckoo-flower (*Cardamine pratense*), the swamp valerian (*Valeriana sylvatica*), the sea-side arrow-grass (*Triglochin maritima*) and the sheathed cotton-grass (*Eriophorum vaginatum*). In the dry woods characteristic plants are the tall tickseed (*Coreopsis tripteris*) and the pale Indian plantain (*Cacalia atriplicifolia*.)—The third region of special interest is along the track of the Chicago and Grand Trunk Railway, between Olivet station and Bellevue. In this neighborhood, characteristic plants are the prostrate amaranth (*Amaranthus blitoides*) and the yellow and purple goats-beard (*Tragopogon pratensis* and *porrifolius*), the two last being very conspicuous.—Finally the village mill pond, and the sluggish stream that enters it afford some plants of interest. The pond, especially at the upper end, was literally almost covered with the stiff white water-crowfoot (*Ranunculus aquatilis stagnatilis*), which I did not find elsewhere, while the common white species (*R. a. tricophyllus*) was not seen at all. Along the banks of the pond's inlet occurs the green dragon (*Arisaema Dracontium*) in considerable abundance.

In the following list, I have followed so far as possible, the nomenclature of Wheeler and Smith's well-known catalogue of the plants of Michigan published in 1881 (addenda in 1898). I have adopted this plan simply for convenience:

Panicum clandestinum. Found in June along the railway.
Glyceria pallida. Occurs in the lake region.
Carex straminea alata. Was found once near the inlet of the pond.
Wolffia columbiana. Occurs abundantly on the mill pond.
Sisyrinchium graminoides. Occurs abundantly in great tufts, 4 or 5 inches in diameter and over a foot high, on a hillside south of Kenyon Lake. The flowers were very pale blue and several of the tufts were pure white.
Sisyrinchium angustifolium. Occurs sparingly in the lake region.
Salix tristis. Beside a road in the lake region.
Stellaria crassifolia. Rather common in the west swamp.
Sisymbrium altissimum. Not common, but occurs along the railway.
Vicia sativa angustifolia. *Vicia cracca.* Both these occur along the railway.
Epilobium molle. Found in September in the west swamp.
Pyrola rotundifolia incarnata. Common in a small patch of tamarack south of Kenyon Lake.
Frasera carolinensis. Rather common in several places, especially on an oak ridge west of the west swamp.
Lonicera oblongifolia. In a dense bit of tamarack near Kenyon Lake.
Senecio aureus lanceolatus. In an open swamp in the lake region.
Helianthus petiolaris. Along the railway, a few scattered specimens.

SOMETHING CONCERNING THE FORESTS OF NORTHERN MICHIGAN.

W. J. BEAL, Ph. D.

Dr. Beal showed a series of lantern views of Michigan forests, and made appropriate comments upon them as they were shown. Among the views were some of a virgin forest, methods of cutting and removing logs, and the sawmill.

NOTES ON UTRICULARIA CORNUTA MICHX.

CHARLES A. DAVIS.

The vegetative parts of this plant are described in Gray's Synoptical Flora as follows: "Filiform radical shoots apparently none; leaves fasciculate, evanescent, rarely at all seen; scape, etc."

In the paragraph describing the group of species to which the plant belongs we find this "Scape leafless and solitary, the base rooting in mud or bog, usually rising from or producing filiform and root like creeping shoots which bear slender subulate—gramineous, occasionally septate simple leaves, or branches, which take the place of leaves, to the lower part of which, as also to the colorless shoots bladders are sparingly attached, usually fugacious or unnoticed, so that the flowering plant appears to be a leafless and naked scape only." Also in farther subdivision for the species under consideration the note "leaves entire, terete; these and the bladders seldom seen." P. 316. Vol. 2. Part I.

In Gray's Manual the description is as follows: Scape solitary slender and naked or with few scales, the base rooting in the mud or soil. The leaves small, awlshaped or grass-like, often raised out of the water, commonly few or fugacious. "Air bladders" few on the leaves or rootlets, or commonly none. Leaves entire, rarely seen (group description, 6 Ed., p. 379).

Britton and Brown have the following: "Stems and branches rootlike, sometimes with a few entire leaves and few bladders or several; scape rooting in the mud." Illustrated Flora Vol. III, p. 189.

These descriptions are faulty in several particulars and probably are so because of poor collecting and because of the peculiar habits of growth of the plant. It grows as I have found it in bogs and other wet places, apparently always in a dense turf with the rootstocks of some of the smaller sedges interlaced with its own stems in such a way that it is practically impossible to find out much about the structure of leaves, stems and bladders. These are very fragile and in the process of separating them from other plants they are easily destroyed or disappear altogether. The usual way collectors attempt to get specimens of the plant is to take hold of the stout scape and pull. The result is that all the underground parts remain underground and we learn that bladders and leaves are few or wanting or fugaceous by the same act. Last summer I had an exceptional opportunity to study the plant, an opportunity for which I had been looking a long time, by the way, and availed myself of it.

A group of plants was found in sand which was not bound together by the roots of any other plant, or by its own underground parts. This was carefully taken up and washed free from sand and the tangled mass was straightened out as far as possible. It was found that not only were the leaves not few, but they were exceedingly numerous and that much of the vegetation forming the "turf" about the base of the scape and for some distance around it in the ordinary habitat was really formed by the emerged tips of these leaves which exactly resemble those of some of the small sedges, and form a compact body of foliage easily mistaken for real turf. These leaves were borne on profusely branching stems which were so much tangled that it was difficult to work them out. The leaves are flattish, slightly curved at the tips and bear numerous filiform or capillary lobes which in turn are the bearers of numerous colorless bladders, extremely delicate and easily pulled off when the lobes are disentangled. The part of the leaf above the surface of the mud is green, the rest colorless, and at the lower part of the green portion are frequently found one or two small bladders. At the base of the leaf from the same node is generally, perhaps always, a long capillary branch which is undivided but bears a large number of bladders arranged alternately. Whatever the true morphology of these various parts may be it is evident that the green parts are functional as leaves and the strings of bladders are more or less roots. The scape arises as a branch from the stem, but from the axils of lower bracts, those below the surface of the ground, come clusters of root-like organs which, when the plant is in bloom form a perfect tangle of fibers and stems about the base of the plant. It is hoped to complete the studies begun on this interesting plant another season, and to determine the real relationship of the various organs, as they are not clear at the present time.

WOLFFIA NOTES.

CHARLES A. DAVIS.

This smallest of our flowering plants is as most of us are aware so insignificant in size and so inconspicuous in everyway that it is rarely seen and reported by collectors. This is instanced by the fact that it is not reported by Mr. C. K. Dodge in his Flora of St. Clair county and that it has not been noted more frequently in the State. It is probable that like all other plants, it has periods of great scarcity and of great plenty, and while in most ponds and slow streams it may be found at all times when the water is open, there are exceptionally favorable seasons. Such a year was 1900 in the water with which the writer is most familiar, the mill pond at Alma. Wolffia, probably of both species, is not an uncommon plant in the pond and is generally not difficult to find in such places as Lemna is found. In October of last year, however, it was very abundant, forming dense green patches at any place on the pond where the various water plants reached the surface and prevented its being blown about by the wind. On the shores of the pond there were often windrows of the plant three or four inches deep, a half foot or more wide and rods in length. The number of individual plants in these masses must have been enormous and when it is said that the plant could have been gathered by bushels there probably is no exaggeration. This extensive propagation of the plant so late in the season may not be uncommon, but it is the first time it has come under my notice in the course of a number of years of work along the shores of favorable localities for such developments and I have brought it to your attention to find out if others have ever seen similar abundance of the plant.

NOTES ON MICHIGAN SAPROPHYTIC FUNGI.

BY B. O. LONGYEAR, AGRICULTURAL COLLEGE, MICH.

In addition to the regular collecting done in the vicinity of the Agricultural College, three other localities were visited, by the writer, during the summer of 1900, for the purpose of studying their fungus flora. The first trip lasting one week and covering territory in Kent and Montcalm counties around Greenville, was made early in July and other material from the same locality was collected by Mr. Bronson Barlow in October and November and shipped in moist sphagnum to the botanical department at the college.

The surface of this region is frequently broken by sandy hills and ridges between which lie small spring-fed lakes and streams often bordered by marshy, sphagnous woods. Much of this land was formerly covered with pine and young growth of this character is often found mixed with the other remaining timber while portions of cedar swamps still remain in what is known as the Wabsis Lake region.

Portions of July and August were next spent in the southern part of Ingham county in the vicinity of Leslie village.

About ten days during the same months were also spent in collecting at Pleasant Lake in the northern part of Jackson county.

The plentiful rainfall during the past season was especially conducive to the growth of fleshy fungi and no time had to be wasted for want of material for study and preservation.

While it is possible for the collector of the higher plants to take care of a large number of specimens, and then study them at leisure, the fungus collector, on account of the transient quality of many of the characters and the perishable nature of his specimens must spend much time in taking notes, making sketches and carefully drying or preserving the material in order to make it worth carrying home.

About seventy-five species new to our previous lists were collected last season and among these are seven species new to science. The following species are noted as being interesting, uncommon or rare.

Amanita frostiana Pk. A few specimens of this small species were found growing in company with A. muscaria small specimens of which it much resembles. Pleasant Lake; July.

Lepiota alluviinus Pk. Several specimens of this little lepiota were collected in the shade of shrubs on the college campus in July.

Lepiota metulaespora B. & Br. The long pointed spores of this small Lepiota serve to distinguish it from others. Several specimens were found in a woods adjoining the College.

Lepiota morgani Pk. This large, showy fungus has acquired a bad reputation. It is readily mistaken for the Parasol Mushroom, Lepiota procera, by the novice and serious results have sometimes attended its eating. It usually grows in pastures and cultivated places while L. procera frequents the woods. However, specimens of L. morgani found in the woods were sent for identification by one correspondent, while the writer found a specimen of the Parasol Mushroom growing in a well cultivated garden during the past season.

Marasmius nigripes Schw. A very small fungus growing on decaying spruce needles, is remarkable for the shape of its spores which are strongly nodulose or stellate. Shade of evergeens, College campus.

Hygrophorous miniatus sphagnophilus Pk. This new variety of the Red-lead Hygrophorous was found quite plentifully on an island in Pleasant Lake. Its deep vermilion colors make it very noticeable. July.

Hygrophorous marginatus Pk. Is an attractive species of a brilliant orange with margined gills of the same color. A few specimens were found in moist woods at Pleasant Lake. July.

Hygrophorous unguinosus Fr. A single specimen of this fungus was found at Pleasant Lake in moist woods. It is an unattractive species of a smoky brown color with viscid cap and stem peculiarly swollen in the middle. It does not seem to have been recorded in this country before.

Tricholema fuligineum Pk. Two specimens of this rare fungus were collected in mixed pine woods at Greenville, July 12. The specimens emitted a strong moldy odor while the lamellæ became black in drying.

Tricholoma tricolor Pk. Is a large handsome fungus with a mixture of red and yellow tints on the cap and yellow gills that assume a dark reddish brown on drying. One specimen was found at Leslie and another was brought from the U. P. Experiment Station by Professor Wheeler.

Clitocybe albissima Pk. Fine specimens of this fungus were found growing in the form of a large ring near Greenville, by Mr. Barlow, and a photograph secured.

Cantharellus cinnabarinus Fr. An unusual form of this attractive and somewhat rare fungus was found at Pleasant Lake. The thick gills were connected by short ridges and were margined with yellow, while the stem was tinted with the same color.

Russula vesca Fr. A single specimen of dark color was found at Pleasant Lake.

Pluteus leoninus Pers. Two specimens of this rather uncommon species were collected near the Agricultural College in September.

Coprinus quadrifidus Pk. This species somewhat resembles the shaggy mane mushroom, but is smaller and was found growing on and near decaying wood. Kent Co. July.

Polyporus umbellatus Fr. A well developed specimen of this branching polyporus was collected at the roots of a tree near Leslie in July. It was at first mistaken for a group of small gill fungi.

Boletus chrysenteron albocarneum Pk. A few specimens of this new variety were found growing on decaying pine stumps at Greenville.

Boletus vermiculosus Pk. Rich woods. Leslie.

Boletus frostii Russell. This fungus is very striking on account of its bright red cap and stem the latter elegantly reticulated with ridges, edged with yellow. The caps of those found were very viscid, a character not mentioned in descriptions. Professor Peck to whom specimens were sent states that B. alveolatus Frost is probably the same thing. Found near Leslie and Michigan Agricultural College.

Boletus mutabilis Morgan. Is a large brown species in which the flesh rapidly changes to blue when cut or bruised. Specimens were collected at Pleasant Lake.

Boletus russelli Frost, is a rare and attractive fungus with greenish pores and a slender stem beautifully reticulated with crimson ridges. Only two or three specimens were found. Rich woods. Leslie.

Boletus spectabilis Pk. Another rare and handsome species with a scaly red cap and annulate stem, was collected by Mr. Barlow near Greenville.

Fistulina hepatica Fr. One large specimen was sent by Mr. Barlow from Greenville.

Fistulina pallida B. & Rav. Two specimens of this rare fungus were collected by Mr. Barlow. It is a much smaller species than the beef-steak mushroom. The cap is tawny or light bay, while the flesh and tubes are nearly white. Two specimens are often found united so as to appear double. It grows at the roots of decaying oak. Fistulina firma, recently described by Professor Peck, proves to be the same species.

Scleroderma geaster Fr. Was found growing in bare, sandy soil at Greenville during July and later in November.

NEW SPECIES OF MICHIGAN FUNGI.

DESCRIBED BY B. O. LONGYEAR, AGRICULTURAL COLLEGE, MICH.

The following species of fungi believed to be new to science have been described from material collected during the summer of 1900:

1. Lepiota cyanozonata n. sp. Pileus 1-1.8 cm. broad, thin except at the disc, conico-convex becoming expanded and broadly umbonate, minutely fibrillose when young, soon glabrous, margin slightly uneven, creamy or pinkish white with a narrow zone of light blue near the margin, brownish tan when dry; gills free, but close to the stem, scarcely crowded, thin, soft, whitish, becoming dingy brown on drying.

Stem 2-3 cm. long 2 mm., thick, equal, apex smooth, minutely silky, scaly below, narrowly fistulose, whitish, attached by strigose fibers; spores white, globose 6-8 microns.

Growing on decaying sticks on ground in woods. Leslie, July 23, 1900.

Considerable doubt is felt as to the true generic position of this little fungus as it seems somewhat intermediate between Collybia and Lepiota. One small unexpanded specimen possessed a delicate fibrous veil similar to that found in the genus Cortinarius, but only the merest remains of it could be found in mature specimens. The flesh of pileus and stem, however, appears to be distinct, and becomes brownish where bruised. Its striking feature is the delicate blue marginal zone which is suggestive of the specific name.

