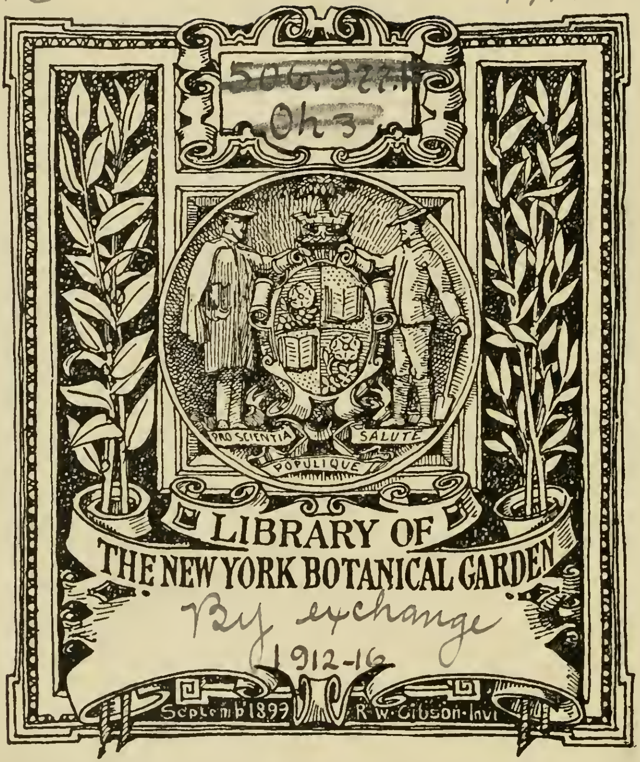
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Proceedings

of the

Ohio State Academy of Science

VOLUME VI, PART 1

Annual Report

Twenty-First Meeting

Annual Report

of the

Ohio State Academy of Science

Twenty-First Meeting 1911

Organized 1891—Incorporated 1892

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J. C. Hambleton E. L. Rice C. G. Shatzer

Date of Publication June 1912

Published by the Academy
Columbus, Ohio

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Carney, Frank, *Geology* .... Granville
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*Subject to ratification of the Society at the annual meeting, 1912.

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Copeland, W. F..............................Athens
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Davis, B. M., *Zoology*..............................Oxford
Detmers, Freda, *Botany*..............................O. S. U., Columbus
Dickey, Malcolm G., *Botany*..............................1986 Indianola Ave., Columbus
Ditto, T. W..............................Delphos
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Dutton, C. F., Jr..............................4816 Franklin Ave., Cleveland
Edwards, E. H., *Zoology, Physiology*..............................
..............................7317 Clinton Ave., N. W., Cleveland
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Feiel, Adolph..............................520 E. Main St., Columbus
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Fischer, Martin H., *Experimental Medicine*..............................
..............................Univ. of Cincinnati, Cincinnati
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Foerste, August, *Geology*..............................Steele High School, Dayton
Foote, E. H., *Biology*..............................812 S. E. Fourth St., Minneapolis, Minn.
Fox, Charles P., *Botany, Chemistry*..............................395 Doyle St., Akron
Frank, J. N., *Botany, Entomology*..............................Colleton, S. C.
Fullmer, E. L., *Botany*..............................Berea
Fulton, B. B., *Entomology, Botany*..............................Newark
Gary, L. B., *Geology*..............................263 Hoyt St., Buffalo, N. Y.
Gibbs, David ....Geneva
*Goetz, *C. H., Forestry*..............................O. S. U., Columbus

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Goodrich, Calvin, *Conchology*....................Toledo Blade, Toledo
Grover, F. O., *Botany*..................................Oberlin
Griggs, R. F., *Botany*..........................O. S. U., Columbus
Guyer, M. F.....................................Madison, Wis.
Hallinan, Thos. H., *Entomology*...........................Erie, Pa.
Hambleton, J. C., *Botany, Zoology*..........212 E. 11th Ave., Columbus
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Hathaway, Edward S., *Zoology, Botany*..Univ. of Cincinnati, Cincinnati
Hawk, J. F., *Biology*...............................Box 302, Lancaster
Hayes, Seth ....135 Center St., Dayton
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Herms, W. B........................Univ. of California, Berkeley, Cal.
Herzer, H., *Paleontology*..................................Marietta
Hillig, Fred J..............................St. John's College, Toledo
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Hine, J. S., *Entomology, Ornithology*...............O. S. U., Columbus
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Hyde, Mrs. Edna,..............School of Mining, Kingston, Ontario
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Jennings, O. E., *Botany*........Carnegie Museum Annex, Pittsburg, Pa.
Johnson, Dora E., *Botany, Physiography*........................Medina
Jones, Lynds, *Ornithology*.....................College Museum, Oberlin
Judson, C. A., *Botany*.....................235 Columbus Ave., Sandusky
King, J. Lionel, *Botany, Entomology*........................Cleveland
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Lamb, G. F., *Biology, Geology*..............Mt. Union College, Alliance
Landacre, F. L., *Zoology*.........................O. S. U., Columbus
Lantis, Vernon, *Botany*...................2509 Ohio Ave., Cincinnati
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Library, Ohio State University................................Columbus
Lindahl, Joshua, *Zoology*.................5700 Peoria St., Chicago, Ill.
Livingston, A. E., *Zoology*...................................Athens
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March, Cora, *Biology*.......................................Wyoming

Mark, Clara Gould, *Geology, Botany*................O. S. U., Columbus
Mather, Kirtley F., *Geology*................................Granville
Mathews, Mary E...Painesville
McAvoy, (Miss) Blanche, *Biology*............................
..........................Box 56, Sta. F., Foley Road, Cincinnati
McCall, A. G., *Agronomy*........................O. S. U., Columbus
McCampbell, Eugene F., *Bacteriology*..............O. S. U., Columbus
McCorkle, W. E., *Zoology*...................................Athens
McCoy, C. T., *Botany*....................................Lancaster
McCray, Arthur H., *Zoology and Entomology*..................Duval
McDaniel, J. E., *Biology*...........................Montrose, Colo.
McFadden, L. H., *Chemistry*.....................40 Warden St., Dayton
McKean, T. L., *Botany*.......................................Berea
Mercer, W. F., *Biology*.........................Ohio University, Athens
Metcalf, C. L., *Botany, Zoology*............86 E. 11th Ave., Columbus
Metcalf, M. M., *Zoology*....................................Oberlin
Metcalf, Zeno P.................................Raleigh, N. C.
Mills, W. C., *Archaeology, Biology*................O. S. U., Columbus
Miller, C. R., *Geology*...........................O. S. U., Columbus
Moody, A. E...Flushing
Morse, W. C., *Biology, Geology*....................O. S. U., Columbus
Moseley, E. L., *Zoology, Botany, Physiography*...............Sandusky
Myers, J. A., *Zoology*..Athens
Nelson, James A., *Zoology, Embryology*.........................
.............U. S. Dept. Agricul., Div. Entom., Washington, D. C.
Nichols, Susan P., *Botany*.....................Oberlin College, Oberlin
Oberholser, H. C..........1444 Fairmont St., N. W., Washington, D. C.
Odenbach, F. L., *Meteorology*............St. Ignatius College, Cleveland
Osborn, Herbert, *Entomology, Zoology*..............O. S. U., Columbus
Osburn, Raymond C., *Zoology, Ichthyology*.......................
...............................Columbia Univ., New York, N. Y.
Oxley, Chares E., *Geology, Physics*........................Coshocton
Parkhurst, C. P., *Science* ....9 W. Long St., Columbus
Peaslee, L. D., *Zoology*..................Central College, Fayette, Mo.
Piwonka, Thomas................226 Superior Ave., N. W., Cleveland
Prosser, C. S., *Geology*..........................O. S. U., Columbus
Rice, Edward L., *Zoology*...................................Delaware
Roudebush, Lowell ....R. F. D., No. 3, New Richmond
Royer, John S., *Biology*....................................Bradford
Rush, R. C., *Conchology*.....................................Hudson
Sanders, J. G., *Entomology, Botany*....................Madison, Wis.
Schaffner, J. H., *Botany*..........................O. S. U., Columbus
Scheffel, Earl R., *Geology*.............................Urbana, Ill.
Selby, A. D., *Botany*.....................Experiment Station, Wooster
Shade, Ernest F., *Physiography, Botany, Physics*................Medina

Sharp, Katherine D., *Botany, Geology*........................London
Shatzer, C. G..........................Wittenberg College, Springfield
Shaw, N. E., *Entomology*........................O. S. U., Columbus
Shilliday, C. L., *Zoology*..............................Athens
Sim, Robert J..Jefferson
Smead, Anna, *Biology*........................624 Nestle St., Toledo
Smith, A. L....................................Valley Crossing
Smith, Ethel M..Rome
Smith, G. D., *Botany, Zoology*........................Richmond, Ky.
Smith, J. Warren, *Meteorology*...........Weather Bureau, Columbus
Snyder, F. D., *Zoology, Ethnology*........................Ashtabula
Stauffer, Clinton R., *Geology*..............Adelbert College, Cleveland
Sterki, Victor, *Conchology, Botany*..................New Philadelphia
Stickney, M. E., *Botany*..............................Granville
Stover, W. Garfield, *Botany*........................Stillwater, Okla.
Stout, W. E., *Chemistry, Geology*........217 E. Mithoff Ave., Columbus
Surface, F. M., *Zoology, Botany*........................Lexington, Ky.
Sweezey, Otto H.....................Twelfth Ave., Honolulu, Hawaii
Todd, Joseph H., *Geology, Archaeology*........Christmas Knoll, Wooster
True, H. L...McConnelsville
Tyler, F. C., *Botany*..............................Perry, Lake County
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Webster, F. M., *Entomology*....U. S. Dept. Agricul., Washington, D. C.
Werthner, William B., *Botany*...........Steele High School, Dayton
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Wieman, Harry L., *Biology*.............Univ. of Cincinnati, Cincinnati
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Wittenmyer, J. G., *Zoology*..............................Peebles
Wright, G. Frederick, *Geology*..............................Oberlin
York, Harlan H., *Botany*..........................Providence, R. I.
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.............Div. Seed and Plant Introduction, Washington, D. C.

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*Subject to ratification of the Society at the annual meeting, 1912.

Report of the Twenty-First Annual Meeting of the Ohio State Academy of Science

The twenty-first annual meeting of the Academy was held at Ohio State University, Columbus, O., on November 30 and December 1 and 2, 1911, the president, Professor Lewis G. Westgate, presiding. On Thursday evening at 7:30 an informal reception was given to the Society at "The Ohio Union" by the faculty representatives and members of the Biological Club of the university. A comparatively large number of the Academy members were present and an enjoyable evening was spent in the spacious rooms of the "Union."

The meeting was called to order on Friday morning at 9:00 in the main lecture room of the Physics Building, after a preliminary session of the Executive Committee and the Program Committee. President Thompson of the university welcomed the society in a cordial speech, and expressed his optimism as to the future of the sciences where freedom of discussion combined with the integrity and intelligence of the individual were among the chief factors.

The president of the Academy expressed his approval of the views advanced by Dr. Thompson, and in behalf of the members thanked the university for the cordiality extended. The regular business meeting then followed a committee on membership consisting of the Secretary, Prof. Griggs, and Professor Hine, and a committee on resolutions consisting of Prof. Brookover and Prof. Carney being appointed. After the Secretary had noted that his report would be found in the current proceedings of the Academy, the Treasurer presented the following report.

REPORT OF THE TREASURER FOR THE YEAR 1911.

For the year since our last annual meeting the receipts, including balance from last year, have amounted to $297.43, and the expenditures to $231.97, leaving a cash balance of $65.46.

RECEIPTS.

Balance from last year	$64 43	
Interest on endowment	2 00	
Membership dues	231 00	
Total		$297 43

DISBURSEMENTS.

160 subscriptions to The Ohio Naturalist	$120 00	
Printing annual report and price lists	73 99	
Miscellaneous expenses	37 98	
Balance due December 1, 1911	65 46	
Total		$297 43

Respectfully submitted,

JAS. S. HINE, *Treasurer.*

After the appointment of an auditing committee consisting of Professors Mills and Moseley, the report of the librarian was presented as follows:

COLUMBUS, OHIO, December 1, 1911.

As Librarian of the Ohio State Academy of Science, I take pleasure in presenting my report upon the receipts from the sale of publications of the Academy and cost of sending out the publications.

Cash on hand November 15, 1911	$10 97	
Collected from the University of Wisconsin	1 00	
Cash sales of publications	37 87	
Total		$49 84

Publications sold but not collected	$12 73	
Total cash sales	37 87	
Total sales of publications		$50 60

EXPENDITURES.

Postage on special paper No. 17	$8 84	
Postage on annual report	6 00	
Envelopes	1 80	
Printing	50	
Express	2 27	
Postage on letters and publications sold	2 15	
Total		$21 56
Balance on hand in cash		$27 28

RESOURCES.

Cash on hand	$27 28	
Publications sold but not collected	12 73	
Total resources		$40 01

WM. C. MILLS, *Librarian.*

In connection with the report of the Librarian, it was moved and seconded that the Librarian be authorized to purchase cards for cataloguing the library and also a stamp for use in denoting ownership of the various volumes and pamphlets by the Academy. This was amended to include the publication of the catalogue. The amended motion was then carried.

Under the reports of Standing Committee the Secretary reported for the Executive Committee that the Academy had been invited to Oberlin for the present meeting, but inasmuch as the meeting for 1910 had been held in the northern part of the state, and furthermore since college instruction was to be carried on during the Friday and Saturday succeeding Thanksgiving at Oberlin, it seemed best to hold the meeting at Columbus.

The Publication Committee noted the need of funds for the work of publication.

The Board of Trustees having in charge the special funds furnished by Mr. Emerson McMillin, reported as follows:

FINANCIAL STATEMENT OF THE EMERSON McMILLIN RESEARCH FUND, 1910-1911.

RECEIPTS.

Cash on hand Nov. 20, 1910	$466 24	
		$466 24

EXPENDITURES.

Nov. 22, 1910.	J. C. Hambleton, expense in research	$16 00	
Dec. 21, 1910.	Freda Detmers, expense in research	10 00	
Jan. 6, 1911.	Bucher Engraving Co., illustration in publication	1 38	
Feb. 16, 1911.	W. M. Barrows, for experiment	10 00	
May 14, 1911.	A. Dachnowski, expense in research	75 00	
June 9, 1911.	Bucher Engraving Co., engravings for Morse's paper	33 50	
Nov. 18, 1911.	F. J. Heer Printing Co., special paper by W. C. Morse	70 00	
	Total		$215 88
	Balance in bank, Dec. 1, 1911	$250 36	
	Appropriations voted but not paid	194 00	
	Unappropriated balance, Dec. 1, 1911	56 36*	

JOHN H. SCHAFFNER,
(Acting for William R. Lazenby).
EDWARD L. RICE,
FRANK CARNEY,
Board of Trustees.

*Since the date of the meeting, when the above report was presented, the Academy has received renewed expression of the interest of Mr. Emerson McMillin, in the form of a check for $250.00 placed to the credit of the Research Fund.

The report of the special committee on the Natural History Survey was made by Professor Osborn. It had been found impracticable to make any progress by reason of the adverse views of members of the legislature. It is to be hoped that the general condemnation of the methods employed by many members of the last legislature in holding up various bills and advancing other bills, will result in the election of a body more favorable toward advancing the scientific welfare of Ohio along lines found advantageous in other states.

Under the order of New Business, a committee consisting of Professor Coghill as chairman and Professors Cole and Osborn was appointed to secure in so far as possible the co-operation through membership in the Academy of the physicists and chemists in the state.

Following this a Nominating Committee was elected. This resulted in the choice of Professors Osborn, Landacre, and Brookover, who were to report nominations for officers at the adjourned business meeting. The society then proceeded with the reading of papers adjourning at 12:00 m. for luncheon at "The Ohio Union."

After a panoramic photograph of the members had been taken from the steps of the Physics Building, the afternoon session opened with the address of the President of the Academy, Professor Lewis G. Westgate upon the Geological Progress of Twenty-five years wherein was summarized the interesting advances made by this science.

This was followed by the continuation of the program, the geologists segregating themselves in the Geological Building while the members of the society remained in the Physics lecture room.

At 4:30 p. m. in accordance with the program three special papers were to be presented to the combined sections. After waiting in vain for the members of the geological section who were reported to be involved in most serious argumentation in the adjoining building, the other members decided that it would be possible to continue the session with the geologists "in absentia." Accordingly Professor Metcalf presented a paper on "Evolution in the Mechanism of Inheritance," Professor Mercer on "A Phase in the Theory of Evolution" and Professor J. Warren Smith on "The Relation of Forests to Floods." These were listened to with interest and evoked considerable discussion.

After adjournment at 6:30 p. m. the Academy enjoyed a dinner given by the Sigma Xi to the visiting members of the society in "The Ohio Union."

At 7:30 the Hon. Julius F. Stone gave the society an account of personal experiences in making a trip through the Grand

Canyon of the Colorado River. This was illustrated by lantern slides which were remarkable for their clearness and beauty.

Directly after the lecture the President called the adjourned business meeting. The nominating committee reported the following nominations for officers and the secretary was instructed to cast a ballot for these as noted below:

OFFICERS OF THE OHIO ACADEMY OF SCIENCE FOR 1911-1912.

President — Professor Bruce Fink, Oxford, O.
Vice-Presidents —
Zoology — Professor M. M. Metcalf, Oberlin, O.
Botany — Professor M. E. Stickney, Granville, O.
Geology — Prof. N. M. Fenneman, Cincinnati, O.
Secretary — Professor L. B. Walton, Gambier, O.
Treasurer — Professor J. S. Hine, Columbus, O.
Librarian — Professor W. C. Mills, Columbus, O.
Executive Committee —
Professor F. O. Grover, Oberlin, O.
Professor W. F. Mercer, Athens, O.
Board of Trustees —
Professor E. L. Rice, Delaware, O.
Publication Committee —
Prof. C. G. Shatzer, Springfield, O.

It was then moved and carried that a Preliminary Program be mailed to the members of the Academy two weeks before the meeting for 1912.

The names of the following members elected by the Executive Committee during the year were ratified by the society:

Calvin Goodrich, Toledo, O.
Vernon Lantis, Cincinnati, O.
Miss Blanche McAvoy, Cincinnati. O.
T. M. Hills, Columbus. O.
C. R. Miller, Columbus, O.
D. D. Condit, Columbus. O.

The names noted below were elected to membership by the society:

R. G. Hoskins, Columbus. O.
F. B. H. Brown, Columbus, O.

Miss Katherine Sharp, London, O.
J. A. Myers, Athens, O.
P. W. Fattig, Athens, O.
Thos. Halliman, Erie, Pa.
W. E. McCorkle, Athens, O.

It may also be noted here that the following was elected by the Executive Committee subsequent to the meeting and consequently subject to ratification by the society at the next annual meeting:

Carl Drake, Berea, O.

The committee on resolutions with Professor Brookover as chairman reported as follows:

RESOLUTION.

Be it resolved, That the Ohio Academy of Science express its great appreciation of the arrangements for its entertainment at Columbus for its Twenty-third Annual Meeting. We would mention especially, President Thompson, for his warm and cordial address of welcome; the faculty of Ohio State University, and its committees, for our entertainment, the Sigma Xi Society for the complimentary dinner furnished us, and Professors Cole and Prosser for operating the stereopticon.

CHAS. BROOKOVER,
FRANK CARNEY,
Committee.

At 9:40 p. m. the Academy was declared formally adjourned. The complete program was as follows:

PROGRAM ANNUAL MEETING OF THE OHIO ACADEMY FOR 1911.

1. Ecological Vegetation Units. 8 min. Alfred Dachnowski
2. A list of Myriapods of Cedar Point and of Oxford, Ohio. 5 min. Stephen Williams
3. The Application of Correlation to Simple Problems. 7 min. J. Warren Smith
4. The Development and Cytology of *Rodochytrium*. 12 min. (Lantern Slides) R. F. Griggs
5. List of Lichens collected in Northern Ohio. 10 min. Edo Claassen

6. Two Trematodes in Molluscs of Cedar Point. 6 min. Charles Brookover
7. Some additions to the Cedar Point Flora. 3 min. O. E. Jennings and E. L. Fullmer
8. The Bearing of Embryonic Optic Centers upon the Evolution of the Retina and Telencephalon. 6 min. G. E. Coghill
9. New and Rare Plants of Ohio. 4 min. J. H. Schaffner
10. Plants from Ohio not recorded in the Ohio List. 3 min. Edo Claassen
11. The Distribution of Moles and Schrews in Ohio. 8 min. J. S. Hine
12. Beechwood Camp. (Lantern Slides). 10 min. Bruce Fink
13. Plants recognized on a Waste Place at the foot of Ninth street. Cleveland, O. 5 min. Edo Claassen
14. The Life Calendar of Some Native Trees. 5 min. D. G. Simpkins
15. The Psychology of Speaking. 6 min. J. S. Royer
16. A Preliminary List of the Myxomycetes of Cedar Point. 6 min. E. L. Fullmer
17. Spore Formation in *Botrydium granulatum* Rost. and Wor. (Lantern Slides). 10 min. M. F. Stickney
18. Protozoan Notes I. *Opalina mitotica*. II. Eruptive Pseudopodia in *Amoeba proteus*. 10 min. M. M. Metcalf
19. The Epibranchial Ganglia of *Lepidosteus osseus*. 7 min. F. L. Landacre.
20. Another Ohio Rubber Plant. 5 min. Charles Fox
21. The Early Development of the Vascular System in its Relation to Somatic Movements in Amblystoma. 5 min. Julia L. Moore
22. Some Adaptive Leaf Hoppers and Their Habitats. (Lantern Slides). 10 min. Herbert Osborn
23. Two new species of *Euglena* with notes on the Classification of the Genus. 6 min. L. B. Walton
24. Recent attempts to cause Variations which are Inherited. 8 min. W. M. Barrows and G. W. Hood
25. Unsymmetrical Regeneration in the Gills of the Worm, *Protula intestinalis* Lamoroux. 10 min. S. R. Williams
26. The Classification of the Anthophyta. 8 min. J. H. Schaffner
27. Ohio Grown Perilla. 5 min. Charles Fox
28. The Relation of Vegetation to the Chemical Nature of the Substratum. 15 min. Alfred Dachnowski
29. Further Observations on the Development of the Commisures of the Brain and Cord in their Relation to Somatic Movements in Amblytoma. 8 min. G. E. Cowgill
30. Control of the Adrehal Glands. R. G. Hoskins
31. The Lepidoptera of Ohio. (Preliminary Paper). 5 min. W. F. Henninger

32. Natural History Notes on Birds and Insects. 15 min. Charles Dury
33. Some Unusual Insect Occurrences During 1911. 7 min. Herbert Osborn
34. The Upper Devonian and Mississippian Formation. 15 min C. S. Prosser
35. Notes on Recent Observations of Glacial Erosion. (Lantern Slides). 10 min. Frank Carney
36. The Springfield Esker. 5 min. C. G. Shatzer
37. The New Geologic Time Table of Ulrich. (Lantern Slides). 10 min. F. L. Fleener
38. An Abandoned Valley near Cedarville, O. 12 min. C. R. Miller
39. The Geology of the Baraboo District. 15 min. W. C. Morse
40. A Geographic Interpretation of Cincinnati. (Lantern Slides). 10 min. Edith M. Southall
41. Contact of the Bedford and Berea Formations in Ohio. 10 min. C. S. Prosser
42. Glaciation in the Bitter Root Mountains of Montana. 10 min T. M. Hills
43. The Petrographic Character of Ohio Sands with Relation to their Origin. 10 min. D. D. Condit
44. Wave Work Along the West Shore of South Bass Island. 5 min. Clara G. Mark
45. The Drainage History of Moots Run, Licking County, Ohio. (Lantern slides). 10 min. D. J. Tight
46. A Preliminary Ecological Survey of Shaking Prairie, Miami County, Ohio. 8 min. W. D. Smith
47. On the Preglacial Drainage of South-western Ohio and Adjacent States. 15 min. N. M. Fenneman
48. Evolution in the Mechanism of Inheritance. 15 min. M. M. Metcalf
49. A Phase in the Theory of Evolution. 20 min. W. F. Mercer
50. The Relation of Forests to Floods. 10 min. J. Warren Smith

Lecture by Hon. Julius F. Stone, "Through the Grand Canyon of Colorado River."

The Geological Progress of Twenty-Five Years

LEWIS G. WESTGATE.

OUTLINE

THE GEOLOGICAL PROGRESS OF TWENTY-FIVE YEARS.

INTRODUCTION.

The feeling of elation which follows one's reception of the news of his appointment to the presidency of an organization like our own is but momentary. It gives place almost at once to a feeling of anxiety as one begins to wonder what subject he shall choose for his presidential address a year later. In the present case I have decided to depart from the custom of recent years, of presenting a piece of research work, which is almost necessarily technical in character, and to take a more general subject, in the hope that such a subject may prove more interesting to the society as a whole; and I do this the more readily since the majority of our members are biologists and not geologists. I shall therefore speak of some of the advances which have been made in the science of geology in the last twenty-five years; for it is almost that time since as an undergraduate at Wesleyan University it was my privilege and my delight to take my first course in geology under Professor W. N. Rice.

In carrying out this purpose I limit myself to the geological principles and theories which have come into prominence in the time under consideration. Detailed studies in the field, laboratory or office are interesting and important, and in many cases mean long months or years of the closest kind of work, but, after all, the general principles which are based on them are the important contribution to geology, and it is these which are of the largest interest to the general student. He wishes, for example, to have a correct theory of mountain formation, but does not care for any greater knowledge of the geological detail than is necessary for a clear understanding of the theory.

I also find myself under two limitations not of my own choosing. The first is the difficulty, the impossibility, indeed, of escaping my American point of view and prejudices. This is more difficult to do in geology than in any other science, because geological progress is more independent in different nations and continents than is progress in the other sciences. And the reason for this greater independence lies in the very nature of the science. The chemist and physicist, even the zoologist and botanist, unless engaged in systematic studies, are working on the same materials the world over, and are interested in each other's detail. But the material with which the field geologist deals varies widely in different countries, and the detailed work of geologists is different for this reason. The peculiar geological history of the North American continent, for example, offers problems to the American geologist in large measure unlike those in any other part of the world. It determines the character of his detailed studies, his geological principles are in considerable part developed from his own field studies, and his geology progresses in semi-independence of the work abroad. Not wholly so, of course, for the workers in every land are alive to the general results obtained elsewhere. But the inevitable result is that the work of one's countrymen bulks largest in one's everyday thought, and unconsciously emphasizes the relative value he places upon their work. Only one who is widely acquainted with foreign literature and work can get away from this limitation.

The other limitation I find myself under is the difficulty of deciding how the state of knowledge of a science at any one time is to be judged. From the best school texts and from the larger manuals? But these, and especially the former, are often some years behind the time, even at the date of their issue. From the views current among the workers in the science? It is not always easy to know what views are current. In many cases matters are in debate, still to be fought out to a conclusion. And if it should be the case that some principle, found later to be of great value, has been published but has not found its way to acceptance by workers in the science, can that principle be counted among the possessions of the science at the time? Twenty-five years ago, in 1886, Le Conte's *Elements of Geology* and Dana's *Text-book of Geology* were the common college texts, and Dana's *Manual of Geology* the only American reference manual, while Geikie's *Text-book of Geology* was the leading English text.* It is to these books and to the reports current at that time in the national and state surveys that I go to learn the state of geological opinion.

Before speaking of the new principles which have found their place in geology in the last quarter-century, it is well to call attention to some facts which show the great growth of the science as a whole; a growth not peculiar to geology, but paralleled in the other sciences. In many of the colleges which now have separate departments of geology, the teaching of geology was then combined with that of other subjects; and in other colleges and universities which then had separate departments of geology, these departments have now grown in instructors and resources. In many states geological surveys were then in existence and doing good work. This work in most cases has grown, and in some cases new surveys have been started.

The earlier western surveys of Hayden, Powell and King were replaced by the U. S. Geological Survey in 1879; and the magnificent series of reports published by the survey make America's greatest single contribution to geology. In 1882 the Geological Survey had been directed to prepare a geological map of the United States. This necessitated a topographic base map, which was at once started. In 1886 the Survey had published maps of a small area in the Appalachian mountains, and of one or two small areas in the far west. Today hardly any considerable part of the country is wholly unmapped, and the work is being rapidly pushed to completion. The influence of this work on the progress of geology it would be hard to estimate. The Survey began publishing the geological map in the form of folios in 1894; and to date nearly 200 folios have been issued.

In 1886 no national geological society existed in the United States, and no magazine devoted exclusively to geology. Both of these deficiencies were soon made good, for in 1888 the Geological Society of America was founded, and the publication of its *Bulletin* was commenced. In 1888, too, the *American Geologist* was started, to be continued after 1905 as the *Economic Geologist*. In 1893 the first number of the *Journal of Geology* was issued.

Today the texts of Dana and Le Conte have been somewhat generally superseded. Scott's *Introduction to Geology* and Chamberlin's and Salisbury's *College Geology* are the common college texts, while the American manual is Chamberlin's and Salisbury's *Geology* in three volumes, which, in the opinion of many, is the leading text of today in its presentation of the principles of the science.

THE STUDY OF LAND FORMS.

In no department of geology has greater progress been made than in the study of land forms. Geology is the history of the earth. That history, until recently, has been read almost exclusively, from the rocks, from their distribution, structure and fossils. But we now know that the history of later geological time can be read also from the forms of the land surface, that streams in particular shape the land to characteristic forms, and that these forms in turn can be used to give us the history of the land's surface. The older geology, dealing with rocks primarily, was largely the study of former areas of deposition, of water bodies. Today geology has, in the study of land forms, a means of supplementing this knowledge of water areas with the history of land areas.

Base-level, peneplain and erosion cycle.[1]

The importance of stream erosion had long been recognized, yet when Powell[2] in 1875 first formulated the idea of the base-level, he was stating what may have been implicit in the statements of earlier writers, but what had not been definitely recognized and defined. A base-level may be defined as an imaginary surface, the projection beneath a drainage basin of the surface of the water body into which that drainage basin empties. Towards this imaginary surface the streams cut their valleys; near their mouths they may actually reach it; but further back they cannot, because of the necessary though, in the case of the large rivers, small rise of the stream up-valley. After the nearest approach to base-level has been made, the widening of the valleys by valley-side weathering and lateral swinging of the streams still goes on, the inter-stream areas are attacked, and the whole land surface is slowly reduced to a low rolling plain not far above base-level. Plains of this origin were recognized by Powell[2] in 1875, in the level surface of tilted rocks on which the Carboniferous limestone of the Grand Canon rested, and similar buried or "fossil" plains were recognized later by Van Hise and Walcott. McGee[3] in 1888 was the first to call attention to such a plain, dissected but existing as a land form today, in the Middle Atlantic slope; and Davis followed with an account of similar plains as developed in Pennsylvania, New York and New England. It was Davis[4] who in 1889 first applied the name *peneplain* to this end-form of long continued subaerial erosion. The time during which the land surface is passing from the initial form of youth to the peneplain which is developed in old age is the cycle of erosion and it is

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[1] See Davis: *Geographical Essays,* (Ginn & Co.), pp. 249-513.

[2] Powell: *Exploration of the Colorado River of the West.*

[3] McGee: *Three Formations of the Middle Atlantic Slope.* Am. Jour. Sci., xxxv., pp. 141-2.

[4] Davis: *Topographic Development of the Triassic Formation of the Connecticut Valley,* Am. Jour. Sci., xxxvii., p. 430.

Davis who, more than any other one person, has given definiteness to this conception of the geographical cycle.

It has been stated that the existing peneplains of eastern United States are not intact, but have been dissected since their formation. In central New England, for example, the even sky line of the plateau, which stands two thousand feet above sea-level, represents an old peneplain, which was later raised, and into which streams have cut their valleys to a depth of more than a thousand feet. In many cases broad lowlands, themselves peneplains of a later cycle, have been cut below earlier peneplains. It is evident that the present position of such peneplains gives us important information regarding the amount and character of the successive uplifts of the region. For if such plains were made near base-level, and are now found far above base-level, the difference in height measures the amount of uplift.

In the case of the Appalachians, the earliest peneplain has been arched up to a maximum of over four thousand feet above sea-level. But in other mountain areas old peneplains are recognized by the evenness of sky-line, at much greater heights. Portions of the Cascade range of central Washington are cut from an eight thousand foot plateau which was a peneplain formed in Pliocene time.[5] In other mountain ranges similar conditions have been found. The bearing of these facts on mountain origin is evident. These mountains have the folded and disordered structure typical of mountain areas, but the original high relief which this disordered structure suggests had been reduced to a peneplain before the present relief was produced. In the case of both the Appalachians and the Sierra Nevada, the range of today is the second which has stood on that site, and we have evidence, in the peneplain from which the later range is cut, of complete destruction by erosion of the earlier range.

Our knowledge of peneplain development in the past brings out with great clearness another great fact of geology, the importance of which is only recently fully recognized, namely the alternation of periods of crustal disturbance with long periods of

[5] Smith and Willis: *Contributions to the Geology of Washington*, Professional Paper No. 19, U. S. Geol. Survey, plates 8 and 19.

crustal quiet. Peneplain production requires that land should remain for a long period in about the same position in regard to base-level. If the land surface is being reduced one foot in five thousand years, and if the average height of a continent after uplift is two thousand feet, the production of a peneplain would take ten million years. This value is suggestive only. Towards old age the rate of downward erosion becomes much less, and, on the other hand, in but few cases are peneplains developed over a whole continent. Yet the value is true in the sense that the times of quiet must be measured in terms of millions of years. While separating these periods of relatively stable crust have been the periods of crustal movement of rock folding, and faulting, and of up-arching of broad areas.

The dissected upland plains which we have been describing were recognized in the mountainous parts of Great Britain, and were explained by Ramsey and later English geologists as plains of marine denudation, which had been later raised and dissected. Evidently we have here a problem in psychology. To the Englishman on his wave-girt island, with its relatively small river systems, sea action was more noticeable than stream work. The American geologists of the western surveys had the erosive work of rivers before them on a stupendous scale. There is of course today abundant reason for believing that peneplains are of subaerial and not of submarine origin; and this explanation is now accepted by English geologists for their "plains of marine denudation," but it is interesting that each country had a theory suggested by its own geological environment.

GLACIAL GEOLOGY.

The progress in glacial geology in the last twenty-five years has been very great, both in itself and in its bearing on general questions. I shall speak of three main lines of work:

1. The subdivision of the Pleistocene.
2. Former glacial periods.
3. Theories of the glacial period.

The Subdivision of the Pleistocene.