2. Lactarius subseriflnus n. sp. Pileus 1.5-2 cm., broad, flesh thin, convex or plane, depressed around the papilliform umbo, fulvous or light brick-red, sometimes slightly irregular, dry, glabrous, margin somewhat crenate; gills concolorous, thickish, subdistant, rather broad, adnato-decurrent. Stem 1.5-2.5 cm., long 2-3 mm. thick, gradually enlarged toward the base, colored like the pileus, smooth, glabrous, base paler and pruinose, hollow; milk watery like serum, mild, odorless; spores

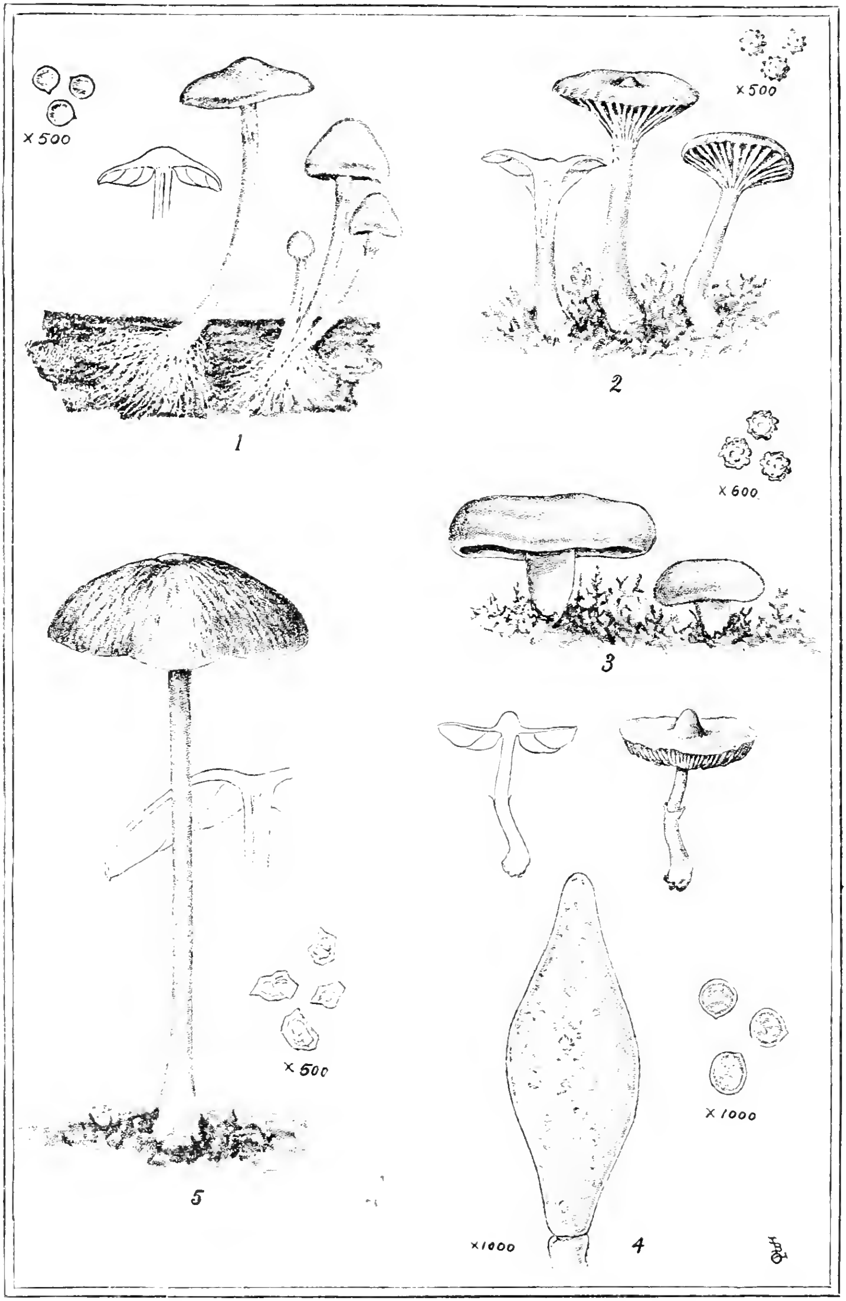

PLATE I.—See Explanation of Illustrations on page 59.

globose, echinulate, 6-8 microns. Growing on naked or mossy soil in upland woods. Leslie, July 24, 1900.

The few specimens found were growing in company with a small form of L. subdulcis Fr. which the species much resembles and from which it is distinguished by its more distant, broader gills and clear milk. It is closely related to L. serifluus Fr., but is separated by its smaller size, umbonate pileus, and more distant gills. The latter species, moreover, is described as growing in moist or damp places.

3. Lactarius brevipes n. sp. Pileus 1.5-3 cm., broad, convex when young, becoming plane and depressed, margin inrolled, dry, whitish-pruinose, reddish tan when rubbed, obsoletely zoned, flesh white; gills adnexed, very narrow, pale tawny, thin, sometimes branched. Stem .6-1.3 cm. long, about two-thirds as broad, equal or tapering downward, smooth, white, solid; spores globose, echinulate, 6 microns. Milk white, becoming light yellow on exposure to air, slowly acrid and astringent to taste, odorless. Growing on moss-covered ground in oak woods. Pleasant Lake, July 27 and 30, 1900.

On account of the short stem the pileus appears to rest on the ground. The species seems somewhat closely related to L. thejogalus, Bull. but is much smaller, while the dry instead of viscid pileus and the very short stem serve to distinguish it from that species.

4. Annularia mammillata n. sp. Pileus 1.7 cm. broad, plane with margin a little elevated when mature, disk raised in the form of a prominent mammilliform umbo, flesh very thin, soft, surface minutely roughish, whitish except the umbo which is lemon-yellow; gills free, ventricose, broad, thin, somewhat crowded, 3 mm. broad, pale flesh color; stem 3.5 cm. long 1.5 mm. thick at apex, gradually enlarging to the base which is 3 mm. thick, smooth above and silky below the ring, white; ring membranous, persistent, white; cystidia spindle-shaped, swollen in the middle 20x50 microns, spores subglobose, smooth, pale flesh color 5-6 microns. On decaying logs in woods. Greenville, July 16, 1900.

This little agaric is evidently rare, only one specimen being found, and is especially interesting because no species of this genus seem to have been thus far recorded as occurring in this country.

The striking character of the specimen is the prominent yellow umbo which rises abruptly from the flattened pileus.

5. Leptonia rosea n. sp. Pileus 3-3.5 cm. broad, flesh thin, convex, obtuse and depressed at the disk, not striate, roughened with brownish fibrils on a roseate ground color, disk darker; gills adnate with a slight tooth, 6 mm. broad, whitish thin flesh-color, not crowded; stem 7-8 cm. long, slender, slightly thickened at apex and base, roseate, base whitened with mycelium, cartilaginous, smooth, stuffed; spores flesh color, angular, 7-8x10-12 microns.

Burnt soil on a sandy hillside, Kent county, July 14, 1900.

EXPLANATION OF ILLUSTRATIONS, PLATE I.

Fig. 1. Lepiota cyanozonata, specimens natural size, attached to decaying wood; section of a pileus; three spores magnified.

Fig. 2. Lactarius subserifluus, three specimens, natural size, growing on mossy soil; three spores magnified.

Fig. 3. Lactarius brevipes, two specimens, natural size, growing among mosses; three spores magnified.

Fig. 4. Annularia mammillata, a specimen, natural size; section of same; three spores and a basidium highly magnified.

Fig. 5. Leptonia rosea, one specimen, natural size; section of pileus; three spores magnified.

The slender, erect form and pleasing color make this an attractive looking fungus. The specific name was suggested by the prevailing rose-color of the pileus and stem, this color being modified in places by brownish tints. Only two specimens were found.

In addition to the foregoing species Professor Peck named two new species from the material sent to him for identification.

Russula pulverulenta Pk. n. sp. having a grayish pileus and yellow stem covered with a pulverulent, yellow scurf. Only one specimen found in woods at Pleasant Lake, July 30.

Hygrophorous paludosus Pk. n. sp. of a pale yellowish color, with a glutinous coating on pileus and stem, the latter having glandular dots at its apex. Growing in sphagnum, Greenville, Sept. 28, Barlow.

Agaricus pusillus Pk. is another new species and was named from material sent to Professor Peck by Dr. R. H. Stevens of Detroit, who has found it growing in Belle Isle Park. A few specimens of the same species were collected by the writer on the campus at the Agricultural College during the past summer. They were at first thought to be A. diminutivus Pk., although differing somewhat from the description of that species. As its name implies, it is small. It also has a very distinct and characteristic ódor and taste of almonds.

A SCLEROTIUM DISEASE OF THE HUCKLEBERRY.

B. O. LONGYEAR, AGRICULTURAL COLLEGE, MICH.

Doubtless few persons who have gathered huckleberries have failed to notice the dry and shriveled ones which seem to be covered with a whitish powder or bloom. An examination of some of this powder in 1898 from specimens collected in a swamp near Michigan Agricultural College showed it to be composed of fungus spores resembling the conidia of Monilia in their manner of growth. These spores are somewhat egg-shaped bodies, united by their ends into chains, which are often branched and which readily break up when mature. Further study led to the belief that this was the conidial form of a sclerotium disease, several species of which are known in Europe on species of Vaccinium and Oxycoccus. Consequently search was made the following spring, early in May, with the result that the ascigerous form was found growing from the mummified berries which had lain under the bushes all winter. The fungus has been identified as Sclerotinia vaccinii Wor.

The life history of the disease is as follows: The dry shrunken fruits which lie on the ground through the winter are permeated with the mycelium of the fungus and form the sclerotia from which grow the ascophores. These latter are little cup-like bodies raised on slender stalks which are furnished with root-like fibers or rhizoids where they start from the sclerotium. The hymenium or spore bearing layer lines the interior of the cup-shaped extremity and is composed of slender asci, each containing eight well developed spores of an oval shape. These spores are ejected at about the time when the young shoots are appearing on the host plant. The tender epidermis of these shoots is pierced by the germ tubes of the ascospores and the mycelium soon permeates the tissues, causing the shoot to wither and die, while portions of the affected part become covered with an outgrowth of whitish, powdery conidia. These conidia have a strong odor of bitter almonds, attractive to flies, which carry the spores on their bodies to the stigmas of the flowers that are opening at this time. In this way the fungus gains entrance to the ovary of the young pistils.

These develop, apparently, in the normal manner, until the time of ripening of the healthy fruits, when they change to a pallid color, dry up and fall to the ground to furnish sclerotia for the coming season.

Some of these diseased fruits were collected in July, 1899, kept dry until autumn and then placed on the ground in the bog house in the botanic garden. A few of them, removed on July 5 following, showed two or three slender pointed outgrowths about one-fourth of an inch long, and on April 28 other specimens possessed growths one-half to two-thirds of an inch long, furnished with rhizoids and enlarging tips. These would later form the mature ascophores.

Young shoots affected with the conidial stage were collected May 18, and some of the spores were placed on the stigmas of Vaccinium flowers, in the botanic garden, where the disease had not appeared. On July

3 a number of typical specimens of mummified fruits were taken from these plants as a result of this innoculation.

No attempts have been made to infect young shoots by means of the ascospores.

The breaking apart of the conidia is hastened by the formation of little plugs of cellulose, called disjunctors, between the walls of the spores where they are united. These crowd the walls apart, at the place of union, and, later, divide across thus setting the conidia free from each other.

Some of the conidia were placed in water in a glass cell for forty-eight hours and at the end of that time were found to have germinated, each spore having produced numerous sporidia from all parts of its surface. These sporidia are nearly globose and are very minute, being about three microns in diameter.

While no record of the occurrence of this disease in this country seems to have been made thus far, it appears to be very prevalent among the species of Vaccinium in this State. In some cases at least fifty per cent of the fruit of a plant has been destroyed by the fungus.

A similar disease, or possibly the same fungus, has been noticed on Gaylussacia resinosa, but has not yet been studied.

PLATE II.

a. Young shoot of Vaccinium, producing conidia from the affected stem and leaves, natural size.
b. Three conidia, highly magnified, showing disjunctors.
c. A conidium germinating, after being 48 hours in water, by sending out sporidia.
d. Sporidia highly magnified.
e. A portion of c more highly magnified.
f. A mature ascophore attached by its long stem to a diseased Vaccinium berry, natural size.
g. Young ascophores growing from a diseased berry.
h. An ascus and a paraphysis, magnified.

ASPARAGUS PLUMOSUS.

L. LENORE CONOVER.

Asparagus plumosus grows from the seed and during the first year forms a crown which sends up primary stems bearing branches with scale leaves and Cladophylls or false leaves. When grown in five-inch crocks for the first year or two, the stems attain a maximum length of thirty-eight to forty-five cm. This stage of the plant exhibits a habit of growth which first called out questions for investigation. Each of the primary stems is orthotropic, or erect, until it attains a height of from twelve to twenty-five cm., according to the vigor of the growth, when it curves to the horizontal and the upper portion becomes a dorsi-ventral member. Lateral off-shoots do not develop until the primary stem has approximately attained its full length and established its curve, but these branches, whether above or below the curve, always assume the horizontal position; in fact, stem, branches, and cladophylls take the common horizontal plane which becomes permanent for all excepting the cladophylls. As the plant grows older the cladophylls may form radiating clusters at each node.

When transplanted to a rich bed of earth the roots form a flat mat near the surface, evidently to obtain the surface organic matter. The crown then sends up more and more vigorous growths, some of which become twining stems of various heights. Under ordinary conditions the twiners grow from five to seven feet high but under special cultivation in old plants they may grow thirty feet high.

The questions to which I gave my attention under Dr. Newcombe's direction are:

1. What are the directive agents of the dorsi-ventral organs?

2. Are the branches sensitive to the same stimuli and in the same degree as the stem?

3. Is there a morphological upper and lower side which is permanent?

4. Nutation and circumnutation of the erect and horizontal stems.

5. To determine the phenomenon and conditions of climbing; whether the stem is sensitive to contact; and the dependence of climbing on the general vigor of the plant.

I reviewed literature on the subject of dorsi-ventral or plagiotropic plant organs and although there was no mention of this plant, I could not but note the variety of conclusions reached by investigators as to the causes of this horizontal growth.

By experimenting with the plant in various positions, i. e., on one side with the vertical portion lying horizontally and the horizontal portion upward in some, downward or diagonally in others, I found that the growing tip almost invariably struck out on a horizontal plane, sometimes reversing the upward turned side, again going through a slight torsion to turn the flank uppermost. A plant with all of its stems and branches approaching maturity but still growing slowly, was inverted and suspended from a rafter in the greenhouse with all sides about equally illuminated. After two days neither stem nor branches showed the slightest change but all parts continued to grow with their morphological upper side turned downward. After another plant with two young erect shoots was likewise inverted, the stems soon began to seek the horizontal plane but in opposite directions. In this condition the plant was placed on the klinostat in a south window and revolved on a horizontal axis for fifty-three hours. Neither of the shoots took a wholly horizontal position but inclined to one side. A plant with two younger and erect shoots was placed on the klinostat with practically the same conditions and results. The inclination was away from the older stems of the plant in both cases. In turning, the young stems were shaded by the older ones at the lower side of the circle while at the upper side, they responded positively to the light. This points to the conclusion that there is considerable sensitiveness to the light factor at the early stage.

To further prove the influence of light, the same plant was given one-sided illumination in a black lined box and turned on its side with the stems lying parallel to the window. In twenty-four hours the curvature toward the lighted side was very pronounced, one stem having passed through an angle of nearly ninety degrees to direct itself toward the light, while to reach the horizontal plane, it would have had to drop but forty-five degrees.

A plant whose stems had established their horizontal position and developed primary, secondary, and tertiary branches, stood erect in one-sided illumination for several days but all parts remained unchanged. It is probable that vigorous growth had ceased and ability to respond to the light had diminished.

During a period of eight days attention was given to five young shoots which grew in this time from 1 cm. to 13 and 15 cm. high. When the plant was placed at an angle of forty-five degrees, the stems through negative geotropism bent and took the vertical position but the growing tips were all positively heliotropic. In various changes of position the same results were noted. After branches had begun to develop the stems became less responsive to the light. The young branches were somewhat positively heliotropic, though in a less degree than a growing stem.

A thrifty plant with a growing shoot about six inches above the earth was revolved on a horizontal axis for two and a half days in a darkened chamber. Gravitation was evidently neutralized and no other external force being present, the shoot continued to grow in a straight horizontal line. On the other hand the shoot of a plant left in a stationary erect position in a dark room took the curve, i. e., responded to transverse geotropism. From these experiments and other observations, I believe that in equally diffused light a shoot which naturally grows from the plant at a small angle will make the diageotropic curve in that direction toward which it is inclined, but when given one-sided illumination, light is the directive agent. The vigorously growing tip seems to be more responsive to light than to gravitation, hence the tip curves from the vertical line in which the tensions from negative geotropism is at a minimum to a position where the equilibrium between the two agents is established. When diageotropism and heliotropism work in the same direction a permanent position is the result.

In all the foregoing experiments, observations were made on the primary and secondary branches and cladophylls. Under changing positions, they invariably sought the horizontal plane.

In the younger stage heliotropic response precedes diageotropic in branches as well as in primary stem, i. e., the branches place themselves with reference to the light before reaching the horizontal plane, but as stated before, the growing tips of older branches seek the horizontal, less influenced by the light.

Lines of ink drawn along the stem, together with the arrangement of the branches determined the fact that there is no permanent morphological upper and lower side. The lighted side of the young shoot becomes the concave and lower side of the dorsi-ventral portion. The upper side of the branch is dependent on the side and place from which it springs from the main stem. With changed positions these first determined upper sides do not necessarily remain constant as shown by the experiments.

On questions of nutation, circumnutation and twining, fewer observations have been made, but a sufficient number of facts have been ascertained which lead at least to temporary conclusions.

Young shoots begin to nutate soon after their appearance through ground and as they grow older their growing tips pass through larger areas until they may be said to circumnutate. Near the time when the stem is beginning to make the diageotropic curve, the curves described by the terminal portion become more complicated and what appears like a periodic wilting and recovering occurs. Later the circuit consists of series of compound curves or loops not unlike those made in Indian club exercises. The point of one stem rose and fell three times before it reached the position from which it started two hours before. While the stem appears to have lost all turgescence during the wilting period, it does not become limp but begins to rise in a short time.

Until a certain stage in the stem's development has been reached, regular twining about strings does not occur but when twining does begin it continues at regular intervals clockwise or counterclockwise until vigorous growth ceases when the last three or four inches become, like the shorter stems, a dorsi-ventral member.

Not only do primary stems nutate but the younger branches rise and fall, often simultaneously, while tracing their curves. This phenomenon was seen to occur on different plants near noon of several different days also late in the afternoon. It took place when the plant stood in a north window in winter, as well as in a well lighted greenhouse in midsummer, which leads me to think it is a fixed characteristic of the plant in its rapidly growing stages.

None of the stems thus far observed have been sensitive to contact, consequently the twining must be due to circumnutating stems striking against a resisting cord which becomes the axis of rotation as long as circumnutation continues.

From the character of the curve, it would seem that internal forces, including varying turgidity, together with geotropism and heliotropism, are the causes of the circumnutation.

From the facts that plants must attain a certain age and be well established in a rich bed of earth, also that a stout shoot is sent out and grows vertically for several feet before lateral off-shoots develop, the conclusion might be drawn that climbing depends on the vigor of the plant and that a shoot is destined from its bud-stage to be a twiner.

To sum up the different points:

1. The directive agents of dorsi-ventral members are light and gravity; heliotropic precedes diageotropic response.

2. Branches in their actively growing periods are sensitive to the same stimuli as stems, but in a less degree.

3. There is no morphological upper and lower side which is permanent.

4. Twining occurs as a result of circumnutation and depends on the general vigor of the plant.

PAPERS READ IN THE SECTION OF ZOOLOGY.

SUGGESTIONS FOR A METHOD OF STUDYING THE MIGRATIONS OF BIRDS.

BY LEON J. COLE.

Many theories have been advanced to account for the striking migrations of birds, and as has been shown by Wallace,[1] and in a somewhat modified way by Brooks,[2] the law of natural selection is capable of accounting for the origin of this habit, which has become so permanently fixed in nearly all of our birds. But there are many phenomena connected with migration to account for which even satisfactory hypotheses are not as yet forthcoming, chief among which may be cited the question of how birds are able to find their way unerringly over hundreds, or even thousands, of miles of land and water to a particular locality which they have left the previous year. Before these questions can be answered a much better knowledge of the facts is necessary.

Various methods have been employed for obtaining data relative to the migration of birds, and an immense amount is contained in miscellaneous notes scattered throughout the ornithological literature. These notes embody in large part the records of single observers on the flights of birds, their abundance at various times of year, and especially records of their first arrival in the spring. The collection of this last mentioned data, together with some further notes on the time the bird became common, whether it breeds at the station of the observer, etc., has been carried on in an extensive and systematic way in this country for many years by the United States Department of Agriculture, under the able direction of Dr. C. Hart Merriam. A very excellent report of some of the results of the first of this work in the Mississippi Valley was prepared by Prof. W. W. Cooke,[3] but so far as I know nothing of the kind has been attempted with the mass of data which must have accumulated since that time. During the period of its activity the Michigan Ornithological Club appointed a committee to collect similar data in the Great Lake region, blanks being used almost identical with those of the Department of Agriculture.

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[1] Nature, X., p. 459.

[2] The Foundations of Zoology, chapter V. New York, 1899.

[3] Report on Bird Migration in the Mississippi Valley in the Years 1884 and 1885, by W. W. Cooke. Edited and revised by Dr. C. Hart Merriam. U. S. Dept. Agr., Division of Economic Ornithology, Bulletin No. 2. Washington, 1888.

Pre-eminent among individual observers is undoubtedly the late Herr Gätke, of Heligoland, whose observations cover a period of some fifty years, while in this country Mr. Leverett M. Loomis has accumulated a mass of notes on the movements of the water birds off the California coast, and Mr. Otto Widmann has for years kept accurate records of migration in the Mississippi valley, which are largely quoted by Cooke in the work mentioned. Some information has also been gathered relative to the movements of birds at night by observations at light houses,[1] and by the use of telescopes turned upon the moon, a record being kept of the birds that crossed the illuminated field. A more or less systematic attempt has been made at the former, and I believe Mr. Winkenwerder at the University of Wisconsin is at present carrying on investigations in the latter line. Some data are gathered also from the birds that meet with accidents while migrating, such as flying against towers, buildings, wires, etc.

While at Woods Holl in the summer of 1900 I had the pleasure of hearing Dr. Robert H. Wolcott give the results of some of his studies on migration in Nebraska, in which he seemed to show beyond doubt that at least some of the birds, in coming into Nebraska in the spring, follow natural routes such as the water-ways; for example, certain species were found to arrive successively at intervals along the Missouri, the Platte, and finally at localities on streams tributary to the Platte. It was with an idea of finding whether similar routes could be mapped in Michigan that I lately undertook to work over the records accumulated by the migration committee of the Michigan Ornithological Club. I found, however, that the records for any one species were far too few and scattered to give any satisfactory results. Although the sheets in use give much valuable information, there are several reasons why, it seems to me, what might be called an *intensive* method might be employed to advantage in place of this more *extensive* one. The ideal would be, of course, a method which would give us complete records of the movements of every species of bird at each station where there is an observer, not only for the period of migration, but throughout the year; but for obvious reasons these cannot be obtained. In the first place, to obtain such records would require practically the whole time of the observer, while for these notes we have to depend almost entirely upon persons whose time is mostly taken up in other ways, and who study birds only as a pleasure and pastime during leisure hours. And again, many of these observers, though familiar with the commoner species of birds, and whose notes on these species are perfectly reliable, are not familiar with the bulk of the birds; and in their migration blanks the list of species is often small, or otherwise, apt to be inaccurate.

Some common bird should be selected, one which is familiar to all amateurs, and blanks sent out with full instructions for recording the data with regard to this species for all times of the year. The species selected should also be one that makes its presence known when it is in a locality, without requiring too much search to find it. It should also be one in which the female is easily distinguishable from the male.

[1] In this connection, Bird Migration, by William Brewster. Memoirs of the Nuttall Ornithological Club, No. 1. Cambridge, Mass., 1886.

Notes on bird migration are scattered throughout all the ornithological publications; no complete bibliography has ever been made, and would be both very extensive and difficult to compile.

and if possible, in which the young differ from both. With proper instructions accompanying these blanks, records could be gathered from which the movements of the species could be mapped with considerable assurance, and incidentally the distribution and relative abundance at the different stations throughout the year could be ascertained. Light would also be thrown upon many vexing questions which are awaiting settlement. For instance, do the birds remain in the neighborhood after breeding, or do they move northward as is supposed to be the case with some species? Do the old birds or the young lead in the fall migrations? This is a question upon which there is considerable difference of opinion among writers at present, and is a vital point in the recently advanced theory of Capt. G. Reynaud[1] on the orientation of animals, in which he advances the theory of a "sixth sense," which he calls the "law of retracement" or "law of reverse scent." He says,[2] "When the time for departure is come, birds of the same species, inhabiting the same region, come together for the journey. Those that have already made the voyage take the lead and retrace the path by which they came. The younger birds, born since the last journey, confine themselves to following their elders, and when, some months later, it becomes time to return, these are able in their turn to follow in a reverse direction the journey previously made." Here is a question of fact that must be settled by observation before we can seriously consider the theory. Again, Is it the young birds that are most apt to stray from the regular paths of migration? Does the species in migrating advance as a whole, or is it "like a game of leap-frog," the birds in the rear continually passing those ahead, as a flock of passenger pigeons is said to advance across a field when feeding? How definitely do birds return to the same locality every summer? Do their routes of migration vary from year to year? These and many other questions could, I believe, be settled by a line of study such as I have indicated, and would open the way to a consideration of the little-understood "homing instinct" of animals, which probably reaches its highest development in birds, enabling them to reach a definite destination over hundreds of miles of land and sea, often without any landmark for guidance, even supposing that they make use of such helps. This faculty appears especially remarkable to one who has seen the murres and other water birds of Bering Sea returning through the ever-present fog to their nests on one of the few islands which afford them a home. As the boat approaches land, which is hidden from sight and its presence and direction known to the navigator only by the help of his charts, long, broken lines or smaller flocks of these birds are seen flying rapidly by. There is no hesitation, no uncertainty; they may swerve aside from curiosity to pass near and inspect the ship, but the flight is then continued in the former direction. What can guide these creatures where the vision is limited to a small expanse of gray water enveloped in cloud? Certainly it cannot be the direction of the wind, as maintained by some, for the wind does not always blow in the same direction, and may even not blow at all.

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[1]Revue des Deux Mondes, CXLVI, 380-102. Translation in Annual Report Smiths. Inst. for 1898, pp. 481-498.

[2]Smiths. Rept. for 1898, p. 490.

It is not an easy matter to select a species of bird that will meet all the conditions given above as desirable for the one to be studied, but there are several that fulfill a part of them, at least. As far as the matter of plumage goes the red-winged blackbird seems to offer as good a subject for easy identification as any, and would also be favorable in other ways; but it is possible that further thought may suggest a better.

To answer some of the questions propounded above an even more exact method will probably be needed, and it is possible that for this some such plan as that pursued by the United States Fish Commission might be utilized. In order to get information of the movements of fish they fasten numbered tags upon individuals that have been caught and let them go again, keeping accurate record of the numbers and all the data of release. Instructions are dispersed among the fishermen of the region asking them to return all labels they may find on the fish they take, together with the data of capture, such as locality, condition of the fish, etc. As I say, it is possible such a plan might be used in following the movements of individual birds, if some way could be devised of numbering them which would not interfere with the bird in any way, and would still be conspicuous enough to attract the attention of any person who might chance to shoot or capture it.

A trial of the methods I have attempted to outline would necessarily entail considerable labor and require much time of the person directing it, and could probably be carried on best by a committee of some scientific society or other organization. A number of years at least would be required to settle with definiteness many of the questions, and some of them might require many years of continued observations. On the other hand a very complete account would be collected of the habits of at least one species, and many interesting things would undoubtedly come out that had not been thought of before. Perhaps it would be found that more than one species could be studied advantageously at the same time, as, for instance, one bird that is a summer resident and another that is a winter visitant within the region where observations are being made. The aim would ever be to obtain the most complete data for as many species as possible.

NOTES ON THE OCCURRENCE OF AMMOCOETES, THE LARVAL FORM OF LAMPETRA WILDERI, NEAR ANN ARBOR.

BY DANIEL C. SCHAFFNER.

Lampetra wilderi, the common brook lamprey of this region, occurs in small streams tributary to the Huron river. It has been reported as abundant during the breeding season from a number of points near Ann Arbor, but previous to October 1900 the larval form had not been taken near here.

In the spring of 1899 Robert T. Young and Leon J. Cole of the University made a study of the nesting habits of Lampetra wilderi in Honey Creek, a small tributary of the Huron river, about four miles west of Ann Arbor. From this same stream the Ammocoetes were secured last October. Young and Cole made their observations form April 15 to 20 inclusive, and during that time a large number of the lampreys appeared, built their nests, laid their eggs, and disappeared.

In a brief paper on the Transformation of the Brook Lamprey, Prof. Simon H. Gage, of Cornell, states that brook lampreys die after the end of the breeding season and that they are not parasitic in their habits, their full size being attained during their larval life. The breeding season lasts about two weeks. After hatching the young remain in the nest until they are from twelve mm. to fifteen mm. in length. This size is attained about the eighth week after the eggs are laid. On leaving the nest the young wander down stream until they find a quiet sandy place and there they burrow and remain until they are fully developed.

The most favorable place for finding the larvæ is in the sand in any quiet portion of the bed of the stream where the water is from three to ten inches deep. Gage advises the use of a shovel for removing the sand from the stream and states that the Ammocoetes can be secured easily from the sand thrown on the bank; but we found this method of taking them quite unsatisfactory as they persisted in wriggling out of the sand and escaping into the water before we could land them on the bank. We found that with a strong dip net frame to which an ordinary bolting sack had been attached the sand could be scooped up readily and after emptying the contents of the sack on the bank the Ammocoetes were found at the bottom of the pile of sand. Pouring water on the sand after it was spread out on the grass caused the Ammocoetes to wriggle about and so make themselves more conspicuous.

With a strong, long handled dip-net one can stand on the bank dry shod and collect Ammocoetes in abundance. Mr. Reade, Mr. Michael, and the writer used this method a part of one afternoon and succeeded in taking fourteen Ammocoetes ranging in length from five to twelve cm.

Since this paper was read we have taken several dozen more of the larvæ ranging in length from three to twenty cm. The larvæ taken a few days preceding the breeding season can be grouped under three divisions as regards size and we took this to indicate that it required three years for the complete development of the larvae. The individuals taken this spring could practically all be grouped as follows: Those nearly fully developed measuring from seventeen to twenty cm. in length, those measuring from nine to eleven cm. in length, and those from three to six cm. in length. Last fall two of the larvae taken measured about fifteen cm. and all the others were less than ten cm. long.

All the work done by us on this interesting form was directed by Prof. Jacob Reighard and whatever of success we attained was due to his suggestion, although the details were left to us to work out.

SOME ASPECTS OF THE ELECTROTACTIC REACTION OF LOWER ORGANISMS.

BY RAYMOND PEARL.

(Abstract.)

1. It has been shown[1] that in the case of the infusoria the electric current causes the cilia of the body to take certain definite positions. The cilia on the kathode half of the body are reversed and point towards the anterior end. This effect is different from that produced by any other stimulus so far as is known, and is distinctly localized with reference to the poles of the electric field. In addition to this effect the current stimulates the organism as a whole to react by its usual "motor reflex." We are able then in the case of the infusoria to distinguish two factors in the reaction to the current; one, a special response marked by the reversal of the cilia on the kathode side, and the other a general reaction ("motor reflex factor"). The question arises: How general is the occurrence of two factors in the reaction to the current? Do they appear in any other group than the Protozoa? From a study of the electrotactic reaction of *Hydra*[2] it appears that in this form there are two distinct phases in the reaction to the current. On the one hand the current causes a localized contraction on the anode side of the extended body, while on the other hand, it brings about, under certain conditions, a general, violent contraction of the animal as a whole such as is caused by any other strong stimulus. The localized anode contraction of the body seems to correspond to the special localized reaction in the case of the infusoria (the reversal of the cilia on the kathode side). Similarly two factors have been observed in the reaction of the rhabdocoele *Stenostoma leucops* O. Schm.