Twenty-five year ago the subdivision of the Pleistocene glacial period was not generally recognized. Le Conte (*Elements* *of Geology,* 1882) had a map of the drift area in which the extreme southern border of the drift was shown, and within that the morainic system of what we now know as the last or Wisconsin drift; but there is no suggestion of more than a single ice-advance. But at the time Le Conte was writing, the geologists of the upper Mississippi Valley were already engaged in the field studies which were to show that the glacial series was more complex than had at first been supposed. Chamberlin and Salisbury, in their paper on the Driftless Area (1885), give an outline of the glacial history of the interior, in which two epochs are recognized, without emphasizing at all the length or significance of the interval between them. In the years that followed an active discussion went on as to the meaning of this two-fold division. Does the "interglacial epoch" signify a slight retreat of the ice, with a later re-advance, in which the Wisconsin kettle-moraine was deposited? or does it mean the disappearance of the ice from the region, perhaps from the continent, and later the invasion of the northern states by an entirely new ice sheet? The outer till is much more deeply weathered and more dissected, and in some cases it is possible to show that it was in this condition at the time of deposit of the inner drift. More than this, the differences in the two drift sheets indicate that the ice-sheets that formed them advanced in quite different manner, and over land surfaces at unlike altitudes above sea-level. These things suggest a long interval and changed conditions between the two ice advances, and create a strong probability for separate ice-sheets.

The same field study has brought out the further fact that there are more than two drift sheets and ice advances. Chamberlin and Salisbury (*Geology,* III. 413) give six, which, commencing with the most recent, are Late Wisconsin, Early Wisconsin, Iowan, Illinoian, Kansan, Sub-Aftonian. The genuineness of the Iowan has been recently questioned by Leverett, and even among Iowan geologists, there is doubt as to its real meaning. Estimates of the relative weathering and erosion of the different sheets indicate roughly that, if the time since the commencement of the retreat of the late Wisconsin ice-sheet is taken as 1, the time since the retreat of the early Wisconsin is 2, of the

Iowan 4, the Illinoian 8, and the Kansan 16. The estimates of the time since the beginning of retreat of the late Wisconsin ice vary between 20,000 and 60,000 years. Using the relative values for the time of the earlier ice-sheets given above, this would make the age of the Kansan between 300,000 and 1,020,000 years, and even here we are not at the actual beginning of the Pleistocene for this does not carry us back to the Sub-Aftonian. These facts and values are suggestive only, but they are sufficient to show that the ice age was a very long and a very complex period, the successive ice advances being separated by long inter-glacial periods in which the climate may have been as mild or milder than today; indeed, it is not certain that we ourselves are not living in an interglacial period. Earlier glacial studies, proceeding on the theory of a single ice age, placed together in many cases events which we now know belong to different ice-advances, but geologists have come to see that the unravelling of the events of the Pleistocene means an immense amount of detailed work, which will occupy many years to come.

In eastern United State the late or Wisconsin drift extends to the southern border of the glaciated area. It is not until central Ohio is reached that any considerable width of the older drift shows outside the Wisconsin area. This outer sheet of older drifts widens to between 200 and 300 miles in the upper Mississippi valley in Iowa, Illinois, and neighboring states. It is the magnificent development of the older drifts in the interior which made it inevitable that the geologists of these states should take the lead in reaching a true understanding of the complexity of the glacial period, in spite of the fact that in the east and in New England long and detailed study had been given the glacial deposits by able geologists. We have here another illustration of the control of local phenomena over the development of the science.

Former Glacial Periods.

Ramsey, in 1855, in a paper "On the occurrence of angular, sub-angular, polished and striated fragments and boulders in the Permian breccia (of England) and on the existence of Glaciation and Icebergs in the Permian epoch" was the first geologist to announce glaciation previous to the last or Pleistocene epoch. Geikie (*Text-book,* 4th ed., 1893) states that "the evidence now accumulated in South Africa, India, Cashmere and Australia seems to point to some general operation on a gigantic scale in the southern hemisphere at the close of the Carboniferous or in the Permian period, whereby boulder beds were produced and limestones and rocks *in situ* were polished, striated and grooved," proving "the occurrence of a former ice-age in later Paleozoic time, which rivalled in its extent and seemed to have surpassed in the magnitude of its deposits, the glaciation of the northern hemisphere" in pleistocene times. "From the fact that the boulder beds are intercalated among marine strata it is clear that, to some extent at least, the ice reaches sea-level. We are still in ignorance, however, of the position of the high grounds from which the ice sheets descended." Twenty-five years ago, the attitude of geologists towards Permian glaciation was an attitude of scepticism. Even in 1893, Geikie (*Text-book,* 3d ed.) would say only, of the glacier-like deposits of the English Permian, that "Ramsey had no doubt that they were ice-borne, and consequently that there was a glacial period during the accumulation of the Lower Permian deposits of the center of England." And the American texts of the time were silent on the subject. Today, however, Geikie's later statement is generally accepted as true. And from Norway and China there comes similar evidence of glaciation which is referred "either to very early Cambrian or to pre-Cambrian time." (Chamberlin and Salisbury, *Geology,* II, 273.) It yet remains to be seen whether evidence brought forward for a still earlier Huronian ice age will be generally accepted.

The importance of Carboniferous and Cambrian glaciation lies not so much in the fact itself, interesting as that may be, as in its bearing on general geological theory. Clearly, with these remote periods of glaciation, there can have been no general progressive climatic change throughout geological time, from an earlier warm to a present cooler condition. Rather, there has been from time to time a recurrence of colder periods, and climatic changes have been in the nature of swings to one side or the other of a mean, rather than an evolutionary progress in one direction. This fact must be considered in any theory of the cause of glaciation.

The Cause of Glacial Periods.

In the middle eighties, various theories of the cause of the glacial age were held, though the only one which had anything like common acceptance was Croll's Hypothesis. Croll's hypothesis is primarily astronomic, and secondarily geographic. At present, winter in the northern hemisphere comes when that hemisphere is nearest the sun (perihelion). 10,500 years hence, due to the precession of the equinoxes, northern winter will occur when the earth is at aphelion. But the eccentricity of the elliptical orbit of the earth slowly changes, under the attraction of other planets on the earth. Today the eccentricity is slight. At other times it has been and will be greater. Croll's hypothesis assumes that the glacial period will occur in the northern hemiphere when that hemisphere is turned from the sun in aphelion at a time of great eccentricity. Aphelion winter recurs every 21,000 years; periods of maximum eccentricity are much longer and more irregular. Certain other changes, such as the shifting of the heat equator, and of the equatorial current, and a consequent variation of the proportion of that current turned into northern and southern latitudes, were believed by Croll to work with the astronomical factors.

If Croll's hypothesis is the true explanation of the glacial period, we should expect (1) the recurrence of glaciation many times in the history of the earth; (2) that in any one period there would be several alternations of glacial and non-glacial conditions, with intervals of 10,500 years between the culminations of successive glacial periods, the development of each ice-sheet occupying perhaps not more than five to six thousand years; (3) that glacial conditions in the northern and southern hemispheres would alternate. Glacial field studies have shown, on the contrary, that the ice advances were vastly longer than Croll's hypothesis admits of, and that the intervals between them do not correspond with the theory. Chamberlin summed up the situation when he wrote: "I think I speak the growing conviction of active workers in the American field, that even the ingenious theory of Croll becomes increasingly unsatisfactory as the phenomena are developed into fuller appreciation. I think I may say this without prejudice, as one who, at a certain stage of study, was greatly drawn towards that fascinating hypothesis."

Within the last fifteen years a new hypothesis has been proposed by Chamberlin. This was first fully presented in 1899 in a paper entitled "An Attempt to Frame a Working Hypothesis of the Cause of Glacial Periods on the Atmospheric Basis." This "atmospheric hypothesis" of Chamberlin's is not simpler than Croll's, but explanations of geological phenomena are not commonly simple. Indeed there is a certain parallelism between the successive steps of this theory and the succession of cause and effect in Darwin's famous illustration of the way in which "animals and plants, remote in the scale of nature, are bound together by a web of complex relations." You will remember that with the increase of cats there went a decrease of field mice; this meant an increase of humble-bees (the field-mouse's victim), and a corresponding increase of clover, which is cross pollenized by the bees. Therefore, the more cats the more clover. Huxley, I believe, extended the series by one term and showed that maiden ladies, through their fondness for cats, belonged in the chain. Even more complex is the atmospheric hypothesis. Primarily it explains glacial climate by the loss of CO_2 from the atmosphere. Air containing CO_2 has greater power of absorbing heat, the waves received from the sun and especially the waves of greater length radiated from the earth. Less heat is thus lost to space and the temperature of the air is higher. With loss of CO_2 there is a smaller amount of heat retained and a lowering of atmospheric temperature. This in turn decreases the amount of water vapor in the air, which, after CO_2 is the atmospheric constituent with the greatest heat-absorbing power.

The hypothesis assigns the loss of CO_2 to land elevation. This is followed by increased weathering, both because of the increased land area exposed to weathering, and because of the greater thickness of the zone of weathering, the ground water level being lowered as streams deepen their valleys, following the uplift. The abstraction of CO_2 from the air in the process of changing carbonates to bicarbonates which accompanies the chemical weathering of limestones, and in the formation of carbonates by combination with the oxides of calcium, potassium and sodium in igneous and metamorphic rocks, is the primary cause of colder climates which bring on glaciation. The diminished area of the continental shelf which follows uplift, with the consequent lessening of lime-secreting organisms, would mean less CO_2 returned to the water and air, as a result of changing the bi-carbonate of lime to the carbonate in shell making. The general theory has consequences in a number of directions which cannot be followed here.

The recurrent glaciations are explained as due to the combination of primary and secondary causes pushing their effects beyond a condition of equilibrium, so that a reaction ensues, bringing on the milder conditions of an interglacial epoch, the conditions swinging to one side or the other of a mean until the general cause has worked out its effect.

The peculiar localization of Pleistocene continental glaciation in North America and Northwestern Europe is attributed to the control of the great area of low atmospheric pressure located over the North Atlantic, upon the winds of the two northern continents.

This statement is wholly inadequate as a description of the atmospheric hypothesis. But I am not attempting to describe that hypothesis fully. I have not time to do that, and it would not accord with the purpose of this paper. But I think I have said enough to indicate in general the *kinds* of agencies which Chamberlin believes were responsible for glaciation. They are fundamentally atmospheric, changes in the amount of CO_2 in the atmosphere. The cause of these changes was geologic, land uplift followed by erosion and weathering. The theory is proposed as a working hypothesis. It has been elaborated in great detail by its author. It seems to be a better explanation of glaciation and of glacial history than any of its predecessors, but it may take many years of study before it becomes established, perhaps much modified, as the accepted theory of glaciation. In the meantime it largely dominates thinking in this, which has been for a half-century one of the chief fields of geological speculation.

THE INTERPRETATION OF THE SEDIMENTARY ROCKS.

Twenty-five years ago the petrographic microscope was a new tool in the hands of the geologist, and with its use there came a renewed interest in the older igneous and metamorphic rocks. One could read between the lines that the problems of the sidementary rocks, of their structure, origin and significance, had been largely solved. Yet one can now believe that since that time geological theory has been advanced at least as much by what we have learned from the story of the sedimentary as from the story of the crystalline rocks. And this in two distinct lines.

Fluviatile, Lacustrine, and Marine Deposits.

In most discussions of the origin of the shales, sandstones and conglomerates of the older periods, it has been assumed that they are of marine origin, the coarser portion near the shore, the finer farther from the shore line. The similar non-marine Tertiary rocks in our western states the geologists of our western surveys, and after them the texts, have until recently unanimously considered lacustrine, deposits in lakes in some cases thousands of square miles in area, and larger than any existing American lakes. Dana (*Manual*, 1895) speaks of "the great lakes of the early Tertiary—the Eocene—in the Rocky Summit region" and "the later Tertiary lake basins either to the east or west of the Summit region." And this was done, curiously enough, in spite of the fact that these same workers found in the field and correctly interpreted the extensive deposits of gravel, sand and clay which are today being formed along the base of mountain ranges where streams find their velocity checked as they issue from their mountain-valley courses and are compelled to lay down their load in the form of broad alluvial cones or fans, which merge at a slight distance from the mountain into one piedmont alluvial slope fronting the whole range. In spite also of the fact that in many regions of the world, along the northern base of the Alps and Pyrenees, over the river plains of northern India and eastern China, such deposits are forming today or have been formed in the past on a scale comparable with that of the Tertiary areas of supposed lake deposits in the west. It would seem to have been the unthinking acceptance of a traditional interpretation, which assumed that such sedimentary deposits must have been made in standing water. But little thought is needed to see that sands, muds, and gravels are deposited subaerially by streams, as well as in lakes or seas.

Davis called attention (1900) to the situation, in his paper on *The Fresh Water Tertiary Formations of the Rocky Mountain Region.* He here showed that Penck (1894) had already recognized the possibility of the occurrence of fluviatile (continental) deposits in the older rocks, and that Gilbert had already applied this interpretation to some of the "lake" deposits of the western plains area. Davis raised the whole question, suggested criteria for discrimination between fluviatile and lacustrine deposits, challenged in particular two of the western Tertiary formations, and put the whole matter on the modern basis. Since then it has been necessary to treat each formation as a separate problem, and the conception of the Tertiary as a "lake" age has rapidly waned. Rather it was a time of extensive plains building along mountain bases and over intermont basins by overloaded depositing and wandering streams on leaving the mountains.

Another result of this discussion has been to raise a doubt as to the origin of many of the non-fossiliferous or sparingly fossiliferous deposits in other parts of the country; deposits of the older periods which formerly were unquestionably accepted as marine; and some of these formations are now coming to be recognized as in part or in whole of subaerial origin, the deposits of rivers. In the second case as in the first, we are driven to a revision of our conception of past geography, for we can no longer consider sandstones and shales, *ipso facto*, as indicating the former presence of water areas.

PALEOGEOGRAPHY.

Another recent development we owe largely to the paleontologists. In the last twenty-five years an immense amount of detailed paleontologic work has been done in this country. Description of new species has been an insignificant part of the work. It has concerned rather faunas, the comparison of faunas of different regions, and the movements or migrations of faunas. This has also required study of the rocks in which the faunas were found, and the use of all possible means to determine areas of past seas, and barriers to and lines of migration. The study of the geography of the past has always been a part of geology, but in recent times the subject has assumed so much importance that it has received the dignity of a name of its own, and we now have paleogeography, paleogeographers, and paleogeographic maps of the different geological periods. Two recent works of the highest value summarize what has already been done, and form the basis from which all work in the near future must be built. These are Schuchert's *Paleogeography of North America* (1908) and Ulrich's *Revision of the Paleozoic Systems* (1910).

Schuchert's paper gives an unrivalled series of paleogeographic maps of North America. Both papers discuss in detail the principles of paleogeographic interpretation and their application to American formations. They give in far greater detail than has been given before the behavior of the continental surface in geological time; the advances and retreats of the sea, and the shiftings of areas of erosion and sedimentation. One important result of this work is to change somewhat the idea which was current a couple of decades ago in regard to continental growth, especially the growth of the American continent. It was Dana's belief that there had been a sort of evolution of the North American continent from the middle or later Cambrian, when the present continental surface was largely submerged, except for land areas in Canada, along the crystalline area of the Appalachians and in the west, to the present condition of continental emergence. Not of course a steady progress, rather a progress with relapses; and yet after each great period of geological revolution a nearer approach to present conditions. Recent stratigraphic studies indicate no such progress: instead, at different times, some later and some earlier even than the beginning of the Paleozoic, land area was as great if not greater than today; while alternating with these periods of land extension and often of high relief, were periods when the lands were worn towards base-level, and widely covered by shallow sea. Periods of emergence have alternated with periods of submergence since very early times; and certainly since the commencement of the Paleozoic we find no support in geology for a continental evolution at all analogous with what is found in the realm of animal and plant life.

LARGER PROBLEMS OF GEOLOGY.

Geology is the history of the earth; of the whole earth, both shell and core. We are coming to see more and more clearly that the changes which we can see going on today over the earth's surface, and which we can infer from the study of the rocks of the earth's crust, are but expressions of changes which are going on within the great mass of the earth, forever hidden from our sight. They are symptomatic of deeper and more fundamental changes. And our geological theory will never be complete until we have clear and correct notions of the history of the earth as a globe, and of the changes which are now going on within it. We have not that knowledge today, it may be years in coming, and in the mean time our writing on these fundamental problems will be highly speculative. Yet such speculation is a necessary part of our science in each advancing stage. If it is carefully controlled by known geological fact, no harm need come. Along two lines of geological theory important advance has been made in recent time.

Continents and Mountains.

The condition of geological thought on the subject of the permanence of continents and ocean basins in the middle of the nineteenth century is well summarized in Tennyson's lines:

> There rolls the deep where grew the tree.
> O Earth! what changes hast thou seen!
> There where the long street roars, hath been
> The stillness of the central sea.

This would mean that there has been no permanence of ocean and continent through the past, that they have been interchangeable. Present opinion however is that continents and deep sea have held in general their present position since the beginning of Paleozoic time, and probably much longer. This is not to deny that at times the present continents have been widely submerged beneath ocean waters, for this has happened again and again. But these epicontinental seas, as they have been called, have been shallow, and the real continental border has been at the edge of the shallow circumcontinental terrace, where the relatively steep slope to the oceanic abyss commences. The continental seas have been the overflowings of the over-full ocean onto the continental platform, so that a modern geological editor, sacrificing beauty to truth, might change Tennyson's lines to read:

> There where the long street roars, hath been
> An epicontinental sea.

One reason for this belief in the permanence of continents is the fact that the marine deposits now showing in the rocks of the continent are essentially shallow water deposits. Even limestones indicate clear rather than deep water. Another line of evidence, developed more recently, lies in the fact, determined by gravity measurements and plumb-line deflections, that the earth mass beneath the continents is of less specific gravity than beneath the oceanic basins. Indeed these measurements show that a practical equilibrium exists between the oceanic and continental segments of the earth, the greater length of radius of the continental segments being compensated for by their less specific gravity, the masses of the two being the same, area for area. If continent and ocean basin are in this isostatic adjustment, the great difference of relief between continental platform and ocean basin is evidently an expression of differing density beneath the surface. It is difficult to see how the difference of density could essentially change, and we have therefore a permanent cause of difference between continent and ocean.

This fact of the essential permanence of continental platform and ocean basin, taken in connection with the shrinking of the earth following cooling and condensation, gives the starting point of geological processes. The earth is divided into continental and oceanic segments, the former lighter, the latter heavier, the former making one-third of the earth's volume, the latter two-thirds. The sinking of the larger heavier oceanic segments crowds the continental segments. This results in a squeezing up of the continental segments, of which we find evidence in the repeated uplift of the land surface. The folded and faulted mountain ranges, which occur principally along the borders of continents, are due to the lateral thrusts and readjustments along the borders of the segments.

The continental platforms have therefore been described as positive elements, the oceanic basins as negative elements. Within each, on a smaller yet absolutely large scale, positive and negative elements occur. The continental platform does not act as a unit, if we consider detail. There have been areas of repeated uplift, positive elements, of which one of the best known is the area of crystalline rocks along the Atlantic sea-board known as *Appalachia*. Through geological history it has been a land area, frequently renewed by uplift, almost always subjected to erosion. While to the west of it the Appalachian trough existed during Paleozoic time as a negative element, an area of repeated subsidence and of deposition. And yet both, in a large way, were but parts of the larger unit, the continental platform. This subdivision of the positive continental areas into positive and negative elements of a lower order is a direct inference from the field studies.

But these views which I have summarized are new. Le Conte in his *Elements of Geology* had a beautifully clear and adequate state of the immediate conditions which led to the formation of a folded mountain range like the Appalachians. But his theory did not apply equally well to ranges like the Sierra Nevada, which is a great block of the earth's crust tipped up along its eastern border, nor to ranges like the Big Horns and Black Hills, cut out of broad, more or less flat-topped up-bowings of the crust, nor to block uplifted plateaus. Le Conte assigns the differences between continents and ocean basins to unequal radial contraction of the earth in its secular cooling but does not suggest that conditions producing and maintaining continents may also be responsible for mountains. Geological theory today makes this contrast of continent and ocean basin the fundamental fact of earth structure. Successive continental uplifts are due to the crowding of the continental segments between the heavier oceanic segments. Folded mountains are due to the yielding to the accompanying lateral thrust. While plateaus, plateau-like folds, and areas of sinking within the continent are due to readjustment between blocks of a second order which make up the continent.

The Planetesimal Hypothesis.

In our school days, as in those of our fathers, the Nebular Theory of La Place held unchallenged sway. This hypothesis is so familiar that I need not state it. Objections to this hypothesis, mechanical, geological and astronomical, have seriously shaken confidence in it. Within the last twenty years a substitute for it has been proposed by Chamberlin, the planetesimal hypothesis. Like the La Placean hypothesis it is a nebular hypothesis. But in so far as it concerns the growth of the earth the two are almost antipodal. On the La Placean hypothesis the earth reached its present size by the cooling and shrinking of a vastly larger hot gaseous mass, and on George Darwin's modification of the theory (the meteoric hypothesis) it is probable that the meteorites would be vaporized early in the earth's growth by collisions; on the new, it grew to a maximum by the in-fall of planetesimals, cold bodies of various size moving in elliptical orbits about the sun, and added to the growing mass of the young earth. Long before the beginning of the Paleozoic the heavens had been cleared in the region of the earth's orbit, of these scattered masses, and the earth had reached its maximum size. Today it is condensing, perhaps as a result of loss of heat, perhaps under the attraction of gravity on its mass. The interior heat of the earth, on the newer theory, is generated by condensation, and is not an inheritance from the nebula.

The planetesimal hypothesis gives a wholly new explanation of the atmosphere and of the oceans. The material of both was brought in dissolved or occluded in the infalling planetesimals, just as now the meteorites contain three to four times their volume of dissolved gases. With the later development of high temperatures these gases made their escape to the surface, and after the earth became large enough for gravity to overcome the tendency of the gaseous molecules to fly off into space an atmosphere and later a hydrosphere came into existence. In this case oceans may have existed on the earth well before it attained its present size. Life, too, may have come into existence at a very early stage, as soon as conditions of air and water were such as to support living beings.

The future of the Planetesimal hypothesis no one can forecast. The hypothesis of La Place held almost undisputed sway for a century. Perhaps this newer one will in its turn pass. Or, more or less modified, it may finally establish itself as a better statement of our earth's earlier history. I wish only to point out that it gives a fundamentally different interpretation of this earlier history and of the forces which are at work within the globe as a whole, and that this new interpretation must modify, indeed, already has modified our thinking on the great fundamental problems of geology. Our conception of the causes of volcanic action, of all movements of the earth's crust, from the great periodic readjustments between continents and oceanic segments, with their accompaniments of mountain folding and plateau formation, to the slighter movements which are constantly present, of the origin of the great complex of rocks which makes up the Archean;—our conception of the causes of all of these and of many minor geological matters, is profoundly different on the two hypotheses. Many of them seem much clearer on the newer than on the older theory.

IN CONCLUSION.

Several matters of human interest come out in the progress of this paper. I have already mentioned the control which local geological phenomena exert over geological theory, in speaking of the different agents which English and American geologists assigned as the cause of peneplains. The same influence of local conditions was seen in the greater readiness of the geologists of the Mississippi valley to accept the divisibility of the glacial period. The work of Ulrich and Schuchert grows out of the appeal which the paleontological richness of the Cincinnati rocks early made to them. The illustrations of this principle are many in all geology, both in that of recent time in America and in the earlier days of the science, as everyone knows who has read Geikie's *Founders of Geology.*

The importance of American contributions to recent progress I have not spoken of separately. This has already been well done by Professor Rice in his paper, *The Contributions of America to Geology.* I need only state my belief that of the different subjects I have treated in this paper, the influence of American geologists has dominated in the following: the study of land forms, the subdivision of the Pleistocene, the recent interpretation of sedimentary rocks, and speculation on the larger problems of geology, in what may be called the philosophy of geology.

Finally I should like to call attention to the great part speculative geology now plays in science. Great as has been the detailed study in field and laboratory in the last quarter-century, the part of geological speculation has been even greater. To some minds this may not be a matter for congratulation. They may prefer study of the facts without generalization, certainly without speculation. The late Professor Lesley of the Pennsylvania survey was one of these. In his *Final Summary,* speaking of what he considers unjustifiable speculation, he writes:

"Our knowledge of details is so poor that all our general statements are mere mutterings in sleep, or the incoherent rhapsodies of fever. The world is a kaleidoscope; at every touch it turns a little, and the scheme of shapes and colors changes to our eye. A malaria of the indefinitely complicated exhales from every region of geology and attacks the wise and simple alike. Happy the investigator whose intellectual constitution is not ruined by it in the end. Foolish generalizer, who mistakes the paroxysms of chill and fever in his own incompetent imagination for an actual rhythm in the energy of the world of which he dimly sees but the part of a part."

But recent time has shown that most geologists do not agree with him. And it is very interesting to see how different geologists, from widely separated points of departure in actual field work are led on to speculation regarding the deeper problems of geology. Willis, from stratigraphic study of the folded Appalachians, and Ulrich and Schuchert, from the study of Cincinnati fossils, go on step by step to the consideration of problems of continental development. While Chamberlin, starting with his field studies on the Pleistocene, is led by the logical necessities of his work to frame a more satisfactory theory of the cause of glaciation and still further to an all-embracing theory of the origin of both atmosphere and the earth which carries it. As of old all roads led to Rome, so it seems as if today all lines of field work, followed to their logical end, lead to speculation as to the larger processes of geology.

I believe that this is best, this combination of detailed field and laboratory study with speculation; best both for the science and the individual. The field studies furnish both the problems for speculation and the control over it, while geological theory stimulates field study by pointing directions of profitable endeavor. And I believe too that a division of thought between detailed studies and speculation on the larger processes of the science is most stimulating to the individual. Certainly all of us have derived both pleasure and profit from the broad range of vision which the newer generalizations have opened up.

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*JACOBS, EDWIN E., *Biology*....................Ashland College, Ashland
JENNINGS, O. E., *Botany*.........Carnegie Museum Annex, Pittsburg. Pa.
JONES, LYNDS, *Ornithology*....................College Museum, Oberlin

*Subject to ratification of the Society at the annual meeting, 1913.

Judson, C. A., *Botany*....................235 Columbus Ave., Sandusky
King, J. Lionel, *Botany, Entomology*........Exp. Station, Wooster, Ohio
Kostir, Wencel J., *Zoology*........................O. S. U., Columbus
Krecker, Frederick H., *Biology*............................Marietta
*Lake, Chas. H., *Physics*..............................Hamilton
Lamb, G. F., *Biology, Geology*..............Mt. Union College, Alliance
Landacre, F. L., *Zoology*........................O. S. U., Columbus
*Langenberg, F. C., *Physics*..............................Athens
Lantis, Vernon, *Botany*....................2509 Ohio Ave., Cincinnati
Lazenby, Wm. R., *Horticulture, Botany*............O. S. U., Columbus
Library, Ohio State University............................Columbus
Livingston, A. E., *Zoology*..............................Athens
Lloyd, John Uri......................Court and Plum Sts., Cincinnati
March, Cora, *Biology*..................................Wyoming
Mark, Clara Gould, *Geology, Botany*..............O. S. U., Columbus
Mathews, Mary E.......................................Painesville
McAvoy, (Miss) Blanche, *Biology*...........................
..........................Box 56, Sta. F., Foley Road, Cincinnati
McCall, A. G., *Agronomy*........................O. S. U., Columbus
McCampbell, Eugene F., *Bacteriology*..............O. S. U., Columbus
McCorkle, W. E., *Zoology*................................Athens
McCoy, C. T., *Botany*..................................Lancaster
McCray, Arthur H., *Zoology and Entomology*..................Duval
McDaniel, J. E., *Biology*............................Montrose, Colo.
McFadden, L. H., *Chemistry*....................40 Warden St., Dayton
McKean, T. L., *Botany*...................................Berea
Mercer, W. F., *Biology*......................Ohio University, Athens
Metcalf, C. L., *Botany, Zoology*..............86 E. 11th Ave., Columbus
Metcalf, M. M. *Zoology*.................................Oberlin
Metcalf, Zeno P..................A. & M. College, W. Raleigh, N. C.
Mills, W. C., *Archaeology, Biology*..............O. S. U., Columbus
Miller, C. R., *Geology*..........................O. S. U., Columbus
*More, Lewis T., *Physics*...............Univ. of Cincinnati, Cincinnati
Moody, A. E...Flushing
Morse, W. C., *Biology, Geology*....................O. S. U., Columbus
Moseley, E. L., *Zoology, Botany, Physiography*..............Sandusky
Myers, J. A., *Zoology*...................................Athens
Nelson, James A., *Zoology, Embryology*.......................
..............U. S. Dept. Agricul., Div. Entom., Washington, D. C.
Nichols, Susan P., *Botany*....................Oberlin College, Oberlin
Oberholser, H. C..........1444 Fairmont St., N. W., Washington, D. C.
Odenbach, F. L., *Meteorology*...........St. Ignatius College, Cleveland

*Subject to ratification of the Society at the annual meeting, 1913.

Osborn, Evelyn, *Zoology*....................485 King Ave., Columbus
Osborn, Herbert, *Entomology, Zoology*.............O. S. U., Columbus
Osburn, Raymond C., *Zoology, Ichthyology*......................
........................Columbia University, New York, N. Y.
Parkhurst, C. P., *Science*..................9 W. Long St., Columbus
Peaslee, L. D., *Zoology*...............Public Museum, Milwaukee, Wis.
Piwonka, Thomas ....226 Superior Ave., N. W., Cleveland
*Prose, Chas. T., *Physics*.................................Zanesville
Prosser, C. S., *Geology*...........................O. S. U., Columbus
Rankin, John P., *Biology, Medicine*.............415 Earl Court, Elyria
Reighley, H. H., *Physics*....................2088 Tuller St., Columbus
Rice, Edward L., *Zoology*.................................Delaware
Richards, Clarissa Audrey, *Botany, Zoology*..............Oxford, O.
*Robinson, Ray R.......................171 W. William St., Delaware
Roudebush, Lowell ....R. F. D., No. 3, New Richmond
Royer, John S., *Biology*...................................Bradford
Rush, R. C., *Conchology*...................................Hudson
Sanders, J. G., *Entomology, Botany*.....................Madison, Wis.
Schaffner, J. H., *Botany*..........................O. S. U., Columbus
Scheffel, Earl R., *Geology*......................341 River St., Dayton
Schroyer, Charles R., *Geology*....................O. S. U., Columbus
Selby, A. D., *Botany*....................Experiment Station, Wooster
Shadle, Albert, *Zoology*............................Lockbourne, O.
Sharp, Katherine D., *Botany, Geology*.......................London
Shatzer, C. G.........................Wittenberg College, Springfield
Shaw, N. E., *Entomology*...........................O. S. U., Columbus
Shilliday, C. L., *Zoology*...................................Athens
Sim, Robert J...Jefferson
Smead, Anna, *Biology*.........................624 Nestle St., Toledo
Smith, A. L.......................................Valley Crossing
Smith, Alpheus W., *Physics*.......................O. S. U., Columbus
Smith, Ethel M...Rome
Smith, G. D., *Botany, Zoology*.........................Richmond, Ky.
Smith, J. Warren, *Meteorology*.............Weather Bureau, Columbus
Snyder, F. D., *Zoology, Ethnology*.........................Ashtabula
Speckman, W. N., *Biology*..............German Wallace College, Berea
Stanley, Clyde M., *Zoology*................84 W. Winter St., Delaware
Stauffer, Clinton R., *Geology*.............Adelbert College, Cleveland
Sterki, Victor, *Conchology, Botany*...................New Philadelphia
Stickney, M. E., *Botany*..................................Granville
Stickney, Mrs. Edith C., *Biology*..........................Granville
Stover, W. Garfiled, *Botany*.......................O. S. U., Columbus

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*Subject to ratification of the Society at the annual meeting, 1913.

STOUT, W. E., *Chemistry, Geology*........217 E. Mithoff Ave., Columbus
SWEEZEY, OTTO H........................Twelfth Ave., Honolulu, Hawaii
TODD, JOSEPH H., *Geology, Archaeology*........Christmas Knoll, Wooster
TURNER, CLARENCE L., *Zoology*...............105 Campbell St., Delaware
UNNEWEHR, EMORY C., *Physics*..........German Wallace College, Berea
*VEEDER, MARTHA ANNA, *Physics*..............................Oxford
WAITE, F. C.....................Western Reserve University, Cleveland
WALTON, L. B., *Biology*....................................Gambier
WEAVER, F. O., *Physics*......................473 Park Place, Springfield
WEBB, R. J., *Botany*.................................Garrettsville
WELLS, B. W., *Botany*..............................Eagleville, Conn.
WEBSTER, F. M., *Entomology*....U. S. Dept. Agricul. Washington, D. C.
*WEINLAND, CLARENCE R., *Physics*...........381 W. 10th Ave., Columbus
WERTHNER, WILLIAM B., *Botany*.............Steele High School, Dayton
WESTGATE, LEWIS G., *Geology*.............................Delaware
WHITMARSH, R. D..Wooster
WILLIAMS, STEPHEN R., *Biology*.............Miami University, Oxford
WILLIAMSON, E. B., *Ichthyology, Ornithology*..............Bluffton, Ind.
WILSON, STELLA S., *Geography, Geology*.........97 N. 20th St., Columbus
WRIGHT, G. FREDERICK, *Geology*..............................Oberlin
YORK, HARLAN H., *Botany*..........................Providence, R. I.
YOUNG, R. A., *Botany*......................................
..............Div. Seed and Plant Introduction, Washington, D. C.
Total Membership 218

*Subject to ratification of the Society at the annual meeting, 1913.

Report of the Twenty-Second Annual Meeting of the Ohio Academy of Science

The twenty-second annual meeting of the Academy was held at Ohio State University, Columbus, O., on November 28, 29 and 30, 1912, with Professor Bruce Fink of Miami University presiding as President.

An informal reception was given to the society at the Ohio Union on Thursday at 7:30 p. m., rooms were assigned to visiting members, programs of the meeting were distributed and an enjoyable evening passed very quickly.

The meeting was called to order on Friday morning at 8:45 in the main lecture room of the Physics Building after a preliminary session of the Program Committee and the Executive Committee. Professor Herbert Osborn extended the hospitality of the State University to the members of the Academy and mentioned the interest which the University had in promoting scientific work by means of its graduate school.