2. It seems probable that the organism as a whole is not stimulated by the current when the reaction is of the special localized form (reversal of cilia or anode bending of body). On the contrary in this case a part of the motor mechanism is set into a certain definite sort of activity—more or less violent—without affecting the whole organism.

3. The contraction of *Hydra* on the anode side of the body when under the action of the current results in its orientation with the oral end towards the anode provided the foot is attached. Experiments with the body extended in line with the current show that the animal is much more strongly stimulated when it is in this position with the oral end towards the anode, than when it is in the opposite position with this end towards the kathode. This indicates that the essential thing in the

[1] Pearl, R.: Studies on Electrotaxis. I.—On the Reactions of Certain Infusoria to the Electric Current. Amer. Jour. Physiol. 4: 96-123. 1900.

[2] Pearl, R.: Studies on the Effects of Electricity on Organisms. II.—The Reactions of Hydra to the Constant Current. Amer. Jour. Physiol. 5: 301-320. 1901.

orienting process is not the getting of the organism into a position where it is not stimulated or only slightly stimulated, but that, on the contrary, the orientation takes place without any reference to whether the animal is to be stimulated in its end position or not. Furthermore, when the foot end of *Hydra* becomes loosened from its attachment and the oral end becomes fixed, the organism becomes oriented to the current by exactly the same process as in the former case (contraction on the anode side); but in this case the orientation is with the oral end directed towards the *kathode*, as a mechanically necessary result of the conditions. From this it appears that the placing of one or the other end of the body towards the source of the stimulus is not the essential of orientation, but is rather a result of the relation of the organism to surrounding objects. It is possible that it may be found to be a general rule that in orientation phenomena the position of the ends of the body with reference to the source of the stimulus is secondary, and that the primary factor is the relation of the longitudinal axis to the lines of action of the stimulus.

A CURIOUS HABIT OF THE SLUG, AGRIOLIMAX.

BY RAYMOND PEARL.

On December 11, 1900, while examining some collections which had been brought into the laboratory two days previously, I noticed a specimen of the common slug *Agriolimax campestris* Binney, crawling on the side of the aquarium jar below the surface of the water. When first observed the animal was about two inches below the surface and was crawling upwards. The material, which was collected in the Huron river just below the dam at Ann Arbor, consisted principally of *Ceratophyllum* and *Elodea*. When the plants were torn loose from the bottom in making the collection a considerable amount of mud had been taken along with them, so that there were from two or three inches of mud in the bottom of the aquarium jar.

The slug was removed from the aquarium immediately and placed in a dish of fresh tap water. On the bottom of this dish it crawled about at a rate slightly faster than the normal. The tentacles were not as much extended as is the case under normal conditions, but this was the only noticeable difference in the appearance of the slug in water from that in air. It is noteworthy, however, that while in the water in the warm room (temperature about 21° C) the animal never stopped crawling. On the contrary, it would keep in active movement until it had reached the side of the dish and crawled up above the surface of the water; then, having reached the air, it would soon come to rest. It may be mentioned here in passing that it was possible, by preventing the slug from passing out into the air when it reached the surface, to induce it to crawl on the under side of the surface film. It was able to support itself on the film, and to progress slowly in the same way that a water form like *Physa* or *Limnaea* does.

Experiments were performed to test the effect of temperature on the behavior of this specimen. As has already been stated, it would not stay in the water in a room at ordinary temperature or a little above, but, under these conditions, crawled out into the air as soon as possible. To determine how it would behave in a low temperature it was first placed in the water at the bottom of the dish and then the dish was put out in the open air and left for an hour. At the end of this time the temperature of the water was + 2° C. The animal was very much contracted; the tentacles were completely drawn in, and the whole body very much shortened. It was quiet and had moved only about two inches since the beginning of the experiment. At the end of the hour the dish was taken into the warm room and in ten minutes the slug began to move again. The body and tentacles expanded and the animal crawled out of the water.

After an interval of an half hour the dish was again put out of doors, but with the slug on the side of the dish above the water. The observations at the beginning of this experiment were interrupted so that I am unable to tell precisely what happened, but at the end of fifteen minutes the slug was in the water resting on the bottom of the dish, and contracted as in the preceding experiment. It is not certain whether the animal crawled down into the water or simply fell in, having loosened its hold on the glass. It seems probable that the former action is what occurred, since the slug was found some distance from where it would have been had it simply fallen into the water. At the end of an hour, the temperature of the water registering + 2° C as before, the dish was taken back into the warm room, and as before the slug soon revived and crawled out of the water.

On account of a pressure of other work it was unfortunately impossible to carry these experiments any farther at the time. The slug lived about two weeks, and since it was kept at room temperature all the time after the experiments recorded above, never again went back into the water.

The most probable explanation of this curious behavior on the part of a mollusc which in its general habit is terrestrial, seems to be that, when it was in the water, the organism was in a *state of hibernation*. This hibernation was induced by the low temperature, and while in the hibernating state the respiratory exchange became extremely low, so that the slug could exist practically as well in water as in air. When, however, the temperature was raised the animal revived, i. e., came out of the hibernating condition, and then crawled out of the water as soon as possible. An objection which has been raised against such an explanation is that it does not seem probable that the organism could pass so quickly from the normal into the hibernating state. There are, however, no detailed experimental results on this point and we do not know how long it takes for the slug to pass from one state into the other under any given conditions. From some observations of my own on *Agriolimax* and *Succinea* I feel sure that these animals are able to pass into a condition of hibernation in a comparatively short time after the cessation of activity (in some cases less than fifteen minutes). So then, in the absence of detailed evidence, this objection on the ground of the too great rapidity of the change from the normal to the hibernating condition required in the given explanation, does not appear to be a particularly strong one.

There seems to be some biological significance in this sort of behavior of an hibernating animal with reference to water. During the winter months the temperature of the water at the bottom of a river or pond is considerably higher than that of the surface layer of the soil. Hence an organism runs much less risk of being frozen to death when at the bottom of a body of water than when simply beneath a stone or the upper layers of the soil.

This explanation of the observations is merely a tentative one and may or may not be correct. I hope to be able at some future time to make the detailed study of the phenomenon which the case seems to warrant.

THE EFFECT OF VERY INTENSE LIGHT ON ORGANISMS.

BY RAYMOND PEARL AND LEON J. COLE.

(Abstract.)

In this study individuals from a number of different species of lower organisms were subjected to the action of the intense light of an electric arc. The light for the work was obtained from the arc of a Thomson "90° carbon" projection lantern, fed by a direct current with a voltage of approximately 210. The bellows of the lantern was extended as far as possible in order to bring the focus near to the front lens. In front of the lantern was placed a parallel-sided glass cell filled with a solution of alum, for the purpose of absorbing the heat rays. Next the heat filter was a compound microscope in an upright position facing the lantern. The concave mirror of the microscope was so arranged as to throw the beam of light from the lantern up through the opening in the stage, on which the organisms were placed for experimentation. In some instances a simple condensing lens placed below the stage further concentrated the light.

After some experience with the apparatus as above described it became very apparent that the alum cell did not absorb all the heat rays. This was clearly shown by the thermometer readings made in connection with the experiments. So, in place of the single alum cell, three large cells arranged in tandem were used. With these three cells very little heat came through but positive results were obtained in the experiments. It then seemed probable that it was the light and not the heat which caused the phenomena observed. In order to further test this *one* of the cells which had previously been used for alum solution was filled with a solution of iodine and put in the place of the *three* alum cells. This iodine cell evidently let through much more heat (verified by measurement) than had the three alum cells, but it absorbed nearly all the light rays. The phenomena observed when the light was acting and the heat as far as possible absorbed, no longer appeared when more heat was passing, but with almost no light accompanying it. This seems to amount to a demonstation that we are dealing with the effects of light and not heat.

The following forms were studied: *Chilomonas paramecium*, *Paramecium caudatum*, *Oxytricha fallax*, *Oxytricha* sp., *Stylonychia* sp., *Stentor coeruleus*, *Hydra viridis*, *H. fusca*, *Hyallela* sp., *Clepsine* sp., a freshwater nemertean apparently agreeing in all its characters with *Stichostemma asensoriatum*, and a species of *Physa*.

The results will be given in a brief, summarized form.

1. None of the Protozoa examined gave any reaction whatever to the intense light. Furthermore they were apparently not affected in any way by it.

2. The results from both species of Hydra were also negative. No definite effect of the action of the light could be made out. This was

somewhat surprising in view of the striking results obtained by Tower,[1] who used methods similar to those employed in these experiments. It is probable though, that in the experiments of this author sufficient attention was not given to the exclusion of heat effects, and on this account he obtained results different from ours.

3. The crustacean *Hyallela* was stimulated by the strong light to increased activity, but it very soon began to weaken. After having been in the light for 30 minutes its movements were much weaker and less in amount than in the case of a normal, unstimulated animal, and its sensitivity to mechanical stimulation was also greatly diminished. There seemed to be a general lowering of the tonus. Recovery was complete in about 40 minutes after removal from the light.

4. A large specimen of a species of *Clepsine* was at first stimulated to strong muscular activity in the light. After the light had been acting for some time however, the sensitivity to mechanical stimulation was so diminished as to be practically lost, and the animal was quiet. Complete recovery occurred after removal from the light.

5. In the case of the nemertean identified as *Stichostemma ascensoriatum* it was found that the animal was stimulated to activity above the normal while in the light. On removal from the light it became quiet and was insensitive to mechanical stimulation.

6. Specimens of *Physa* while under the action of the light kept in continuous and rapid movement. The sensitivity to mechanical stimuli was greatly diminished while in the light and after removal. On removal all movement ceased. Complete recovery occurred.

The general result of these experiments is that certain organisms are stimulated to great activity by intense light; but, at the same time the light has something of a paralyzing effect (reduction of tonus), so that the organism moves more and more slowly as the stimulus continues to act.

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[1] Tower, W. L.: Loss of the Ectoderm of *Hydra viridis* in the Light of a Projection Microscope. Amer. Nat. 33: 505-509. 1899.

CERTAIN REACTIONS OF THE COMMON SLUG AGRIOLIMAX CAMPESTRIS BINNEY.

BY RAYMOND PEARL AND MAUD M. DE WITT.

(Abstract.)

1. The reaction most studied was that given by the slug on encountering the edge of the solid body on which it was crawling.

2. The usual reaction of the animal on coming to the edge is to pass over and hang for a time by the mucus thread secreted by the foot.

3. Approximately two-thirds of all the slugs tested react in this way on coming to the edge for the first time.

4. It is found that this positive reaction changes to a negative after the animals have encountered the edge a certain number of times. That is, the slug does not crawl off after a number of trials.

5. This change in the reaction does not seem to be due to general weakness, or to the diminution in the supply of mucus, or to any process of "learning" on the part of the slug; but is, apparently, merely an expression of a sort of "physiological variability" of the organism.

SOME FURTHER NOTES ON THE BREEDING HABITS OF AMIA.

JACOB REIGHARD.

(Abstract.)

The paper referred to two disputed points with regard to the breeding habits of Amia.

1. In an earlier communication to the Academy the writer had stated that the nests of Amia are built by the male fish at some time in advance of spawning. In the communication referred to[1] some evidence was brought forward in support of the position taken, which is opposed to that held by most earlier observers. During the spring of 1900 the writer attempted to get experimental evidence on this point.

A fyke-net was stretched across the mouth of a small bay in which about twenty-five Amia nests had been located in each of the years 1898 and 1899. The net was placed in position before the beginning of the breeding season, and at a time when, presumably, there were few Amiæ in the bay, or none at all. The net was so located as to shut off all access to the bay and so that any fish attempting to enter would be caught and kept alive. As the fish were taken in the net the males were placed in the bay back of the net while the females were confined in a small crate. Seventy-five males were thus placed in the bay in the interval between April 18th and April 28th. These males were unable to escape from the bay and by April 26th had built twenty-three nests within the bay. Of these nests only five contained eggs. These five nests were in two groups, one group consisted of three nests in a row and about five meters apart. The other group contained two nests near together. The eggs in all five nests were in approximately the same stage of development and must have been laid at about the same time. There were very few eggs in each nest, and all the nests were afterward abandoned by the males. The small number of eggs in these five nests and the fact that the nests were near one another indicates that the eggs in all the nests were laid by one or two females, females probably present in the bay before the net was placed across its opening. The fact that no eggs were laid in the remaining eighteen nests seems to be conclusive evidence that these nests were built by male fish exclusively. On April 28, fifteen females were placed in the bay behind the net, but no eggs were subsequently laid in any of the unoccupied nests in the bay. Probably the keeping of these fifteen females in the crate had in some way prevented their afterward spawning.

2. Dean[2] reports that fishermen believe that the young Amiæ together with the male fish leave the nest shortly after hatching, remain for a time in retirement, presumably in deep water, and after a time return again to shallow water. Dean is inclined to accept this statement. The fishermen believe further that during this interval the young fish are

[1] First Report of the Michigan Academy of Science, p. 135.

[2] Dean, Bashford '96. The Early Development of Amia.—Quar. Jour. Uni. Sci., xxxviii.

attached to the male by means of the adhesive organ. During the past season the writer has carefully watched the young fish in a number of nests and has visited the nests daily in order to see when and by what means the young fish leave the nest. As a result of these observations it may be stated positively that the young fish do not leave the nest until they have learned to swim independently and not until the adhesive organ has been absorbed. They then leave the nest in a swarm with the male and remain *in shallow water in the vicinity of the nest* for some days. As the young increase in strength the range of the swarms becomes greater and they are found at increasing distances from the original nest, which becomes obliterated. The young fish continue with the male and in shallow water until they are between eighty and ninety millimeters (about three and one-half inches) long. At this time they have acquired the brilliant larval coloration and are extremely active. The writer has not seen fish of larger size in swarms or attended by the male.

ON THE ANTERIOR HEAD CAVITY OF THE ELASMOBRANCHS.

JACOB REIGHARD.

(Abstract.)

It was shown that the anterior head cavity of the Elasmobranchs is exactly comparable to the adhesive organ of Amia. The two structures originate in the same region and in the same manner. Both subsequently degenerate.

In view of this fact the anterior head cavity of the Elasmobranchs was interpreted as an aborted adhesive organ. The view was expressed that this structure, which is incapable of supporting a heavy weight, had been rendered useless to the Elasmobranch embryo by reason of the accumulation of yolk in the eggs of the members of that group. The organ had consequently degenerated. If this interpretation be accepted it follows that the Elasmobranch and Ganoid lines must have separated before the accumulation of yolk in the eggs of the former. In other words the persistence of an adhesive organ in the Ganoids is evidence that these forms never possessed a large amount of food yolk such as now occurs in Elasmobranchs.

ON THE EARLY HISTORY OF THE AUDITORY AND LATERAL LINE ORGANS OF AMIA.

CORA J. BECKWITH, PRESENTED BY JACOB REIGHARD.

(Abstract.)

A study was made of the early stages in the development of the auditory and lateral line organs of Amia, with a view of determining whether these originate from a common anlage or independently. It was shown:

1. That the auditory vesicle is formed in the midst of a mass of mesectoderm, differentiated from the adjacent neural crest. The vesicle appears in surface view to be continuous with this mass of mesenchyme and to form a part of it. Subsequently the mass of mesenchyme divides into two parts corresponding to the first two branchial arches and the auditory vesicle lies between these two portions. In surface view the original mass of mesenchyme with the included auditory vesicle has the appearance of a proliferation or ridge of ectoblast—a common anlage of auditory vesicle and lateral line systems. When this original mass of mesectoderm divides in the manner indicated and its two portions separate from the auditory vesicle, the appearance is as if the common anlage of auditory vesicle and lateral line systems had divided into three portions. Such a division was described by Wilson in the trout and the three resulting portions were believed by him to give rise to the branchial sense organ, the auditory vesicle and the lateral line anlage respectively. In Amia there is a simulation of the division of such an ectoblast ridge into three portions, but in reality two of these masses are mesenchyme while the third is the auditory vesicle which is from the first independent of this mesenchyme.

2. The anlage of the lateral line system was found to arise at a much later stage than the auditory vesicle, and quite independently of it in the form of ridges or thickenings of the ectoblast.

THE CLASSIFICATION OF BIRDS.

HUBERT LYMAN CLARK.

(Abstract. Published in full in the *Auk*, October, 1901.)

The tendency of recent systems of avian classification is toward a great increase in the number of orders. Such orders are not equivalent to the orders of other zoölogical groups. So far as possible orders should be, and usually are, based on the most important character of the class. At any rate, the character or characters taken for a basis should be those least likely to vary with habits. Among birds such a character is to be found in the *arrangement of the pterylæ.* There are apparently, judging from such knowledge as we now have, *ten* types of pterylosis. Each one of these might therefore be taken as the basis for an order. Such a plan is not free from difficulties, but there is certainly much to be said in its favor.

THE BREEDING HABITS OF HOLOTHURIANS.

HUBERT LYMAN CLARK.

The following brief sketch of the breeding habits of holothurians is not intended as a complete account, but is merely to call attention to some facts of general interest in connection with the way in which those animals care for their young. Like most marine animals, the Echinoderms as a rule, set their eggs free in the water and there they are fertilized and there the young develop. Such a method reminds one forcibly of those plants which rely on the wind to scatter the pollen and carry it to the ovules, which without it must die. In the one case, it is necessary to produce incalculable millions of spermatozoa and countless ova, in the other equally incalculable numbers of pollen-grains. Both cases illustrate what we term extravagant or wasteful methods. As we study the line of development among both plants and animals, it is interesting to note how this wasteful method of reproduction becomes modified in the higher forms of life, until at last very few young are produced at a time and those are carefully tended. Now the holothurians are without doubt the most specialized form of echinoderms and it is instructive to see how, as their peculiar type of structure has developed, there have appeared a number of instances of improved methods of reproduction. There can be no doubt that the struggle for existence among the minute, free-swimming inhabitants of the ocean is very severe, and very likely is more severe with the introduction of each new generation. In this struggle, the larval forms of echinoderms and many other invertebrates play an important part, and the chances of survival for any one individual are very small. Merely increasing the number of ova produced therefore is not the best way of meeting the difficulty. Far better will be the results of caring for the ova and young until the latter are better fitted for the struggle for life. This may be done in various ways but will result almost certainly in fewer eggs being produced, and these will be more vigorous and more likely to produce normal, healthy young. If these young are protected by the parent until well along in life, the great majority will have a chance of becoming sexually mature and reproducing, and thus the species will be benefited.

We have no means of knowing how recently this change has occurred among holothurians, but it is interesting to note that the great majority of known cases have been discovered within about twenty years. The earliest recorded instance of a holothurian caring for its young is that of *Synapta vivipara* discovered by Oerstedt in the West Indies in 1851. In this species the young are born in the body cavity of the parent, whence they escape by openings in the body-wall near the anus. The eggs pass from the genital ducts directly into the body cavity, where they are fertilized and develop until the young have assumed adult form and are nearly an inch long. As many as 175 young may be cared for in this way at one time, and their chances of survival are excellent. In 1867, Kowalevsky discovered that a Mediterranean species, *Phyllophorus urna*, cared for its young in the same way, and in 1881, Ludwig discovered that *Chiridota rotifera* was also viviparous. Since 1880, no less than ten species are reported as caring for their young, but curiously enough, only one of these ten carries the young in the body cavity, and that one is a little thyone (*T. rubra*) found on the coast of California. Of the remaining nine, three brood the young under the body; in *Psolus antarcticus* and *Cucumaria parva*, Antarctic species, and in *Cucumaria curata* of the coast of California, this is the case. No less than three species, carry the young on the back; these are *Cucumaria crocea* and *Psolus ephippifer*, of the Antarctic ocean and *Thyonepsolus nutrians* of the California coast. Of the remaining three species, *Cucumaria laevigata* of the Antarctic ocean and *Cucumaria glacialis*, an Arctic species, carry the young in special brood pouches, while *Chiridota contorta*, an Antarctic species, has the eggs develop, and the young born, in the genital ducts themselves.

These thirteen cases seem to illustrate at least two, and perhaps three, perfectly distinct lines of development. In the first place, we have the line which certain synaptids are following, where the eggs no longer escape into the water, but by rupture of the genital ducts pass into the body cavity, or they remain in the ducts and develop there. It is hard to say whether the latter is the more primitive or the more specialized way. It is curious to note that two widely separated Dendrochirotæ have also adopted this body cavity method. It seems to me that this is probably the primitive arrangement and that the genital-duct method of *Chiridota contorta* is a modified form of it. In all the other cases mentioned the eggs are laid and fertilized in the water but are immediately taken in charge by the mother and cared for by her.

But here, there appears a divergence of method for *C. crocea*, *Ps. ephippifer* and *T. nutrians* place the eggs on the back, where extra plates or extra folds of skin of some sort serve to protect the young. On the other hand *Ps. antarcticus* and the four other *Cucumarias* mentioned place the eggs underneath the body. In *C. glacialis* and *C. laevigata*, they are there received into two brood pouches which are formed as invaginations of the skin. There can be no doubt, I think, that this brood pouch method is a modification of the simpler ventral brooding of the other species.

In conclusion it is interesting to note that all of these thirteen species, which care for their eggs and young are either *Synaptidæ* or *Dendrochirotæ*, and no less than five are *Cucumarias*. The geographical distribution is also peculiar, for six species are Antarctic, while three occur on the coast of California; two are West Indian, one is Arctic and one is found in the Mediterranean. All are shallow water forms, most of them littoral, though *C. glacialis* occurs nearly down to the 100 fathom line, *Ch. contorta* passes that line and *Ps. ephippifer* is said to occur at 315 fathoms.

BLACK GUILLEMOT.

Shot in the Detroit river off foot of Lieb street, Detroit, Michigan, December 14th, 1895, owned by Robert McKinnell, 748 17th street, Detroit, Mich. Mounted by Charles Lummer, taxidermist, 354 Monroe avenue, Detroit. Communicated by O. A. Farwell.

PAPERS READ IN THE SECTION OF SANITARY SCIENCE.

THE STUDY OF AN EPIDEMIC AMONG GUINEA PIGS.

(Abstract.)

BY L. M. GELSTON.

In January, 1901, the supply of guinea pigs in the hygienic laboratory of the University of Michigan being nearly exhausted, animals were ordered from several different sources and within a few weeks over six hundred guinea pigs were sent to the laboratory. Of these nearly five hundred were received from one source, and among these a peculiar and highly fatal epidemic soon appeared, and after about three weeks extended to all the guinea pigs kept in the laboratory. The infected animals began to emaciate and to lose their hair. They gradually failed and apparently died of inanition. Post-mortem examination was made upon two hundred animals, and in 88.2 per cent of these a certain bacillus was found in the blood of the heart. Post-mortem examination showed the lungs in a pneumonic condition; the serous coat of the intestines, the omentum and the mesentery markedly congested; the spleen dark and enlarged; slight enlargement of the inguinal and axillary glands, and heart in diastole. The germ found in the blood of the heart is a short bacillus with rounded ends, growing singly or in pairs, rarely in threads. The bacilli are found to be capsulated when seen in the tissues, but not when grown in cultures. This bacillus takes the ordinary anilin stains readily and is exceedingly motile. Spore production has not been observed. In bouillon after twenty-four hours there is an abundant, diffuse growth with the formation of a thin pellicle. After five days the pellicle is found to be greatly increased in thickness and folded on the surface. The growth does not readily subside. This organism does not coagulate milk. In the stab cultures, the growth appears all along the line of inoculation and forms a film over the surface of the medium. In glucose media there is a marked production of gas. Streak cultures on plain agar show a thin film; on glycerin agar the growth is somewhat thicker and pearly white; on blood serum there is a rapidly spreading, moist, thick growth; on potatoes the growth is moist, thick and white. On agar plates the colonies are white and show a marked tendency to coalesce on the surface. The surface colonies are without distinct borders and are coarsely granular, while the deeper colonies are rounded but somewhat irregular.

The germ does not liquefy gelatin. This bacillus has its optimum growth at a temperature of from 37.5 degrees to 39 degrees. It grows

well at room temperature, but not below 18 degrees. It is destroyed by five minutes exposure at 60 degrees moist heat and by an exposure of one minute to 70 degrees. It resists exposure for one hour to 50 degrees in moist heat. This organism is a facultative anaerobe, growing well in glucose and plain media and in an atmosphere of hydrogen. Gas production has been observed in all media, but more abundantly in glucose preparations. Mercuric chlorid, 1:1000, destroys the organism in one minute, and carbolic acid of five per cent strength has the same effect. The bacillus is pathogenic to all of the ordinary laboratory animals,—guinea pigs, rats, mice and rabbits; other animals have not yet been tested. Intraperitoneal injections of one cubic centimeter of a twenty-four hours bouillon culture kill in from twelve to eighteen hours. Subcutaneous injections of one cubic centimeter of a like culture kill in from one to three days. The lymphatic glands near the point of inoculation are markedly enlarged and a thick, bloody, gelatinous exudate is found subcutaneously about the place of inoculation. One drop of blood from the heart of an animal dead from infection with this germ, injected into the peritoneal cavity of a guinea pig, kills in from eighteen to twenty-four hours. A small piece of the spleen of an infected animal inserted subcutaneously in a healthy pig was followed by death in from one to three days. Whatever the mode of inoculation, the bacillus is always found in the blood of the heart after death. The period of infection when animals are fed with cultures varies from one to three weeks.

THE DETECTION OF BORAX AND BORIC ACID IN MILK.

(In abstract.)

BY W. H. VEENBOER.

There is still some diversity of opinion and some contradiction of statement concerning the injurious effects on man of borax or boric acid when used as a preservative in his food. However, it is not the purpose of this paper to enter into this discussion, but to state briefly some of the tests by means of which borax or boric acid may be detected in milk.

When turmeric paper is moistened with a solution of boric acid and then allowed to dry it takes on a characteristic pink color which changes to a slaty-blue or green when a weak alkali is added. This test may be made by adding tincture of turmeric to boric acid solution and then evaporating the mixture to dryness, when the residue becomes pink, and changes to blue or green on the addition of dilute alkali.

The above mentioned test may be applied to milk in a variety of ways. One of the simplest methods of procedure consists in placing one drop of the milk, after it has been well shaken, in a porcelain dish, then adding two drops of a saturated tincture of turmeric and an equal quantity of strong hydrochloric acid, and drying on the water-bath. To the residue thus obtained, as soon as it is cool, one drop of dilute ammonia is added, when a slaty-blue color turning to green indicates borax or boric acid. By means of this test 0.001 gram may be detected. A smaller amount gives the green but not the blue coloration. The hydrochloric acid may blacken the residue and mask the test; this can be avoided by evaporating the turmeric and milk and adding the acid to the dry residue and then evaporating to dryness again. When this is done the residue is found to be pink and turns to blue and green on the addition of a drop of ammonia. This test can be very rapidly applied to a large number of samples by using a porcelain plate. Drops of milk from the various samples are placed side by side and numbered or marked with a wax pencil; then the plate is dried and the test completed as above indicated. If the amount of borax or boric acid is not sufficiently large to be detected by the procedure just given, 100 c. c. of the milk may be used. In this case, the milk is rendered alkaline by the addition of lime or baryta water, in order to precipitate the phosphates, and is then evaporated to dryness and charred. The residue is dissolved in as little concentrated hydrochloric acid as possible and filtered from the insoluble carbon. The filtrate is evaporated to dryness in order to drive off the excess of hydrochloric acid and the residue is again dissolved in a small amount of dilute hydrochloric acid, and this again evaporated. By this application of the test one part of the preservative in a million of the milk may be detected.

When borax is treated with some strong acid and methyl alcohol added and the mixture ignited, a green flame is obtained.

This test may be applied directly to the milk by placing one cubic centimeter of it in a large tube-test, adding one-half cubic centimeter of strong hydrochloric acid and ten cubic centimeters of methyl alcohol. This mixture is rapidly boiled down nearly to dryness when it may be ignited and the green flame obtained. The methyl borate which is formed may be taken up on a platinum loop and the flame obtained by ignition with a Bunsen burner. By another method, the milk can be evaporated to dryness over a water-bath, and the powdered residue rubbed up with anhydrous sodium sulphate in order to extract the water. The boric acid is now abstracted from this mass with absolute methyl alcohol and the filtered extract is distilled into a concentrated soda solution, which is evaporated and tested by the flame.

The flame tests are not as delicate as those with turmeric and the color of the flame is easily masked by sodium, potassium, copper, and some other substances.

THE INFLUENCE OF FORMALDEHYDE ON THE GROWTH OF CERTAIN BACTERIA IN MILK.

(In abstract.)

BY ARTHUR J. HOOD.

The purpose of this paper is to ascertain the per cent of formaldehyde that must be present in milk in order to prevent the growth of the lactic acid bacillus, and the typhoid bacillus.