After thanking Prof. Osborn in behalf of the members of the Academy for the cordial expression of good will, the regular business meeting followed. The President appointed a committee on membership, consisting of Professors Schaffner, Williams, and Coghill, on resolutions consisting of Professors Fenneman, Grover, and Shatzer, and on Necrology consisting of Professors Hine, Lazenby, and Williams. After the Secretary had noted that his report would be found in the current proceeding of the Academy, the report of the Treasurer was presented as follows:

REPORT OF THE TREASURER FOR THE YEAR 1912.

For the year since our last annual meeting the receipts, including balance from last year, have amounted to $325.46, and the expenditures to $236.82, leaving a cash balance of $88.64.

RECEIPTS.

Balance from last year	$65 46	
Interest on endowment	2 00	
Membership dues	258 00	
Total		$325 46

DISBURSEMENTS.

180 subscriptions to The Ohio Naturalist	$135 00	
Printing annual report	71 00	
Miscellaneous expenses	30 82	
Balance December 1, 1912	88 64	
Total		$325 46

Respectfully submitted,

JAS. S. HINE, *Treasurer.*

This was referred to an auditing committee consisting of Professors Griggs and Budington. The report of the Librarian was then presented.

REPORT OF LIBRARIAN.

COLUMBUS, OHIO, Nov. 29, 1912.

As Librarian of the Ohio State Academy of Science, I take pleasure in presenting my report upon the receipts from the sale of Publications of the Ohio State Academy of Science and cost of sending out the regular Publications of the Academy.

Cash on hand Dec. 1, 1911	$27 28	
Publications sold but not collected	12 73	
Total resources		$40 01
Cash sale of publications during past year		58 76
Total		$98 77

EXPENDITURES.

Postage on Special Paper No. 18	$12 00	
Postage on Annual Report No. 21	6 12	
Postage on Special Paper No. 19	15 40	
Boxes for shipment of Special Paper No. 18	1 00	
Cartage to Depot	1 50	
Letter postage and for Special Papers and Reports	9 01	
Express	3 16	
		$48 19
Balance		$50 58

The executive committee reported the following elected to membership during the year:

Drake, Carl, Entomology, Berea.
Black, J. G., Geology, R. D. No. 10, Wooster.
Bryant, E. R., New Concord.
Goetz, C. H., Forestry, O. S. U., Columbus.
Wells, B. W., Botany, Knox College, Galesburg, Ill.
Whitmarsh, R. D., Wooster.
Schroyer, Charles R., Geology, O. S. U., Columbus.
Stanley, Clyde M., Zoology, 84 W. Winter St., Delaware.
Hamlin, Howard E., Biology, Chemistry, Box 227, Delaware.
Turner, Clarence L., Zoology, 105 Campbell St., Delaware.
Fox, Errol, Botany, Chemistry, 395 Doyle St., Akron.
Rankin, John P., Biology, Medicine, 415 Earl Court, Elyria.
Bevan, Arthur, Geology, Delaware.
Kostir, Wencil J., Zoology, O. S. U., Columbus.
Speckman, W. N., Biology, German Wallace College, Berea.

These names were ratified by the society. The following members were elected by the society after being duly vouched for by two members:

Ikel, Margaret, Zoology, 1814 N. High St., Columbus.
Osborn, Evelyn, Zoology, 485 King Ave., Columbus.
Shadle, Albert, Zoology, Lockbourne, O.
Weaver, E. O., Physics, 473 Park Place, Springfield.
Faville, Esther, Zoology, N. Emporia, Va.
Buchanan, J. W., Zoology, Athens, O.
Allen, S. J. M., Physics, Univ. of Cincinnati, Cincinnati.
Unnewehr, Emory C., Physics, German Wallace College, Berea.

Hershey, J. Willard, Chemistry and Physics, Defiance College, Defiance.

Fountain, C. R., Physics, Kenyon College, Gambier.

Smith, Alpheus W., Physics, O. S. U., Columbus.

Farhart, Robt. F., Physics, O. S. U., Columbus.

Culler, J. A., Physics, Oxford, O.

Reighley, H. H., Physics, 2088 Tuller St., Columbus.

Blake, Frederic C., Physics, O. S. U., Columbus.

Richards, Clarissa Audrey, Botany, Zoology, Oxford, O.

Humphrey, Lillian F., Botany, 1866½ N. High St., Columbus.

The report of the Board of Trustees followed.

FINANCIAL STATEMENT OF THE EMERSON McMILLIN RESEARCH FUND, OHIO STATE ACADEMY OF SCIENCE, 1911-1912.

RECEIPTS.

Cash on hand Dec. 1, 1911	$250 36
Check from Emerson McMillin, Dec. 5, 1911	250 00
Total	$500 36

EXPENDITURES.

Jan. 19, 1912.	L. B. Walton, expense in research	$14 00
Feb. 12, 1912.	J. S. Hine, expense in research	12 50
May 9, 1912.	F. J. Heer Printing Co., 500 copies special paper, by W. G. Storer	117 50
May 21, 1912.	Alfred Dachnowski, expense in research	21 70
Oct. 8, 1912.	Alfred Dachnowski, expense in research	18 30
Oct. 8, 1912.	L. B. Walton, expense in research	16 60
Oct. 18, 1912.	F. J. Heer Printing Co., 500 copies special paper, by Freda Detmers	125 50
Oct. 22, 1912.	J. S. Hine, expense in research	25 00
Nov. 6, 1912.	N. J. Koster, expense in research	22 55
	Total	$373 65
Balance in Capital City Bank, Nov. 16, 1912		$126 71

* Since the above report was prepared a check for $250.00 has been received from Mr. Emerson McMillin. This in addition to the balance reported makes a total available credit of $376.71.

WILLIAM R. LAZENBY.
EDWARD L. RICE.

In connection with the research fund, the following motion was presented: "It is the sense of the Academy that the Research Funds be utilized for actual expenses of research instead of for publication, except in special cases." After being seconded, this was discussed by Landacre, Dachnowski, Schaffner, Griggs, Earhart, Osborn, and Walton. The motion was then passed.

Under reports of special committees, Professor Osborn noted that the Natural History Survey had been organized with twelve cooperating institutions, and that the State University has requested an appropriation from the legislature to assist in carrying on the work. Professor Walton as chairman of the committee, appointed by the representatives of the various colleges, reported that nearly all the educational institutions were taking an active interest in the work proposed by the survey, and that twelve of the colleges had promised definite financial assistance. He also stated that the election of Professor Osborn as Director of the Survey had been unanimous.

The reports were accepted, and the committee dismissed.

Professor Coghill, chairman of the committee appointed to consider enlisting the cooperation of the Physicists, noted the formation of a Physics Section brought about by the work of Professor Blake of the Department of Physics at O. S. U. The committee was dismissed.

Under the order of New Business, a special committee was appointed to consider a place of meeting for 1913. This consisted of Professors Landacre, Metcalf, and Mercer.

It was then moved, seconded and carried that the courtesies of the society be extended to the Physicists until they had been incorporated with the Academy.

After announcements by the chairman of the local committee relative to arrangments for visiting members, the dinner at the Ohio Union, etc., an invitation was extended to members of the Academy by the State Board of Agriculture, to visit the serum farm at Reynoldsburg.

The following nominating committee was then elected:

Prof. Herbert Osborn.

Prof. S. R. Williams.

Prof. W. F. Mercer.

At 10:45 A. M. the society proceeded with the reading of the papers, adjournment being made at 12:00 M. for luncheon at the Ohio Union. At 1:30 P. M. President Bruce Fink of the Academy addressed the members on "Botanical Instruction in Colleges" a paper which was listened to with much interest. The reading of papers continued, those in Physics being presented in the smaller lecture room. Adjournment was made at 6:15 P. M. to the Ohio Union where a special dinner was served to the members of the Academy, the remainder of the evening being spent informally in the rooms of the Union.

At 8:30 on Saturday occurred the adjourned business meeting the committee on resolutions reporting as follows:

REPORT OF THE COMMITTEE ON RESOLUTIONS.

Resolved, That the thanks of the Academy be tendered to the authorities of the Ohio State University who have placed their building and apparatus at our disposal during this meeting.

Also to the Local Committee and to the fraternities and other friends who have generously afforded lodging to our members.

Resolved, That this academy emphatically approves the proposed biological survey of Ohio undertaken by a group of colleges and universities and requests the legislature of the state to appropriate for this work so much money as is needed to supplement the support already given by these institutions.

It is recommended that members of the Academy communicate individually with their several representatives in furtherance of this movement.

Resolved, That it is the sense of this Academy that the legislature of Ohio should pass a law designed to make it impossible for the insane, the feeble-minded and confirmed criminals to propagate their kind. That to this end we commend to its attention and study the laws providing for sterilization already in force in six of the United States;

That copies of this resolution be sent to the several county and city medical societies of Ohio, asking their co-operation in the accomplishment of this purpose.

Signed,

N. M. Fenneman,
Charles G. Shatzer,
F. O. Grover,

The committee on Necrology reported the following:

REPORT OF THE COMMITTEE ON NECROLOGY.

Your committee finds that five active members of the Academy have died since the last report.

Information in regard to Dr. Josua Lindahl was procured from Volume XXI of the Journal of the Cincinnati Society of Natural History.

An article on Dr. H. Herzer was contributed by Professor W. N. Speckman of German Wallace College, Berea.

The Morgan County Democrat contributed the facts in regard to Dr. H. L. True.

Mrs. Hobbs at our request very kindly furnished statements in regard to Dr. P. L. Hobbs.

Miss Cora Armstrong sent an announcement of the decease of C. A. Armstrong.

Information from the above sources constitutes our report which follows:

Jas. S. Hine,
Wm. R. Lazenby,
Stephen R. Williams,
Committee.

JOSUA LINDAHL, A.M., P.H. D.

Dr. (Johan Harald) Josua Lindahl, for several years a member of the Ohio State Academy of Science and once its president, died in the City of Chicago, of bronchial pneumonia, on April 18, 1912. From the family it is learned that his illness was short. He contracted a cold on the 11th of April, he took to his bed on the 14th; later pneumonia set in, and on the evening of the 18th he passed away without suffering.

Dr. Lindahl was a man of rare scientific attainments and won for himself distinction on two continents. His earliest claim to recognition was as a zoologist.

Born at Kungsbacka, Sweden, on January 1, 1844, he received his education at the Royal University at Lund. This institution conferred on him the degree of A.B. in 1863. In 1870, he accompanied Gwyn-Jeffries and Carpenter, as assistant zoologist in the British deep sea exploring expedition in H. M. S. Porcupine. In 1871, he was the zoologist in charge of an expedition to Greenland in Swedish warships Ingegard and Gladan. In 1874 he was instructor in Zoology at the Royal University, and there received the degrees of A. M. and Ph. D. In 1875 he was the Secretary of the Royal Swedish delegation to the International Geograpical Congress at Paris. Later in the year 1875, and until some time in 1877, he was the Secretary of the Royal Swedish Commission to the Centennial Exposition in Philidelphia. After the work of the Commission was ended in 1877, he concluded to remain in this country, only returning to Sweden to be married. His wife was Sophie, the daughter of Major C. A. Pahlman, a woman of noble birth and of charming personality. Mrs. Lindahl died September 15, 1909. Soon after his marriage, he brought his bride to America, and from 1878 to 1888 he was Professor of Natural Sciences at Augustana College at Rock Island, Illinois. The following five years, or until 1893, he was Curator of the Illinois State Museum of Natural History at Springfield. During the year 1894 he was

Professor of Greek in Augustana College, and the following year he was Professor of Botany at Martin Luther College, Chicago. Late in the year of 1895 he became the Director of the Museum of Cincinnati Society of Natural History, and continued until 1906, when he removed to Chicago, and set up a laboratory for the manufacture in America of a chemical preparation known as Salubrin, after the formula of his friend, Dr. Hakanson, of Eslof, Sweden. He was manager of this laboratory at the time of his death. In forty-two years of active participation in the world's affairs, he had contributed in no small way to the advancement of human knowledge. His mind seemed specially adapted to the reception and rapid assimilation of scientific intelligence of any character. He was intensely interested in every phase of scientific endeavor. His place among the scientists of his day was fittingly recognized, when, in 1876, he was made a member of the French Academy of Sciences, upon whose lists are inscribed the name of such zoologists as Baron Georges Cuvier and the two Geoffroy-Saint Hilaire. Two years later, in 1878, he was decorated by King Oscar II of Sweden with the Royal Order of Vasa. He served a term as the President of the Swedish Historical Society of America, and in 1900 he was President of the Ohio Academy of Science. He was a member of the American Society of Vertebrate Paleontologists; of the American Association of Museums, and of the American Association for the Advancement of Science. In 1908 he was elected a life member of the Cincinnati Society of Natural History. He was the author of various scientific papers and a frequent contributor to American and European scientific journals. He was as gentle and lovable in disposition as a child and compelled the instant affection of all who came in contact with him. His quiet and modest demeanor and want of aggressiveness doubtless lost him some prizes in life to which he was entitled. No one who ever enjoyed the pleasure of an intimate acquaintance with him would rank him far below the highest in the field of natural science. While not given to boasting of himself, it is well known that he was very proud of the fact that he was a fellow-countryman of the celebrated naturalist, Linnaeus.

DR. HERMAN HERZER.

Rev. Herman Herzer, A.M. D. Sc., was born July 1, 1833 in Neustadt on the Orla, Saxony-Weimar. When fifteen years of age he came to America with his parents and soon obtained work in New York as a cobbler. having learned the trade in Germany.

After trying in vain to flee from the call to the ministry, he finally yielded and served as a German Methodist itinerant in Ohio, Michigan, Pennsylvania, and Kentucky from 1855 to 1875 and again from 1877 to 1907, part of which time he was a presiding elder and for four years superintendent of the German Methodist Orphan Asylum at Berea, Ohio.

He was an indefatigable worker and, although he did not attend a higher institution of learning he mastered several languages and spent his Mondays in Scientific research, making several notable discoveries as the specimens bearing his name indicate, viz: Dinichthys herzeri and Lingula herzeri. The former is "Herzer's terrible fish" as geologists were wont to call it in derision until he proved to them that he had discovered a new species of fossil fish.

During the two years from 1875 to 1877 suffering with throat trouble which prevented his speaking in public, he was appointed State Geologist of Kentucky.

Although his special field was paleontology as shown by the extensive collection that he presented to the Museum of German Wallace College, that bears his name and of which he was curator for years, he was also well versed in conchology and made an excellent collection of mosses and mounted birds.

Dr. Herzer was for several years a member of the American Association for the Advancement of Science and of the Ohio State Academy of Science, serving as First Vice President of the latter in 1901. He contributed several interesting papers and descriptions which were published. He is said to have been the first to discover the origin of oil.

Since 1899 he resided in Marietta, Ohio, where his constant pleasure was collecting geological specimens. Besides the many presented to Museums, he left some four thousand specimens which were purchased by the German Wallace College at Berea, consisting of fishes, numbering 270 specimens, Corals 2300, favosites 150 large pieces, blastoids 250 specimens, bryozoa 400, spongia 40, pelecypoda 40 species, brachiopoda 200 species, and about 100 genera of crinoids, besides an excellent complete specnnent of Sphaerexochus romingeri, which as far as known is the only complete specimen in existence.

He married Miss Pauline Seiberlich of Waterloo, Michigan, in 1859 who died November 3, 1911.

Some years ago he received a stroke of apoplexy and upon the death of his wife, heart trouble followed which ended his life May 26, 1912.

W. N. Speckman.
German Wallace College, Berea, Ohio.

DR. H. L. TRUE.

The sad news reached McConnelsville Tuesday morning, October 22nd, that Dr. H. L. True of this place had passed away at Grant Hospital, Columbus, at 5:30 o'clock.

Hiram L. True was born in Athens County, Ohio, June 4, 1845 and received his literary education at Weethee College, in that county, and at a Chillicothe Commercial school. His medical education was obtained at the Eclectic Medical College, of Cincinnati, which he attended in 1869 and 1870, and where he became acquainted with his present wife.

When the civil war broke out young True was not old enough to enlist, but June 28, 1863, enlisted for six month in the 169th Regiment, Co. A. He has always been loyal to the local Post and loved by all the boys.

When the Morgan County Scientific and Historical Society was established here several years ago, who but Dr. True could be its president? He has given to the Society the very best of his thought and research. As he rode over the country, he was a part of nature. No flower, shrub, plant, grass, weed, leaf, fruit-age, tree or rock escaped him. The Society had the benefit of his store of information on every subject. The explanation of specimens which preceded every paper at the Society devolved upon Dr. True. While he was scientific always, he was not without a rich vein of droll humor and in presiding and in the valuable papers he delivered the members and guests were always given a wide range of enjoyment. He shaped his work so that he rarely missed Scientific, driving early and late and planning ahead so as not to conflict. His familiar opening words have come to be a part of the Society, and to those who have attended in the past the Society will never be the same without him no matter how well it is officered. And yet, it should be maintained, for it was his wish, and it has made for itself a place too important to give up. The Society is known far and wide, very largely through the genius of its distinguished president, deceased.

The Ohio State Academy of Science is proud to have enrolled him as a member for many years. Although his professional duties prevented his attendance at many regular meetings his interest in the academy was ever apparent and he always made it his duty to recommend for membership persons of his acquaintance who were interested along scientific lines.

Dr. True was always kind and lovable to everybody, and the bereaved wife finds his loss doubly hard. He was a part of the county life as no other man has been and all join in the deepest sorrow. The world, to us, will always seem to be minus something that seemed a part of it.

PERRY LYNES HOBBS, Ph. D.

Born September 10, 1861 at Cleveland, Ohio. Died April 6, 1912 at his residence 6508 Euclid Avenue, where he had lived for forty years. Married Mary Everett Marshall, April 6, 1892.

Graduated at the Cleveland Central High School 1882; Case School of Applied Science 1886 and University of Berlin 1889, at which time and place he received the degree of Ph. D.

Dr. Hobbs was president of the Anglo-American Students Club of Berlin 1886-1889; Professor of Chemistry in Western Reserve Medical College 1889-1903; Chemist for the Ohio Dairy and Food Commission 1896-1911. Only one case was lost during fifteen years of service. At one time he was gas inspector of Cleveland. He established himself as a consulting and analytical chemist and his opinion was sought in various matters pretaining to his specialty.

He was one of the accredited representatives of the Dairy and Food Commission of Ohio, to the National Congress of the Dairy and Food Departments of the various States of the United States held during the St. Louis Exposition at St. Louis in 1904. He delivered a paper on "The Legislation and Condition of Flavoring Extracts."

His contributions to the manufacture of building concrete won for him a national reputation. He was called to the Pacific coast many times to inspect the Pacific Portland Cement Co., and to advise as to operation, processes, etc. During the years 1906-7-8 he superintended the designing, construction equipment and early operation of the Cowell Portland Cement Plant costing about $1,500,000.

At the time of his death he was working on cultures for butter and cheese and had just established a business at his laboratory called the Dairy Ferments Co. He designed a unique bottle for the shipment of these cultures. His laboratory was considered one of the finest private laboratories in the country. In all kinds of litigation involving chemical questions he was regarded first authority in this part of the country. He analyzed the bombs that were used by the McNamara brothers in blowing up bridges around Cleveland and was retained as a witness in the trial at Los Angeles.

His researches in organic chemistry were published in the Journal of the German Chemical Society 1889.

One of his characteristics was his great optimism and his desire to help and place the boy who was starting out in life. Every day he lived he was doing some kind act for the welfare of humanity.

C. A. ARMSTRONG.

C. A. Armstrong was a member of the Ohio State Academy of Science for many years. He was mainly interested in General Geology. He died at Canton, Ohio, in the fall of 1911.

The newly organized section of Physics presented the following report.

REPORT OF THE PHYSICS SECTION OF THE ACADEMY.

At the meeting of the physicists of the State to organize a physics section of the Ohio Academy of Science, from thirty to thirty-five men from various parts of the state were present. The following colleges and universities sent representatives: Miami, Ohio Wesleyan, Wittenberg, University of Cincinnati, Ohio University, Kenyon, Defiance, Heidelberg, Wilmington, Oberlin, Denison, and Ohio State University.

Professor Culler of Miami was chosen chairman of the meeting. After the reading of the program of papers, the following names were recommended to the nominating committee of the Academy for section officers: Vice-President, Prof. T. C. Mendenhall of Ravenna; Assistant Secretary, Professor F. C. Blake of Ohio State University; Member of Executive Committee, Professor S. J. Allen, Cincinnati, Ohio.

At the Academy business meeting, held Saturday morning, these men were elected to their respective offices. The new officers of the Academy being, Professor L. B. Walton, Gambier, President; Professor E. L. Rice, Delaware, Secretary.

Professor Mendenhall gave an excellent ten-minute talk, urging all those present to co-operate in making the section a live and interesting body and to maintain at any cost the high ideals of the science they profess. In a free discussion the unanimous sentiment of the meeting was, that the physicists have now done something they should have done several years ago. There was no question in the mind of any one present, that great good can accrue to each and all of us by meeting together once a year for mutual fellowship and counsel, and for the discussion of the papers read. Undoubtedly another year, more time will be available for discussion than was possible this year, with only a single half-day session.

Many of those present joined the Academy by filling out an application blank, indorsed by two members, and paying the annual dues of $1.50.

F. C. Blake,
Secretary Physics Section.

The auditing committee reported that they had approved the financial statements made by the Treasurer and by the Trustees of the Emerson McMillan Research Fund. The acceptance of this carried the acceptance of the report of the Treasurer and the Trustees.

The committee on place of meetings stated that Oberlin had been selected for 1913.

The program was then continued until 9:30 when an additional business session was called.

Prof. F. C. Blake was appointed Assistant Secretary to aid in the farther organization of the new section in Physics.

It was then moved, seconded, and carried that Dr. T. C. Mendenhall be made an honorary member of the Academy.

In connection with the enlargement of the scope of the Academy through the addition of physicists and chemists, a discussion occurred as to the advisability of retaining the name "Ohio Naturalist" for the official publication of the society. While it seemed to be recognized as inadvisable to change the name of a periodical of long standing, it was suggested that the difficulties might be met through the addition of a clause broadening its scope. A motion was then passed referring the subject to the board of editors of the "Ohio Naturalist" and to the Executive Committee of the Academy.

The following officers were reported by the nominating committee for 1912-13:

President — Prof. L. B. Walton, Kenyon College, Gambier, Ohio.
Vice-Presidents —
(Zoology)—Prof. Chas Brookover, Buchtel College, Akron, Ohio.
(Botany)—Prof. F. O. Grover, Oberlin College, Oberlin, Ohio.
(Geology)—Prof. August Foerste, Dayton, Ohio.
(Physics)—Dr. T. C. Mendenhall, Ravenna, Ohio.
Secretary — Prof. E. L. Rice, Ohio Wesleyan University, Delaware, Ohio.
Treasurer — Prof. J. S. Hine, O. S. U., Columbus, Ohio.
Librarian — Prof. W. C. Mills, O. S. U., Columbus, Ohio.
Executive Committee (Ex-officio) —
Professor L. B. Walton, Gambier, Ohio.
Professor E. L. Rice, Delaware, Ohio.
Professor J. S. Hine, Columbus, Ohio.

(Elective) —

Professor S. J. Allen, University of Cincinnati, Cincinnati, Ohio.
Professor C. G. Shatzer, Wittenberg College, Springfield, Ohio.

Board of Trustees — Prof. W. R. Lazenby, O. S. U., Columbus, Ohio.
Publication Committee — Prof. J. H. Schaffner, O. S. U., Columbus, Ohio.

At 10:00 A. M. after finishing the reading of the remaining papers on the program the Academy was formally declared adjourned. The complete program was as follows:

1. New and Rare Plants added to the Ohio List in 1912. 3 min. J. H. Schaffner
2. Some Applications of Biometry to Agricultural Problems. 5 min. A. G. McCall
3. The Influence of Topography on Bird Migrations. 15 min. Lynds Jones
4. Experiments in Fertilization. 10 min. R. A. Budington
5. Heredity (Eugenics). 25 min. W. F. Mercer
6. The Ohio Biological Survey. 10 min. Herbert Osborn
7. Notes on some Rare Ohio Mosses. 3 min. Clara G. Mark
8. Effect of Road Oil on Rubber Tires. 10 min. Errol L. Fox and Chas. P. Fox
9. Notes on Ohio Oaks. 5 min. W. R. Lazenby
10. The Mississippian-Pennsylvanian Uncomformity and the Sharon Conglomerate. 10 min. G. F. Lamb
11. The Primary Motor Column of the Central Nervous System of *Amblystoma* and its Relation to the Motor Nerves. 10 min. C. E. Coghill
12. Note on the Tactile Reactions of some Orb Weaving Spiders in Their Webs. 8 min. W. M. Barrows
13. *Balanoglossus* and the Origin of the Central Nerve Tube in Vertebrates. 15 min. M. M. Metcalf
14. Additions to the Cedar Point Flora. 3 min. E. L. Fullmer
15. Seeds and Seedling of some Forest Trees, 8 min. W. R. Lazenby
16. Lorain County Myxomycetes. 3 min. F. O. Grover
17. The Cerebral Ganglia of the Frog Tadpole. 10 min. F. L. Landacre and Marie F. McLellan
18. An Ancient Lake in Ohio with unlevel shorelines. 6 min. Geo. D. Hubbard
19. Terraces associated with the Terminal Moraine near Delafield, Wisconsin. 8 min. C. G. Shatzer
20. An Ecological Study of Forest Types near Columbus. 5 min. F. B. H. Brown

21. Algae of Lorain County, Ohio, with notes on their Distribution. 8 min. Susan P. Nichols
22. Yerba Mate (Paraguay Tea). 10 min. Chas. P. Fox
23. Mississippian Conglomerates in Northern Ohio. 5 min. G. F. Lamb.
24. Charts illustrating Feeblemindedness. 20 min. W. F. Mercer
25. A Supernumerary Appendage in *Otocryptops sexspinosus,* and a Theory of Heterorythmic Development. 8 min. L. B. Walton
26. The Soaring Flight of Birds. 10 min. Lynds Jones
27. The Aquarium at the Naples Station. 15 min. Stephen R. Williams
28. Geography of the Balkan Peninsula. (Lantern Slides). 15 min. N. M. Fenneman
29. A Botanical Survey of the Sugar Grove Region. (Lantern Slides). 20 min. Robert Griggs
30. The Application of Physics to Agriculture. A. G. McCall
31. The Resistance of Aluminum Oxide Films. H. E. Graber
32. The Differentiation of Diffraction Effects from the Extra Transmission of Electric Waves. C. R. Weinland
33. The Spectrum of Cored Carbons. C. D. Coons
34. The Effect of a Constriction in a Discharge Tube. R. F. Earhart
35. The Production of Light by the Firefly. C. R. Fountain
36. The Hall Effect and Allied Phenomena in Magnetic Alloys. A. W. Smith
37. Twist in Nickel and Steel Rods due to a Longitudinal Magnetic Field. S. R. Williams
38. The Effects of Temperature and Potential on the Thermionic Emission Heated Wires. Charles Sheard
39. The Scattering of Gamma Rays by Matter. S. J. Allen
40. Some Peculiarities of the High Frequency Graphite Arc. A. D. Cole
41. The Fauna of the Conemaugh Formation. 3 min. Clara G. Mark
42. A Preliminary Report on the Crayfishes of Ohio. 5 min. C. I. Turner
43. Induced Modifications in the Pigment Development of Spelerpes larvae. 8 min. A. M. Banta
44. Review of the Genus *Dero* (Aquatic Oligochates) with a Description of Two New Species. 5 min. L. B. Walton
45. The Composition of a Typical Prairie. 5 min. J. H. Schaffner
46. A List of Plants Collected in Cuyahoga County and New to the County or to Ohio. 3 min. Edo Claassen
47. The Effects of Changes in Sea Beds on the Fauna and Lithology of the Richmond Period. 10 min. G. M. Austin

DEMONSTRATIONS.

Charts showing distribution of Mitosis in the Central Nervous System of Amblystoma as Correlated with Functional Development.
G. E. Coghill and S. W. Camp

A Supernumerary Appendage in *Otocryptops sexspinosus* (Chilopoda). L. B. Walton

Fine crystals of Hopeite and of Tarhuttite, two rare hydrous phosphates of Zinc from Africa. Geo. D. Hubbard

Maps and diagrams illustrating an Ecological Study of Forest types. F. B. H. Brown

President's Address

Botanical Instruction In Colleges

Bruce Fink.

Recent years have brought great expansion in botanical knowledge and notable changes in methods of instruction. It means much more to be a good teacher of Botany now than it did two or three decades ago, when more teachers were beginning with scanty knowledge and faulty methods, which would scarcely be tolerated in a college teacher today.

With the widening of the botanical horizon has come increased difficulty in selecting material, especially for first courses. Shall we teach morphology, physiology, taxonomy, or all of these and more? This question and the other one of what should be selected from the rapidly increasing mass of material must be settled by every teacher of the science. The temptation is to give attention to matter at the expense of method, and to force upon the student more than he can possibly be expected to assimilate.

At a recent meeting of the Ohio Academy of Sciences, it was the prevailing opinion that the lecture or other class room work in sciences should precede the laboratory work, the main argument being that more ground can be covered in this manner. There is great doubt about this method being best for the teacher of Botany, except perhaps with students so far advanced in the science that their botanical imaginations are thoroughly developed.

Assuming that a first course should deal with morphology and physiology, the first hours may well be spent in the laboratory, studying structures and functions in some plant. There the microscope and the hand lens should supplement the eye, and some simple physioligical experiments should be performed.

The plant used may be a simple one, as the omnipresent *Pleurococcus*, which unfortunately, like other plants having the advantage of simplicity, is so small that the student cannot imagine its minuteness. In spite of this difficulty, the advantages of studying a simple plant first are so great that it seems best to begin with the lower plants, giving the advantage of proceeding from the undifferentiated to the more complex. By study *en masse* and with the microscope, the student soon comes to have a fairly good knowledge of the morphology, physiology, and reproduction of this easily understood organism. He should be asked to describe the structure of the protoplast and to state the probable functions of its parts, only after he has seen them. Then he should be required to read about the plant; then should follow a careful discussion in the class room with questioning and quizzing. Finally, the student should be required to make an outline, then a summary of his knowledge of the plant, the latter being done without other aid than his laboratory drawings, which should be referred to in the summary by numbers of figures. Points observed but not drawn may be indicated by (obs.) in parentheses. The order propsed is observation and study of the plant, then reading, then class room work, and finally the written summary. After the student has studied other lower plants in similar fashion, *Pleurococcus* should be compared with one or more of them with respect to structure, physiology, and reproduction, and each of the others studied should be compared in the same manner, so that the work may really be comparative morphology and physiology.

Throughout the course, the work may well be attacked in similar fashion, modified only by the increasing complexity of the material studied. For instance, when the Bryophytes are reached, the student should see and study some of these plants first of all with the eye and the hand lens. Then should follow the microscopic detail, enlivened by comparative morphology and physiology. Never should the student attempt a description of the plant or any part of it until all knowledge to be acquired by direct observation is his own. Then may come the reading, lecturing, quizzing, and summary as before, and a real knowledge of the plant will result, not a memory of words on printed pages and in note books. The study will have been attacked as one must pursue the problems that will confront him in life, which he must conquer largely for himself. The thoughtful student will see the advantage of this method of study over the plan too commonly followed, and will soon understand how much more it means for him to study a thing through for himself. The indolent and poorly trained may fall by the way, but so will both of these in the work of real life to follow. We should follow proper methods, but should, at the same time, make the work so difficult as to call for strenuous effort constantly.

After the student understands *Bryophytes* thoroughly, he is ready to attempt the much more complex and difficult *Pteridophytes.* He will know the moss archegonium, and his botanical imagination will enable him to picture before his mind's eye the fern archegonium from descriptions before he has seen it. Likewise, many fact of comparative morphology and physiology will be thoroughly understood and ready for use in acquiring further knowledge of this difficult group. But the student will find, in ferns, structures unknown to him; and these can scarcely become realities to him except by direct observation, since they can be connected with nothing found in the simpler plants previously studied.

Finally, we pass to the seed-plants, nor may the teacher safely assume that these most complex plants are easy to understand, except in a very superficial way, because of knowledge of lower forms. Here again first steps are slow if the student is really to know anything about these plants, which are studied, most of all and so often without any foundation in the morphology and physiology of lower plants, and consequently in a very slipshod, superficial and unsatisfactory manner, admissible only where a science may with some degree of propriety be treated as a hodgepodge, never in college where every science should be treated in a systematic way.

After a course has been taken that is sufficiently coherent to give the thorough, systematic science training which should come at the outset, it makes less difference what work comes next. Consequently, the teacher may feel more at liberty to follow his own inclinations after the first year; and the student will not suffer the great injury incurred by improper methods at the outset, for he will now have some pegs on which to hang his facts. No teacher can hope to give more than a general outline of botanical science in a first course; so nothing is gained and much is lost by overcrowding these courses. We only wish to insist further that the first course is by far the most important one and should receive a large amount of attention from the head of the department. Turning beginners over to inexperienced instructors to the exclusion of a considerable amount of attention from the man at the head is to be condemned as bad padagogics and very unfair to the student.

There is no great difficulty in getting recitations on what is given in text-books or what is said in lectures, even without any experience with plants in the laboratory, the greenhouse, or even in the field. However, the student, though able to do this, has no real knowledge of the plants about which he has only read or heard, until his botanical imagination is developed by the study of plants themselves, when he can read and listen to matter pertaining to unknown plants with profit, afterwards widening his experience by direct observation so far as possible at unexplored points and using his imagination, aided by descriptions and figures, wherever observation is impossible. So the method in advanced work may be very different from that employed in first courses; and the teacher should guard against over-estimating the grasp that his beginners have on his science and employing methods adapted only to those who are well grounded in Botany. The only safe way is to assume that students who have not had college Botany or have had only a hodgepodge course know next to nothing about plants. First steps should be taken slowly to gain time for rapid progress after the foundation is laid. Haste at first usually means a slow, unsatisfactory bewildering, and unprofitable finish.

Beginning with text-book or lecture is much easier for the teacher than the method outlined above. One who understands his subject can instruct most comfortably by pouring out orally the intricacies of structure and function. Ground is covered more rapidly in this manner, and perhaps as many survive first courses by this method as by the one that we are proposing. But the average student loses himself in a maze of difficulties and is so occupied in assimilating the plethora of good things imparted that he has no time to think or even care about plants. When this method is followed with beginners, the printed page and text figures stand before the student's imagination before he goes to the laboratory, and plants and plant parts leave little impression after the work is done. Laboratory work seldom becomes irksome when the plant is studied first. The student passes as good or better quizzes when the plant study follows instruction by text and lecture; but this is because many persons prefer to get their knowledge passively from printed page, or word of mouth, and the written test becomes merely a memory exercise, showing little if anything regarding the students' knowledge of plants.