Tubes each containing ten cubic centimeters of fresh skimmed milk were sterilized in the autoclave, and then treated with dilutions of formaldehyde and subsequently some of these tubes were inoculated with the above mentioned micro-organisms. Eight series of tubes containing formaldehyde were prepared, in which the dilutions were as follows: No. 1, 1:100; No. 2, 1:500; No. 3, 1:1000; No. 4, 1:5000; No. 5, 1:8000; No. 6, 1:10000; No. 7, 1:25000; No. 8, 1:50000. With each set there were control tubes containing no formaldehyde which were inoculated with the germs. After the tubes had been inoculated plates were made from each tube at the intervals indicated in the accompanying tables and the colonies developed on these plates were counted. The following tables give the results of this investigation:

B. Coli Communis.

Time after inoculation.	1:100	1:500	1:1000	1:5000	1:8000	1:10000	1:25000	1:50000	No formaldehyde.
Immediate...	6	4	360	240	240	544	674	720	481
1st hour............	18	2	120	66	360	960	....	130	2700
2nd hour...........	1	19	14	12	840	780	720	840	5640
3rd hour............	0	20	31	6	5	....	720	541	8750
1st day	0	1	50	6	40	2700	6900	21000	21141
2nd day...	0	0	0	1	6600	351000	27000	73000	79000
3rd day.............	0	0	0	2	42000	141000	78000	49000	140000
6th day.............	0	0	0	0	124000	146000	33000	73000	196000
9th day.............	0	0	0	0	281000	350000	147000	266000	430000

B. Acidi Lacti. Number of germs found in 1-40 c. c. of milk containing formaldehyde.

Time after inoculation.	1:100	1:500	1:1000	1:5000	1:8000	1:10000	1:25000	1:50000	No formaldehyde.
Immediate..........	11	23	6	330	36	78	746	17	14
1st hour............	2	31	3	145	20	220	120	4	40
2nd hour...........	0	0	12	0	25	....	220	70	216
3rd hour............	0	0	0	0	95	300	47	300	2220
1st day.............	0	0	6	0	2	2881	81	3800	34400
2nd day.............	0	0	1	0	2	240	2790	57000	133000
3rd day.............	0	0	0	0	3000	500	13200	28000	179000
6th day.............	0	0	0	0	240	9780	137000	51000	700000
9th day.............	0	0	0	0	90000	140000	224000	192000	1300000

B. Typhosus. Number of germs found in 1-40 c. c. of milk containing formaldehyde.

Time elapsing after inoculation.	1:100	1:500	1:1000	1:5000	1:8000	1:10000	1:25000	1:50000	No formaldehyde.
Immediate..........	24	300	233	23	60	84	3360	240	270
1st hour............	0	125	60	90	47	480	2800	1500	40
2nd hour...........	0	2	8	120	25	420	1500	2880	3900
3rd hour............	0	120	4	5	20	300	540	2340	7440
1st day.............	0	6	39	11	540	9000	180	540	94000
2nd day.............	0	0	0	4	1380	13	120	2450	48000
3rd day.............	0	0	0	0	3800	2	67	45	67000
6th day.............	0	0	0	0	0	3	3	19	95000
9th day.............	0	0	0	0	0	0	1	0	140000

It will be seen that the following deductions may be drawn from the results as stated in the tables. 1. Formaldehyde when added to milk in the proportion of 1:100 destroys the three germs used in the experiments within three hours. 2. In the strength of 1:500 formaldehyde destroys the lactic acid bacillus within two hours. The typhoid bacillus is slightly more resistant and the colon bacillus still more resistant. 3. In the strength of 1:1000 formaldehyde destroys the lactic acid bacillus after three hours, the typhiod bacillus practically within the same time, while the colon bacillus is somewhat more resistant. 4. In the strength of 1:5000 formaldehyde destroys the lactic acid bacillus within two hours, the typhoid bacillus within two days, while the colon bacillus may persist a day longer. Practically all three of these bacilli are killed by the use of one part of formaldehyde to five thousand of milk within one day. 5. In the strength of 1:8000 the lactic acid bacillus is much retarded in its growth until the end of the second day, when it begins to grow abundantly. The typhoid bacillus is retarded until the end of the first day, but grows more abundantly during the second and third, and died out altogether before the sixth day. The colon bacillus is retarded in its growth until the end of the first day, after which it grows abundantly. 6. In the strength of 1:10000 the lactic acid bacillus does not grow abundantly until after the second day, while the typhoid bacillus is nearly exterminated at that time; but the colon bacillus grows luxuriantly after that time. In a strength of 1:25000 there is a decrease in the number of colonies of the lactic acid bacillus during the first day, after which there is a gradual increase. The typhoid bacillus growth decreases in numbers, while the colon bacillus growth increases from the beginning; in other words, formaldehyde in milk in the proportion of 1:25000 does not retard the growth of the colon bacillus. 8. In the strength of 1:50000 the growth of the lactic acid bacillus is retarded during the first day; that of the typhoid bacillus is not markedly affected until after the second day; while the growth of the colon bacillus is not influenced.

PAPER READ BEFORE THE SECTION OF AGRICULTURE.

SOME OF THE RELATIONS OF BOTANY TO AGRICULTURE.

BY W. J. BEAL, PH. D.

It may seem the height of folly to attempt to enumerate a considerable number of the relations of botany to agriculture before such a company as this, but I have learned that there is often gross ignorance, even in high places, concerning such things.

For example, in 1890, the Botanical Laboratory and its museum at the Agricultural College burned to the ground. The Legislature of 1891 was asked to appropriate money to build a new one. Some of the members, including a portion of the special committee on the College, stoutly opposed rebuilding on the ground that botany had no business to be taught at an agricultural college. It was no part of agriculture and the farmer had no need of any botany whatever.

We must acknowledge that many farmers still retain a prejudice against botany. What they have in mind, is probably the old botany, as they conceived it, or as taught or studied 75 years ago. They may have supposed that botany consists of little else than merely giving technical names to plants, or parts of plants. Did they know all the facts then, there could be no difference of opinion as to its great value. In fact, most farmers are all the time discussing botanical subjects from their point of view,—and not a small number of them are giving what they believe to be good reasons for the statement that wheat turns to chess, or why is it best to plant potatoes in the new of the moon, or why and how the moon causes the potatoes to rot, or the damp, hot and still weather causes wheat to rust, plums to rot and pears to blight.

In its broad and true sense, agriculture includes horticulture, and horticulture includes pomology, floriculture, vegetable gardening, viticulture, and a portion of landscape gardening. Agriculture includes the art of growing various kinds of live stock, various kinds of field crops, and many other things. Agriculture also includes apiculture.

Botany relates mainly to the science, and not much to the art of agriculture or horticulture.

Baron Von Liebig said: "The scientific basis of agriculture embraces a knowledge of all the conditions of vegetable life, of the origin of the elements of plants, and of the source from which they derive their nourishment."

Prof. Lindley said: "Good agriculture and horticulture are founded upon the laws of vegetable physiology. No man deserves the name of gardener who is not master of everything known as to the way in which plants feed, breathe, grow, digest, and have their being."

In an address, ex-President T. C. Abbot made the statement that: "Agriculture, horticulture, forestry are applied botany and botany is the only secure basis of agriculture."

Prof. W. W. Tracy, in 1877, made the statement before the Michigan State Horticultural Society, that horticulture had advanced but little in the past 150 years, except in two directions. The greatest progress had been made by botanists, who had by systematic efforts originated new varieties. Progress nearly as great has been made by the entomologist in his systematic warfare against insect enemies. Probably the statement is as true in 1901 as it was twenty-four years ago. We should certainly, also, at this time, credit the botanist, with many investigations of the life history of the lower forms of plant life, which are injurious to cultivated plants, and in discovering remedies for many of those most destructive, such as black rot of the grape, the curl of peach leaves, apple scab and others.

Botany, as taught today by the best teachers, is emphatically a science in which the student is sent directly to nature for his facts. In this way he should become an accurately trained and reliable observer. He applies numerous questions to his plants, by observation, trying many experiments, and in studying their behavior; in this manner the student cultivates his judgment and learns to draw correct conclusions.

Well grounded in systematic botany, he is likely to avoid falling into numerous errors so often made by persons who learn horticulture as a mere trade.

Farmers, bee-keepers, florists, vegetable gardeners,—all classes of enquiring minds are often anxious to learn of the botanist the names and some of the peculiarities and uses of some plant which is new to them, or, if it is supposed to be injurious, they are eager to learn the best methods of extermination.

The botanist is often beset to identify the seeds which the farmer finds in grass seed or clover seed. Seedsmen often appeal to a botanist to ascertain whether certain seeds are genuine or not.

Prof. Caruthers was the consulting botanist for members of the Royal Agricultural Society of Great Britain, and for a small fee, he identified samples of grass seeds, that the farmer might know by the sample what he was buying, for he bought subject to the inspection of the botanist. Many members availed themselves of this privilege, and this in a very few years was the means of improving in a striking manner the quality of seeds offered in the markets.

This systematic side of botany is indispensable to one to enable him to distinguish and name plants in cultivation, and to observe their affinities.

Geographical botany may teach of the soil and climate in which a certain plant thrives, and how to treat it when carried to a new country. Here, however, experience, experiment and the judgment are all valuable aids. Plants are not always found in a wild state where they will thrive best. This is true of many of our weeds, and of many plants cultivated for various purposes.

Who will point out the relationship of plants and find suitable stocks on which to "work" our cultivated shrubs and trees? The botanist. And the botanist will know better than to attempt a union of scions of chestnut on stock of horse-chestnuts—something actually attempted by a horticulturist of my acquaintance. The resemblance of the fruit of the one to the seeds of the other deceived him into thinking the union practicable.

The botanist alone is competent to plan and perfect a botanic garden or arboretum and give instructive lessons on these subjects.

No one, excepting a systematic botanist, would be competent to visit foreign countries to select new plants worthy of cultivation. Systematic botany is not only essential in identifying, describing and classifying plants, but it is well equipped with all the necessary paraphernalia in the way of technical terms and methods to perform the task of describing in an exact manner, all "artificial" forms that have been bred or selected. I mean the numerous sorts of cabbages, beets, apples, pears, gooseberries, wheat, corn, oats, and many others. The time has already come for more accurate and complete descriptions of varieties and races of vegetables than have yet been written.

Cultivated varieties of strawberries are usually described by the fruit, with a few references to the leaves and possibly to the length of the stems. The botanist who had never compared the runners, the inflorescence and the flowers in detail, will be surprised to find that in them we have very marked differences which could well be illustrated and described. Twenty-eight years ago or more, I discovered this fact and described some varieties, though the descriptions were never published. I have described 150 varieties of apples by a careful examination of inflorescence and flowers, in most cases making drawings to equal scales. There are now so many varieties of cultivated fruits, that we need to make use of all the good characters that can be found to aid in making complete characterizations. I have many times made the statement that no variety of fruit can now be called well described, unless the peculiarities of inflorescence and flowers are considered in connection with every other characteristic feature.

A knowledge of systematic botany will enable a teacher or the worker in horticulture to group his information, thus greatly aiding the memory and shortening the process of giving or receiving instruction. He learns that plants known as cucurbits have monoecious flowers, which must be pollinated by insects, wind or by hand; that they love heat, are sentitive to frost, that similar insects prey upon many of them. The garden plants known as Cruciferæ have many peculiarities in common, well understood by botanists, such as a pungent, watery juice, the seeds starting early, the young plants enduring some frost, and in many cases the same insects trouble numerous species. He learns that seeds of the Umbelliferæ have a low vitality and are slow to germinate. These are but a few examples out of many which could be given.

(The reader who desires to pursue this subject further is referred to Rep. Mich. Pom. Soc. 1873, Proc. Amer. Pom. Soc. 1879 and 1881, Amer. Naturalist, 1886.)

The botanist understands why some varieties of strawberries, apples and other fruits frequently fail to "set fruit," and in some instances he can prescribe a remedy. Strawberries sometimes fail because the flowers of an isolated variety are all pistillate—and destitute of good stamens. Apples fail to set, sometimes because the pollen is poor, or because of unseasonable rains which prevent insects or the wind from transporting the pollen from one variety to another.

He has learned to see that the visits of insects to the flowers aid in ensuring a larger crop of fruit, as he knows that the showy portions of the flowers are hung out as mere advertisements, to attract insects; that surplus pollen and nectar are placed in the flowers as wages to reward and encourage their visits.

Some knowledge of botany, at least, is essential to aid the judgment in selecting with intelligence the sorts that may be crossed or hybridized.

Long ago, Darwin learned that some pistils refused to be fertilized by pollen upon the same individual plant, that pistils of a horticultural variety were not well fertilized by flowers of the same variety.

Some years ago, a man in Virginia owned an orchard consisting largely of Bartlett pears, in which were scattered other varieties. The Bartletts were so prolific and profitable that a near neighbor set 22,000 standard Bartletts in a block, which, with good care for eighteen years had never borne over one-fourth of a crop. The trees had been well cared for. In 1894, M. B. Waite of the United States Department of Agriculture, published a bulletin giving the results of his investigations of these orchards and learned the reasons for the eminent success of one orchard and the lack of success of the other. Here are some of his conclusions:

1. Many of the common varieties of pears require cross-pollination, being partially or wholly incapable of setting fruit when limited to their own pollen.

3. Cross-pollination is not accomplished by applying pollen from another tree of the same grafted variety, but is secured by using pollen from a tree of a distinct horticulture variety, i. e., which has grown from a distinct seed. Pollen from another tree of the same variety, is no better than from the same tree.

4. The impotency of the pollen is not due to any deficiency of its own, but to the lack of affinity between the pollen and the ovules of the same variety.

5. The pollen of two varieties may be absolutely self-sterile and at the same time perfectly cross-fertile.

7. Bees and other insects are the agents for the transportation of pollen.

11. Self fecundated pears are deficient in seeds, usually having only abortive seeds, while the crosses are well supplied with sound seeds.

From these experiments he arrived at the following practical directions for growing pears:

1. Plant mixed orchards, and not solid blocks of one variety.

3. Be sure that there are sufficient bees in the neighborhood or within two or three miles to properly visit the blossoms.

Mr. Waite and others have shown that the same rules apply to orchards of apples and plums.

Botany is often a great help to a man in detecting a new weed, while it has yet only been sparingly introduced. If then attacked, it may be easily subdued, before spreading all over the farm. The unbotanical person might scatter quick grass and other troublesome pests far and wide over his premises before he became aware of their presence. A knowledge of the shapes, sizes, colors, markings and internal structure of seeds is valuable to the horticulturist, enabling him to distinguish the true from the spurious.

The trained eye of a botanist is necessary to aid one to see beauties, defects, harmonies and incongruities in selecting, combining and arranging trees, shrubs, flowers and foliage plants to best advantage for producing the most pleasing effect at the least outlay of money and labor.

If a man knew the structure and functions of roots, he would not carry trees in the sun on a windy day for miles without any covering. yet this is often done, and then the man wonders why his trees did not grow. He does not know that roots are almost as soon killed as a black bass when out of water or exposed to the wind or sun.

The man who knows the structure of a tree and how it grows, would at least be amused at the following statement, once made by a "practical" man at a meeting of our State Horticultural Society. To kill the insects on leaves, to add health and vigor to a fruit tree and cause it to produce abundantly of luscious fruit, he bored a hole into the trunk of the tree, filled it with flowers of sulphur, and secured it with a plug. He was careful to avoid boring very far into the tree because he might thereby injure its heart! A knowledge of vegetable physiology teaches a person the effect on a plant of flowering, of seeding, of high cultivation or poor cultivation, of root pruning, of pruning the top at different seasons of the year. It teaches how to manage plants for producing flowers, and how to manage them to prevent their flowering.

A person might as well attempt to become a surgeon without a knowledge of human anatomy and physiology as to become a horticulturist without botany. The horticulturist who merely learns the trade will not so quickly change his practice and adapt himself to the new circumstances of a different climate in a remote country, as the one who has studied well the principles of plant growth.

Formerly many gardeners came to this country from Great Britain and the continent of Europe, where the climate is very unlike our own. If they are ignorant of the science of botany, and have only learned by experience as an apprentice learns a trade, they are almost sure to fail in America, till they begin and learn the trade over again,—and by that time most of them are too old to learn new tricks, and go on making mistakes. If well trained in botany, in the full sense of this word, he will likely soon become master of his new situation, no matter where he may go.

Many worthless experiments have been made, wasting time and money, attributing results to wrong causes, from a lack of knowledge of plants.

No horticulturist without a thorough knowledge of the principles of several departments of botany is capable of planning and conducting and interpreting experiments. Think of the time occupied in making experiments, in discussing the subject in the press and in conventions on the cause or nature of pear blight!

In horticulture, in most respects, botany will make a person more capable. It will make him a good observer, improve his reason, strengthen his judgment, cultivate his taste, broaden his views, weaken his respect for the traditions of his fathers. It will sharpen his wits, make him a reliable investigator. It will enable him to become a leader instead of a follower.

Descriptions of plants for dictionaries or other purposes is not possible, without some knowledge of botany.

In Morton's Cyclopedia of Agriculture, nearly one-fourth of the text consists of descriptions of useful and ornamental plants by botanists. The preface contains this comment: "The comparative quality and productiveness of the different kinds of wheat, barley, oats, together with the successive introduction of new species from other countries, have so connected the researches of the botanist with the interest of the farmer, that to no science, historically speaking, is the agriculture of this country so deeply indebted as to botany."

Who have written on the science or the theory of horticulture? Such men as Dr. John Lindley, President Knight, of London, Maxwell T. Masters, all of England, botanists of more or less repute.

Who suggest the most intelligent and valuable horticultural experiments? Lindley, Knight, Darwin and other botanists.

Who experiment, select, and test grasses and clovers? No one can make much progress unless he be a botanist. Even stock breeders are often ignorant of most grasses.

Who have found out the life history of our minute plants, known as parasitic fungi, and bacteria, which are so numerous and destructive that they take rank in their depredations along side of the hosts of injurious insects? Such men as Farlow, Burrill, Bessey, Arthur, Galloway, Erwin F. Smith and others. Those men show as clearly as the noonday sun can show anything, that wheat rust, potato rot, pear blight, corn smut, and many other so called plant diseases, are the result of minute parasitic plants which rob the host plants of their protoplasm and starch.

Who, not a botanist, could ever have imagined half of the bright thoughts stated by Asa Gray in his essay in the Transactions of the American Pomological Society in 1873: "Were the fruits made for man, or did man make the fruits?" Here, among other things, he discusses what our pomology would have been if the civilization from which it, and we ourselves, have sprung had had its birthplace along the southern shores of our great lakes, the northern shores of the Gulf of Mexico, and the intervening Mississippi, instead of the Levant, Mesopotamia and the Nile, and our old world had been open to us as a new world, less than four hundred years ago.

Who, except the botanist—Darwin—could have written two of the most suggestive and valuable works ever published as guides to the horticulturist? These are, first: "Animals and Plants Under Domestication;" second, and in my opinion most valuable of all books to the educated horticulturist, "The Effects of Cross and Self-Fertilization in the Vegetable Kingdom."

The former is the easier to understand and the more popular—it has been much read and quoted, and has already made a lasting impression on horticulture; the latter has yet apparently scarcely produced an impression, and was undoubtedly written in advance of the times.

The Gardeners' Chronical remarked, upon the advent of this latter book,—The Effect of Cross and Self-Fertilization in the Vegetable Kingdom: "For our horticultural readers the great value of Mr. Darwin's last work consists in the practical applications which follow from the author's very numerous, protracted and laborious experiments, yet it is certain, that *those practical results will be a long time filtering into the minds of those who will eventually most profit by them.*" The lines which I have italicised are prophetic.

It is now twenty-five years since this book appeared, yet we have heard of scarcely any horticulturists who have practiced what Mr. Darwin showed to be advantageous. I have heard of nothing that has since been done in a practical way, in Europe, to confirm or disprove any experiments of Darwin. In this country, I have heard, as I now recollect, of only a very few instances of experiments in this line, excepting some which I conducted soon after the book was published.* These results were presented at several conventions and a report printed in several journals, yet scarcely any one seems to have taken any note of them.

The following from Mr. Darwin's book should be committed to memory by every progressive horticulturist: "It is a common practice with horticulturists to obtain seeds from another place having a very different soil so as to avoid raising plants for a long succession of generations under the same conditions; but with all the species which freely intercross by the aid of insects or the wind, it would be an incomparably better plan to obtain seeds of the required variety, which had been raised for some generations under as different conditions as possible, and sow them in alternate rows with seeds matured in the old garden.

"The two stocks would then intercross, with a thorough blending of their whole organizations, and with no less purity to the variety; and this would yield far more favorable results than a mere exchange of seeds."

A thorough knowledge of botany will every day add much to the pleasure and satisfaction of the agriculturist, as plants in various conditions in the ever changing seasons are everywhere about him in great variety and profusion. Such knowledge is indispensable to enable him to receive the greatest benefit possible from a visit taken in any country at any time.

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* See Amer. Journ. Sci. and Arts, May, 1879.

PAPER READ BEFORE THE JOINT SESSION OF THE ACADEMY AND THE BIOLOGICAL SECTION OF THE SCHOOL-MASTERS' CLUB.

HOW SHALL A YOUNG PERSON STUDY BOTANY?

(A sequel to the New Botany, printed in 1879.)

BY W. J. BEAL, PH. D.

Mr. President, Members of the Botanical Section of the Academy of Science and the Biological Section of the Schoolmasters' Club:

While studying four years in the classical course at the University of Michigan and coming under the instruction of Alexander Winchell, I was seized with a desire for more knowledge of natural history. It was two years later, in April, 1861, that I went to Harvard to study under the guidance of Agassiz and Gray. In those times, the gross anatomy, morphology and the classification of animals and plants were about all that received much attention.

Agassiz said he was glad to see me there and asked a few questions, observing that, "You must make up your mind to be a poor man all your life if you become a naturalist. With my mode of treatment students are about sure to become discouraged at first. I shall try your patience. You have read books, but have not studied the subjects themselves. If you study with me you must not look at a book for some time,—for several months. You must learn to see,—to observe for yourself. After students get started once in this way, the longer they study here the better they like it, and the more reluctant they are to leave."

After some more questions, he handed me half a dozen dead sea-urchins, and left me with the remark: "I want you to see what you can make of them, and in a day or two I will see how you get along."

He assigned me a table in the laboratory, where ten or a dozen other special students were at work, the floor being largely covered with cords of shallow wooden boxes sitting tightly over each other containing various kinds of specimens. This was a queer way to study, six dry specimens about as large as so many Baldwin apples and no books! I looked them over and over, part of the time using a small hand lens. I was glad when night came, for it seemed as though I had learned all there was to be learned of sea urchins. I broke them to pieces and made some drawings. The next day the professor called with a smile, saying: "Well, Mr. Beal, what have you seen?" He glanced at the drawings and I told him what I had done. He gave me a very few general hints of what to look for, and a few names of the parts, noticing some mistakes, but made no corrections.

I supposed certainly, all of one day spent on these specimens was enough. Not so; I was to study them longer. Thus he called every day for about five minutes during a period of three weeks, hearing what I had to say, till I made some mistake, when he uniformly turned on his heel and left me, saying, "You are wrong." I was surprised at my own work,—surprised to find at the end of the three weeks, that I was still discovering something new every day. You must understand, that during this time, I had only two lectures a week on other subjects, devoting all the rest of the time to sea urchins. After this I dissected specimens which had been in alcohol, and occasionally went to Chelsea beach to get fresh living specimens which I examined while in motion. I began to learn to see sea urchins, and it made little difference to me whether it was daylight or dark, whether the specimens were before me or not, visions of sea urchins in all their details were all the time before me.

In a similar manner, one species of star fish was examined, occupying a week or so. Agassiz said: "These two animals, the sea urchin (a flattened sphere) and the star fish (with five rays or arms), are composed of similar parts arranged in a similar manner. Learn how it is." The comparison occupied several days.

The next specimen was a spatangoid, an animal somewhat different from either of the others. "Now homologize these three." Then a third and a fourth specimen were given me, differing from the others in appearance, and I was told again, "Compare. It is easy to observe isolated parts,—any one can soon learn to do that,—but when you compare two objects, you take a step in philosophy." In one case I was asked to make a paper model of a coral, to illustrate my idea of the hard portions. Corals were compared with sea urchins and star fishes. This work occupied me for over two months, and during all this time, Agassiz never corrected a mistake, but kept me working till I found out for myself.

Perhaps it was three months before I was permitted to see books on these subjects, but at that time their contents were carefully read and fully understood. Agassiz often said: "Study specimens and refer to books, and not the reverse, as is usually done. Text-book knowledge about nature does not amount to anything; it is a very poor basis of culture."

It has seemed to me that the work with Agassiz helped me more than that of any other teacher with whom I ever came in contact, and yet no teacher ever told me so little. I learned to observe and learned to rely on myself. At that time we supposed that this kind of work was beginning the study of zoölogy in the right way, but in these days, some people are trying to make a new thing out of it, by calling it nature study. Nature study is seeing the things one looks at, and the drawing of correct conclusions from what is seen. In this connection it may be well to keep in mind Dr. Goodale's definition of botany. "Botany attempts to answer all reasonable questions about plants."

I spent months studying asters, golden rods, sedges, and other plants in the laboratory with Dr. Asa Gray, who was always on the alert to keep me in the right track and point out the mistakes at once, saying: "It isn't worth while to pursue a subject when you have got off the right track."

For at least half a school year of daily work in beginning botany, I require all students to pursue the plan of studying plants and not books. By all devices, I seek to get the results of the combined observations of all members of the class before I tell them what I think, or before they study books on the topic. It makes no difference what grade of a high school or what class in a college they belong to, the process is the same. With young pupils and undergraduates, I do not carry out Agassiz's plan to the full extent, but keep it constantly in mind, tempering the severity of the breeze to the shorn lambs.

After the students have learned well how to see for themselves by practicing for eighteen to twenty weeks, in succeeding terms, I am by no means so particular to adhere to this plan.

In many of our elementary text-books in these times—and they are numerous and multiplying rapidly—most authors recommend the study of what they call types. For example, they advise studying one Spirogyra, one Vaucheria, one Mucor, one Puccinia, one Ascomycete, one Marchantia, one Polytrichum, and so on through from low plants to the highest. In pursuing this plan, my experience convinces me that most students fail to see the connection and loose interest in passing from one isolated family or class to another. It may be well enough to study types, but pupils should not fail to study in that connection a considerable number of species that are somewhat nearly related, and by this means have the benefit of comparing similar objects. After learning the structure of one violet, it is better to examine the structure of at least ten other species, than to spend the same time in studying a single crowfoot, a chickweed, a geranium, a spiræa, a rose, a mint, a phlox, a mallow, a dandelion, a fern; though all of these may be studied at other times in connection with allied forms.

Twenty-five years ago, we often met teachers in Michigan who required their pupils to begin botany by getting lessons from a text-book, where they saw some pictures and diagrams, instead of plants or some of their parts. This was the practice, especially in winter, when it was claimed that no specimens were to be obtained. I am sorry to say that such persons in some of the back districts are still retained as teachers. Perhaps I ought not to mention this matter, but it isn't three years since I met one of your teachers who occupied a high place, and he followed the book-lesson plan, with little or no use of specimens. Is it possible that he was unable to procure large seeds of some common plants and set his pupils to observing, experimenting, and growing them in the class room? Had he not collected many dry seeds, fruits, and racemes in summer and kept them in bunches or in loose sacks hung on the nails in the rafters of an attic till wanted in winter? The fact appears not to have entered his head, that he could secure each in its season, a great assortment in quantity of the soft fruits, buds of flowers,—that he could keep them in jars in two per cent of formalin till wanted. They will keep their shape and part of their color very well, and the odor of formalin disappears after washing in water for a few minutes. True, we cannot collect roses from a Michigan garden in January, nor maple blossoms in February, but our trees and shrubs in their winter garb furnish excellent lessons to profitably employ pupils for many weeks of winter, and this all comes within the scope of botany, just as much as though we examined flowers in May or June. By the roadside, in the swamp, in the woods or the front yard, are hundreds of branches of a hundred kinds of woody plants, the buds of which are formed in summer and resting in winter, some of them waiting to be studied by inquisitive pupils. The branches have pith, wood and bark, to say nothing of the delicate contents of the buds. Students can pursue the following order with branches of our elms and find plenty to do:

1. Note the general characteristics of branches, including the arrangement of buds and the abortive stem above the upper bud.

2. Lenticels, corky ridges, and the bark.

3. Leaf-scars, their position, shape, structure.

4. Scars left by the bud-scales, and minute buds in their axils.

5. Scars left by some of the dying buds.

6. The buds: (a) those containing a stem and leaves; (b) those containing flowers.

The longer I teach, the less I lecture my students and the talks that are given are mostly regarding things which the students have previously examined. As a rule, I have to keep cautioning our instructors not to lecture so much. I have had some of these, who apparently delighted to show their wisdom and would spend more than half of the laboratory hour in telling students what they should attempt to discover for themselves, or in giving other information. Students are inclined to like this plan, as it is much easier and quicker to get information this way, than it is to work it out for themselves. They do not stop to think that they are pursuing the study to learn how to work, rather than to acquire information.

In 1869, I gave members of the junior class in Chicago University some lectures on zoölogy. I had been particular to tell them about the structure of the heart, and the circulation of the blood. Two of the class afterward dissected a dog that was good for nothing else. They wondered what those broad things were at the large end of the heart, and were going to cut them off and throw them away, not mistrusting that these were the auricles about which I told them the day before.

In 1885, I gave to an advanced class, five illustrated lectures on the pollination of flowers. After the course, I asked questions and made the following record in my note book: "As far as the lectures are concerned, many points were imperfectly understood, erroneous notions were entertained. The five lectures were to a great extent a loss of time, which could have been spent to better advantage by a careful study of the flowers of several living species."

Better than lectures, I have found the following to work well, not omitting laboratory work. I teach agricultural students something concerning grasses, weeds, parasitic fungi, forestry, plant physiology. After they have done some laboratory work, students are supplied with duplicate books, bulletins, or separates, which treat especially of the subjects in hand. These are read by each one during the laboratory hours, and the students take their time for making good notes. These books and bulletins are a part of the laboratory equipment. For example, beginners study seeds and seedlings of peas and beans for four hours, making some notes and drawings, *after* which I give each a copy of my bulletin No. 1, on *Elementary Science* which treats of the same kinds of seeds and seedlings. Copies of this bulletin are on the table at this meeting. Wheat and buckwheat are studied in the same manner, and later, seeds and seedlings of timothy and clover, each time finishing up with a bulletin. I can conceive of no more desirable method than to have the whole series of topics which are studied during a term, written up and illustrated in this manner, that the text and cuts may not be seen till considerable attention has been given the objects. In case a book is furnished a beginner, while he has specimens, he is almost certain to use it as freely as a student would use the translation of a German or Latin text which he is trying to translate.

In Michigan many persons preparing for examinations with a view of securing certificates, cram in botany and zoölogy, physics and chemistry, instead of making original observations or of making the experiments for themselves.

Not long ago, our State Superintendent of Public Instruction introduced a fine scheme for a portion of his examinations in botany. Those who were trying for State certificates, were given some questions to be answered in writing on the usual plan, while another portion of the examination consisted in using a stage microscope with paper and pencil and no books. Applicants were asked to give the results of their observations covering some fresh plants placed in their hands. Such questions are most admirable, and they are fair, but in this case, most of them were unanswered, showing that the candidates were destitute of the most important part of the preparation. Some of them failed to make a passing record.

In examining candidates to enter an advanced class, I invariably make considerable use of laboratory work and less of oral quizzes.

Students should keep the following four points constantly before them to aid in arriving at correct conclusions:

1. Where possible, examine many specimens of one species.

2. Pay considerable attention to counting and measuring and finding the relative sizes of the parts studied.

3. Carefully compare homologous parts of allied species.

4. Study plants of any species in all stages of development.

As we must expect, beginners are often at a loss to know how to express themselves clearly and fully, especially in writing descriptions of plants or parts of plants that they have never seen before. Their notes are very often too meager. After all have tried and done the best they can, I show them what I can do or permit them to copy an apt description from some book or from a blackboard. After repeating this process for several times, they soon begin to acquire considerable skill in description.

I like to keep a syllabus of the course on the blackboard or to have it on a chart hung before the class.

Many text-books contain in the introduction or in some of the early chapters a lengthy account of the classification of the subjects treated in later chapters. Here they attempt to teach classification before the beginner has acquired a knowledge of facts as a basis sufficient to comprehend the text.

I wish to call your attention to a notable exception to this rule in a *First Book of Zoölogy* by E. S. Morse, published more than twenty-five years ago, before some of you were born. The plan is admirable. The author speaks to his pupils by text and excellent illustrations of snails, clams, insects, centipedes and lobsters, and in the last part of the book, where you would least expect to find it, he inserts a few chapters concerning natural groups. Here we have the natural order of work; a multitude of facts are given before the author attempts to generalize or classify.