Therefore, some teachers of Botany have abandoned the lecture method for beginners, have substituted observation first, then study with outlines for guides, and for the class room, informal discussions and quizzes, both oral and written. Students find that this requires more of them and often ask for the lectures before it has proceeded far. They also object to the inadequate presentation, conrtadictory statements, and errors of text-books; but it scarcely seems best to do away with these altogether, imperfect as they are. An introduction to the literature seems important, even for the first year student in college. But the text and other literature admitted should be secondary to the plant and the teacher.

Many years ago a friend, who had just graduated from college, secured a position as professor of Biology. In a short time he wrote that he intended to give his students more field work and some of the practical botany, in which the community about his college was interested. After three or four years of graduate study, this teacher visited me, and went with us on a class field trip. It was at once apparent that he had lost much of his knowledge of the local flora, and inquiry brought the information that he had abandoned his field work with students for the reason that he found the matter pertaining to minute comparative morphology so absorbing that he could not find time for the trips for observation and study. Another college teacher was, a few years ago, giving one semester of Botany and devoting all of the time to histology and cytology. This teacher was in the midst of a most interesting flora, covering a large area of virgin nature with streams, hills, valleys, mountains, woodlands, and meadows within a few miles of his laboratory. Yet he had never taken his students into the rich field about him.

Microscopic study alone will never suit the tasts of all beginners in Botany. It is too far removed from plant life as they know it in its natural environment. Nor can microscopic study give a good understanding of the fundamental relationship of plants to everyday life, except perhaps when applied to the minute, lower plants, which must be studied mainly with the microscope. Study of the plants as a whole should precede microscopic detail; and courses may easily be arranged with this end in view by introducing the student to the various groups of plants in the field or the greenhouse in fall or spring, and reserving more of the microscopic study for winter. We advocate the field work only as a means for obtaining a better knowledge of plants. For this purpose, it still has its legitimate use. The laboratory, the microscope, and simple physiological experiments are much more important, even in first courses in College Botany; for without these, one can have no adequate knowledge of lower plants, nor could we ever give our students the elementary insight into the structure, functions, and relationships of higher plants, which, when related to experience and human interest, can be made to appeal to all persons.

Because of its relationship with living and its adaptability as a means of culture, Botany is constantly gaining a larger place in the curricula of our colleges. Plants are of great value to man, and the economic phases of Botany are probably as important as those of any other science. Likewise pure botanical science has its peculiar advantages as a subject for study. Plants are more numerous than animals and more accessible in field and laboratory. Plant tissues are more easily manipulated than animal tissues, and plant structures stand out more plainly in dissection and microscopic study. Reproductive processes can be studied more easily in plants than in animals. Plants stand in closer relationship to the inorganic world than do animals, being intermediate chemically and physiologically. Plant evolution has taken a direction mainly different from animal evolution, so that Botany has a special interest from the standpoint of racial development.

Whether man is a feeling rather than a thinking animal is debatable. The child's curiosity indicates that he is thinking of things about him. But we stifle thought and train the memory and sensibiltities until he ceases to be curious. Then we try to remedy the injury by allowing him to study one or more sciences. In thought training and for other purposes, Biology has sufficient value so that no student should go through college without a year's course in Botany or Zoology. If man is a feeling rather than a thinking being, so much more does he need the peculiar training obtained from careful and accurate observation, the close dealing with facts, the exercise of reasoning and judgment, and the imparting of a painstaking, scientific spirit, which come with biological training. But laboratories are expensive, and it is difficult to handle large numbers of students in a bioligical science; therefore most teachers of Biology and most institutions would be overtaxed, were all to take Botany or Zoology. Though the procedure would be sound educationally, teachers of biological sciences do not, at present, long to have all students enrolled in their classes. This would mean overtaxing teaching force and equipment for many years. Nevertheless, we cannot refrain from saying that if people studied these sciences more, there would be less inaccuracy and exaggeration in our speaking and writing, and more careful thinking and candid statement of fact. In cultivating respect for facts and in remedying the proneness to giving vent to feeling in inaccurate and exaggerated statement, Botany has its value and deserves a larger place than it now has, even in some colleges that have separate departments for this science.

We get, in beginning classes in botany, students who take the work for liberal culture only and those who expect to use their training in some occupation. The needs of all must be considered, nor can any one course meet them all equally well. Hence the courses presented must be a compromise. For instance, studies in general Botany in which the important biological principles may be discussed broadly, have more value for liberal culture than a course in Phytopathology, which covers a more limited field and has special occupational worth, more pronounced than its cultural value. Yet each institution has its special functions to perform, somewhat different from those of any other, and Plant Pathology may be required in some colleges. Surely the courses for liberal culture are more fundamental than others, and should be required as prerequisites. Considering his special preparation as well as the needs of his institution, each teacher must decide what courses and how many are to be given. Surely morphology should not be spelled with capital M, nor physiology with a capital P, and so forth; but other work should be offered, and the whole should be well rounded and as general as possible.

The college aim should not be mainly vocational. But where is the teacher who does not prefer the student who enters his classes knowing, or who soon finds out, what he is to do with his training? Most difficult to reach are those who take the work because it is in the curriculum to give them the liberal culture, which they so seldom understand. For this reason, we prefer one who expects to use his Botany in teaching, in agriculture, in horticulture, in pathology, in forestry, in research, or for some other definite purpose. We are inspired by the change of attitude which seems to transform the student when he finds out why he is taking a course, for we then see so much clearer how we can help him.

No teacher of limited experience should attempt a heavy program of botanical courses. A teacher of long experience should be able to give as much aid in a half hour in the laboratory or class room as he could do in three hours when a beginner in college teaching. In both laboratory and class, we should try to have an *esprit de corps* which makes the students feel that the department is not the teachers but theirs to use for their own best advantage. Some of the strongest students may even be set to assisting in certain courses which they have completed. One undergraduate can assist especially will in one course, another in a second. The head of the department can thus have two or three courses going at once and spend his afternoon passing from laboratory to laboratory, giving suggestions to assistants and to workers. These assistants would not be able to plan the work independently, but this method may be made as satisfactory as depending on a single graduate instructor. The assistants are hardly worthy of a place in the printed list of helpers, but they are valuable in the hands of an experienced teacher, who is at the same time a good organizer and supervisor. Some person teach the science better with a first course than others do after years of study. No head of a department of Botany should recommend even the best student for teacher at the end of a year's course, though some of them will succeed if a high school position is thrust upon them. Still, in some instances, I am willing to let these same persons assist in my laboratory under my own eye, provided they are at the same time broadening their botanical view by pursuing advanced courses and are doing the assisting to further perfect themselves as instructors. For assisting under supervision, tact and initiative are as important as the number of courses one has had, and some of these undergraduates may do even better than the graduate who has had little or no experience with instructing. It is a source of inspiration to see the enthusiasm and good sense with which some of these students assist. They should never be given full charge of the work at first, but may be tried and allowed such share in the instruction and management as their abilities justify. For a time they may be of no use as time and energy savers, but they can sometimes be held for one or two years of undergraudated assisting and for several years as graduate students and instructors, finally becoming valuable aids, able to take full charge of a laboratory.

Our teacher's course has proved an aid to our own laboratories, since there have never been more than four or five students who expect to teach and are far enough advancd to take the course in the same year. These observe and suggest in the class room and the laboratory under the direction of the head of the department and the graduate instructor. At the same time they are reading on methods of teaching Botany, studying laboratory administration, and are reviewing texts and literature. Assistants are chosen from those who have taken this course. In more specialized courses, assistants are sometimes chosen from those who have not taken the teacher's course.

No college teacher of short experience should attempt to use student assistants, and some of them never. The graduate should be employed instead, for any independent instructing. If the graduate schools were giving us better teachers, it might be advisable to take the university graduate student in every instance where funds are available to pay the price demanded. But these persons are sometimes imbued with the research spirit and have so little teaching experience that they regard instruction secondary to investigation, and think that it consists in pouring all that they know into the heads of undergraduates, whether they can assimilate it or not. Persons who are more interested in their subject and research than in teaching and their students do well enough in the universities, but need to change their point of view before they can be of much value in the colleges.

As the graduate schools frequently fail to produce good college teachers because interested chiefly in research, so the colleges often fail to prepare efficient teachers for the high schools and academies because their main work is not preparing teachers. Fortunately, the Botany taught in college is as much more difficult than what should be taught in the high school as is that of the graduate school more difficult than that which should be given in the college,—fortunately because the teacher should know much more of his subject than he expects to teach. But it becomes a misfortune to know so much when the college graduate tries to give his high school pupils as difficult Botany, and as much, as they could get in the same time in college. It is the duty of every college teacher to study the courses of the high school with his prospective teachers and to warn them against teaching college Botany in the high school. If there is opportunity for these students to observe the work of a competent teacher of Botany in the high school, this should be done. Without special attention to those who expect to become high school teachers, the result of sending our well prepared graduates into the high schools to teach may be no less objectionable than the too common practice of starting young persons into teaching Botany with little or no preparation. When our student leaves us to teach in an educational environment entirely different from the college, he should not show the imprint of his instructor too strongly, and much less should he teach in the high school as he was taught in college. If he commits either of these faults, he must be counted a stupid teacher; and unless he has been fairly warned and instructed, his college instructor is more at fault than he. Botany stands high among the high school sciences, and there is a large and increasing demand for high school teachers of this science. These teacher come largely from colleges, and the college teacher cannot shirk responsibility in this respect. Unfortunately, our science is often wanted in combination with some non-related subject. Our students carefully prepared in this and other sciences frequently miss the grotesque combination, and the Botany is given to one who is not prepared to teach it. The remedy for this side of the problem rests with the high schools.

Botany is a vast and rapidly growing science, which can no longer be completely covered in any course, or by any man or institution. At best we can give our students only a perspective of the subject. If we accomplish this in separate courses, as it seems we must, these courses should dove-tail into each other in such manner that one will see the inter-relationships plainly and always think of the science as a whole rather than a series of detached subjects. This is more easily accomplished in the smaller institution, where all the work is under the supervision of a single teacher, than in the undergraduate courses in a large university. If the college teacher succeeds in giving his student such a view of his subject, he accomplishes something which compensates in part for the disadvantage of being under one or two instructors instead of several and of having the smaller equipment of the college rather than the large amount of apparatus and laboratory supplies found in the larger institutions. Indeed, it is possible that one who has had his undergraduate courses under one or two competent instructors with rather limited facilities will succeed better with the conditions found in most high schools, and even in many colleges, than the one who has had his undergraduate botanical work in a large university with more teachers and with everything that he could wish constantly at hand.

The place of research in the college may well be considered. The spirit of investigation appears in the normal person in early childhood, and it should never be stifled. When the teacher of Botany ceases to be an investigator in the best sense, he should retire. His studies should extend at least to the things of nature about him and to the literature connected with his teaching. Some botanists fear that this spirit will, if carried farther, interfere with teaching in the college. Very possibly for the one who lacks power of self-restraint, but research is as much a tonic to some as is a pleasure trip, or the unceasing round of social enjoyment, or games to others; and for such, investigation kept within proper bounds is an aid to teaching, not a hindrance. Whether the teacher's investigation should extend far beyond the field of his teaching is a question for each one to consider for himself.

Certainly, the college teacher of Botany should include in his studies many things which may never be used in the class room, but which round out his knowledge of his subject, make him a better instructor, and may be drawn upon if needed. His investigation should be secondary to his teaching and should be closely enough connected with it, at least in its initial stages, so that some of the facts ascertained may bear directly on the teaching. If he be an investigator in the best sense, he will eventually push his work to the limits of human knowledge in some direction. This is the natural outcome of persistent effort, and his investigation now becomes real research. The question is whether he shall continue or stop. He certainly would better do the latter if he does not regard his research of some human interest, and if his enthusiasm for such isolated effort does not make it a pleasure rather than a burden for part of his spare hours. If he has this faith in the value of his work and is disposed to continue, the institution for which he works can afford to lighten his burden somewhat, if possible, for the helpful influence that thorough investigation of a problem has on the teaching of one who can restrain himself and for the benefit that such example will have on other teachers and on students in encouraging them to scholarly attainment.

Many kinds of botanical research can be carried forward on two or three hours work each day, and the teacher can easily learn to drop his advanced work and go to his students refreshed and the more ready to instruct them, because of the keen mental gymnastics connected with his own laborious study, the instruction by its different and disconnected nature seeming like diversion. And indeed one can even solve difficult problems connected with teaching better because of the high order of effort demanded in thorough investigation. The man of strong body and active mind can do this work and still have time to keep abreast his profession as a teacher and be the stronger because of the keen intellectual insight acquired in his own private study. Instruction being of prime importance, the product of the college teacher's investigation should never be required at a given time, and he should be free to drop it for a day, a week, or a month, whenever his teaching requires all of his time. Teaching and research aid each other, and there are lines of study that touch college instruction rather than university work. Members of a university staff may make research their main work, the college teacher should never. No member of a college faculty should be chosen or retained mainly on account of his ability as an investigator, but encouraging one in a limited amount of research is a different matter. No science stimulates to investigation and research more than Botany, and the teacher of this science who is not an investigator, even if he be a member of a college faculty, is scarcely worthy of his profession.

Regarding undergraduate botanical investigation, doubtless all agree that no one should be thrown on his own resources in special study to the exclusion of regular instruction after two or three years of botanical class work. The student is too narrow at this time and will remain so if he begins to give much of his time to special problems. But some young persons should begin specialization in the teens, and in rare instances a part of this may best be some sort of investigation, even in undergraduate courses. We often thwart the desire of the youth for scientific attainment until the last bit of enthusiasm for independent study is crushed. Some would smother it in the best prepared undergraduate and expect it to burst into a living flame soon after the student reaches the university. The rare college student who has the desire, ability, and time for work on some definite problem and who has a teacher who can not or will not encourage and direct him is unfortunate. On the other hand, it is fortunate for the college teacher that few of the students in our classes are ready to attempt special problems. After many years of experience, the writer does not think that he should attempt to direct more than two or three of his students in extended individual work at one time. These he tries to select early and to suggest to them something which may be carried along for a time with their regular work and finally take more of their time as they advance, sometimes being finished under his direction after graduation. These efforts may or may not result in something worth publishing, but they should not be tabooed simply because done by undergraduates.

Like the teacher's research, the student's investigation should centre about something related to his college course and his life work. There are many questions of this kind which the experienced investigator may suggest to the few who should attempt such study. This work should never exclude thorough training in the student's specialty, nor should it replace a knowledge of many subjects in the college curriculum. Hence it must be confined to the rare student who has time and ability for this special study and the more imporant work which will give broad mental training.

We have pleaded for a botanical instruction which will develop initiative, resourcefulness, and independence. This can never be accomplished by pure text-book and lecture methods, supplemented by set tasks in the laboratory. Reproducing from printed pages or from lecture notes and passing quizzes and examinations is but a small part of scholarship. The one who can get results for himself should be allowed to pass the course first of all, and every student should be frequently tested in some independent laboratory work and reading. Those who do not get satisfactory results in this study should not be passed, however well they may do in the set tests. Life consists largely in solving problems for ourselves, and grading should be based largely on ability to do this, rather than on the reproduction of what has been imparted. The scholar is not he who has received most, but he who has found out most and can make the best use of what he knows. In life, we make little use of what we are told, and excellent use of what we find out for ourselves. I fear not, though some teachers may impart to their students twice as many facts as I impart to mine in the same time. I will willingly place my product against their, if only I can give my students perspective, initiative, resourcefulness, and independence.

To summarize partially and to conclude, teaching Botany has come to be a serious responsibility. Because of importance economically and educationally, the place of the branch in colleges is constantly growing. Difficulties have increased as the field has broadened. In face of the multiplicity of material, the teacher should not lose sight of the training that is so important. Selection must not give way to a desire to fill young heads with knowledge. It is much more important to adapt methods to the botanical advancement of our students. The instruction should be built upon direct study of the plant and reasoning about it. Lectures, reading, and quizzes should follow instead of precede, at least until botanical imagination is somewhat developed. One should proceed from the simple to the complex in matter and method.

Amount of ground covered is by no means so important as the breadth of the instruction and the character of the product that results. The chief concern should be to make the strongest and most independent students possible; for this is our greatest responsibility as teachers, whether we train for vocational purposes or for liberal culture. If some students reach the point where they can do creditable investigation, partly or wholly as undergraduates, there is no cause for alarm, for they probably could not do it, had not the foundation been laid in proper instruction in the fundamentals of the science.

Teaching is one of the best known stimuli to high thinking and is therefore an aid to valuable research. The college teacher will not accomplish so much as the botanist who devotes himself largely or wholly to research; but he should be able to work as effectively as any, and perchance often accomplish more in a given time than the man who devotes himself largely or exclusively to study. This is in itself one argument for investigation by the teacher, but the reciprocal argument that the research is an aid in teaching is of course a far stronger one.

The investigation of some college teachers of Botany may be of doubtful value; but so is some of that of an occasional botanist who devotes himself largely or wholly to research, and this surely does not destroy the value of our argument regarding the relation of research to teaching in the college. No teacher of Botany who believes that a limited amount of research is an aid to his teaching should fail to carry on private investigation. He may be wise in working long and faithfully in oblivion rather than let a piece of work pass from him before he feels sure of its value. The reward for the teacher is in the stimulating effect of the effort quite as much as in the amount that he may be able to produce. One should not consider it beneath him to investigate some problem of real value to his community, region, or state, though it may be regarded lightly by certain trained botanists, who may not after all be competent judges. Again, one should hesitate least of all to investigate some problem belonging to college conditions, of which college teachers are themselves the best judges. Or the problem may be something related to our teaching, and likewise of world-wide botanical interest.

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STAUFFER, CLINTON R., *Geology*....Adelbert College, Cleveland
STERKI, VICTOR, *Conchology, Botany*....New Philadelphia
STETSON, R. H., *Psychology*....Oberlin College, Oberlin
STICKNEY, M. E., *Botany*....Granville
STOVER, W. GARFIELD, *Botany*....O. S. U., Columbus
STOUT, W. E., *Chemistry, Geology*....Sciotoville
SWEEZEY, OTTO H....Twelfth Ave., Honolulu, Hawaii
THOMPSON, LAWRENCE J., *Biology, Chemistry*....
....21 University Ave., Delaware
TODD, JOSEPH H., *Geology, Archaeology*....Christmas Knoll, Wooster
TURNER, CLARENCE L., *Zoology*....105 Campbell St., Delaware
UNNEWEHR, EMORY C., *Physics*....Baldwin-Wallace College, Berea
VEEDER, MARTHA ANNA, *Physics*....The Western College, Oxford
WAITE, F. C....Western Reserve University, Cleveland
WALTON, L. B., *Biology*....Gambier
WEAVER, F. O., *Physics*....473 Park Place, Springfield
WEBB, R. J., *Botany*....Garrettsville
WEBSTER, F. M., *Entomology*....U. S. Dept. Agricul., Washington, D. C.
WEINLAND, CLARENCE R., *Physics*....381 W. 10th Ave., Columbus
WELLS, B. W., *Botany*....Manhattan, Kas.
WELLS, G. R., *Psychology*....Oberlin College, Oberlin
WERTHNER, WILLIAM B., *Botany*....Steele High School, Dayton
WESTGATE, LEWIS G., *Geology*....Delaware
WHITMARSH, R. D....Wooster
WILLIAMS, SAMUEL R., *Physics*....Oberlin College, Oberlin
WILLIAMS, STEPHEN R., *Biology*....Miami University, Oxford

WILLIAMSON, E. B., *Ichthyology, Ornithology*......................Bluffton, Ind.
WILSON, STELLA S., *Geography, Geology*............97 N. 20th St., Columbus
WRIGHT, G. FREDERICK, *Geology*..Oberlin
YORK, HARLAN H., *Botany*......................Brown Univ., Providence, R. I.
YOUNG, R. A., *Botany*..............Dept. of Agriculture, Washington, D. C.
Total Membership 232

Report of the Twenty-Third Annual Meeting of the Ohio Academy of Science

The Twenty-Third Annual Meeting of the Ohio Academy of Science was held at Oberlin College, Oberlin, Ohio, on November 27, 28, and 29, 1913, under the presidency of Professor L. B. Walton of Kenyon College. The following is the summarized program:

PROGRAM

Thursday, November 27.

8:00 P. M.	Informal gathering of members in Park Hotel.

Friday, November 28.

8:30 A. M.	Meetings of Committees.
9:00 A. M.	Business Meeting.
10:00 A. M.	Reading of Papers in General Session.
12:00 M.	Luncheon.
1:30 P. M.	Address on "The Evolutionary Control of Organisms, and Its Significance," by Professor L. B. Walton, President of the Academy.
2:30 P. M.	Reading of Papers. Sections for Zoology, Botany, and Geology in Joint Session; Section for Physics in Separate Session.
5:30 P. M.	Dinner in Park Hotel; Address of Welcome by President Henry C. King, of Oberlin College.
7:00 P. M.	Illustrated Lecture on "Sound," by Professor Dayton C. Miller, Case School of Applied Science.
8:30 P. M.	Reception in Men's Building.

Saturday, November 29.

8:30 A. M. Adjourned Business Meeting.

9:00 A. M. Reading of Papers in Sectional Meetings.

MINUTES OF BUSINESS MEETINGS

November 28, 1913.

First business session called to order by President Walton at 9:00 a. m.

After announcements by Professor Metcalf, Chairman of Local Committee, the chair announced the appointment of the following committees:

Committee on Membership—M. M. Metcalf, F. C. Blake, R. F. Griggs.

Committee on Resolutions—T. C. Mendenhall, Martha Anna Veeder, G. F. Lamb.

Committee on Necrology—J. S. Hine, W. R. Lazenby, Lynds Jones.

The following Auditing Committee was appointed by the Academy: Lynds Jones, W. N. Speckmann.

The Secretary presented an oral report, which was followed by the report of the Treasurer. The report of the Treasurer was referred to the Auditing Committee.

Report of the Treasurer for the Year 1913

For the year since our last annual meeting the receipts, including balance from last year, have amounted to $355.64, and the expenditures to $268.62, leaving a cash balance of $87.02.

RECEIPTS.

Balance from last year	$ 88 64	
Interest on endowment	2 00	
Membership dues	265 00	
Total		$ 355 64

DISBURSEMENTS.

180 subscriptions to The Ohio Naturalist	$ 135 00	
Printing annual report	73 50	
Miscellaneous expenses	60 12	
Balance December 1, 1912	87 02	
Total		$ 355 64

Respectfully submitted,

JAS. S. HINE, *Treasurer.*

The report of the Librarian was read, adopted, and ordered filed, as follows:

Report of Librarian

November 25, 1913,
Columbus, Ohio.

As Librarian of The Ohio State Academy of Science I take pleasure in presenting my report upon the general condition of the Library of The Ohio State Academy of Science.

Also my report upon the receipts from the sales of publications of The Ohio State Academy of Science and the cost of sending out these publications.

Balance on hand November 29, 1912	$50 58	
Cash sales of publications during the year	45 35	
Total		$95 93

EXPENDITURES.

Postage on annual report	$ 7 20	
Postage on letters and publications sent out	7 33	
Account Book	50	
Books for the Library	4 25	
Envelopes for sending out publications	2 96	
Moving of the Library from Page Hall to the New Bldg.	11 25	
Wrapping Paper	1 25	
Cards for the Library	3 00	
Supplies such as paste, glue, brushes, ink, pens & pencils	1 20	
Total		$38 94
Balance in the hands of the Librarian		$56 99

It is the purpose of the Librarian to set aside a certain alcove in the New Building where the Academy of Science Publications will be placed, as well as the publications received in exchange. The Librarian is now making out sets of the publications received in exchange and, with the money on hand, it would seem advisable to have these sets bound and properly cataloged and placed in the Library.

Respectfully submitted,

WM. C. MILLS,

Librarian.

The Executive Committee reported the appointment of Professor F. C. Waite as Vice President for Zoology, to fill the vacancy caused by the resignation of Professor Charles Brookover.

An informal report of the Publication Committee was presented by the Secretary.

The following report of the Trustees of the Research Fund was presented and referred to the Auditing Committee. Voted that the hearty thanks of the Academy be extended to Mr. McMillin for his continued generous support of the research work of the Academy.

Financial Statement of the Emerson McMillin Research Fund, Ohio State Academy of Science, 1912-1913

RECEIPTS.

Cash on hand, November 16, 1912	$126 71
Check from Emerson McMillin	250 00
Total	$376 71

EXPENDITURES.

Nov. 26, 1912, Clara G. Mark, expense in research	$ 20 00
Apr. 11, 1913, Alfred Dachnowski, expense in research	42 15
May 5, 1913, Charles Brookover, expense in research	14 65
Sept. 8, 1913, Freda Detmers, expense in research	50 00
Sept. 27, 1913, S. R. Williams, expense in research	50 00
Nov. 6, 1913, Clara G. Mark, expense in research	20 00
Total	$196 80
Balance in Capital City Bank, Nov. 7, 1913	$179 91

Of this unexpended balance $60.00 has been appropriated but not yet used. This leaves an unappropriated balance of $119.91.

(Since the above statement was prepared a check for $250.00 has been received from Mr. Emerson McMillin. It has been placed in Capital City Bank, Columbus, where the balance reported above is now deposited.)

WILLIAM R. LAZENBY,
EDWARD L. RICE,
FRANK CARNEY.

A gratifying report of the organization and beginning work of the Ohio Biological Survey was presented by Professor Osborn, the Director.

The Special Committee on the Scope and Title of the Ohio Naturalist made a partial report. The report was received and the committee continued.

Voted that the President appoint a committee to consider the possibility and desirability of merging the library of the Academy with the library of Ohio State University, and to report at the next Annual Meeting. Chair appointed W. C. Mills, F. O. Grover, E. L. Rice.

Voted that, in the election of the nominating committee, each member shall vote for one representative of each of the three sciences, Biology, Geology, and Physics; and that the representative of each science receiving the largest vote shall be elected. In accordance with this action the Academy elected the following Nominating Committee: Herbert Osborn, G. D. Hubbard, Samuel R. Williams.

Meeting adjourned to reconvene at 8:30 Saturday morning.

November 29, 1914.

Adjourned Business Meeting called to order by President Walton at 8:30 a. m.

The following officers were nominated by the Nominating Committee and elected by the Academy, the Secretary being instructed to cast the ballot of the Academy:

President—President T. C. Mendenhall, Ravenna.

Vice President for Zoology—Professor Stephen R. Williams, Miami University, Oxford.

Vice President for Botany—Professor E. L. Fullmer, Baldwin-Wallace College, Berea.

Vice President for Geology—Professor N. M. Fenneman, University of Cincinnati, Cincinnati.

Vice President for Physics—Professor A. D. Cole, Ohio State University, Columbus.

Secretary—Professor E. L. Rice, Ohio Wesleyan University, Delaware.

Treasurer—Professor J. S. Hine, Ohio State University, Columbus.

Librarian—Professor W. C. Mills, Ohio State University, Columbus.

Elective Members of Executive Committee—Professor Frank Carney, Denison University, Granville; Professor L. B. Walton, Kenyon College, Gambier.

Member of Publication Committee—Professor C. H. Lake, Hamilton.

Trustee of Research Fund—Professor M. M. Metcalf, Oberlin College, Oberlin.

The following list of members elected by the Executive Committee since the last Annual Meeting was ratified by the Academy.

Ankeney, Wm. N., Botany, Wellington.

Atkinson, A. A., Physics and Allied Subjects, Athens.

Bleile, A. M., Physiology, Biology, O. S. U., Columbus.

Breiel, Clarence A., Biology, Chemistry, Physics, Sturges Hall, Delaware.

Bucher, Walter H., Geology, Physics, Univ. of Cincinnati, Cincinnati.

Coons, C. D., Physics, Denison Univ., Granville.

Frasure, N. W., Botany, Canal Winchester.

Getman, Minnie Ryder, Botany, Lake Erie College, Painesville.

Gowdy, Robert Clyde, Physics, 2115 Auburn Avenue, Cincinnati.

Gregory, Emily Ray, Zoology, Botany, Physiology, Hygiene, Buchtel College, Akron.

Grober, M. E., Tiffin.

Hopkins, Lewis S., Botany, Kent.

Hormell, W. G., Physics, Delaware.

Jacobs, Edwin E., Botany, Biology, Ashland.

Kaufman, L. M., Biology, 36 Griswold Street, Delaware.

Kingsbury, G. G., Biology, 216 N. Franklin Street, Delaware.

Lake, Chas. H., Physics, Hamilton.

Langenberg, F. C., Physics, Athens.

Lorenz, Edw. J., Physics, University of Cincinnati, Cincinnati.

Manchly, S. J., Physics, 2706 Eden Avenue, Cincinnati.

McIntosh, Will, Botany, Zoology, Oberlin Academy, Oberlin.

Moore, E. J., Physics, Oberlin.

More, Lewis T., Physics, University of Cincinnati, Cincinnati.

Mote, Don C., Zoology, Entomology, Wooster.

O'Neal, Claude E., Botany, 162 North Sandusky Street, Delaware.

Orcutt, Alfred W., Zoology, Granville.

Philpott, Rees, Biology, 171 W. Lincoln Ave., Delaware.

Prose, Chas. T., Physics, Zanesville.

Recker, Paul C., Biology, Physics, 60 Park Avenue, Delaware.

Robinson, R. R., Geology, Biology, Orton Hall, O. S. U., Columbus.

Rogers, Charles G., Physiology, Oberlin College, Oberlin.

Schear, E. W. E., Biology, Westerville.

Shuman, W. L., Botany, Quaker City.

Stetson, R. H., Psychology, Oberlin College, Oberlin.

Thompson, Laurence J., Biology, Chemistry, 21 University Avenue, Delaware.

Veeder, Martha Anna, Physics, The Western College, Oxford.

Weinland, Clarence R., Physics, 381 West Tenth Avenue, Columbus.

Wells, G. R., Psychology, Oberlin College, Oberlin.

Williams, Samuel R., Physics, Oberlin College, Oberlin.

The following new members were elected by the Academy on the recommendation of the Committee on Membership:

Barnett, S. J., Physics, 1634 Neil Avenue, Columbus.

Coe, Fred O., Geology, Zoology, Chemistry, 17 Griswold Street, Delaware.

Graber, Philip E., Physics, Chemistry, General Science, 9501 Pratt Avenue, Cleveland.

Irwin, Oscar W., Physics, Toledo University, Toledo.

Kumler, Ralph W., Geology, Physiography, 277 East Perry Street, Tiffin.

Lechner, Robert L., Chemistry, Biology, Physics, 323 Paige Avenue, Warren.

McConnell, Mrs. R. A., Botany, Oberlin.

Sheard, Charles, Physics, O. S. U., Columbus.

Shideler, W. H., Geology, Oxford.

The Committee on Necrology reported that, so far as is known, no member of the Academy has died since the last Annual Meeting.

The following report was presented by the Committee on Resolutions, and enthusiastically adopted by the Academy:

Report of the Committee on Resolutions

Resolved, That the thanks of the Academy are due and are hereby tendered to the Authorities of Oberlin College, who have placed their buildings and apparatus at our disposal during this meeting, and especially to members of the faculty who have provided excellent facilities for illustration and demonstration in connection with the various papers presented.

To the local committee, whose arrangements for the meeting of the Academy and the convenience and comfort of its members have been unusually complete and satisfactory.

To members and friends of the Academy residing in Oberlin who have generously extended the hospitality of their homes.

To Professor Dayton C. Miller for his lecture on "Sound," which was listened to with intense and unflagging interest not only by members of the Academy but by hundreds of others to whom the opportunity of hearing him was afforded by the local committee. The labor and anxiety involved in the presentations, under peculiar difficulties, of his numerous and beautiful experimental illustrations can be appreciated only by those who have attempted similar work, and the Academy wishes to record its appreciation of his generosity in accepting as his only reward the pleasure given his audience.

T. C. MENDENHALL,
MARTHA ANNA VEEDER,
G. F. LAMB,
Committee.

The Auditing Committee presented the following report, which was accepted and ordered filed:

Report of the Auditing Committee

Your Auditing Committee begs to submit the following report:

We find on the books of the Treasurer:

Balance from 1912	$ 88 64
Membership fees received	265 00
Interest on deposits	2 00
Total receipts	$355 64
Expenditures as shown by vouchers	268 62
Balance on hand November 29, 1913	$ 87 02

We find in the Emerson McMillin Fund:

Balance carried forward from 1912	$126 71
Two checks received from Emerson McMillin for research	500 00
Total	$626 71
Expended as shown by vouchers	196 80
Appropriated but not paid out	60 00
Total payments authorized	$256 80
Balance on hand November 29, 1913	$369 91

Respectfully submitted,

LYNDS JONES,
W. N. SPECKMANN,
Committee.

Voted that the Constitution and By-Laws be printed with the report of the current meeting in the Proceedings of the Academy.

Voted also that the separate printing of the Constitution and By-Laws and of the list of members be authorized.

Meeting adjourned without determining place for the next Annual Meeting.

SCIENTIFIC SESSIONS

The complete scientific program of the meeting follows:

Presidential Address

The Evolutionary Control of Organisms, and Its Significance. L. B. Walton

Illustrated Lecture

Sound........Dayton C. Miller

Papers

1. Plum Creek as a Glacial Chronometer. 15 min.
G. Frederick Wright
2. Hybridization, Variability, and Size. 8 min.
L. B. Walton

3. Marengo Cave. 10 min. (Opaque Projection.) W. N. Speckman
4. A Statistical Study of the Physical Measurements of a Class of Students. 10 min. Carl J. West
5. The Effect of the Eruption of Katmi on Vegetation. 15 min. (Opaque Projection.) Robert F. Griggs
6. The Structure of a Fossil Starfish from the Upper Richmond. 10 min. (Lantern Slides.) Stephen R. Williams
7. With the International Phytogeographic Excursion in America. 12 min. A. Dachnowski
8. Comparison of the Mollusk Faunas of the Palæarctic and Nearctic Provinces. 15 min. V. Sterki
9. Flood and Drainage Conditions in Vicinity of Bellevue, Ohio. 20 min. George D. Hubbard
10. The Species Concept as Applied to the Genus Pyrosoma. 10 min. Maynard M. Metcalf
11. Geographic Influences in the History of Milan, Ohio. 10 min. C. G. Shatzer
12. The Acclimatization of Trees and Shrubs. 10 min. William R. Lazenby
13. The Life History of Euglena. 12 min. Charles G. Rogers
14. Botanical Observations in Alaska. 20 min. (Opaque Projection.) Robert F. Griggs
15. Conjugation in Amoeba. 8 min. Ralph E. Hedges
16. Variation in Scirpus atrovirens and S. georgianus. 10 min. F. O. Grover
17. The Transparency of Various Substances for Infra-Red Radiation obtained by Focal Isolation. 8 min. Alfred D. Cole
18. Note on the Electrical Conductivity of Glass. 5 min. Robert F. Earhart
19. The Villari Reversal Effect in Ferro-Magnetic Substances. 15 min. (Lantern Slides.) S. R. Williams

20. On the Longitudinal Thermo-Magnetic Potential Difference. 15 min. A. W. Smith
21. The Spectrum of Silicon in the Carbon Arc. 10 min. (Lantern Slides.) C. D. Coons
22. On the Vibrations of a Lecher System using a Lecher Oscillator. 15 min. F. C. Blake and Charles Sheard
23. The Wiedemann Effect in Monel and Nichrome Wires. 10 min. H. H. Reighley
24. Notes on the Metamorphosis of Two Ascidians. 10 min. (Lantern Slides.) R. A. Budington
25. The Effect of Variation of Intensity and Duration of Stimuli to Reaction Time. 10 min. G. R. Wells
26. Pressure Sensation and the Hair Follicle. 15 min. R. H. Stetson
27. Further Notes on Embryonic Skull of Eumeces. 10 min. (Opaque Projection.) Edward L. Rice
28. An Addition to the Odonata of Ohio. 3 min. Rees Philpott
29. The Box-Elder Bug, Leptocoris trivittatus, in Ohio. 5 min. W. J. Kostir
30. An Occurrence of Atypus milberti Walck, in Ohio. 3 min. Carl J. Drake
31. Remarks on the Distribution of Certain Species of Jassidae. 10 min. Herbert Osborn
32. Observations on the Action of the Heart in Mollusca. 10 min. V. Sterki
33. Chromosomes in Opalina. 12 min. Maynard M. Metcalf
34. The Cerebral Ganglia of an Embryo Salamander, Plethodon glutinosus. 7 min. W. J. Kostir
35. Report on the Work done with the Mollusk Fauna of Ohio. 8 min. V. Sterki
36. Some Additional Records for Ohio Mammals. 5 min. James S. Hine
37. Notes on the Cheese Skipper, Piophila Casei. 5 min Don C. Mote

38. The Distribution and Abundance of Some Animal Parasites of Ohio Live Stock. 5 min. Don C. Mote
39. The Ecology of Fishing Point, Pelee Island. 10 min. Lynds Jones
40. Migration Phenomena in the Sandusky Region. 20 min. Lynds Jones
41. The California Tarweed Industry. 5 min. Charles P. Fox
42. A Provisional Arrangement of the Ascomycetes of Ohio. 10 min. Bruce Fink
43. The Sprouting of the Two Seeds of a Cocklebur. 3 min. John H. Schaffner
44. Additions to the State Flora, presenting Two Species of Isoetaceae from Portage County. 5 min. L. S. Hopkins
45. Notes on a Typical Ohio Woodlot. 10 min. William R. Lazenby
46. Ecological Varieties as illustrated by Salix interior. 5 min. John H. Schaffner
47. Certain Peculiarities of the Botrychia. 5 min. L. S. Hopkins
48. A New Variety of Carex tribuloides, with Notes on the Variability of the Species. 8 min. F. O. Grover
49. The Behavior of Some Species on the Edges of their Ranges. 15 min. Robert F. Griggs
50. The Catalog of Ohio Vascular Plants. 5 min. John H. Schaffner
51. A new method in Lichen Taxonomy. 10 min. Bruce Fink
52. Additional Information on the Ohio Devonian. 5 min. C. R. Stauffer
53. Some Geological Features in the Newark and Frazeysburg Quadrangles. 15 min. G. F. Lamb
54. The Stratigraphy of the Upper Richmond Beds of the Cincinnati. 15 min. W. H. Shideler
55. Metamorphism in the Ordovician System of Giles County, Va. 5 min. E. P. Rothrock

56. Evidence of Basining and Folding during the Eopaleozoic of the Southern Appalachians. 5 min.
P. H. Cary
57. An Ancient Finger Lake in Ohio with Tilted Shorelines. 6 min. George D. Hubbard
58. Unconformity and Basal Conglomerates of the Mississippian Age in the Wooster Quadrangle. 5 min.
G. F. Lamb
59. Methods of Mapping the Shorelines of Pre-Glacial Lakes. 10 min. (Lantern Slides.) Frank Carney
60. An Eroded Channel in the Cleveland Formation.
W. G. Burroughs
61. Symposium: The Quantum Theory of Matter and Energy.
    I. The Quantum Theory applied to Black Body Radiation. 20 min. E. J. Moore
    II. The Quantum Theory applied to the Determination of the Specific Heat of Solid Bodies. 20 min. Charles Sheard
    III. The Quantum Theory applied to Photoelectric and Thermionic Emission. 20 min.
    S. J. M. Allen
    IV. General Discussion.

Demonstrations

1. Rare Minerals from Rhodesia. George D. Hubbard
2. Alaskan Plants. Robert F. Griggs
3. Specimens illustrating California Tarweed Industry.
Charles P. Fox
4. Specimens of Mollusca. V. Sterki
5. Ohio Odonata. Rees Philpott
6. Chromosomes of Opalina. Maynard M. Metcalf
7. Herbarium Specimens of Scirpus and Carex.
F. O. Grover

President's Address

THE EVOLUTIONARY CONTROL OF ORGANISMS AND ITS SIGNIFICANCE.

L. B. WALTON

A comparatively brief period has passed since the evidence brought together by Darwin in connection with the results slowly accumulated from other sources has clearly demonstrated that the diversity of organic life in the world occurs through evolution. It is one thing, however, to clearly diagnose a condition and quite another to understand the causes which have brought about the phenomenon so that similar results may be produced advantageously. With the assumption that evolution was merely the survival of those forms best adapted to the environment generation after generation, the explanation of the method as well as its practical application, namely the improvement of organisms in any given direction, was apparently a simple matter. It seemed evident that man had modified and adapted to his welfare various plants and animals by a more or less unconscious and haphazard selection long before history records civilization. One need not be a pessimist to assert the actual evidence thus far obtained indicates that the supposed progress made in the improvement of domesticated animals and plants is nothing more than the sorting out of pure lines and thus represents no advancement. The studies by Lloyd on races of rats in India are extremely suggestive in this connection. Why then could not civilized man carry forward the work and with the knowledge gained since the principles of evolution were recognized, obtain far reaching results within a brief period of time? All that seemed necessary was to have individuals of a particular organism in large numbers and by continued selection of the variations best meeting the conditions move rapidly forward by a series of increments toward the goal of perfection. What could be more simple? Instead of corn having an acreage yield of fifty bushels, there would with a proper supply of plant food be a production of two hundred, two hundred and fifty, or even three hundred bushels. Instead of politicians with no perspective beyond their immediate welfare—a re-election,—instead of college presidents and faculties with their numerous shortcomings—according to the students and occasionally the trustees—there would be the ideal individual bred to specification and not necessarily made in Germany.

Unfortunately variations with a perverseness incomprehensible, uniformly refused to accumulate in the manner desired and at times even demonstrated their obstinacy by retrogression. It was plainly evident that there were limits imposed by nature not easily passed and in connection with which much experimental work must be undertaken before definite progress was made and the facts fully understood.

With a realization of the difficulties involved in an attempt to apply evolution, it will be well to pause for a moment and consider certain fundamental principles before discussing the results of some of the investigations which for a time at least promised much toward the solution of the problem. Thus it may be stated that evolution in its different modifications postulates in general (1) the occurrence of numerous varying individuals, some of which are (2) eliminated by environmental stimuli leaving few or no offspring, while (3) the survivors transmit to their progeny the characters which proved of selective value with the result that (4) through the continuation of the process the race eventually becomes adapted to surrounding conditions. The first two propositions are merely statements of fact. The real difficulties of the situation are those of ascertaining how variations which are transmitted may be recognized and produced so that the result will be a cumulative one. Until this is done breeders must continue to proceed in the same haphazard manner that they have followed for countless generations.

By selecting the largest and most perfect ears of seed corn from the variations present in the field, conversely eliminating the remainder from reproducing, the corn grower plants with a fatuous trust in providence that a crop somewhat better or at least as good as the preceding crop will be produced. If it is a type comparatively pure the average may be maintained and the hope partially realized, but the chances for retrogression are far greater than for advancement inasmuch as there is no means for distinguishing a variation that will be transmitted with equal or better results than in the preceding generation, from one presenting a fluctuation due to nature and which is non-transmissible. Thus the apparently inferior ear of corn will frequently produce a yield far better than obtained from one which is perfection as graded by the methods of the "corn show," and, if from the same pure race, the resultant crop will be at least as good. Artificial methods of hybridization which furnish an immediate advancement in the succeeding generation result in a gain only temporary. The increased stimulus to growth vanishes as a fluctuation.

Thus it is quite evident that there exists a problem in the evolutionary control of organisms even the partial solution of which will mark an extraordinary advancement not only for agriculture, horticulture, and animal breeding, but also for society in general.

The general results of the investigations bearing upon the evolutionary control of organisms may be grouped around the principles of Mendelism, the Mutation Theory, and Pure Line Breeding.

The rediscovery in 1900 of the fundamental laws governing hybridization so brilliantly established by Mendel in 1865, but unfortunately concealed in the obscure publications of the Natural History Society of Brunn, opened an extraordinary field for experimental work. This has already developed to vast proportions in connection with both the results obtained and the speculations involved, while the end is not in sight.

The investigations of Mendel, now so familiar to all biologists, and which may be mentioned somewhat in detail here because of their bearing on mutation, consisted primarily in the crossing of tall and dwarf peas with the result that the first filial (F_1) or hybrid generation consisted entirely of tall plants. When, however, seed from these plants was sown the ratio of tall to dwarf plants became 3 to 1 in the second (F_2) hybrid generation, a result explained by the theory of dominant and recessive characters on the basis that there are certain determiners of unit characters in the germplasm dominating over others during the development of the somatoplasm or body of the individual in the higher forms of life. More recently the presence and absence theory has been applied in interpreting the results. In a manner similar to the preceding, when smooth, yellow peas were crossed with wrinkled green peas, the first hybrid generation consisted of smooth yellow forms inasmuch as the character smooth and the character yellow were dominant over the character wrinkled and the character green, and the crosses were known as dihybrids inasmuch as they differed in respect to two characters. In the second hybrid generation the resultant ratio was 15 to 1 pure recessive, i. e., wrinkled green although the fifteen consisted of smooth yellow, smooth green, and wrinkled yellow in the proportion of 9:3:3. In the same way trihybrids have the ratio 63 to 1 pure recessive while and polyhybrid differing in "n" characters, which mendelize in the usual manner, will give an expected ratio of 4^n-1 to 1 pure recessive and only become apparent through the breeding of large numbers of individuals.

While the preceding summary represents the normal results in connection with the segregation of unit characters, studies of the past few years have demonstrated that many interesting relationships may occur between the factors governing the production of characters. For example it has been found that two or more determiners are often present, either of which will produce the given character, as Nillson-Ehle demonstrated in hybrids of brown and white chaffed wheat, while on the other hand two or more determiners acting together may be necessary to bring about an effect. Such a condition exists as Bateson in 1910 showed in certain white flowered sweet peas which when crossed produce purple flowers in the first hybrid generation. The results which have led to the theory of coupling and of repulsion, particularly the latter where the expectancy of a pure recessive may be one among many thousands, go far toward suggesting a possible explanation of many so-called mutations on the basis of ancestral individuals heterozygous for one or more characters.

Do the Mendelian principles assist us, however, in attaining the goal which we are seeking, namely, the building up of an ideal organism which will continue to transmit its characters. The answer must be in the negative so far as the originating of anything new is actually concerned. Recessives may be obtained. Characters may be redistributed. They were present in the forms first utilized, however.

The Mutation Theory formulated by Devries in 1901 approximately at the time interest was being awakened by the rediscovery of the hybridization principles of Mendel needs no extended explanation to those who have been interested in evolution. Based on cultural experiments with *Oenothera lamarckiana*, one of the evening primroses, the appearance of relatively small numbers of forms which were quite distinct from the parental species and which bred true in subsequent generations led to the inference that evolution had in many cases proceeded by discontinuous variations or mutations.

Long series of breeding experiments followed in connection with other organisms, both plants and animals, with results quite similar to those obtained by DeVries. Investigations were also made (Fischer, MacDougal, Tower, etc.) where organisms were subjected to stimuli abnormal in their nature with the result that a modified progeny was obtained which bred true to the apparently induced character in succeeding generations. Furthermore, cytological studies (Gates, etc.) demonstrated some interesting relationships so far as differences in chromosome composition among "mutants" were concerned.

While the evidence is far too insufficient to allow more than a tentative opinion, there are several conclusions concerning mutation which appear justified. The nature of the results obtained through the various agencies makes it quite evident that they are not all due to a single underlying principle. There are many "mutants" the origin of which is most certainly to be explained on the basis of a heterozygous condition of the gametes, and much evidence has accumulated that *O. lamarckiana* of Devries, on which the mutation theory was founded, belongs to this class. Furthermore, there are mutants developing in connection with the action of abnormal stimuli, although it is not at all improbable that some of these result from heterozygotes. It may be mentioned that Humbert (1911) in experiments with 7500 pure line plants of *Silene noctiflora*, one of the "pinks," utilizing methods similar to those of MacDougal, failed to obtain any "mutants." Another explanation of the results in connection with the influence of abnormal stimuli is that the modification takes place through the destruction of a factor and thus the process is one of subtraction instead of addition. There are also investigations, notably those of Gates, in which the aberrant organism apparently results from the abnormal behavior of the chromosomes at some stage during the life cycle. *Oenothera gigas* with its tetraploid chromosomes is here of much interest.

Notwithstanding these diverse results, there is little indication that anything actually new has been added to the organism which would not have occurred within a pure line. If this is true the heterogeneous school of mutationists can be of little assistance beyond suggesting the way in which evolution did not take place.

The experiments on the basis of Pure Line Breeding belong to a comparatively recent period and are of the utmost importance. Johannsen in 1903 published results based on a pure line of beans self-fertilized for successive generations, and evidently homozygous. From a bean weighing 95 centigrams and far above the average in size he obtained plants producing beans varying in weight from approximately 35 to 70 centigrams but all far below the weight of the parent. Utilizing these in turn as parental forms, from those having a weight of 35-40 centigrams, there resulted a progeny with an average of 57.2 centigrams, while from those having a weight of 65-70 centigrams a progeny was obtained which had an average of 55.5 centigrams. In other words, selection had not only failed to make any advancement but actually resulted in a slight retrogression. Facts quite in accord with this but giving much more pronounced results have been obtained by Tower (1906), Jennings (1908), Johannsen (1909) and others. It should be noted, however, that there have been several experiments, notably those of DeVries with buttercups, Tower with potato beetles, and Smith with Indian corn, where a possible advance in a character resulted in a group. Heterozygotes here may have been responsible for the result although again the explanation may consist in the elimination of the effects of a determiner.

The results in mixed races as exemplified by corn, beans, etc., where selection has gradually improved a group of organisms but finally reached a limit beyond which no progress appeared possible are comparatively well understood and are due, as explained by Shull (1908), to the separation of the pure lines which were present in the race at the beginning. This is where the average agriculturist, horticulturist and animal breeder has gone far astray, and, having succeeded for a few generations in making progress, has failed to understand why he may not continue to be successful.

Thus we find that attempts to modify a character by selection within pure lines within a small number of generations have almost universally failed, and that the few apparent results to the contrary must be looked upon with the suspicion that the population was a mixed race and that Mendelian principles applied.

Once again we are led to propound with still greater emphasis the question, "How then has evolution taken place?" "In what manner have organisms acquired their characters?" "Is it possible to escape the difficulties that confront the investigator on every side?"

The application of statistical methods to problems of biology has provided and will continue to provide facts of decided value obtainable in no other way. Nevertheless the use of data "en masse" uncoordinated with experimental methods cannot solve the riddle of existence so easily as some, at an earlier period at least, would have had us believe. There are, however, certain investigations which seem fundamental to the problem under discussion and which may well be approached from the statistical side. These relate to the influence of factors composing the environment as well as to the part played by asexual and sexual reproduction, corresponding in reality to close and cross breeding, upon variability and size in organisms.

Some studies undertaken in 1890 in connection with the influence of food supply on variability[1] based upon the comparison of groups of *Chrysanthemum leucanthemum* L., the common white daisy, as well as *Perca flavescens* Mitch., the yellow perch, indicated that the difference in variability as evinced by the Coefficient of Variation for a group with a maximum food supply as compared with a group having a minimum food supply was extremely small and well within the limits allowed by the probable error. From this the inference was that external stimuli played an extremely unimportant part under normal conditions as a cause producing variability in general.

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[1] Science, p. 728, 1907.

Attempts were subsequently made to obtain data bearing on the results of close breeding and cross breeding which differ merely in degree from parthenogenesis and amphimixis. The question is an important one for if cross breeding is only valuable in sorting out and combining existing characters, it not only obscures the facts, a knowledge of which is necessary before progress can be made in building up new characters, but results in no actual advancement in cumulative evolution. Here the material for study consisted of scalariform or cross bred, and lateral or close-bred (parthenogenetic) zygospores—in reality the young individuals—of the common filamentous green alga *Spirogyra inflata* (Vauch). Upon applying statistical methods the close bred zygospores were found to be 33 per cent. more variable[2] in size as well as larger, both in length and actual volume, than the cross bred zygospores. The results were not in accord with the general belief that cross breeding increased variability, although studies by Warren, Kellogg, and Casteel and Phillips had pointed out that this belief was not substantiated by facts, which however did not actually warrant the idea that variability was decreased in cross bred forms. The studies on the zygospores also suggested that sex existed primarily for the purpose of limiting variability, an hypothesis proposed on purely theoretical grounds by Hatschek in 1887. Another conclusion from the same investigation was that in connection with the origin of death[3] and which may be mentioned here. This may be summarized by stating that death apparently occurs as the result of the continually forming body cells becoming so variable through absence of control by amphimixis that eventually some one group of functional importance fails to meet the limits imposed by the environment. In consequence of this the group together with the remainder of the colony—the individual—perishes.

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[2] Science, p. 907, 1908.

[3] Science, p. 935, 1912.

In connection with the difference in the variability of close bred and cross bred zygospores it seems quite evident that the result is brought about by some factor other than the environmental stimuli are assumed to produce fluctuation inasmuch as the material was homogenous in every respect with the exception of the manner of reproduction. The question is a difficult one, however, not to be settled by a single investigation giving positive results, and because of its importance should receive attention.

In reference to those who hold to the belief that cross breeding, conjugation, and amphimixis—the three terms differ merely in degree—increase variability, it may be well to inquire concerning some of the evidence instrumental in formulating the opinion. Without any desire to be critical and at some risk of exceeding the controversial bounds which a paper of this nature allows, a few of the more important investigations touching upon the subject will be considered.

Castle, Carpenter, Clark, Mast, and Barrows (1906) in a series of observations as to the effect of cross breeding and close breeding on the variability and fertility of the small fruit fly, *Drosophila ampelophila* Loew. stated that "inbreeding did not affect the variability in the number of teeth on the sex-comb of the male, nor the variability in size," basing the opinion on the Coefficient of Variation in the number of spines and the Standard Deviation in the length of the tibia. In the former case the data certainly do not permit a clear conclusion one way or the other, but the value of the character which represents the sum of the teeth of the sex combs of the right and left proximal tarsal segment, where there is undoubtedly correlation, may be open to objection under any consideration. If however, from the data presented in the study the value of the Coefficient of Variation is computed, which strange to say was not done in the original paper, and thus allowance made for the larger mean length of tibia in the cross bred forms, the inbred forms exhibit a variability relatively 68 per cent. greater than the cross bred forms.

Jennings (1911) in summarizing breeding experiments with Paramecium concluded that "The progeny of conjugants are more variable in size and in certain other respects than the progeny of the equivalent non-conjugants," and farther, "Thus conjugation increases variation." Continuing the investigations, he subsequently stated (1913) that conjugation increased the variation in the rate of reproduction. While the careful methods used by Jennings have brought to light many interesting and valuable facts, it is evident from a critical consideration of the data that they by no means allow such conclusions.

So far as size is concerned in a Pure Race, non-conjugants and their progeny were more variable than conjugants and their progeny as noted in table No. 28. In a Wild Race the progeny of the conjugants were slightly more variable than the progeny of the non-conjugants as illustrated in table No. 32, although in two of the nine generations tabulated the variability was greater in the case of the non-conjugants. So far as the rate of fission is concerned the evidence is unmistakable that the conjugants were more variable. There is, however, a comparatively simple explanation for this when the statement is noted that the number of abnormal individuals as well as the mortality was greatest among the progeny of the conjugants. With a considerable number of forms thus having a lower rate of fission, one could expect nothing except a greater variability in the rate of fission.

Considering the data obtained in the breeding of plant forms where the assumption has long been prevalent that hybridization increases variability, it is found that the variability of the F_2 generation as compared with the F_1 generation or a single parental generation may be increased but that the actual variability as a whole is not increased when the united parental types are taken into account. This may be illustrated by utilizing data from an interesting paper by Hays (1912) dealing with correlation and inheritance in tobacco. Here calculating the constants for two parental types combined (401 and 403) in respect to number of leaves and height of plant it is found that the Coefficient of Variation has decidedly decreased through the hybridization, although the number of combinations (amphimutations) have increased.

There exists the possibility, however, that variability will appear to be increased when forms having the same phenotype but different genotypes are bred together. Such a condition may be illustrated by the two white strains of sweet peas crossed by Bateson which produced purple flowers in the first (F_1) hybrid generation, and purple, pink, mixed, and white flowers in the second (F_2) hybrid generation. New combinations occur, but there is evidence of no increase in unit characters nor is there any actual increase in the variability with which we are concerned.

Turning for a moment to size characters the influence of cross breeding or conjugation is of decided interest inasmuch as facts bearing on the solution of the problem as to how size may be increased to the physiological limit, even though the results hold for a single generation, have the greatest practical value for the future of agriculture and animal breeding.

It should first be noted that size in a unicellular organism is dependent on the absolute size of the individual cell with a limit undoubtedly imposed by laws governing the ratio between volume and surface in connection with osmosis. In multicellular organisms, however, size characters may depend either upon the size or the number of the component cells or upon both factors. This distinction possibly explains an apparent diversity in results obtained in the two groups.

Darwin, Mendel, and others who have seriously considered the question have recognized that hybrids among plant forms in particular usually grew to a larger size than either parental form, a result undoubtedly due to the greater rapidity of cell division and consequently greater number of cells as conjectured by East. In the study of zygospores of Spirogyra it was therefore noticed with some interest that the cross bred forms were smaller than the close bred forms both so far as length and volume were concerned. Jennings (1911) in his study of Paramecium reached a contrary conclusion, stating that "The progeny of conjugants * * * were a little larger than the progeny of non-conjugants and the difference appears to be significant." This is correct merely in reference to length, however, and that it is not true for actual size as indicated by volume is evident on applying the formula for the volume of a prolate spheroid ($V = 1\text{-}6\ \Pi l d^2$) by which it may be demonstrated that the non-conjugant forms, while smaller than the others at the beginning of the experiment, actually became larger. Thus in agreement with the zygospores of Spirogyra, conjugation decreased size.

The question immediately occurs as to the cause of the increased size and vigor among cross bred multicellular organisms when the evidence indicates that cross bred unicellular forms are smaller instead of larger. Some investigations that I have undertaken indicate an answer apparently meeting the conditions. While sufficient control experiments have not been made to venture more than a provisional opinion, the data suggest that the cells of cross bred multicellular organisms are actually smaller than the cells of inbred or Pure Line forms, and that the more rapid division is a function of the greater ratio surface has to volume in a small cell with the better opportunity thus obtained for increased metabolism.

That there is need of farther investigation on size and variability in pure lines and in cross bred forms through the application of statistical methods in connection with the maintenance of pedigree through long series of generations seems evident. Eventually theories will make way for facts which will allow a proper perspective.

Where do the results presented in the preceding pages lead us? Does their value so far as their bearing upon the production of new and transmissible characters that will build up an organism in a required direction, consist merely in the formulating of hypothesis after hypothesis which as investigations proceed will in turn make way for other hypotheses equally transient? Or on the other hand do they mark a definite progress along the lines we are endeavoring to follow, namely the control of evolution?

Before attempting a reply which must prove more or less unsatisfactory to those looking forward to immediate results, it seems advisable to pause for a moment and in the light of the preceding discussion consider the types of differences—variations—that exist in so far as they may affect the result with which we are chiefly concerned.

Beginning at an early period in the history of evolution with the idea that all variations might be inherited, results soon suggested that the characters due solely to surrounding influences, such as food supply, etc., were not thus transmitted. These were called *fluctuating variations.* On the other hand variations due to the structural changes in the germ cells were passed on from one generation to another have been spoken of as *inherited variations.*

The evidence at present indicates that farther subdivisions must be made and that normal inherited variations consist of two quite distinct classes, the variations where the results are due to the interaction of factors in accordance with Mendelian principles and which, adapting a term used by Plate (1913) may be called *amphimutations,* inasmuch as the condition is due to the mingling of two lines of descent, the other all variations as a class in which the results—evolution in the abstract—are due to a series of units added as increments, may well be called *cumulations.* It is quite evident that the term "mutation" cannot continue to include both types. As a co-ordinate term fluctuating variations may be spoken of as *fluctuations.*

Under abnormal variations must be classified forms ranging from monstrosities to slight departures from the ordinary condition, some of which are undoubtedly due to the losses or modifications of unit characters through the action of extraordinary stimuli, while others may be due to abnormal and unequal distribution of chromosones occurring at the time of their division. The *idiomutations* of Plate are here included. Once more, however, there should be emphasized the lack of any evidence as to any character, unit, factor or gene actually new thus being added.

The answer to the questions as to the progress made in the application of evolution to the creation of new forms rests in the statement that the attack on the problem is becoming more concentrated. The selection of fluctuations has been tried and has failed. Efforts by means of amphimutations end in a maze of circles with no evident progress. *Idiomutations,* so far as one may judge from the evidence, present retrogression rather than advancement. It is by means of pure lines under normal conditions that one may search with advantage for cumulations, the units by which to build the new. There the evidence will be unobscured either by the pyrotechnic of Mendelian formulae, or by the facticiousness of abnormal stimuli. Fluctuations will be present but statistical methods will permit their evaluation. Should the measurement of the mean in the tenth or even the one hundredth generation present no advancement, failure is not necessarily implied. Nature has devoted fifty millions of years or more to her work. There should be no discouragement if a few paltry years of investigation fail in duplicating her methods.

It is with a feeling not unmixed with pessimism, however, that one views the conditions under which work of the character outlined must evidently go forward. Those engaged in teaching have with a few exceptions time for little more than an occasional investigation of limited scope, particularly in a field which requires continuous application. Governmental departments where it could best be taken to a successful issue have only too often been subservient to political policies demanding immediate results. An ounce of compiled compendium is—to them—worth more than a ton of painstaking investigations which makes an advance on a theory. Looking a few generations into the future is not their concern. Exceptional work has been done by those more or less closely connected with certain State Agricultural Experiment Stations. The names of East and Hayes, of Connecticut, Pearl, of Maine, Emerson, of Nebraska, Dean Davenport, Rietz and Smith, of Illinois, are familiar to all interested in the application of the principles of evolution. One often conjectures, however, as to the extent to which some of the most valuable contributions are in reality "by-products" of investigations meeting the approval of the "Missouri" type of legislator. A remedy for such conditions clearly lies in endowments either in connection with universities, or through the establishment of the specialized private institution.

That the problem of applied evolution will eventually be solved there can be no doubt. That it will occur in our generation may only be expressed as a hope.

Constitution

Adopted November 28, 1908.

ARTICLE I, NAME.

This society shall be known as the "Ohio Academy of Science."

ARTICLE II, OBJECTS.

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

ARTICLE III, MEMBERSHIP.

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

2. *Resident Members* shall be persons interested in scientific work and resident in the State of Ohio.

3. *Corresponding Members* shall be persons interested in science and not resident in the State of Ohio.

4. *Honorary Members* shall be persons distinguished for their attainments in science and not resident of the State of Ohio. Their number shall not exceed twenty-five.

5. *Patrons* shall be persons who have bestowed important favors upon the Academy as defined in the By-Laws.

6. Corresponding Members and Honorary Members are not entitled to vote or to hold office in the Academy.

ARTICLE IV, OFFICERS, COMMITTEES, ETC.

1. The officers of the Academy shall consist of a President, a Vice-President of each Section organized, a

Secretary, a Treasurer, a Librarian, and three trustees of the Research Fund.

2. The President, Secretary, and Treasurer, together with two elective members, shall constitute an *Executive Committee.*

3. The *Publication Committee* shall consist of three elective members.

4. The *Program Committee* shall consist of the Secretary and the Vice-Presidents of the various sections.

5. Three trustees elected in accordance with section 14 shall be designated as *Trustees of the Research Fund.*

6. *The President* shall discharge the usual duties of a presiding officer at all meetings of the Academy and of the Executive Committee. 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 annual meeting of the year for which he is elected.

7. The duties of the President in case of his absence or disability shall be assumed by one of the Vice-Presidents designated by the Executive Committee.

8. *The Vice-Presidents* shall be chairmen of their respective Sections. They shall further, with the Secretary acting as chairman, constitute a Program Committee to arrange for the presentation of papers at the annual meeting.

9. *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 co-operate with the President in attending to the ordinary affairs of the Society and also attend to the preparation, printing and mailing of circulars, blanks and notifications of elections and meetings. The Secretary shall superintend printing ordered by the Executive Committee, which is not within the province of

the Publication Committee, and shall have charge of its distribution under direction of the Executive Committee. The Secretary shall also be chairman of the Program Committee as constituted in Section 4.

10. *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.

11. *The Librarian* shall have charge of the distribution of publications, and in so far as practicable, shall arrange exchanges with other societies. He shall furthermore act as custodian of all property belonging to the Society. All books, periodicals, pamphlets, etc., belonging to the library shall be accessible for consultation by members of the Academy under such regulations as may be provided.

12. *The Executive Committee* is clothed with executive authority and with legislative powers of the Academy in the intervals between the regular annual meetings. No extraordinary act of the committee shall however remain in force beyond the next annual meeting unless ratified by the Academy. The Executive Committee shall receive nominations for membership and on approval shall submit such nominations to the Academy for action. It shall have the power to fill vacancies *ad interim* in any of the offices of the Academy.

13. *The Publication Committee* shall have charge of the preparation and publication of the Annual Report and of such other papers as may be considered by them desirable to have printed.

14. *The Trustees of the Research Fund* shall be three in number. They shall have charge of the allotment and distribution of the income or of the principal of the Research Fund.

15. *Terms of Office.* The President, Vice-Presidents, Secretary, Treasurer, and Elective Members of the Execu-

tive Committee and Publication Committee, shall be elected annually at the annual meeting, and shall be eligible to reelection without limitation, with the exception of the President, who shall not be elected for successive terms. The Librarian shall be elected for a period of three years. The Trustees of the Research Fund shall be elected for a term of three years. This shall be so arranged however that the expiration of the terms of office of no two trustees occurs in the same year.

ARTICLE V, VOTING AND ELECTIONS.

1. *Nomination of Members.* (a) Nominations for Resident Membership shall be made by two Resident Members in accordance with a form provided by the Executive Committee. One of such Resident Members must be acquainted with the nominee and his qualifications for membership. The nominations shall be considered by the Executive Committee and if approved by each of its members, shall be submitted to a vote of the Academy at any annual or special meeting.

(b) Nominations for Corresponding Members, Honorary Members, and Patrons, shall be made by the Executive Committee of the Academy, the elections to take place as in the case of Resident Members.

2. *Election of Members, etc.* All elections shall be by ballot. To elect a Resident Member, Corresponding Member, Honorary Member, or Patron, shall require the assent of three-fourths of all Resident Members voting.

3. *Expulsion.* Any member may be expelled by a vote of nine-tenths of all members present at any annual meeting, provided notice that such a movement is contemplated, be given to members at least three months previous to such action.

4. *Election of Officers.* Nominations for office shall be made by a nominating committee as provided in the By-Laws. The nominations shall be submitted to a vote of

the Academy at its regular annual meeting. The officers thus elected shall enter upon their duties at the adjournment of the meeting.

ARTICLE VI, MEETINGS.

1. *Meeting.* The Annual Meeting shall be held during the Thanksgiving recess, the place being determined by the Executive Committee and announced by circular at least thirty days before the meeting. The details of the daily session of each meeting shall be arranged by the Executive Committee, and announced in the official program immediately before the meeting.

2. *Field Meeting.* A field meeting may be called at the option of the Executive Committee.

3. *Special Meeting.* A special meeting of the Academy may be called by the Executive Committee upon the written request of twenty Resident Members.

4. *Quorum.* Fifteen Resident Members shall constitute a quorum for the transaction of business.

ARTICLE VII, SECTIONS.

1. Members not less than fifteen 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 Geology of The Ohio 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 VIII, AMENDMENTS.

1. This Constitution may be amended at any annual meeting by a three-fourths vote of all Resident Members voting, provided that the substance of the amendment shall have been submitted at a preceding Annual Meeting.

By-Laws

CHAPTER I, MEMBERSHIP.

1. No person shall be accepted as a Resident Member or as Corresponding Member unless dues for the year are paid within three months after notification of election. The annual dues shall be one dollar and fifty cents, payable in advance. A single payment of twenty-five dollars however 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 converted into the Research Fund.

3. Non-payment of annual dues shall deprive a Resident Member of taking part in the management and receiving the publication of the Academy. An arrearage continuing over two years shall be construed as notification of withdrawal. The Secretary, Treasurer, and Librarian shall be exempt from the payment of dues during the year in which they hold office.

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

CHAPTER II, OFFICIALS.

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

2. The Treasurer shall give bonds with two good sureties approved by the Executive Committee in the sum of five hundred dollars, for the performance of his duties and the safe keeping of the funds of the Academy. He may at his discretion deposit the funds in a bank, but shall

not invest them without the authority of the Executive Committee. His accounts shall be balanced on the first day of the Annual Meeting of each year.

CHAPTER III, ELECTION OF MEMBERS.

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

2. The form for the nomination shall be as follows:

OHIO ACADEMY OF SCIENCE.

To the committee on Membership..........................191...... I desire to become a member of the Ohio Academy of Science.

Name ....

Address ....

Branches of Science interested in..

Countersigned by Members { ....
....

3. This form when filled is to be transmitted to the Secretary who shall bring all nominations before the Executive Committee at either the Annual, Special, or Field meetings of the Academy, and the Executive Committee shall signify its approval or disapproval of each. The list of candidates approved shall then be presented to the Academy for election.

4. Patrons, Honorary Members, and Corresponding Members shall be nominated by the Executive Committee and shall be elected in the same manner as Resident Members.