What I term beginning botany is expected to continue daily for eighteen to twenty weeks, devoting an hour and a half a day in the laboratory, with sections containing each twenty-five to thirty persons. Each student is furnished a stage microscope, with two needles in handles, a pair of forceps and usually a small knife. During this period, the teacher must see:

1. That he learns to use these instruments to best advantage,—correctly.
2. That he learns to draw diagrams, vertical and cross sections, rather than artistic views.
3. To make good and full notes.
4. To learn something about plants.

In certain cases, I find it very instructive to require students to make models out of paper or large rutabagas or potatoes. After studying the structure of the epidermis of Tradescantia, I once required the members of a class to construct models from turnips. I was surprised to find that some of them supposed that a stoma was closed by a cell placed between the guard cells.

Certainly in no course should a student attempt to study everything pertaining to botany. We must select some of the good portions with reference to that which is most suitable for the students we teach and the apparatus that is available. We select with reference to what shall give the best training, and lastly that which will give them the most useful information. If all were intending to pursue the study of medicine, or of mechanical engineering, or of agriculture, or of horticulture, the fact might influence more or less the topics to be selected, but in most schools, the pupils will pursue a great variety of callings after completing a course, or before that time. We must keep in mind all the time that, "What a man can do is more important than what he knows."

For acquiring the power of observation every day, there can be nothing better than the study of the gross anatomy of plants, and for cultivating the judgment, plant morphology is unsurpassed, especially where frequent comparisons are insisted on.

While these two lines of work are kept at the front, from the first lesson on the first day and all through the courses, I encourage every student not to forget to ask himself the question, "Why and How?" This will call in more or less of physiology, ecology, description and classification or relationship. Under ecology especially, the following questions are always interesting. Why are plants not all found in the same region, why do they not all flower at once? Here comes in the modes of plant dispersal, the struggle for existence and more room, zonal distributions, plant communities, adaptation to climate, how plants protect themselves.

Fortunate, thrice fortunate is the botanical teacher who can draw diagrams well and with some alacrity, for it helps amazingly in making explanations. It will save many tedious repetitions in the explanations, if a short syllabus or specific statements be produced in duplicate, so that each student can have a copy. There will always be some in a class who were not giving close attention when something was said, or some member will be absent.

No person for the first twenty weeks of botany should be at the trouble of learning to use a compound microscope. He should leave it until he has made a somewhat intimate acquaintance with the gross anatomy of plants.

There are a dozen or more designs or blank forms published, leaving spaces opposite printed names in which to answer direct questions about a plant in flower. It is well enough to place about three copies of this in the hands of each student as he examines three different plants, but to continue their use for a greater length of time will tend to relieve the student of thinking and make a machine of him. The quicker he learns to ask his own questions and answer them the better, even at the risk of some omissions.

It seems to be necessary to spend some time in the class room, to aid pupils in becoming familiar with artificial keys which lead to families where a plant in hand may be described and named, but with the other instruction provided for, but little time need be given to this work. This is too often spoken of as analyzing plants, instead of identifying plants. I place a very low estimate on a common practice of requiring each person in the class to collect, dry and mount fifty to one hundred plants.

I haven't had much experience in conducting field excursions, because my teaching has been done at a college which had a large campus containing a great assortment of trees and shrubs, and because there was at hand a botanic garden where the plants were arranged in families, each plant growing back of a label which contained its name.

It is a part of our plan, in the spring term to go once a week, with the students in small companies of about a dozen, where some interesting features can be pointed out.

A botanical club or a natural history society in a school is well worth encouraging. Let it be officered by the students, and help them to get up programs, remembering that no society of this kind can long maintain an interest among its members, if they plan to have little else than a lecture at each meeting. The members should be the actors on the program. (Here the interested reader may consult Vol. 1, Michigan Academy of Science, pp. 94, 95, 96, for a list of topics suitable for discussion by members of a botanical club.)

For many years I have assigned each term one or more suitable topics, a different one to each member of the class, which he considers his personal property. Those topics the pupils investigate thoroughly so far as they can, and each member in turn presents his paper or talk, usually with illustrations, to the other members of the class. The quality of the work, like that of a recitation is credited or equivalent to two or three or more good or poor recitations.

I have uniformly found that students took an unusual interest in this plan. For numerous suitable topics, consult *The New Botany*, noticed elsewhere.

Frequently an opportunity arrives for advertising the members of a class a little. I consider the time well spent, provided the preparation is all in line with the legitimate work of the class during that term.

Some of the teachers may be interested in a plan which I tried in 1886. In Michigan we have a thrifty State Horticultural Society that holds meetings in different parts of the State, thus performing missionary service. A meeting was to be held near the college with which I am connected. College was in session. I thought to stimulate the students of a certain class and interest the members of the society.

Seventeen young persons gave three-minute talks to the horticulturists upon topics which they had been studying by the aid of the compound microscope. The subjects of the talks given were as follows:

1. Structure of a leaf.
2. The mouths of a leaf.
3. Young hairs of a leaf.
4. Sting of a nettle.
5. Talking about and showing drawings of protoplasm in motion.
6. Palisade cells in a leaf.
7. Starch of common and wild potato from Arizona compared.
8. The frame work of a leaf.
9. Fibers of cotton, flax, silk and wool compared.
10. Why nuts are hard.
11. Tough and brittle white ash compared as seen magnified.
12. Structure of a grain of wheat.
13. Pollen and its growth.
14. Quince rust.
15. Corn smut.
16. A study of common bread mold.
17. Effect of severe cold or heat on the cells and their contents.

The secretary reported, "The drawings were admirably executed, and on the whole the entire exercise was as interesting as anything ever presented to the society."

The illustrations were copied and with the text appeared in the report of the society in 1886, which gratified the students and probably did them no harm.

Some of you may find occasion where a short exercise illustrated and presented by a class, each saying a little, will attract much greater interest than where only one or a very few speak longer; and no doubt some of you may have already tried this plan.

Mr. Chairman (Newcombe), I am pleased to see you carrying out this plan, where you avail yourself of an opportunity to advertise the students of the University, as a considerable number of them participate in the program at this meeting.

Even for college students, I have found it beneficial to write neatly on the blackboard, some motto or sentiment which shall catch the eye for two or three days. I have picked up some good mottoes from speakers at this meeting. Here are some that I have used:

No real progress can be made in botany, until the student learns to observe.

Neatness begets accuracy.

Mere book knowledge of natural history is a sham and a delusion. (Huxley.)

The pupil must earn his facts. (Goodale.)

The teacher of biology will keep the student in the right track, but let him find the truth himself. (Farlow.)

Make frequent and thorough comparisons of two or more plants or similar parts of plants.

In biology, laboratory work should precede any detailed course of lectures. (Farlow.)

Details and facts before principles or conclusions.

To learn to observe well, concentrate the attention for some time on a very small portion of the field, then in like manner study other portions.

As an instrument of research, the microscope now occupies a position which is second to none.

A trained eye is valuable in any kind of business.

Merely learning the name of a plant or part of a plant can no longer be palmed off as valuable training.

Correct teaching of botany is simply giving the thirsty a chance to drink.

He who expectorates on the floor must not expect to rate high in his class.

To lose a lesson is to unsettle a week.

He who can teach only by the book had better not begin. (Prof. Wesley.)

From first to last the student should be an investigator. (Prof. Wesley.)

Patting one on the back and saying, "Don't you see this and don't you see that?" does not tend to produce a very robust mental development. (Farlow.)

You should not neglect to tell the members of your board of control, whether they like to hear it or not, that giving good instruction in natural history is costly, but, notwithstanding the cost no one in these times can any longer lay claim to a liberal education unless he has had a pretty good drill in botany or zoölogy, or both of these. By costly I mean, not only to take into account the apparatus required, but the sizes of the sections and the hours for the work. For example, it costs about five times as much to teach a class of thirty in the subject of parasitic fungi, as it does to teach the same students history or political economy.

None of us will ever live to perfect a course in botany that will stand the test of future discoveries and methods of teaching, nor shall we ever agree for a single year as to what should be taught or how it should be taught. In his report for 1888-1889, President Eliot, of Harvard, said: "During recent years every college teacher has been forced to answer anew the personal questions,—What can I best teach and how shall I teach it? Every man has really been obliged to take up new subjects and to treat them by new methods. There is not a single member of the faculty who is today teaching what he taught fifteen years ago, as he then taught it. Each teacher has to recast his work . . . and the faculty has to invent, readjust, and expand the comprehensive framework of the course."

Altogether likely most of those present agree as to the great value of a training in botany. I venture to give my opinion:

1. There is nothing better for training the powers of observation.

2. The comparison of one plant or one part of a plant with another cultivates the power of inductive reasoning.

3. In learning the definition of new words, the memory is strengthened, the vocabulary enlarged.

4. There is nothing better to train the power of precise and brief description in using each word with a definite meaning.

5. To follow successive changes that take place in shape, proportion, size, color, as seen in one plant from seed to maturity, develops the observation, powers of description, and the judgment.

6. By experimenting to learn the results that follow changes in temperature, light, moisture; by mutilating or removing certain parts, many facts may be obtained enabling one to arrive at certain correct conclusions.

7. To become acquainted with the minute anatomy of plants by the aid of sections made in different directions and seen with a compound microscope, cultivates the imagination, as well as the powers of observation and reasoning.

8. The preparation of material for examination trains the hand to precision as well as the eye and the judgment.

9. "In studying botany a student gains in analytic and synthetic powers." (T. C. Abbot.)

10. "It is the best system of practical logic, and the study exercises and shapes at once both the powers of reasoning and observation, more probably than any other pursuit." (Asa Gray, who possessed a good knowledge of mathematics and Latin as well as of botany.)

What shall I say of the value of training acquired by studying bacteria and lichens, by experimenting to demonstrate that certain fungi, like wheat rust and many others, assume two distinct forms on each of two different plants?

In these times text-books for beginners are appearing in rapid succession, in great numbers. It is a barren month in which one or more is not published. In two instances within my knowledge, the editor has prepared two books for young students, and in one case three books by one author have appeared within a period of two years. New text-books are always welcome to teachers, but the difficulty of selecting just the right one is not so easy. What does this influx of botanical text-books mean? Simply this, there are many persons interested in botany and the subject is undergoing rapid changes. New discoveries in new channels make it an inducement for teachers to try a hand in making a new book. At present, the subject is in a somewhat chaotic condition.

I have shown myself to be a person who lacks decision of character, by not being able to select a text-book for beginners that just suited me. I have tried several, to at last discard all of them; and finally to put into the hands of competent instructors,—and no others should attempt to teach,—a small work I made myself. Of course you have not seen it, for it is not in the list of any publisher.

In the preface I wrote the following lines:

"I object to telling students at every step what they are to see, or to imply as much by numerous direct questions. I think it unwise to place in the hands of beginners books containing good pictures of what is to be learned from specimens. To give him a full text and good pictures is much like placing a translation in the hands of one who is studying Greek, Latin, or German. Excepting as a model now and then, I do not think it best to supply printed schedules for plant study."

With those views in mind, all we need to put into the hands of a student is a brief outline of the course and a good glossary at the end of the pamphlet. Students are all supplied with good specimens in abundance at all times of the year. In such case what is the use of pictures, except to tell the students what to look for and having seen that, they believe they have seen all there is to be discovered? Their curiosity ends then and there.

Neither is it a good plan to lecture a class of young students implying that you are telling all there is known on a certain point,—that there is nothing more to learn about the subject. Tell them, rather, that no one knows it all, that here is a fine chance to make original investigations and you are about sure to be right in such statements.

As helps to teachers of botany, no one can afford to neglect to read The Teaching Botanist, by W. F. Ganong. Published in 1899 by the Macmillan Co.

To my students who are about to study by the aid of a compound microscope, I take great pleasure in reading parts of a most interesting paper by Dr. W. G. Farlow on Biological Teaching in Colleges, and printed in the Popular Science Monthly, March, 1886. Some of you may like to secure the *The New Botany*—a lecture on the best method of teaching the science, by W. J. Beal. Third edition. 1890. Published by *The Rural New Yorker.* New York City.

A PARTIAL LIST OF BOOKS INTENDED FOR BEGINNERS IN BOTANY.

Atkinson, G. F.:
1. Elementary Botany. New York: Henry Holt & Co., 1898 .... $1 25
2. Lessons in Botany. New York: Henry Holt & Co., 1900. 1 10

Bailey, L. H.:
1. Lessons With Plants. New York: The Macmillan Co., 1898 .... 1 10
2. First Lessons With Plants. New York: Macmillan Co., 1898 40
3. Botany. An Elementary Text for Schools. Macmillan Co., 1900 .... 1 10

Barnes, C. R.:
1. Plant Life, considered with special reference to form and function. New York: Henry Holt & Co., 1898.. 1 12
2. Outline of Plant Life, with special reference to form and function. New York: Henry Holt & Co., 1900.. 1 00

Bergen, J. Y.:
1. Elements of Botany. Boston: Ginn & Co., 1896...... 1 20
2. Foundations of Botany. Boston: Ginn & Co., 1901....

Bessey, C. E.:
The Essentials of Botany. New York: Henry Holt & Co., 1896 .... 1 08

Bower and Vines: A course of Practical Instruction in Botany. London: Macmillan & Co., 1885..........

Campbell, D. H.:
Elements of Structural and Systematic Botany. Boston: Ginn & Co., 1891.......... 1 00

Clark, C. H.:
A Laboratory Manual of Practical Botany. New York: American Book Co., 1898.......... 96

Coulter, J. M.:
1. Plant Relations. New York: D. Appleton & Co., 1900.. 1 10
2. Plant Structures. New York: D. Appleton & Co., 1900 1 10

Darwin, Francis:
The Elements of Botany. Cambridge, Eng.: The University Press, 1895..........

Evans, Ernest:
Botany for Beginners. New York: Macmillan & Co., 1899.

Gray, Asa:
1. How Plants Grow. New York: American Book Co., 1862 .... $0 80
2. Elements of Botany, Lessons in Botany. New York: American Book Co., 1887.......... 94

Kellerman, W. A.:
Elements of Botany. Philadelphia, 1883..........

MacBride, T. H.:
Lessons in Elementary Botany for Secondary Schools. Boston: Allyn & Bacon, 1896..........

MacDougal, D. T.:
The Nature and Work of Plants. New York: Macmillan Co., 1900 .... 1 10

Massee, George:
The Plant World. London, Eng.: Whittaker & Co., 1898.. 2s 6d

Newell, Jane H.:
Outline of Lessons in Botany. Parts I and II. With Readers, Parts I and II. Boston: Ginn & Co., 1892,
Outlines 90
Readers 70

LIST OF MEMBERS OF THE MICHIGAN ACADEMY OF SCIENCE.

The list includes the names of actual resident members, on June 30, 1901; also former resident members who have removed from the State. Names of charter members are in capitals.

Baker, Henry B., M. D., Lansing.
BARR, CHARLES E., Albion College, Albion.
BARROWS, WALTER B., Michigan Agricultural College, Agricultural College P. O.
BEAL, WM. J., Ph. D., Michigan Agricultural College, Agricultural College P. O.
Bradley, Frank J., Alma.
Brotherton, Wilfred A., Rochester.
Brush, Wm. A., 64 Hastings St., Detroit.
Carrow, Flemming, M. D., University of Michigan, Ann Arbor.
Clark, Hubert Lyman, Olivet College, Olivet.
Cobb, Mrs. Frank I., 391 Cass Ave., Detroit.
Cole, Frank N., Columbia College, New York City.
Cole, Leon J., 703 Church St., Ann Arbor.
CONNOR, LEARTUS, M. D., 103 Cass Ave., Detroit.
COURTIS, W. M., A. M., 449 Fourth Ave., Detroit.
Cowgill, Paul A., Michigan City, Indiana.
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