CHAPTER IV, ELECTION OF OFFICERS.

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.

2. The Academy shall select by ballot a Nominating Committee consisting of three members who shall nominate a candidate for each office including elective members of the Executive Committee, the Publication Committee, and the Trustees of the Research Fund. Additional nominations may be made by any member of the Academy.

CHAPTER V, FINANCIAL METHODS.

1. No pecuniary obligation shall be contracted without express sanction of the Academy or the Executive Committee. It is understood however that all ordinary expenses in connection with the meetings have the permanent sanction of the Academy without special action.

2. Every creditor of the Academy must present to the Treasurer an *itemized* bill certified by the official ordering it, and approved by the President. The Treasurer may then approve and 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 who are not officers of the society, 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 Chap. II, Sec. 2, of the By-Laws. These Auditors shall examine the accounts and vouchers of the Treasurer and before the adjournment of the meeting shall render a report, and the Academy shall take appropriate action.

CHAPTER VI, PUBLICATIONS.

1. The publications of the Academy are in charge of the Publication Committee.

2. One copy of each publication shall be sent to every Resident Member, Corresponding Member, Honorary Member, and Patron, while each author shall receive thirty copies of his memoir. This provision shall not be under-

stood as including publications in journals not controlled by the Academy.

3. The official organ of the Academy is the Ohio Naturalist under the following terms of agreement:

(a) The Academy shall pay to the Ohio Naturalist seventy-five cents for each subscription sent to members not in arrears for payment of dues.

(b) The Ohio Naturalist shall publish announcements of meetings, list of publications for sale, etc., whenever the Academy desires. Such matter however may be restricted to one-half page of advertising space in any one issue.

(c) The Ohio Naturalist will print papers of from 300-1,500 words presented at the annual meeting provided such papers are submitted in typewritten form within two weeks from the time of adjournment of the meeting, and have been passed upon favorably by the Publication Committee and by the Editor of the Naturalist.

4. The Annual Report of the Academy, including list of officers, list of members, presidential address, and such other matter as the publication committee may determine shall be printed as a separate issue by the publication committee.

5. Papers exceeding 1,500 words may be published at the discretion of the publication committee as a part of the series of Special Papers.

6. The publication committee shall assemble the Annual Report and the Special Papers into volumes of proceedings of convenient size, paged consecutively in each volume, under the general title "Proceedings of the Ohio Academy of Science."

CHAPTER VII, RESEARCH FUND.

1. The Research Fund shall consist of moneys paid by the general public for publications of the Academy, of donations made in the aid of research, and of sums paid

in commutation of dues according to By-Laws, Chapter I, Paragraph 1.

2. Donors to this fund, to the sum of twenty-five dollars or more, shall be entitled without charge, to publications subsequently appearing.

3. The aim of the Academy shall be to accumulate a fund of which the income alone shall be used for the encouragement of research and for the publication of papers bearing upon the development of science in the state.

CHAPTER VIII, ORDER OF BUSINESS.

1. The order of business at the Fall Annual Meeting shall be as follows:

1. Opening.
   a Call to order by the Presiding Officer.
   b Statements by the President.
   c Appointment by the chair of a committee of three on membership. To secure nominations of new members.
   d Appointment by the chair of a committee of three on resolutions.
2. Reports of officers.
   a Secretary.
   b Treasurer.
   c Librarian.
3. Appointment by the Academy of an Auditing Committee of two members.
4. Reports of Standing Committees.
   a Executive Committee.
   b Publication Committee.
   c Program Committee.
   d Trustees of Research Fund.
5. Reports of Special Committees.
6. New Business.
7. Election of Nominating Committee.

8. Report of Nominating Committee and Election of Officers.
9. Election of Members.
10. Report of Committee on Resolutions.
11. Report of Auditing Committee.
12. Unfinished Business.
13. Adjournment.

2. Items of business under 1 to 7 shall be taken up at the first business meeting where possible and be followed by reading of papers. At an adjourned session the order shall be resumed at the place reached on the previous adjournment, but new announcements, motions, and resolutions, shall be in order before the resumption of the business pending.

3. At a Special Meeting or a Field Meeting items of business under 2, 3, 4, except "a," 7, 8, 11 shall be omitted.

4. At any Special Meeting or Field Meeting the order of business shall be 1, followed by the special business for which the meeting was called, and this in turn followed by 9, 12, 13, when advisable.

CHAPTER IX, AMENDMENTS.

These By-Laws may be amended by a majority of those voting at any annual meeting.

Proceedings

of the

Ohio Academy of Science

VOLUME VI, PART 4

Annual Report

Twenty-Fourth Meeting

PROCEEDINGS OF THE OHIO ACADEMY OF SCIENCE
VOLUME VI PART 4

Annual Report

of the

Ohio Academy of Science

Twenty-Fourth Meeting 1914

Organized 1891 — Incorporated 1892

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Date of Publcation, March 27, 1915

Published by the Academy
Columbus, Ohio

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1892.	Columbus.	1904.	Cleveland
1893.	Columbus	1905.	Cincinnati
1894.	Columbus	1906.	Columbus
1895.	Cincinnati	1907.	Oxford
1896.	Columbus	1908.	Granville
1897.	Columbus	1909.	Delaware
1898.	Columbus	1910.	Akron
1899.	Cleveland	1911.	Columbus
1900.	Columbus	1912.	Columbus
1901.	Columbus	1913.	Oberlin
1902.	Columbus	1914.	Columbus

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Total Membership 234

Report of a Meeting of the Executive Committee of the Ohio Academy of Science

On the call of President Mendenhall, a meeting of the Executive committee of the Ohio Academy of Science was held on May 2, 1914, in the Biological building of the Ohio State University. The invitation was extended to the officers of the Academy to meet with the committee.

Professors Mendenhall, Hine, Walton, and Rice, of the committee, were present; also Professors Osborn, Lazenby, Mills, Schaffner, and Cole.

It was unanimously voted that the invitation of the Ohio State University to hold the next annual meeting of the Academy in Columbus be accepted with thanks.

Voted that the Executive Committee recommend to the annual meeting of the Academy the holding of a field meeting during the month of May of 1915.

Voted that the President and Secretary be authorized to appoint a representative to consult with the Secretary of State of Ohio and to take such steps as may be necessary to secure the change of the corporate name of the Academy from "The Ohio *State* Academy of Science" to "The Ohio Academy of Science" in conformity with the revised constitution and the general usage of the Academy. Professor Lazenby was appointed after the close of the meeting.

Voted that the President be requested to communicate with Governor Cox with a view to securing closer mutual relations between the Ohio Academy of Science and the State Government.

A careful discussion of the relations of the Ohio Academy of Science and the Ohio Naturalist showed a general sentiment in favor of a broadening of both scope and title of the Naturalist to correspond with the broadening scope of the Academy, as shown especially in the recent organization of a Section for Physics. As the result of this discussion, it was voted that the recommendation be presented to the publishers of the Ohio Naturalist that the name of that journal be changed for the year 1914-1915 to "The Ohio Naturalist and Journal of Science", with a view to the further change in 1915-1916 to "The Ohio Journal of Science"; also voted that the editor and business manager of the *Naturalist* (both officers of the Academy) be requested to report to the annual meeting concerning the advisability of the financial coöperation of the Academy in the publication of the *Naturalist*.

EDWARD L. RICE, *Secretary*.

Report of the Twenty-Fourth Annual Meeting of the Ohio Academy of Science

The Twenty-fourth Annual Meeting of the Ohio Academy of Science was held at Ohio State University, Columbus, Ohio, on November 26, 27, and 28, 1914, under the presidency of Professor T. C. Mendenhall of Ravenna.

GENERAL PROGRAM

Thursday, November 26.

8:00 P. M.	Informal Gathering of Members. Ohio Union.

Friday, November 27.

8:30 A. M.	Meetings of Committees.
9:00 A. M.	Business Meeting.
10:00 A. M.	Reading of Papers in General Session.
12:00 M.	Luncheon, Ohio Union.
1:30 P. M.	Reading of Papers. Sections of Zoology, Botany, and Geology in Joint Session; Section of Physics in Separate Session.
6:00 P. M.	Dinner. Ohio Union.
7:30 P. M.	Address on "Some Pioneers of Science in Ohio," by Professor T. C. Mendenhall, President of the Academy. Auditorium, Ohio State Archaeological and Historical Society Museum.
9:00 P. M.	Informal Reception and Inspection of Collections. Ohio State Archaeological and Historical Society Museum.

SATURDAY

8:30 A. M.	Adjourned Business Meeting.

9:00 A. M. Lecture on "Hoof and Mouth Disease", by Dean D. S. White of the College of Veterinary Medicine of Ohio State University.

9 30: A. M. Reading of Papers in Sectional Meetings.

MINUTES OF BUSINESS MEETINGS

November 27, 1914.

First business session called to order by President Mendenhall at 9:00 A. M.

After announcements by Professor Osborn, Chairman of Local Committee, the chair announced the appointment of the following committees:

Committee on Membership—F. C. Waite, August Foerste, Frederick C. Blake.

Committee on Resolutions—N. M. Fenneman, Stephen R. Williams, E. L. Moseley.

Committee on Necrology—L. B. Walton, Wm. R. Lazenby, J. A. Culler.

The following Auditing Committee was appointed by the Academy: Frederick C. Blake, Stephen R. Williams.

The following report was presented by the Secretary. After some discussion of the contained recommendations, the report was referred to a special committee for consideration and report during the present meeting. Chair appointed F. C. Waite, Wm. R. Lazenby, N. M. Fenneman, J. A. Culler.

Report of the Secretary

Delaware, Ohio, November 25, 1914.

The work of the secretary is largely routine; but, during the past year, a number of points have arisen on which an expression of opinion by the Academy would be welcome.

In accordance with the instructions of the Academy, a preliminary announcement of the annual meeting was mailed November 1, followed by the program, mailed November 18. Would it be more convenient for the members if these communications were mailed earlier? Should there be a longer interval between the two?

Notices of the annual meeting were sent to the following papers: Columbus Citizen, Dispatch, and State Journal; Cleveland Plain Dealer, Leader, Press and News; Cincinnati Enquirer, Commercial Tribune, Times-Star, and Post; Toledo Blade, News-Bee, and Times. These notices were accompanied with programs and printed statements, prepared by a former secretary, concerning the work and history of the Academy. This statement is now out of print. Does the Academy wish the same revised and reprinted? This is the recommendation of the secretary.

Several suggestions concerning the date of meeting and the arrangement of the program have been received by the secretary and may well be transmitted to the Academy.

Dr. F. D. Snyder, of Ashtabula, protests against holding the meeting on Thanksgiving, when "most" of the members are "entertaining or being entertained", and are "unable to attend the meeting". He urges that some other day, not a legal holiday, "would be much better for the members to attend".

A seemingly unrelated protest from a member of the Section for Geology may well be mentioned in this connection. This is to the effect that the present arrangement of the Friday session makes it necessary for a geologist to suffer a rather large amount of other science in order to enjoy a rather small amount of geology. To the geologists and botanists this difficulty is less serious because of the very close relation of botany and zoology; the physicists have already cut the knot, and are holding a sectional meeting Friday afternoon. Would it be better to hold a single joint session and then dissolve into four sections? Would it not be well for each section to canvass the opinion of its membership on this point and report to the secretary either directly or through its representative on the program committee?

Such a change in the program would also permit at least a partial solution of the difficulty urged by Dr. Snyder. The program, thus shortened, might well begin Friday noon, thus giving greater freedom for the Thanksgiving Day, and still adjourn by Saturday noon.

Another suggestion of a radical change in the date of the annual meeting is contained in a letter from Dean Leutner, of Adelbert College, on behalf of the executive committee of the Ohio College Association. I quote the essential part of his letter: "The Executive Committee of the Ohio College Association is anxious to stimulate interest in the annual meetings which fall regularly in the week preceding Easter, by organizing sectional meetings in the Sciences. Such meetings have been regularly organized for the Modern Language Section, for the Philosophy-Education Section, for the Classical Section, and have as a rule been satisfactory. It has been suggested to me that it might be possible to have the meeting of the Ohio Academy of Science arranged so as to synchronize with the meeting of the Association. Many members of the Association would be interested in the work of the Academy and vice versa". The suggestion deserves the fair consideration of the Academy.

Lastly, this is the twenty-fourth annual meeting, counting the organization meeting of 1891 as the first. Does the Academy desire a special celebration of the Quarter Centennial? If so, when? Either the twenty-fifth annual meeting, next fall, or the completion of twenty-five years of activity, a year later, would seem a logical time for such a celebration. The secretary suggests the appointment of a special committee to consider this matter.

Respectfully submitted,

EDWARD L. RICE, *Secretary*.

The report of the Treasurer was received as follows, and referred to the Auditing Committee.

Report of the Treasurer for the Year 1914

For the year since our last annual meeting the receipts, including balance from last year, have amounted to $362.52, and the expenditures to $277.25, leaving a cash balance of $85.27.

RECEIPTS.

Balances from last year	$ 87 02	
Interest on endowment	2 00	
Membership dues	273 50	
Total		$ 362 52

DISBURSEMENTS.

190 subscriptions to The Ohio Naturalist	$ 142 50	
Printing annual report	85 38	
Miscellaneous expenses	49 37	
Balance December 1, 1914	85 27	
Total		$ 362 52

Respectfully submitted,

JAS. S. HINE, *Treasurer*.

The report of the Librarian was read, adopted, and ordered filed, as follows:

Report of the Librarian.

NOVEMBER 25, 1914.

As Librarian of the Ohio State Academy of Science, I take pleasure in presenting my report upon the condition of the Library of the Academy, as well as a report upon the receipts form the sales of the publications of the Academy and the general expense in the administration of the Library.

Balance on hand, November 25, 1913	$ 56 99	
Cash sales of publications during the year	31 07	
Total		$ 88 06

EXPENDITURES.

Postage on Annual Report	$ 7 95	
Postage on letters and publications sent out	5 72	
Wrapping paper	2 00	
Express and cartage	1 10	
Envelopes	2 71	
Paste, glue, etc	1 50	
Total		$20 98
Balance in the hands of the Librarian		$67 80

During the year the Librarian has set aside an alcove in the new library of the Ohio State Archaeological and Historical Society, and the exchanges of the Academy as far as possible have been placed in this alcove. The greater part of the spare time of the Librarian has been devoted to arranging the sets of the various publications received in exchange and the entire library is now in shape for the members of the Academy to make use of whenever they find it to their advantage to do so.

An itemized list of the publications on hand might be of special interest at this time. This inventory was made November 24, 1914, and we find that special paper No. 15, "The Trees of Ohio", is the lowest one on the list, having only 25 copies. This was occasioned by the rapid sale during the last few years of this publication. The next lowest one is No. 13, "The Protozoa of Sandusky Bay and Vicinity", having 36 copies of this publication. Beginning with special paper No. 1, the Academy has 229 copies, and special paper No. 19, 235 copies. (With the exception of Nos. 13 and 15 the Academy has on hand at least 150 copies of each special paper. Secretary.)

Of the Annual Reports, we have on hand quite a number, beginning with the First Annual. By good fortune, I have been able, within the last few days, to secure quite a number of the First Annual Report without cost, and, at the present time, there are more than 100 of these reports on hand, and I feel that eventually, these early numbers can be increased by careful watch upon the second-hand book stores in the vicinity of the University, as well as other parts of the city. The lowerst number of the Annual Reports, outside of the First Annual Report, is No. 15, having 144 of these reports on hand.

Respectfully submitted,

WM. C. MILLS,

Librarian.

The report of the Executive Committee was received as follows and ordered filed.

Report of the Executive Committee.

DELAWARE, OHIO, November 25, 1914.

A meeting of the executive committee was held in Columbus, May 2, 1914. The minutes of this meeting (read for information) have been printed in the Ohio Naturalist and will appear in the Proceedings of the Academy.

In addition, the executive committee has provisionally elected 3 members, whose names will be presented later for the ratification of the Academy.

Respectfully submitted,

EDWARD L. RICE,
Secretary of Executive Committee.

An oral report was presented by Professor Schaffner for the Publication Committee. The only publication during the past year is the Annual Report. Emphasis was laid upon the necessity for adequate financial provision for the prompt appearance of the publications of the Academy.

The following report of the Trustees of the Research Fund was presented by the chairman, Professor Lazenby, and referred to the Auditing Committee.

Financial Statement of the Emerson McMillin Research Fund, Ohio Academy of Science for the Year 1913-14

RECEIPTS.

Cash on hand, November 10, 1913	$ 179 91
Check from Emerson McMillin, November 12, 1913	250 00
Total	$ 429 91

There have been no bills presented during the year and no money paid out. Balance in Capital City Bank, November 10, 1914, $429.91.

The following assignments have been made:

Jan. 9.	J. S. Hine	$ 50 00
Feb. 10.	F. B. H. Brown	40 00
Feb. 20.	O. W. Pflueger	50 00
Oct. 25.	R. F. Griggs	50 00
	Total	$ 429 91

This leaves an unassigned balance of $239 91.

Mr. Emerson McMillin has forwarded a check of $250 00 for the year 1914-15. This, in addition to the amount reported above, is deposited in Capital City Bank, Columbus.

William R. Lazenby,
Chairman.

The following report was received from the staff of the Ohio Naturalist, to whom had been referred the question of the name, scope, and financial management of the Ohio Naturalist.

Report of Staff of the Ohio Naturalist

Columbus, Ohio, November 26, 1914.

To The Ohio Academy of Science.

Gentlemen:

In consideration of the formation of a section of Physics in the Ohio Academy of Science and the possible addition of other sections outside of natural science and also of the recent organization of the Ohio Biological Survey, the staff of the Ohio Naturalist has voted favorably on the following:

1. That the Biological Club of the Ohio State University continue to publish the Ohio Naturalist under the name "The Ohio Naturalist and Journal of Science" for the present year and the "Ohio Journal of Science" beginning in November, 1915.

2. That the present arrangement in accordance with which the Ohio Naturalist acts as the official organ of the Ohio Academy of Science be continued. If the Ohio Academy of Science can devise means by which it can give the Ohio Naturalist more substantial financial support this can be used to advantage in improving the publication.

3. That for this year the name of the publication be changed to the Ohio Naturalist and Journal of Science and next year to the Ohio Journal of Science.

4. That the Ohio Biological Survey use the Ohio Naturalist and its successor for the publication of papers not considered of sufficient length for publication in the regular Biological Survey Bulletin and that the entire expense of issuing such papers and reprints therefrom be borne by the Biological Survey.

Since all of the organizations mentioned are publishing we believe it is to the best interests of all concerned to agree on a common organ for publication and thus prevent the unnecessary addition of others. The Ohio Naturalist has been in the field for nearly fifteen years and is anxious to expand in order to meet legitimate demands.

Most of the members of the staff have had a meeting with the Executive Committee of the Ohio Academy of Science and have agreed to some of the matters mentioned and they are in operation at the present time.

Respectfully submitted,

CHARLES S. PROSSER,
HERBERT OSBORN,
JOHN H. SCHAFFNER,
JAS. S. HINE.

Voted that the parts of the report relative to name and scope of the Ohio Naturalist be adopted, and that the financial part of the report be referred to a special committee for report at the adjourned session. Chair appointed on the committee Frederick C. Blake, L. B. Walton, Jas. S. Hine.

An oral report was presented by the chairman, Professor Mills, for the Commitee on the Proposed Deposit of the Library of the Academy with the Ohio State University Library. The committee recommended that the library be thus deposited, and presented a statement of conditions mutually agreeable to President Thompson and Acting Librarian Reeder of Ohio State University and to the committee of the Academy. After discussion and slight modification of the conditions (accepted by Mr. Reeder for the University), it was voted to adopt the report of the committee and to authorize the deposit of the Library of the Academy with the Ohio State University Library under the terms of the following agreement.

Agreement Between The Ohio Academy of Science and The Ohio State University Library Concerning the Deposit of the Library of the Academy with the University Library.

(1) The Academy agrees to deposit with the University Library its collection of books, pamphlets, periodicals and other publications, now constituting its library, together with future additions. The Academy also agrees to deposit the surplus stock of its own publications, together with future parts as issued.

(2) The University Library agrees to move the Academy's collection from the Archaeological Museum to the Library Building at no expense to the Academy.

(3) The University Library agrees, for the time being, to keep the library of the Academy as a separate collection.

(4) Ultimately, it is mutually agreed that the library of the Academy shall be classified with, and distributed in the University Library.

(5) The University Library agrees to keep a separate card catalog of the library of the Academy, showing the accession records.

(6) The Academy agrees that the University Library may place in its public card catalogs, such records as will render accessible to the users of the University Library, the resources in the collection of the Academy.

(7) The Academy agrees that the University Library may use its collection for reference purposes and circulation according to library rules.

(8) The University Library agrees to circulate the material in the Academy's collection to the several members.

(9) The University Library agrees to circulate its own books to the members of the Academy in the usual terms of inter-library loans.

(10) The University Library agrees to store the surplus stock of the Academy's publications, and to care for the additions.

(11) The University Library agrees to mail out the publications of the Academy to the several members and to the exchanges.

(12) The Academy agrees to pay the postage, express and freight bills incurred by the University Library in mailing or sending out the various publications.

(13) The University Library agrees to extend the number of exchanges as far as the financial resources of the Academy will permit.

(14) The Academy agrees to furnish sufficient copies of its publications for such exchanges, as far as funds will permit.

(15) The University Library agrees to conduct the sales business of the Academy's publications, and to be responsible for such funds.

(16) The University Library agrees to report at the annual meeting of the Academy concerning the various details inherent in the administration of the Academy's deposit.

(17) The Academy agrees to appoint a Standing Library Committee to advise with the University Library on questions as they arise.

(18) The University Library agrees to bind the volumes in the Academy collection together with future additions as rapidly as its funds permit.

(19) It is agreed that the above arrangements may be discontinued by either party upon one year's notice given at the Annual Meeting of the Academy, at which time a committee of three shall be appointed to determine whatever financial and other adjustments may be involved. The committee shall consist of one member from the Academy, one member from the University, and one outside member selected by the two appointed members. The determination of the committee shall be subject to the approval of the Academy and the University.

President Mendenhall, Special Committee on the Relations of the Ohio Academy with the State Government and with the National Academy of Science, reported progress, and the committee was continued.

Professor Lazenby, Special Committee on the Change of the Corporate Name of the Academy, reported that all legal steps had been completed, and presented to the Academy the certificate of amendment changing the name from Ohio State Academy of Science to Ohio Academy of Science.

Voted that the Academy join with other organizations in extending an invitation to the Central Association of Science and Mathematics to meet in Columbus next year.

The Nominating Committee was elected by ballot, as follows: Herbert Osborn, C. S. Prosser, Frederick C. Blake.

Meeting adjourned to reconvene at 8:30 Saturday morning.

November 28, 1914.

Adjourned Business Meeting called to order by President Mendenhall at 8:30 A. M.

The following officers were nominated by the Nominating Committee and elected by the Academy, the Secretary being instructed to cast the ballot of the Academy:

President—Professor J. Warren Smith, Ohio State University and U. S. Weather Bureau, Columbus.

Vice-President for Zoology—Professor F. C. Waite, Western Reserve University, Cleveland.

Vice-President for Botany—Professor F. O. Grover, Oberlin College, Oberlin.

Vice-President for Geology—Professor C. G. Shatzer, Wittenberg College, Springfield.

Vice-President for Physics—Professor J. A. Culler, Miami University, Oxford.

Secretary—Professor E. L. Price, Ohio Wesleyan University, Delaware.

Treasurer—Professor J. S. Hine, Ohio State University, Columbus.

Elective Members of Executive Committee—Professor C. D. Coons, Denison University, Granville; Professor T. M. Hills, Ohio State University, Columbus.

Member of Publication Committee—Professor L. B. Walton, Kenyon College, Gambier.

Trustee of Research Fund—Professor N. M. Fenneman, University of Cincinnati, Cincinnati.

The following list of members elected by the Executive Committee since the last Annual Meeting was ratified by the Academy.

Chase, H. D., Zoology and Botany, O. S. U., Columbus.

Evans, Morgan W., Botany, Agronomy, General Science, New London.

Knower, Henry McE., Anatomy and Biology, University of Cincinnati, Cincinnati.

The following members were elected by the Academy on the recommendation of the Membership Committee.

Cogan, Eric L., Zoology and Botany, 36 W. 9th Ave., Columbus.

Cottingham, Kenneth C., Geology, 1870 N. 4th St., Columbus.

DeLong, Dwight M., Zoology and Entomology, Dept. of Zoology and Entomology, O. S. U., Columbus.

Gormley, Rose, Plant Physiology, Botany-Zoology Hall, O. S. U., Columbus.

Hauck, Charles Wesley, Zoology and Entomology, Walhalla Park Place, Columbus.

Johnson, E. H., Physics, Gambier.

Kurtz, S. Aaron, Botany, Geology, Physics, Chemistry, Archaeology, 525 Rogers St., Bucyrus.

Metzger, Albert C., Chemistry, Ornithology, Geography, 380 Deshler Ave., Columbus.

Morningstar, Helen, Geology, 1275 Franklin Ave., Columbus.

Oliver, Mary H., Zoology, Biology, 186 Sixteenth Ave., Columbus.

Perry, Fred, Botany, Delaware.

Phillips, Ruth L., Biology and Allied Sciences, Western College, Oxford.

Reese, Charles A., Zoology and Entomology, 80 E. 13th Ave., Columbus.

Robinson, J. M., Mt. Victory.

Rood, Almon N., Botany, Phalanx Station.

Seymour, Raymond Jesse, Physiology, Zoology, Botany, Dept. of Physiology, O. S. U., Columbus.

Smith, Roger C., Entomology, Dept. of Zoology, O. S. U., Columbus.

Thayer, Warren N., Geology, Ohio Mechanics Institute, Cincinnati.

Verwiebe, Walter A., Geology, Orton Hall, O. S. U., Columbus.

Walters, Dorothy E., Zoology, 268 W. Fountain Ave., Delaware.

Wiltberger, P. B., Entomology and Zoology, 18311 N. 4th St., Columbus.

The following report was presented by the Committee on Resolutions, and adopted by the Academy.

Report of the Committee on Resolutions.

Resolved, That the thanks of the Academy be tendered to the authorities of the Ohio State University and to the local committee for the arrangement for the meetings and for the use of the buildings and apparatus.

That we thank Mr. Emerson McMillin for the generous continuance of his support of research work in Ohio.

That we thank Professor Mills, who retires from the position of Librarian of the Academy, for his long and efficient services to the Academy.

N. M. Fenneman,
Stephen R. Williams,
E. L. Moseley.

The following report was presented by the Committee on Necrology.

The Report of the Committee on Necrology.

The committee reports the death of only one member of the Academy during the past year, Clarance Breiel of Chillicothe, Ohio, who died October 5, 1914, in Delaware after a short illness with typhoid fever. Mr. Breiel was born in Chillicothe, December 7, 1892. At the time of his death he was a senior in Ohio Wesleyan University and a student assistant in the Department of Zoology. He was a man of attractive personality, the highest character, and marked promise for scientific work. Mr. Breiel was elected to membership in the Academy at the Oberlin meeting in 1913.

W. R. Lazenby,
L. B. Walton,
J. A. Culler,
Committee.

The Auditing Committee presented the following report, which was accepted and ordered filed.

Report of the Auditing Committee.

The Auditing Committee begs leave to report as follows:

The books of the treasurer have been audited, all vouchers have been checked, and the accounts of the treasurer found to be correct and in good condition.

Since there have been no bills as yet paid out from the McMillin Research Fund for the year just closing, it was not necessary to audit the report of the treasurer of this fund.

Respectfully submitted,
F. C. Blake,
S. R. Williams.

An oral report was given by Professor Osborn, Director of the Ohio Biological Survey, outlining the work already accomplished and now in preparation by the Survey.

Voted that E. W. E. Schear be added to the Committee on Catalog of Scientific Journals in Ohio Iibraries.

The following report was presented by the Special Committee on the Report of the Secretary.

Report of Committee on Report of the Secretary.

Your committee finds in this report four matters for recommendation.

1. It is undoubtedly desirable to have on hand copies of a brief printed statement as to the scope of the Academy; and it seems worth while to revise the former statement and print it.

2. A quarter of a century of the Academy's life is worthy of note. The committee recommends that the Twenty fifth Meeting be made an anniversary meeting with some special features.

3. The holding of a field meeting of the entire Academy entails obligations on some members not commensurate with the interests of those members. The committee recommends that each vice-president be em-

powered to arrange a field meeting for the section of science which he represents in April or May, 1915. It is evident that coöperation of two or more sections is possible.

4. The committee feels unable to take the responsibility of recommending as to change of date of meeting. There are varied and to some extent conflicting interests to be considered; and the committee recommends that at the present business session fifteen minutes be given to the discussion of this question, and, if the matter is still in doubt, that a referendum of the entire membership be taken by mail.

Respectfully submitted,

F. C. Waite, *Chairman.*

Voted that the Secretary be authorized to revise and reprint the circular of information concerning the scope of the Academy.

Voted that the Twenty-Fifth Annual Meeting, November 1915, be celebrated as the Quarter Centennial Anniversary of the Academy, and that the details of the celebration be referred to the Executive Committee.

Voted that an informal ballot be taken on the question of the change of date of the annual meeting from Thanksgiving to Easter; also that the Executive Committee be instructed to canvass the sentiment of the entire membership of the Academy and to report at the next Annual Meeting, this action to be considered as notice of proposed amendment of the Constitution. Informal vote showed twenty-seven members favoring change and seven opposing change.

Voted that each vice-president be authorized to arrange for a sectional field meeting in the spring of 1915.

The following report was presented by the Special Committee on the Financial Management of the Ohio Naturalist.

Report of Committee on Financial Management of the "Ohio Naturalist and Journal of Science"

The Committee recommends that

1. The Academy ask the Biological Club to consider under what conditions they would be willing to transfer to the Academy the financial control and publication of the Ohio Journal of Science.

2. A committee of three be appointed at this meeting (to act in case of a favorable report from the Biological Club) to investigate the

cost of publications to the Academy, and the best means of financing the publication, and to report at the next meeting.

F. C. BLAKE,
L. B. WALTON,
JAS. S. HINE.

Voted that the report be adopted. The chair continued the same committee to carry out the recommendations of the report.

Notice was given by the Secretary of proposed amendments of the Constitution to do away with the office of Librarian and to provide for a standing committee on the Library in accordance with the new agreement with the State University Library,—this committee to consist of three members, one to be elected each year for a term of three years.

Voted that a temporary library committee be appointed for the coming year. Chair appointed W. C. Mills, F. O. Grover, E. L. Rice.

Meeting adjourned without determining place of next annual meeting.

SCIENTIFIC SESSIONS

The complete scientific program of the meeting follows:

Presidential Address

Some Pioneers of Science in Ohio. T. C. Mendenhall

Lecture

Hoof and Mouth Disease. D. S. White

Papers

1. Efficacy of Lightning Rods. 15 min. J. Warren Smith
2. Thunderbolt from Whitecliff Bay. 10 min. Katharine Doris Sharp
3. A Preliminary Survey of Plant Distribution in Ohio. 6 min. John H. Schaffner
4. Akron Fishbait Industry. 3 min. Chas. P. Fox
5. The Physiographic Provinces which meet in Ohio. 10 min. N. M. Fenneman
6. Color and Coat Inheritance in Guinea Pigs. 30 min. W. M. Barrows
7. Note on a New Nematode Parasite of Cryptobranchus. 10 min. F. H. Krecker
8. Prediction of Minimum Temperatures for Frost Protection. 8 min. J. Warren Smith
9. Is a Dry Summer and Autumn Apt to be Followed by a Wet Winter and Spring With Possible Floods? 10 min. J. Warren Smith

10. Comparative Rate of Growth of Certain Timber Trees. 8 min. William R. Lazenby
11. Inheritance of Taillessness in the Cat. 5 min. W. M. Barrows and C. A. Reese
12. The Cause of Milk Sickness and Trembles. 15 min. E. L. Moseley
13. Notes on Euglenoidina. 5 min. L. B. Walton
14. Recent Eruptions of Mount Lassen. 15 min. (Lantern.) Thos. M. Hills
15. Glaciation in the High Sierras. 15 min. (Lantern.) Thos. M. Hills
16. Inheritance of Weights in Tomatoes. 8 min. (Lantern.) Fred Perry
17. The Municipal Care of Shade Tress. 25 min. (Lantern.) J. S. Houser
18. Influence of Glaciation on Agriculture in Ohio. 8 min. (Lantern.) Edgar W. Owen
19. The Reflection of X-rays and Gamma Rays from Crystals. 20 min. (To be followed by discussion.) S. M. J. Allen
20. A Class Demonstration of the Peltier Effect. Experimental. 10 min. J. A. Culler
21. Behavior of the Arc in a Longitudinal Magnetic Field. 5 min. R. F. Earhart
22. Effect of Heat Treatment on the Physical Structure, Permeability, and Hysteresis of Steel. 10 min. R. J. Webber
23. The Electron Theory of Metallic Conduction. 20 min. (To be followed by discussion.) A. W. Smith
24. The Effect of Changes in Water Resistance and Dielectrics on the Vibrations of a Lecher System. 10 min. Geo. W. Gorrell
25. Exhibit of Apparatus for Electric Waves: (1) Drude Apparatus for Refractive Index of Electric Waves. (2) A Wavemeter for Wireless Frequencies. 8 min. A. D. Cole
26. Some Additions to the Known Orthopterous Fauna of Ohio. 5 min. W. J. Kostir
27. Ohio Spiders. 5 min. W. M. Barrows
28. The Egg Capsules of a Bdellodrilid on the Crayfish. 10 min. (Lantern.) Stephen R. Williams
29. Observations on the Life Histories of Jassidae and Cercopidae. 10 min. (Lantern.) Herbert Osborn
30. Habits and Food of the American Toad. 10 min. ReesPhilpott
31. Note on the Occurrence of Demodex folliculorum var. bovis in Ohio. 10 min. D. C. Mote
32. Arrangement of the Muscles in the Mouth Parts of Embryo Cockroaches and its Bearing on the Phylogeny of the Hexapoda. 6 min. L. B. Walton
33. Winter Record of King Rail in Ohio. 3 min. Edward L. Rice
34. On the Synthesis of Proteins. 10 min. A. M. Bleile
35. Additions to the List of Heteroptera of Ohio. 3 min. Carl J. Drake

36. The Cranial Nerves of an Embryo Shark. 15 min. F. L. Landacre
37. Myxomycetes of Northern Ohio. 5 min. E. L. Fullmer
38. The Forest Types of the Ohio Quadrangle. 8 min. Forest B. H. Brown
39. New and Rare Plants Added to the Ohio List in 1914. 5 min. John H. Schaffner
40. A Provisional Arrangement of the Ascomycetes of Ohio. 10 min. Bruce Fink
41. The Collemaceae of Ohio. 15 min. (Lantern.) Bruce Fink
42. Notes on Ohio Higher Fungi. 5 min. Wilmer G. Stover
43. The Leaf Mold Disease of Tomato (Cladosporium fulvum). 10 min. Wilmer G. Stover
44. Summit County Marl. 3 min. Chas. P. Fox
45. History of the Olentangy River Below Delaware, Ohio. 15 min. L. G. Westgate
46. The Physiography of Mexico. 15 min. Warren N. Thayer
41. Notes on Some Richmond Fossils. 10 min. (Lantern.) W. H. Shideler
48. The Classification of the Niagaran Formations of Western Ohio. 10 min. Charles S. Prosser
49. The Defiance Moraine in Relation to Pro-Glacial Lakes. 10 min. (Lantern.) Frank Carney
50. Some of Dr. H. Herzer's Last Fossil Descriptions. 5 min. W. N. Speckman
51. On the Origin of Oolite. 10 min. (Lantern.) Walter N. Bucher
52. Magnetic Rays. 20 min. (To be followed by discussion.) L. T. Moore
53. On the Free Vibration of a Lecher System. 10 min. F. C. Blake and Charles Sheard
54. Measurements of the Magnetic Field. 10 min. (Lantern.) Samuel R. Williams
55. On the Radioactive Deposit from the Atmosphere on an Uncharged Wire. 10 min. S. M. J. Allen
56. Demonstration of Simple Harmonic Motion on Rotation Apparatus. 5 min. Charles Sheard

Demonstrations

1. A Nematode Parasite of Cryptobranchus. F. H. Krecker
2. Cross Sections Illustrating Rate of Tree Growth. William R. Lazenby
3. Varieties of Domestic Guinea Pigs. Tailless Cat. W. M. Barrows
4. Orthoptera not Hitherto Recorded from Ohio. W. J. Kostir
5. A Scale of Ohio Forest Types to Indicate the Fertility of Soil for Agricultural Crops. Forest B. H. Brown
6. Photographs of Leaf Hoppers and Frog Hoppers. Herbert Osborn

President's Address

SOME PIONEERS OF SCIENCE IN OHIO

T. C. Mendenhall

The Pioneers of Science in Ohio were also pioneers in the more common meaning of the word. With few exceptions they lived their lives during the first three quarters of the nineteenth century. The period of their activity extended from that of the hardy frontiersmen through the political turmoil and sectional bitterness of the middle of the century, culminating in the civil war, well on into the last quarter when the thinking portion of mankind was startled into a recognition of the significance of science by the revolutionary character of its numerous applications.

There was little specialization in those early days. Science itself had not yet specialized in any great degree. Those were the happy days when men engaged (usually only during their "spare hours") in exploring the mysteries of nature, might meet in groups and discuss the latest news from the domain of astronomy, botany, chemistry, geology or phsics, each having an intelligent idea of what the others were talking about.

Under the conditions prevailing in Ohio during the period under consideration it would presumably follow that the so-called natural history sciences would be most cultivated. For these the field of observation was conterminous with the boundaries of the state and as it was largely an unstudied region their pursuit would offer great attractions. Anything in the way of original investigation in astronomy, barring the purely mathematical side of that subject, would require an observatory; for chemical or physical research at least a small room set aside for the work must be available, together with a meagre supply of such apparatus as might be obtained after long delay from eastern cities, generally to be supplemented by the ingenuity and mechanical skill of the worker. It will surprise those not familiar with the subject to learn that during this period in spite of these material obstacles the actual contribution to our knowledge of these three more exact sciences, though less in quantity, ranks as high in quality as the larger output of the naturalists; and that the most potent instrument for scientific research produced in the nineteenth century, today in use in one form or another in every laboratory in the world, was first imagined, constructed and used by one of the pioneers of science in Ohio.

In attempting to present to the members of the Ohio Academy of Science some account of their intellectual ancestry, I am much embarrased by the large amount of available material. Limitations of time and space forbid an exhaustive treatment of the subject and for details regarding the published contributions to science of the men whose lives I shall briefly sketch, I must refer you to the archives of the several grand divisions to which they refer.

To the present generation with its restless activities and its acute specialization many of them are unknown, even by name, in spite of the fact that the results of their labors are every day utilized and builded upon. It was my privilege to know many of them personally and if I am correct in believing that Time and Circumstance developed in them a more pronounced individuality than is common at the present day, some emphasis upon their personality and the conditions under which they worked will not be unwelcome.

During nearly all of the nineteenth century there were in Ohio three well defined loci of scientific activity, corresponding approximately to the concentration of population at Cincinnati, Columbus and Cleveland. In some respects a geographical is more convenient than a chronological grouping, but I shall not adhere closely to either.

My first "pioneer" is one who has no claim whatever to be found in such good company except that he was the author of a theory of the form and figure of the earth so extravagant and improbable that it brought Ohio science in the very beginning into great but most undesirable notoriety. As far as can be ascertained John Cleves Symmes, who invented and exploited the theory that the earth consisted of seven concentric spheres with large openings at each pole for the admission of sunlight, gave no other evidences of an unbalanced mind. Nephew and namesake of the famous jurist who founded the city of Cincinnati, he was himself distinguished as an officer in the army during the war of 1812. At the age of thirty-eight years he made public his singular hypothesis regarding the structure of the earth, calling at the same time for one hundred volunteers to accompany him on an expedition, starting from Siberia with reindeer and sledge in search of the opening to the first shell. On the inner concave surface of this he engaged to find a warm and rich land, stocked with vegetables and animals of known and unknown variety, including man. While in general this doctrine was received with ridicule there were numerous converts among people usually thought to be intelligent. Capt. Symmes died in 1829, but an ardent disciple named Reynolds continued the propaganda and was successful in receiving financial support. With his backer and convert, a Dr. Watson of New York, he sailed in the autumn of 1829 for the southern gate to Symzonia or Symmes's Hole (as it was variously called, according to the state of mind of the speaker or writer) which they fully expected to find, in accordance with the theory in latitude 82° South. After many privations and adventurous escapes the expedition was admitted to be a failure and the explorers turned their faces homeward. At Valparaiso, Chili, their seamen mutinied, put them ashore and sailed off on a voyage of piracy. Some years later Reynold reached New York and afterwards met with success in exploring the earth through the more promising method of organizing mining companies.

As Symmes's principal argument in support of his theory was that a solid earth inhabited only on the outside was an unpardonable waste of matter and space, he may be regarded as the unrecognized forerunner of our modern economy and efficiency expert.

Over the grave of Captain Symmes in the old burying ground at Hamilton, Ohio, was placed a monument consisting of a shaft bearing a hollow globe, which may still be found by the curious.

Fortunately the reputation of Cincinnati as a literary and scientific centre rests on something more substantial than the work of this erratic geophysicist. Indeed very important work in Geodesy and Astronomy was done there at a very early day by Col. Jared Mansfield, an officer of the Engineer Corps of the U. S. Army who, having been appointed by Thomas Jefferson Surveyor General of the Northwest Territory, established a small observatory at his residence in Cincinnati for the purpose of determining latitude and longitude and establishing the primary meridian on which is based the admirable system of land surveys covering the great north-west. This observatory was one of the very first in the United States and during several years important observations were made there. Col. Mansfield's residence in Ohio was only temporary though it covered nine years, from 1803 to 1812. Our city of Mansfield was named in his honor and his son, E. D. Mansfield became one of the most widely-known citizens of the State, famous as an author and publicist.

From among many Cincinnatians quite worthy of consideration I select a quartet of the most brilliant, who enjoyed a high reputation among their peers in both Europe and America. These were John Locke, Ormsby M. Mitchell, Daniel Vaughan and J. B. Stallo, whose names, no doubt, have an unfamiliar sound to many members of the Academy. The earliest in point of time was Locke; the latest, Stallo, and although their joint lives covered somewhat more than a century, for nearly twenty years the four were contemporaneous residents of Cincinnati. John Locke was a native of Maine, born in 1798. Graduated from Yale College in 1819, he became geologist to a government exploring expedition and after work in the territory of the Ohio, he settled in Cincinnati where he spent the remainder of his life and where his most important work was done. He was appointed professor of chemistry in the Ohio Medical College, but while an ardent student of chemistry, botany and geology, Locke was by nature a physicist and his reputation rests mostly on his contributions to physical science.

He was a pioneer student of electricity and magnetism, his observations of terrestrial magnetism being especially important. He designed and constructed new and original forms of apparatus for physical research and it was probably this phase of his work that was of greatest value to science. Among other devices, special mention should be made of the very ingenious and useful hand-level, generally known as Locke's level, of inestimable value in geological reconnoissance and in the exploration of a mountainous or hilly country. He is credited with the invention of a gravity escapement for clocks of the highest precision which has never been surpassed in excellence, and to him unquestionably belongs the design and invention of the Electric Chronograph. This he brought out about 1848 and for the first completed model the United States government paid him ten thousand dollars. What the microscope is for space and the balance for mass measurement, the Electric Chronograph is for time and its use is now almost co-extensive with that of the balance. Locke died in 1856. During his life he made many valuable contributions to scientific journals, had published many volumes and was a member of numerous learned societies in this country and in Europe.

The story of the life of Ormsby M. Mitchell, Locke's contemporary, associate, and sometimes bitter rival, is full of interest and incident. Born in Kentucky in 1810, of Virginia stock, at the age of four years he was brought by his parents to Lebanon, Ohio. At the age of fifteen with his knapsack on his back, as became a nascent soldier, he started for the military Academy at West Point, travelling a good part of the way on foot and reaching his destination, the youngest member of his class (which included Robert E. Lee and Joseph E. Johnston) as well as, no doubt, the poorest, for he had but twenty-five cents left in his purse.

After a few years service in the Army he resigned, settled in Cincinnati; studied law and was admitted to the bar. His fondness for exact science soon drew him away from the legal profession, and he became Chief Engineer in the construction of the Little Miami Railroad. In 1836 he "found his pace" as professor of astronomy, mathematics and natural philosophy in the College of Cincinnati; an institution long ago extinct. During the discharge of his duties as professor of astronomy, Mitchell conceived the idea of having an astronomical observatory in Cincinnati. At that time there was no observatory really worthy of the name in America; no telescope of more than a few inches aperture and practically no interest in the science of astronomy among the people generally. Mitchell possessed a rare power of exposition. His lectures were charming in style, excellent in matter and clear in presentation. In the spring of 1842 he gave in the College hall a series of six lectures on astronomy of such rapidly increasing popularity that the last of the series was given in one of the great churches of the city before more than two thousand enthusiastic listeners. At the end of this lecture he presented his project for the building of a great Observatory, with an appeal for voluntary contributions from the people of Cincinnati. A fund for the purpose was to be raised by the issue of "shares" of twenty-five dollars each. Three hundred shares were soon subscribed for and Mitchell went to Europe to visit astronomical observatories and to arrange for the purchase or construction of an equitorial telescope. Under the inspiration of this visit his ideas expanded wonderfully and he did not return until he had tentatively contracted for a twelve inch glass, the cost of which was nearly double the amount previously estimated as sufficient to cover both instrument and building.

Returning to America he found the country suffering from an industrial and financial depression which made it extremely difficult for him to obtain the necessary additional pledges of money to warrant the purchase of this great glass, then one of the largest in existence. Having secured, after a great effort, enough to make the first payment the definite order was sent and a suitable location for a building was donated by Nicholas Longworth. On the ninth of November, 1843, the corner stone of the building was laid by the venerable John Quincy Adams, then in his seventy-seventh year, who delivered an oration which will always be famous in the annals of oratory and of astronomical science.

But the last available and apparently the last collectible dollar had been sent to Munich to pay for the great telescope and only the foundation of the building was laid. Turning all of his private resources into the building fund, Mitchell made an appeal to the intelligent mechanics of the city who had already shown great interest in the work. The response was worthy of the skilled workmen of that period who were something more than "machine tenders." Within six weeks more than a hundred men were at work on the building, men of all trades subscribing for stock and paying for it in labor. When, in February 1845, the great telescope arrived safely in Cincinnati, the building was ready for its reception. Regarding the successful accomplishment of this task Mitchell has left on record a brief statement well worth repeating. He says, "Two resolutions were taken in the outset; *first,* to work faithfully for five years during all the leisure that could be spared from my regular duties; *second,* never to become *angry* under any provocation while in the prosecution of this enterprise."

Soon after this came the burning of the buildings of the Cincinnati College, cutting off his only source of income, a catastrophe which afterwards proved to be, in the interests of astronomy in America, a blessing in disguise. Mitchell now undertook the delivery of lectures on astronomy in all the principal cities of the country. His success was immediate, and so great that an interest in the subject was created among the many thousands of intelligent hearers that was unquestionably the initiative cause of the building of a half dozen splendidly equipped astronomical observatories within the next few years. Twenty years later Americans were in the front rank of the world's astronomers, a position which they have had no difficulty in maintaining from that day to this.

Mitchell contested with Locke the invention of the Electric Chronograph and although its first conception has been generally conceded to the latter Mitchell was probably the first to apply it to astronomical observations.

He was by birth and sympathy distinctly a western man, and was inclined to resent the generally assumed and accepted superiority of the East in matters relating to literature and science. When, after a brilliant success with his course of lectures on astronomy in New Haven, he went to Boston, it was with keen delight that he saw, on entering the large auditorium for his first appearance there, that every seat was occupied and "standing room at a premium." His pleasure was greatly enhanced when he recognized in his audience Professors Bond and Peirce, of Harvard University, the most eminent of American astronomers of that day, who had declared to be absurd and preposterous Mitchell's claim that the precise moment of the transit of a star could be determined by the "Cincinnati Method" to within one one-hundredth of a second. Afterwards he was fond of relating how at the close of the lecture in which he had described and illustrated this method, when a storm of applause burst from the audience, he saw the two Harvard skeptics "standing upon their chairs and clapping for dear life!" "It was", he said, "the supreme moment of my existence."

Mitchell served as director of the Cincinnati observatory, without compensation, for a period of ten years, during which he made many important contributions to astronomical science, especially regarding double stars, nebulae, sun spots and comets, for the study of which the great equatorial was particularly fitted. His more important work included also the invention of an instrument for measuring personal equation and a telegraph determination of the longitude of Cincinnati and of St. Louis, as related to Washington. He was a member of scientific societies in this country and in Europe and the author of several books on astronomy, one of which, the "Planetary and Stellar Worlds" should be read by every lover of that science. On the firing of the first gun of the civil war, in 1861, Mitchell immediately offered his services to the national government and was made Brigadier General of Ohio volunteers. His career as an army officer was brief but brilliant. He greatly distinguished himself in a famous raid into the country of the enemy, during which he seized and held possession of the railroad between Corinth and Chattanooga. In a recent able review of the civil war it is declared that "had Mitchell been properly reinforced, as he had expected to be on that occasion, he might have forestalled the later victories of Grant and Sherman." The exploit brought him a commission as Major General and he was given the command of the department of the south, but in October, 1862, "Old Stars" as he was affectionately called by his men, died of yellow fever at Hilton Head.

The third member of our Cincinnati "quartet" Professor Daniel Vaughan, was unquestionably the most profound scholar of the group and it is my great regret that I know so little about him. He was born in Cork, Ireland, about 1818-1821, the date is uncertain. Coming to America at the age of sixteen years, his first occupation was that of a teacher of boys in Bourbon County, Kentucky. From an early age he had been absorbed in the study of mathematics and natural science and lacking books he shortly migrated to Cincinnati for the purpose of utilizing its library facilities which even at that early day were considerable. In Cincinnati he spent the remainder of his life, a recluse, indifferent even to his own bodily comfort and physical condition in, his devotion to his favorite studies.

In order to be fully informed of the results of scientific research throughout the world, he mastered the German, French, Italian and Spanish languages as well as ancient and modern Greek. He was chiefly interested in astronomy in its broader aspects and he discussed the profounder problems of physical science with the deep insight and perfect independence of a strong and original thinker. Of his command of language a competent critic has said, "His writings are marked by a daring boldness and a splendor of diction which reveal the workings of a poetic imagination coupled with a logical reason." He enjoyed an extensive correspondence with learned men at home and abroad and contributed about fifty papers to the scientific journals of this country and of Europe. They bear such titles as "The Doctrine of Gravitation;" "The Cause and Effects of the Tides;" "The Light and Heat of the Sun," etc. He issued in book form "Popular Physical Astronomy — or an Exposition of Remarkable Celestial Phenomena" and on his deathbed he corrected the proofs of an article on the "Origin of Worlds." He died in April, 1879, at the Good Samaritan Hospital in Cincinnati. I remember that at the time of his death there was much newspaper talk of his having died from starvation, and there was sharp comment on the fact that such a thing could occur in the heart of the "Queen City of the West." Investigation proved, however, that he alone was responsible. Intense devotion to and absorption in study led him to neglect the wants of his own body to which he had always been indifferent. Few people in Cincinnati knew of his existence. Of his hermit-like life, one of his few friends, his eulogist, after his death, said: "For his support he lectured on science and gave private lessons in mathematics, astronomy and the languages. He thus managed to eke out a miserable existence and was in almost abject poverty. He lived in a single room, cheap, inaccessible and cheerless. A chair and a bedstead with a pile of rags, a worn-out stove and an old coffee pot with a few musty shelves of books covered with soot were all his furniture. An autopsy revealed the wreck of his vital system and proved that the long and dreadful process of freezing and starving the previous winter had dried up the sources of life. Yet he was the only man among the hundreds of thousands of our people whose name will survive the next century."

In sharp contrast with the life of this martyr to science is that of Johann Bernhard Stallo, physicist, philosopher, great lawyer and distinguished diplomat. Arriving in Cincinnati from Germany, in 1839, at the age of sixteen years, he quickly found employment as a teacher in a private school, for his scholarship, even at that early age, embraced ancient and modern languages, mathematics, science and philosophy. Admitted to the bar at the age of twenty-four years, a judge of the Cincinnati Court of Common Pleas at thirty, he soon resumed the active practice of his profession, winning a reputation as one of the ablest and most brilliant attorneys of the Mississippi Valley. His legal arguments were remarkable for their forceful logic and scholarly presentation of facts and authorities. Throughout a busy life as a lawyer he kept up his scientific and philosophical studies. As early as 1848 when only twenty-five years of age he had published a volume which he had ambitiously christened, "General Principles of the Philosophy of Nature." A third of a century later on the publication of his second book, the result of his matured studies of the fundamental principles of physical science, he wrote of the first as follows:—"I deem it important to have it understood at the outset that this treatise is in no sense a further exposition of the doctrines of a book, "The Philosophy of Nature" which I published more than a third of a century ago. That book was written while I was under the spell of Hegel's ontological reveries, at a time when I was barely of age and still seriously affected with the metaphysical malady which seems to be one of the unavoidable disorders of intellectual infancy. The labor expended in writing it was not, perhaps, wholly wasted and there are things in it of which I am not ashamed even at this day; but I sincerely regret its publication which is in some degree atoned for, I hope, by the contents of the present volume." This work was entitled "The Concepts and Theories of Modern Physics" and was published in 1882 as one of the "International Scientific Series." As the author was not sparing in his criticism of and attacks upon many of the doctrines and principles then generally esteemed as "fundamental" by the leading physicists of the world his book was made the subject of sharp and not always friendly comment. Among its most severe critics was Professor Simon Newcomb, who was inclined to denounce it outright. It was my privilege to make these two stalwart interpreters of natural phenomena personally acquainted with each other soon after the appearance of Judge Stallo's book. In personality it would be hard to find two men more unlike. Each was mighty in his own way; one was flint; the other steel, and I need hardly say that the half hour following the introduction was extremely illuminating, at least to the "innocent bystander." The remarkable advances in physical science since the publication of Stallo's book, especially as affecting our fundamental notions of the nature of matter and energy have made its title quite inappropriate, but both mathematician and physicist will find in it much that is still and must always be of great value. The physicist especially will be interested in the not infrequent foreshadowing of concepts that are today regarded as "modern;" indeed before the acceptance of *any* doctrine of fundamentals this book should be thoroughly studied.

Besides the severer studies Stallo also cultivated music, art and literature and his large library contained many rare and choice volumes. So extensive was the range of his intellectual activity that no matter how restricted one's own horizon might be a half hour spent with him, especially in his own home was sure to be remembered with pleasure. In 1885 he was appointed United States Minister to Italy where he continued to reside until his death in the year 1900.

That an interest in science and scientific pursuits developed among the people of Northeastern Ohio in the early part of the last century is due, more than to anything else, to the influence of the life and character of Dr. J. P. Kirtland. Born in Connecticut in 1793, he was graduated from the medical department of Yale College in 1815. At the age of thirty years he came to Poland, a small village in Mahoning County, Ohio. While in New England he had developed a strong taste for botanical studies and was an expert in the cultivation of flowers and fruits. In science he was essentially self-educated and although successful in the practice of his profession, it was in scientific investigation that he found his greatest happiness. In 1841 he removed to Cleveland and joined with others in founding the Cleveland Medical College. For several years he served as Assistant on the Geological Survey of Ohio, organized in 1837 by Mather to which he contributed a report on the Zoology of Ohio. He published numerous papers in the "American Journal of Science" and in the "Journal of the Boston Society of Natural History." Perhaps the most important of his discoveries was that of the sexual distinction in the Naides, proving that sex could be distinguished by the form of the shell, as well as by the internal organism. This was an extremely disturbing revelation at the time and was strongly disputed by eminent naturalists throughout the world, only to be universally accepted in the end. He founded the Cleveland Academy of Science in 1845 and was its president for twenty years when by vote of its members it became the Kirtland Society of Natural History. Dr. Kirtland was active in the improvement of agriculture and horticulture and had great influence in matters relating to them throughout the Northwest. He was one of the early members of the National Academy of Sciences, having been elected at its second meeting. He was a member of the State Legislature for three terms and served without compensation as examining surgeon for recruits during the civil war. Physically as well as intellectually, Dr. Kirtland was a big man with broad sympathies, greatly beloved by all who knew him. He died in Cleveland in 1877 in the eighty-fifth year of his age.

W. M. Mather, a lineal descendant of Richard Mather who gave to New England and America that famous "brood" of Mathers, deserves mention as the organizer and director of the first geological survey of Ohio in 1837. Born in 1804, he was graduated at the West Point Military Academy at the head of his class in the then newly established department of chemistry and mineralogy. While still an officer in the army he published several papers on chemistry and geology in the American Journal of Science. A few years after the organization of the geological survey of Ohio, he accepted an appointment as professor of Natural Science in the Ohio University at Athens. In 1850 he resigned to accept an appointment as State Agricultural Chemist and he was also for a time editor of the "Western Agriculturist." He died in Columbus in 1859.

Still another alumnus of the Military Academy at West Point finds a place on our roll of pioneers in the person of Col. Charles Whittlesey, who was born in Connecticut in the year 1808 and brought to Ohio at the age of five years by his parents who settled in the small village of Tallmadge in Portage County. He was a nephew of Elisha Whittlesey, member of Congress, one of the many stalwart sons of Connecticut who gave to the Western Reserve that flavor of New England which, after the lapse of a hundred years, is still much in evidence. After a brief service in the army, which included some real fighting in the Black Hawk War, he resigned, studied law and began the practice of his new profession in Cleveland. In 1837 he was appointed assistant geologist on the Ohio Survey under Mather, having allotted to him the topographical and general "surface" work of that organization. He became actively interested in archaeology and especially in the earth works of the so-called mound-builders. He made surveys and maps of many of these under an arrangement with Mr. Joseph Sullivant of Columbus, (who was also deeply interested in the subject,) for a joint investigation and publication. Later, however, much of this material was turned over to the Smithsonian Institution for publication as a part of the great work of Squier and Davis. While in the employment of mining companies in the investigation of copper mines in Northern Michigan, Col. Whittlesey made interesting studies of ancient methods of mining, the results of which were published in the "Smithsonian Contributions to Knowledge" as were other important papers. From his busy pen came also a number of books, mostly on archaeological or historical topics. On the breaking out of the civil war he promptly offered his services to the government, winning fame as an officer of the army, from which, however, he was obliged to resign at the end of a year on account of failure in health. Resuming his explorations in the Lake Superior and Upper Mississippi basin he was able to make very important additions to our knowledge of the mineral wealth of that region. His published papers were about two hundred in number and were highly esteemed on both sides of the Atlantic. His training as an engnineer and surveyor made him cautious and conservative and he did great service in exposing archaeological frauds and "fakes". He died in Cleveland in October, 1886, having just entered upon his seventy-ninth year.

Although many years of his life were passed outside of the State, Dr. John S. Newberry always regarded himself as an "Ohio man." He was brought to the state at the age of two years by his parents, his father having founded the village of

Cuyahoga Falls in Summit County, and he remained a legal citizen of Ohio until his death. He was graduated at Western Reserve College and received the degree of Doctor of Medicine from the Cleveland Medical College in 1848. After spending two years in study in Paris he practiced medicine in Cleveland until 1855, when he entered the United States army as Assistant surgeon. During the next half dozen years he served as physician, botanist and geologist in several government expeditions in exploration of western territories.

During the civil war, Dr. Newberry abandoned his scientific work and devoted himself to the National Sanitary Service, displaying extraordinary executive ability as well as medical skill, for which he received the highest commendation on all sides. In 1886 he became professor of geology and paleontology in the school of mines at Columbia University, the marked success of which was largely due to his efficient service and already established reputation. In addition to discharging the duties of this professorship for more than a quarter of a century he served as director of the geological survey of Ohio having as assistants a group of distinguished men including Orton, Andrews, Wormley and Lesquereux. He was also paleontologist to the United States geological survey. His contributions to his favorite science were very extensive and received full recognition both at home and abroad. The geological society of London bestowed its Murchison Medal upon him; he was one of the original corporate members of the National Academy of Sciences and served as president of the American Association for the Advancement of Science, the New York Academy of Sciences and the Torrey Botanical Club. Dr. Newberry possessed a rather rare catholicity in his attitude towards sciences other than those closely related to his own specialities. Educated before specialization had "set in" he had an intelligent interest in all departments of natural science and he was especially generous in his appreciation of the work of the young men of his day, many of whom will never forget his helpful and encouraging words.

In the decade following the close of the civil war, the city of Columbus housed a group of men whose scientific work and reputation reflected great distinction on the capital of our state. Prominent in this group were the two Sullivants, William and Joseph, sons of Lucas Sullivant who brought the virtues of his Scotch-Irish-English ancestry from Virginia to Ohio near the end of the eighteenth century. As a surveyor of our Virginia Military lands, he laid out, in 1798, the village of Franklinton (long ago absorbed in that part of the city of Columbus west of the Scioto river) where he spent the remainder of his life. There his son William was born in 1803. He was graduated at Yale College in 1823 and in the same year his father died leaving upon him, the eldest son, the responsibility of the management of a large landed estate. In the discharge of this responsibility he found it desirable to take up the profession of his father and until late in life he was occasionally active in the work of a surveyor or civil engineer. Interested in botanical studies from an early age, he published in 1840, the results of an exhaustive study of the flora of central Ohio. He next began the study of mosses and in a few years became the foremost authority as a bryologist in this country, without a superior anywhere in the world. The results of his studies were published in the memoirs of the American Academy of Arts and Sciences and in the scientific journals of this country and of Europe. Mosses collected in various parts of the world were referred to him for examination and report and he made extensive journeys himself principally for the purpose of gathering specimens. His *magnum opus* was the magnificent "Icones Muscorum" published in 1864, followed by a supplement which appeared shortly after his death in 1873—at the age of seventy years. Dr. Asa Gray said of him, "His works have laid such a broad and complete foundation for the study of bryology in this country and are of such recognized importance everywhere that they must always be of classic authority. Wherever mosses are studied his name will always be honorably remembered. In this country it should long be remembered with peculiar gratitude."

The American Academy of Arts and Sciences at Boston, in a lengthy notice of his life and work printed in their annual report, declared "In him we lose the most accomplished bryologist this country has ever produced." He was a member of numerous scientific societies at home and abroad, including the National Academy of Sciences, to which he was elected in 1872. William Sullivant was an admirable type of a species of scientific man, now, if not almost extinct, at least relatively much less common than half a century ago; I mean the amateur, as distinguished from the professional man of science; not the dillettante, whose intellectual excursions are restricted to two dimensions, but the man of genuine scholarly instincts who, free from the restraint of a connection with an institution of learning or other restriction upon his intellectual liberty, pursues with ardent zeal the investigation of some department of science finding his reward in the unalloyed delight of original discovery.

Eminent men of science from different parts of the world were frequently guests at his house. It was there that I first had the privilege of meeting that most distinguished of American botanists, Dr. Asa Gray, and I recall his remark at a subsequent meeting that *Columbus, Ohio,* was known in every country of the civilized world, not on account of its city hall, but because it was the home of William Sullivant and Leo Lesquereux.

Joseph Sullivant, the younger of the three sons of Lucas was born in 1809, and died in 1882, after a long, honorable and honored life, devoted largely to the promotion of the welfare of the people of his city and his state. His interest in science was less specialized than that of his brother, but, possibly to some extent due to this fact, he was an inexhaustible source of aid and encouragement to young and enthusiastic students in any department of human knowledge provided only that their work was serious and likely to prove worth while. He was engaged with Col. Whittlesey in carrying on the survey of the ancient earthworks of Ohio and he took an active part in the advancement of the interests of agriculture and in the improvement of agricultural methods and conditions. He gave freely of his time and means to any project for the betterment of public education and as a member of the first Board of Trustees of the Ohio State University he was of that group that resolved from the beginning to put the institution upon a foundation so broad and so deep that it would bear the great superstructure that is growing up under the eye of the present generation. With an inflexible tenacity of purpose that characterized his attitude towards any measure which he believed to be of the highest importance he labored to this end through the rather stormy period preceding the election and organization of its first faculty and for a number of years after its doors were open for the admission of students. That the institution is today what it is, rather than something radically different, is due in my judgment, to him more than to any other one man.

Many of our pioneers heretofore mentioned represented, through their ancestry, the culture and spirit of the Puritan and Pilgrim. In the Sullivants that of the Cavalier is reflected. To a stalwart physique was joined a natural dignity of manner and speech which was sometimes misinterpreted as an index of a lack of democratic feeling and sympathy. Possessed of ample material resources they were able to make use of the best instrumental aids to research and, while despising sham and charlatanry, they were every ready to share this advantage with others who were really deserving.

Fifty years ago, there was to be seen on the south side of High Street, opposite the State House in the city of Columbus, a modest jewelry and watch repairing shop over the door of which was the sign "Lesquereux and Son." Notwithstanding the prominent location of this establishment and the fact that the senior partner was usually to be found there for a short time each day (often himself at the repairer's bench), Leo Lesquereux was personally known to hardly more than a handful of the people of the city. A larger number knew of his existence and had heard that he was a "scientific man" associated in some way with William Sullivant. If addressed on the street he was likely to make no reply for he was totally deaf. Although he spoke French perfectly and German also, his knowledge of the English language had been acquired after the complete loss of the sense of hearing so that while he wrote it with ease and elegance correct pronunciation offered almost insuperable difficulties. Lesquereux was one of that famous trio of naturalists to whom American science is so enormously indebted, the other two being Arnold Guyot and Louis Agassiz. The story of his life is a romance such as one expects to find only in the pages of an imaginative novelist. His ancestors were Huguenots who sought refuge and religious liberty in Switzerland where his father employed four or five workmen in a small factory for the manufacture of watch springs. His mother, a cultivated woman and a lover of learning urged him to become a scholar, and when thirteen years of age, he was sent to Neuchatel to begin his academic career. Here he had as school mates Arnold Guyot and August Agassiz, a younger brother of Louis Agassiz, who was then continuing his studies in Germany. The training young Lesquereux received at Neuchatel was of the rigorous kind then in vogue everywhere, consisting mostly of Latin, Greek, mathematics and philosophy, with not a word of natural science. Having developed a great fondness for learning at the age of twenty years he resolved to continue his studies at the German Universities. For this, however, he must first earn money and the easiest way to do this was to teach the French language in German families.

Even when an old man, after years of almost complete isolation from his fellows, by reason of his great affliction, he was remarkable for his cheerful disposition, unlimited patience and charming manners. It is not strange then that at twenty, handsome, a lover of music and an accomplished scholar, he had no difficulty in finding clients. He became a tutor in a noble family in the city of Eisenach, with the privilege of doing a certain amount of teaching in other families. Among these was that of a distinguished general of noble birth, an attaché at the Court of the Duke of Saxe Weimer. His pupil there was the beautiful and highly accomplished daughter of the general, Baroness Sophia, who made extraordinary progress in learning to speak the French language. Before the end of the year teacher and pupil understood each other so well that young Lesquereux was inspired with courage to ask the hand of the daughter in marriage.

Fortunately the head of the house took a kindly view of this bold request and after thoroughly investigating the young man as to his intellectual resources (he had no other) his ambitions and his character, consented that he might return and claim his bride when he was established with a sufficient income to support her. It was not long before he received appointments which promised an annual income of five hundred dollars and at the age of twenty-five he was united in marriage with the daughter of General Von Wolffskel, of Saxe Weimer.

The young lady who then joined her fortunes with the son of a maker of watch springs had stood, only a little while before as bridesmaid to Augusta, daughter of the Grand Duke of Saxe Weimer, when Prince William of Prussia came for his future consort, the two who forty years later became the first Emperor and Empress of United Germany. When her own marriage took place, Mr. Lesquereux's "best man" was a young lieutenant of the army named Von Moltke, whose name will always be linked with that of Bismarck and the first Kaiser. Two years of contented happiness followed this union when misfortune came in the shape of a loss of hearing due originally to a fall at the age of ten years, over the edge of a mountain cliff, from which he narrowly escaped death. Treatment by eminent physicians in Paris served only to accelerate the trouble and in a few months Lesquereux was absolutely and irrevocably deaf. His career as a professor, to which they had both looked forward with so much delight, was thus suddenly ended and to support himself and his wife he was obliged to turn to manual labor. Buying a lathe he began life anew as an engraver of watch cases and at first, though working from early in the morning until late at night, his earnings were barely one dollar a day. His wife, who had been bridesmaid to an empress, was as brave as he and on this slender income they lived, always cheerful and happy. Even this occupation had to be given up on account of failure in health due to close confinement, and then his father came to his aid by making him his partner in the small watch spring factory.

During the years thus spent in simple mechanical toil Lesquereux had developed a taste for the study of flowers and plants. His genius was beginning to assert itself and the time was coming when he was to find his place in the world. Among the forms of vegetation which had especially attracted his attention during his Saturday afternoon and Sunday excursions into the open, were the peat bogs, in which the government was then taking great interest as a source of fuel.

A prize of a gold medal had been offered for the best report of the "Formation and Preservation of Peat" and when the competing manuscripts were examined it was found that Lesquereux knew far more of the subject than any one else and the medal was easily his. This report, the triumph of which was a great joy to his loyal wife, is even today, after three quarters of a century regarded everywhere as a classic. To Lesquereux it was the beginning of a new and happier career. He was granted five hundred dollars for writing a text book on peat to be used in the public schools and later he was made Director of Peat Bogs, a newly created office. He was commissioned by the King of Prussia to examine and report upon the peat bogs of Germany, Sweden, Denmark, Holland and France, with which appointment we may imagine the Queen, not forgetting her bridesmaid, had something to do. In the meantime his work had brought him into close association and intimate friendship with Louis Agassiz.

But soon came the political disturbances which affected all Europe in 1847-48 and put an end to the operations in which he was engaged. Lesquereux and Guyot were driven to America, the land of promise for the naturalist, whither Louis Agassiz had preceded them. Received with generous hospitality in the home of the latter at Cambridge, Lesquereux collaborated with Agassiz in the preparation of a report on plants collected in the Lake Superior region. Near the close of the year 1848 he was invited by William Sullivant to come to Columbus and here he spent the remainder of his life, a little more than forty years. During these years his fame grew rapidly, especially in the field of paleo-botany, in which he came to be ranked as perhaps the first authority in the world. In addition to his collaboration with Mr. Sullivant in the production of the great *Icones Muscorum* he was constantly employed by the National Geological Survey and numerous state surveys in the study of and report upon specimens sent to him from the field.

Honors came to him from institutions of learning and in election to membership in a score of scientific societies in Europe. He was the first to be chosen for membership in our own National Academy after its organization in 1863. His home in Columbus during most of his later years was in a small brick cottage on the back part of a lot on the corner of Mound and Fourth Streets. All of the available land space was converted into a flower garden in which much of his time was spent. His ever loyal wife, who, for his sake, had given up social position and rank (hardly a half dozen people in Columbus knew that she was a baroness in her own right) was during all of his long life his most efficient support and helper. The French language, which she had first learned from him, she now spoke so perfectly that after the coming of his deafness he learned to read her lip movements and it was in this way that much of his intercourse with his friends was carried on. He survived her death only a few years, dying in 1889, in the eighty-third year of his age.

A contemporary of the Sullivants and Lesquereux was Dr. Theodore G. Wormley, the distinguished toxicologist, who, though not a native of Ohio, was for a quarter of a century a citizen and resident of Columbus. It was here his greatest work was done and here he found his wife who was a most important contributor to that work. Born in 1826, in the village of Wormleysburg, Pennsylvania, founded by his Dutch ancestors, he was educated at Dickinson College and at the Philadelphia Medical College, from which he received his degree in 1849. In 1852 at the age of twenty-six years he came to Columbus as professor of chemistry and natural science in Capital University and two years later he was appointed professor of chemistry and toxicology in Starling Medical College, continuing to serve as such until he resigned in 1877. Soon after assuming his duties in the Medical College, he began a series of important contributions to the "Chemical News" of London, the first being "A Study of the Chemical Reactions of Strychnine," and for a few years he was the editor of the Ohio Medical and Surgical Journal." He rapidly specialized in the study of poisons and especially in the microscopic examination of their effect upon bloods, the by no means impossible tradition being that in the nearly ten years during which these investigations were going on, he immolated upon the altar of science no fewer than two-thousand cats and dogs. At any rate, his laboratory in the Medical College building was always an open market for the disposal of stray specimens of *Felis domestica* or *Canis familiaris,* and in an emergency he did not hesitate to draw upon the resources of his friends. I recall the fact that an incorrigible puppy, adopted into my own family and foreordained to scientific renown by the bestowal upon him of the name "John Tyndall" was hastily summoned to contribute his life's blood to the solution of a certain important problem. The culmination of these years of patient research was in the publication in 1867 of that great work, "The Micro-Chemistry of Poisons" to the preparation of which his accomplished wife contributed in a remarkable manner; first. by making beautiful and accurate drawings of minute crystals as seen under the microscope; and then, after expert engravers had completely failed in their attempts to reproduce them. teaching herself the art of engraving on steel so successfully that the illustrations when published commanded the admiration of both the artistic and the scientific world.

While residing in Columbus, Dr. Wormley served as chemist to the Ohio Geological Survey and filled other important offices to which he was appointed by various governors of the state. He was the author of numerous state reports and of a volume on "Methods of Analysis of Coals, Iron Ores, Furnace Slags, Fire Clays, Limestones and Soils." He was frequently called upon from all parts of the country to make examinations and give testimony in cases of suspected poisoning. His "Micro-Chemistry of Poisons" was pronounced to be the most valuable contribution to toxicology and medical jurisprudence that America has ever made, and unsurpassed by anything done in Europe.

It is still regarded as a classic authority in all parts of the world.

Largely on account of the reputation which it gave him, he was invited in 1877 to fill the important chair of chemistry and toxicology in the medical department of the University of Pennsylvania where he remained until his death in 1897.

Dr. Wormley was reserved in manner and not given to unnecessary speech, though among his intimate friends he was charming in social intercourse and ready in the expression of his views. In lecturing to classes of medical students, whose average intelligence, fifty years ago could hardly be considered as extraordinary, he found less pleasure than in doing research work in his small laboratory but his duties as instructor were discharged with the utmost fidelity. To those of his students who were "fit," in both precept and example he was most inspiring. By nature and doubtless largely on account of habits formed during years of exacting scientific research, (his published papers were marvels of painstaking accuracy), he was wonderfully methodical and precise in his mode of life. He would never fail to enter the lecture room at the precise hour, neither a minute too soon nor a minute too late, and he was equally prompt at the other end of the hour allotted to his work. I remember a lesson he taught me in the early days of my acquaintance with him. In a bit of work that I had undertaken I needed a particular piece of apparatus that on account of my small equipment of tools I could not build and which limited resources forbade my buying. While listening to Dr. Wormley's lectures I had discovered in one of his instrument cases a thing that could be made to answer my purpose. Knowing that he would have no immediate use for it, I summoned courage to ask him to lend it to me for a few weeks. When I made my request he rose from his chair, walked to the case in which the instrument was, and without the slightest hesitation handed it to me. Then picking up a slip of paper he wrote my name and that of the instrument on it and put it in the vacant place on the shelf. For an instant there came over me a flash of resentment; it was as though he had asked me for a written receipt; my *amour propre* was wounded. But during the nearly fifty years that have passed since that day I have many, many times regretted that I had not always followed his example.

Associated with Newberry, Orton, Wormley and Lesquereux in the State Geological Survey was Professor E. B. Andrews, a scion of New England stock, born at Danbury, Connecticut in 1821. He was a student at Williams College and also at Marietta College, graduating from the Ohio institution in 1842. He studied theology at Princeton and after preaching for several years returned to Marietta in 1850 as professor of geology. Seventeen years later, in 1869, he was appointed Assistant Geologist in the newly organized geological survey of Ohio, under Dr. Newberry. He contributed numerous papers on geological subjects to the American Journal of Science, and full reports of his work on the state survey are to be found in the volumes issued annually by that organization. Besides being an able geologist, Professor Andrews was possessed of a rich store of knowledge relating to other departments of science, as well as literature and art. He was blessed with a keen sense of humor and was a worthy member of that coterie of scientific men by whom the intellectual life of Columbus was greatly enriched during the "seventies" of the last century.

There are two eminent astronomers whom I should much like to include in my list of pioneers, though I fear that one of them did not reside in the state long enough to justify me in so doing. In the early years of two or three of the older of our Ohio colleges they served as training schools for young professors who were subsequently called to the older institutions of the East. Notable in this respect was Western Reserve College during the years it was located at Hudson. To this institution located in a small village, literally in the "back woods of Ohio" came in the year 1838, Elias Loomis, an alumnus of Yale College, recently returned from Europe where he had studied with the great astronomers of that day, to assume the duties of professor of mathematics and natural pholosophy. He had brought with him from Paris a considerable collection of philosophical instruments including the necessary equipment of a small astronomical observatory which he soon found means for building and which almost completely hidden by vines may still be seen by the visitor to the deserted campus at Hudson.

This was the first permanent observatory erected west of the Allegheny mountains and one of the very earliest in America. Loomis remained in Hudson for six or seven years, during which he managed to do an almost incredible amount of work, observing hundreds of moon culminations, and culminations of Polaris for determining longitude and latitude, complete observations of five comets whose orbits he computed, besides an extensive series of magnetic observations at over seventy stations extending from the Atlantic Ocean to the Mississippi river.

He left Hudson in 1844 to accept a professorship in an Eastern College, but he returned to his Ohio observatory for a short time in 1849 to take charge of the observations at the Hudson end of a telegraphic connection with Philadelphia for the purpose of determining its longitude by the then new and novel method of using the telegraph in longitude work. Of his laborious life and extensive contributions to science subsequent to his leaving Ohio, it is not my purpose to speak.

Just twenty years after the coming of Loomis there came to the same college, still much in the woods, another astronomer destined to achieve great fame. After graduating, at the age of eighteen years, from Dartmouth College, the leader of a class of fifty, Charles A. Young spent a few years at Andover, teaching Latin and Greek in Phillips Academy, and at the same time studying theology at the seminary for which that place is noted. His father was a famous professor at Dartmouth, as also was his grandfather in his day and when the call came from Hudson inviting him to accept the chair of mathematics and natural philosophy his inherited love for exact science made it impossible for him to decline. "It saved me," he once said to me with a twinkle in his sparkling black eyes, "from being food for cannibals," as he had intended becoming a missionary. He was but twenty-two years of age when he came to Hudson, but it is not too much to say that at that time no other college in Ohio or in the west could boast of so brilliant an exponent of the sciences of mathematics, physics and astronomy. In 1866 he was invited to return to Dartmouth to succeed his father as professor of mathematics and natural philosophy.

During a part of his last years at Hudson it was my privilege to be his pupil in astronomy and his occasional assistant in his lectures in physics and out of this relation there grew an intimate friendship that terminated only with his death in 1908. While observing star transits in the little observatory at Hudson, with the instrument mounted by Loomis, he told me of the call to Dartmouth and of his reluctance either to accept it or decline it. On the one hand he had become really attached to Ohio. He had lived in this state throughout the dark period of the civil war and for a time he had served as captain of a company in the 85th Regiment of Ohio Volunteers, composed largely of students from the college. On the other hand, he deplored the lack of instrumental equipment of the college at Hudson, and the meagre outfit of the observatory, obstacles that stood in the way of his initiating and carrying out certain studies and investigations the germs of which were already stirring in his brain, and for this lack there seemed to be at that time no remedy. At last, however, his natural pride in being called to succeed his father and grandfather turned the scale. He left Ohio and within a few years was climbing the ladder of fame as the most distinguished spectroscopic astronomer in America and one of the first in the world. The last twenty-eight years of his life he spent at Princeton, as professor of astronomy, and there much of his most important work was done.

During his residence in Ohio Professor Young mingled with others of his kind whenever opportunity offered. He was a man of charming personality; the twinkle of his eye, combined with a most winning smile, was irresistible. Students called him "Twinkle" a name which they thought appropriate for two reasons. The influence of such a combination of rigorous scholarship with the best elements found in human nature upon the students and the college men of Ohio of his time was great and lasting and we must be allowed to claim him as one of our scientific forebears.

The ground on which we now are is hallowed by the memory of Dr. Edward Orton, whose passing from us seems, to me at least, so recent that I am unable to think of him as belonging to a generation that is gone. His great work as a geologist; his great work as director, for several years of the State Geological Survey; his great work as a teacher and administrator of the affairs of the Ohio State University, during the most critical period of its existence; all of this is so well known to you, as is also to most of you his inspiring personality, that no words of mine can add to the clearness of the picture. Nor need I speak of the many honors that came to him in recognition of his scientific attainments. Although not a native of the state, no son of Ohio has done more to enlarge her material resources or to encourage and augment her intellectual activities.

Out of the science of the nineteenth century has come the civilization and abounding material wealth of the twentieth. In recognition of this indebtedness we have witnessed during the last fifteen or twenty years the most lavish gifts of money by private individuals and the most liberal appropriations by national and state governments for the promotion of scientific research. It is literally true that grants of money are lying in wait for those who give the slightest evidence of real ability to do research work. Where fifty years ago an investigator was compelled to work against a poverty of resource in both time and instrumental equipment, today every demand he makes for either may easily be met. Then a college professor who determined to have a share in the increase as well as the diffusion of knowledge was usually obliged to accomplish his desire by taking time out of an already overfull day and money from a purse which was far from being in the same condition. Now his hold upon his place is more or less imperiled by a failure to send at least an occasional paper to the journal representing his particular branch of science, for the preparation of which every facility is afforded him.

But in spite of all of these and many other encouraging facts, I suggest that on the whole, conditions today are not as favorable for the development of scientific ability of a high order as they were forty or fifty years ago, and that in relative proportion to the number of students of science, then and now, fewer men possessing talent of the first rank are likely to appear during the present century than we know to have lived in the nineteenth.

I know it demands courage akin to recklessness to make such a prediction, and in self defense I ask you to give serious consideration to the generally admitted fact that within the last twenty-five years there has been a remarkable change, amounting to a revolution, in the intellectual life of the people as a whole; that this change has permeated all classes of society and that it threatens to result, nay, indeed that it has already resulted in an enervation of the intellectual faculties with paralysis not far away. During the "sixties and seventies" of the last century the lyceum flourished; men and women flocked to hear such orators and thinkers as Lowell, Beecher, Sumner, Wendell Phillips, Emerson and others of nearly equal rank and reputation. Louis Agassiz lectured to crowded houses in all of our principal cities. Tyndall and Huxley came from across the sea to give scientific lectures in our largest halls from the doors of which hundreds were turned away. In the city of Columbus, with a population not more than one quarter of that at present the largest audience room was packed with interested listeners, while some of the ablest scientific men in this country and Europe discoursed on such topics as "The Doctrine of Evolution;" "Spectrum Analysis;" "The Stars and Nebulae;" "Geologic Time" etc., etc. While all of these lectures were made interesting by the accomplished men who gave them, their distinctive characteristic was that every listener was sent home with *something to think about.*

The "tired business man" had not then been invented. Country clubs, bridge whist, high-power cars, vaudeville shows, moving pictures and grotesque dances had not yet appeared above the horizon. The gospel of amusement had not yet been revealed. Books were vastly fewer then than now and, in the opinion of many of us today, correspondingly better, most of them being actually worth buying and reading. Newspapers were comparatively few in number, but some of them were edited by such men as Horace Greeley and William Cullen Bryant, and there was no Sunday Supplement. It is not necessary to extend the contrast. Out of the social and intellectual class of the present must be evolved the Lockes, the Mitchells, the Sullivants, Newberrys and Ortons of the future. I am not claiming that existing conditions are not more desirable than those of forty years ago; I leave that for others to discuss and decide; but I cannot avoid the conclusion that they are inimical to the development of intellectual virility and fecundity and that unless there shall be a return to a more rational existence, the candid reviewer at the end of the twentieth century will concede that it has failed to maintain, in the field of original investigation and discovery, the standard set for it by the nineteenth.

NOTE—For the biographical data in the above address I have depended upon standard Biographies, special memoirs, personal knowledge and information kindly furnished by descendants or relatives of my subjects; and for many facts regarding the life of Leo Lesquereux I am indebted to the late Dr. Edward Orton and to Dr. C. Leo Mees, President of Rose Polytechnic Institute, to whom Lesquereux was godfather. To Professor Cleveland Abbe, of the U. S. Weather Bureau of Washington, I am indebted for information relating to Colonel Mansfield.

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Twenty-Fifth Meeting

Quarter—Centennial Anniversary

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Atkinson, A. A., *Physics and allied subjects*........ Ohio Univ., Athens
Bales, B. R., *Ornithology, Entomology*...... 149 W. Main St., Circleville
Ball, E. D., *Entomology*................................ Madison, Wis.
Barnett, S. J., *Physics*................. 241 W Eleventh Ave., Columbus
Barrows, William M., *Experimental Zoology*........ O. S. U., Columbus
Baumiller, G. N., *Geology, Chemistry, Zoology*..................
.... 145 Chittenden Ave., Columbus
Benedict, H. M......................... Univ. of Cincinnati, Cincinnati
Berger, E. W., *Zoology*............................ Gainesville, Florida
Bevan, Arthur, *Geology*.. Rosenwald Hall, Univ. of Chicago, Chicago, Ill.
Black, J. G., *Geology*............................ R. D. No. 10, Wooster
Blair, Kate R............................. 991 Neil Ave., Columbus
Blake, Frederick C., *Physics*...................... O. S. U., Columbus
Bleile, Albert M., *Physiology, Biology*............ O. S. U., Columbus
Bownocker, John A., *Geology*...................... O. S. U., Columbus
Braam, Maximilian, *Biology*........... Hughes High School, Cincinnati
Bradfield, R. M., *Botany, Chemistry*........................ Westerville
Braun, Annette F., *Zoology*.................. 2702 May St., Cincinnati
Brookover, Charles, Medical Department, Univ. of Arkansas,,
.... Little Rock, Ark.
Brown, F. B. H., *Botany*........... 104 Lake Place, New Haven, Conn.
Brugger, Harvey, *Botany*....................... 412 South St., Fremont
Bryant, E. R... New Concord
Bubna, Matthias, *Entomology*.......... 2629 Woodhill Road, Cleveland
Bucher, Walter H., *Geology, Physics*... 172 E. McMillan Ave., Cincinnati
Budington, R. A., *Zoology, Physiology*.......... Oberlin College, Oberlin
Burgess, A. F., *Entomology*.......... U. S. Dept. Ag., Washington, D. C.

Burton, E. Ray, *Zoology*........................60 Park Ave., Delaware
Burton, Mrs. E. Ray, *Zoology*..................60 Park Ave., Delaware
Caldwell, F. C., *Electricity, Light*..................O. S. U., Columbus
Carman, J. Ernest, *Geology*..............Univ. of Cincinnati, Cincinnati
Carney, Frank, *Geology*.................................Granville
Chase, H. D., *Zoology, Botany*............Christian Univ., Canton, Mo.
Claassen, Edo., *Botany*..............18 Fernwood Ave., East Cleveland
Clevenger, J. F., *Botany*...........U. S. Dept. Agr., Washington, D. C.
Coe, Fred O., *Geology, Zoology, Chemistry*........320 Cherry St., Marion
Cogan, Eric L., *Zoology, Botany*....................O. S. U., Columbus
Cole, A. D., *Physics*...............................O. S. U., Columbus
Colton, Geo. H., *Physics, Geology*............................Hiram
Comstock, Frank M., *Vert. Zoology*............Case School, Cleveland
Coons, C. D., *Physics*......................Denison Univ., Granville, O.
Copeland, W. F...Athens
Cottingham, Kenneth C., *Geology*...........1870 N. 4th St., Columbus
Cotton, E. C., *Entomology*.....................................Elyria
Cramer, William G., *Zoology*...........3138 Madison Road, Cincinnati
Culler, J. A., *Physics*.....................................Oxford, O.
Davis, B. M., *Zoology*.......................................Oxford
Davis, V. H., *Horticulture*.........................O. S. U., Columbus
Dearness, Donald F., *Geology, Palæontology*....................
..................................Univ. of Cincinnati, Cincinnati
DeLong, Dwight M., *Zoology, Entomology*..........O. S. U., Columbus
Detmers, Freda, *Botany*...........................O. S. U., Columbus
Detrick, O. J., *Geology*.......................................Huron
Devereaux, W. C., *Meteorology*............Weather Bureau, Cincinnati
Dietz, Harry F., *Entomology*.......................O. S. U., Columbus
Doren, Jane Macartney, *Botany, Zoology*..................Bexley, O.
Drake, Carl, *Entomology*...........................O. S. U., Columbus
Durkee, P. W., *Physics*....................................Delaware
Durrant, E. P., *Biology, Geology*..........................Westerville
Dury, Charles.................537 Ridgway Ave., Station I, Cincinnati
Dutton, C. F., Jr.........................4816 Franklin Ave., Cleveland
Earhart, Robt. F., *Physics*........................O. S. U., Columbus
Edwards, E. H., *Zoology, Physiology*, 7317 Clinton Ave., N. W., Cleveland
Elliott, Frank, *Botany and Zoology*.......................Wilmington
Evans, Morgan W., *Botany, Agronomy, General Science*....New London
Fattig, P. W., *Zoology*.......State Normal School, Valley City, N. Dak.
Feiel, Adolph.............................520 E. Main St., Columbus
Fenneman, N. M., *Geology, Geography*...Univ. of Cincinnati, Cincinnati
Fink, Bruce, *Botany*..Oxford
Fischer, Martin H., *Experimental Medicine*..General Hospital, Cincinnati
Fish, Harold Dufur, *Animal and Plant Genetics*................
....................................Denison Univ., Granville

FLYNN, MAUD, *Zoology*..................338 W. Sixth Ave., Columbus
FOERSTE, AUGUST, *Geology*..................Steele High School, Dayton
FOX, CHARLES P., *Botany, Chemistry*...............395 Doyle St., Akron
FOX, ERROL, *Botany, Chemistry*..................395 Doyle St., Akron
FULLMER, E. L., *Botany*..................................Berea
FULTON, B. B., *Entomology, Botany*............Exp. Sta., Geneva, N. Y.
GOODRICH, CALVIN, *Conchology*....................Toledo Blade, Toledo
GORMLEY, ROSE, *Plant Physiology*...................O. S. U., Columbus
GOWDY, ROBERT CLYDE, *Physics*.............2115 Auburn Ave., Cincinnati
GRABER, PHILIP E., *Physics, Chemistry, General Science*..........
..................................9501 Pratt Ave., Cleveland, O.
GRIGGS, R. F., *Botany*............................O. S. U., Columbus
GROBER, M. E...Tiffin
GROVER, F. O., *Botany*...................................Oberlin
GUYTON, THOMAS C., *Entomology*.....................O. S. U., Columbus
HALLINAN, THOS., H., *Entomology*...............................
Bethlehem, Chile, Iron Mines Co., Minas Tofa, La Higuera,
Coquimbo, Chille, S. A.
HAMBLETON, J. C., *Botany, Zoology*.........................Galloway
HANSEN, MRS. HERMINA Z., *Biology*...........258 E. Market St., Akron
HANAWALT, F. A., *Biology*................313 Garfield Ave., Middletown
*HARMOUNT, GEORGE P., *Geology and Archæology*................
..................................2290 Indianola Ave., Columbus
HAUCK, CHARLES WESLEY, *Zoology, Entomology*..................
..................................268 Webber Road, Columbus
HENDERSON, CHAS. W., *Physics*............................Granville
HENDERSON, NELLIE F., *Botany*..........High School, Little Rock, Ark.
HERMS, W. B........................Univ. of California, Berkeley, Cal.
HERSHEY, J. WILLARD, *Chemistry, Physics*......Defiance College, Defiance
HILLS, T. M., *Geology*...........................O. S. U., Columbus
HINE, J. S., *Entomology, Ornithology*...............O. S. U., Columbus
HOFFMEISTER, ALEX. C., *Biology*.....................Ohio Univ., Athens
HOLT, W. P., *Geography, Geology, Zoology, Botany*...............
..................................Normal College, Bowling Green
HOPKINS, LEWIS S., *Botany*...................................Kent
HORMELL, W. G., *Physics*.................................Delaware
HOUSER, J. S., *Entomology*................................Wooster
HOWE, MARY BLANCHE........................14 Poplar Ave., Athens
HUBBARD, G. D., *Geology, Physiology*........125 Woodland Ave., Oberlin
HUMPHREY, LILLIAN E., *Botany*.............................Ironton
HYDE, MRS. EDNA.....Adelbert College, Western Reserve Univ., Cleveland
HYDE, J. E., *Geology*..Adelbert College, Western Reserve Univ., Cleveland
ICKES, MARGUERITE, *Zoology*...............12582 Clifton Blvd., Cleveland

* Subject to ratification of the Society at the annual meeting, 1916.

Irwin, Oscar W., *Physics*........................Toledo Univ., Toledo
Jacobs, Edwin E., *Botany, Biology*............Ashland College, Ashland
Jennings, O. E., *Botany*.............Carnegie Museum, Pittsburgh, Pa.
Johnson, E. H., *Physics*...................................Gambier
Jones, Lynds, *Ornithology*....................College Museum, Oberlin
Judson, C. A., *Botany*....................235 Columbus Ave., Sandusky
Kauffman, I. S., *Physics, Geology*...........................De Graff
King, J. Lionel, *Botany, Entomology*.......3233 Carnegie Ave., Cleveland
Kirk, Joseph M., *Meteorology, Geology, Physics*..................
....................................321 E. 19th Ave., Columbus
Knower, Henry McE., *Anatomy, Biology*..Univ. of Cincinnati, Cincinnati
Kostir, Wencel J., *Zoology*........................O. S. U., Columbus
Krecker, Frederick H., *Biology*....................O. S. U., Columbus
Kumler, Ralph W., *Geology, Physiography*...........61 Clay St., Tiffin
Kurtz, S. Aaron, *Botany, Geology, Physics, Chemistry, Archæology.*
....525 Rogers St., Bucyrus
Lake, Chas. H., *Physics*....................................Hamilton
Lamb, G. F., *Biology, Geology*...............Mt. Union College, Alliance
Landacre, F. L., *Zoology*..........................O. S. U., Columbus
Langenberg, F. C., *Physics*...................................Athens
Lazenby, Wm. R., *Horticulture, Botany*.............O. S. U., Columbus
Lloyd, John Uri......................Court and Plum Sts., Cincinnati
Lord, H. C., *Astronomy, Mathematics*................O. S. U., Columbus
Lorenz, Edw. J., *Physics*.................Univ. of Cincinnati, Cincinnati
Lutz, Dexter N., *Biology, Agriculture, Meteorology*.............
....................................Fisk Univ., Nashville, Tenn.
March, Cora, *Biology*.....................Woodlawn, Hamilton County
Mark, Clara Gould, *Geology, Botany*................O. S. U., Columbus
Mathews, Mary E...Painesville
McAvoy, Blanche, *Biology*.......Box 56, Sta. F., Foley Road, Cincinnati
McCall, A. G., *Agronomy*..........................College Park, Md.
McCampbell, Eugene F., *Bacteriology*......................Columbus
McFadden, L. H., *Chemistry*....................40 Warden St., Dayton
McKean, T. L., *Botany*..Berea
McPherson, Wm., *Chemistry*........................O. S. U., Columbus
Meckstroth, Gustav A., *Botany ,Entomology*.........State College, Pa.
Mendenhall, T. C., *Physics*.................................Ravenna
Mercer, W. F., *Biology*........................Ohio University, Athens
Metcalf, C. L., *Entomology, Zoology*............................
............Dept. of Zoology and Entomology, O. S. U., Columbus
Metcalf, M. M., *Zoology*.....................................Oberlin
Metcalf, Zeno P...................A. & M. College, W. Raleigh, N. C.
Metzger, Albert C. D., *Chemistry, Ornithology, Geography*........
....................................380 Deshler Ave., Columbus
Mills, W. C., *Archæology, Biology*..................O. S. U., Columbus

Moore, E. J., *Physics*..........................Oberlin College, Oberlin
More, Lewis T., *Physics*..................Univ. of Cincinnati, Cincinnati
Morningstar, Helen, *Geology*.............1275 Franklin Ave., Columbus
Morse, W. C., *Biology, Geology*........Washington Univ., St. Louis, Mo.
Moseley, E. L., *Zoology, Botany, Physiography*..................
..........................State Normal College, Bowling Green
Mote, Don C., *Zoology, Entomology*.........................Wooster
Napper, Charles W., *Geology*.............................Greenfield
Nelson, James A., *Zoology, Embryology*........................
.............................Bur. Entomology, Washington, D. C.
Nichols, Susan P., *Botany*........................257 Elm St., Oberlin
Oberholser, H. C...........1444 Fairmont St., N. W., Washington, D. C.
Odenbach, F. L., *Meteorology*...........St. Ignatius College, Cleveland
Oliver, Mary H., *Biology*.........................Mt. Holyoke, Mass.
O'Neal, Claude E., *Botany*..............................Delaware
Orcutt, Alfred W., *Zoology*................1495 E. 118th St., Cleveland
Osborn, Herbert, *Entomology, Zoology*.............O. S. U., Columbus
Osburn, Raymond C., *Zoology, Ichthyology*....................
........................Connecticut College, New London, Conn.
Parkhurst, C. P., *Science*.....................9 W. Long St., Columbus
Perry, Fred, *Botany*..................................R. F. D., Leipsic
Phillips, Ruth L., *Biology and Allied Sciences*..Western College, Oxford
Philpott, Rees, *Biology*..................171 W. Lincoln Ave., Delaware
Piwonta, Thomas.................226 Superior Ave., N. W., Cleveland
Plowman, Amon B., *Botany, Physiology, Zoology*................
.....................................126 S. Maple St., Akron
Pratt, Delbert R., *Botany, Zoology, Bacteriology*..............Granville
Prose, Chas. T., *Physics*.....................1333 Maple Ave., Zanesville
Prosser, C. S., *Geology*............................O. S. U., Columbus
Rankin, John P., *Biology, Medicine*.............415 Earl Court, Elyria
Recker, Paul C., *Biology, Physics*, 203 4th St., Huntington, W. Va.
Reese, Chas. A., *Zoology, Entomology*.....................Ames, Iowa
Rice, Edward L., *Zoology*.................................Delaware
Richards, Clarissa A., *Botany, Zoology*...................Oxford, O.
Robinson, J. M...................................O. S. U., Columbus
Robinson, Ray R., *Geology, Biology*.......................Newcastle
Rogers, Charles G., *Physiology*.................Oberlin College, Oberlin
Rood, Almon N., *Botany*.....................R. F. D. 2, Phalanx Station
Roudebush, Lowell....................R. F. D. No. 3, New Richmond
Rush, R. C., *Conchology*..................................Hudson
Sanders, J. G., *Entomology, Botany*..................Harrisburg, Pa.
Schaffner, J. H., *Botany*.........................O. S. U., Columbus
Schear, E. W. E., *Biology*.....................107 W. Park, Westerville
Scheffel, Earl R., *Geology*........................341 River St., Dayton
Schroyer, Charles R., *Geology*......230 S. Pugh St., State College, Pa.

SCOTT, EDWARD B., *Meteorology, Botany*......1894 Summit St., Columbus
SEARS, PAUL B., *Botany, Entomology*...............O. S. U., Columbus
SEYMOUR, RAYMOND JESSE, *Physiology, Zoology, Botany*............
..............................Dept. Physiology, O. S. U., Columbus
SELBY, A. D., *Botany*....................Experiment Station, Wooster
SHADLE, ALBERT, *Zoology*..................Cornell Univ., Ithaca, N. Y.
SHARPE, MRS. KATHERINE DORIS, *Botany, Geology*..............London
SHATZER, C. G...............................25 E. Cecil St., Springfield
SHAW, N. E., *Entomology*......................State House, Columbus
SHETRON, H. C., *Archaeology*......Museum and Library Bldg., Columbus
SHIDELER, W. H., *Geology*...................................Oxford
SHILLIDAY, C. L., *Zoology*.........University of Buffalo, Buffalo, N. Y.
SHUMAN, S. C., *Botany*................................Quaker City
SHUMAN, W. L., *Botany*...........................Chicago Junction
SIM, ROBERT J...Jefferson
SMITH, ALPHEUS W., *Physics*.....................O. S. U., Columbus
SMITH, ARTHUR L...................................Valley Crossing
SMITH, ETHEL M...Rome
SMITH, G. D., *Botany, Zoology*........................Richmond, Ky.
SMITH, J. WARREN, *Meteorology*..........U. S. Weather Bureau,
....Washington, D. C.
SMITH, ROGER C., *Entomology*..............Cornell Univ., Ithaca, N. Y.
SNYDER, F. D., *Zoology, Entomology*.........................Ashtabula
SPECKMAN, W. N., *Geology*.............Baldwin-Wallace College, Berea
STANLEY, CLYDE M., *Zoology*.....................High School, Alliance
STAUFFER, CLINTON R., *Geology*...Univ. of Minnesota, Minneapolis, Minn.
STERKI, VICTOR, *Conchology, Botany*..................New Philadelphia
STETSON, R. H., *Psychology*.....................Oberlin College, Oberlin
STICKNEY, M. E., *Botany*...................................Granville
*STOUT, HARRY O., *Botany, Geology, Agriculture, Zoology*..........
....1031 Alger St., Fremont
STOVER, W. GARFIELD, *Botany*......................O. S. U., Columbus
STOUT, W. E., *Chemistry, Geology*............40 E. Lane Ave., Columbus
SWEEZEY, OTTO H.....................Twelfth Ave., Honolulu, Hawaii
THAYER, WARREN N., *Geology*......Ohio Mechanics Institute, Cincinnati
THOMAS, ROY C., *Botany, Zoology, Geology*............Rd. 5, Mt. Gilead
THOMPSON, LAWRENCE J., *Biology, Chemistry*.....................
....................................21 University Ave., Delaware
TODD, JOSEPH H., *Geology, Archaeology*..........Christmas Knoll, Wooster
TRANSEAU, EDGAR N., *Botany*......................O. S. U., Columbus
TROTT, T. ELMER, *Mathematics, Astronomy*.......................
...................................2221 Ridgewood Ave., Alliance

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TURNER, CLARENCE L., *Zoology*.................................
.................Marquette Univ. Medical School, Milwaukee, Wis.
UNNEWEHER, EMORY C., *Physics*........Baldwin-Wallace College, Berea
VAN CLEVE, M. R., *Physical Geography, Botany*..................
..............................Morrison R. Waite H. S., Toledo
VERWIEBE, WALTER A., *Geology*..........Orton Hall, O. S. U., Columbus
VIVIAN, ALFRED, *Agriculture, Chemistry*.............O. S. U., Columbus
WAITE, F. C.....................Western Reserve University, Cleveland
WALTON, L. B., *Biology*....................................Gambier
WEBB, R. J., *Botany*...................................Garrettsville
WEINLAND, CLARENCE R., *Physics*...........381 W. 10th Ave., Columbus
WELLS, B. W., *Botany*............................O. S. U., Columbus
WELLS, G. R., *Psychology*......................Oberlin College, Oberlin
WERTHNER, WILLIAM B., *Botany*...........1025 Stillwater Ave., Dayton
WESTGATE, LEWIS G., *Geology*..............................Delaware
WILLIAMS, JOHN H., *Mathematics, Physics, Chemistry*............
....................................227 W. Reynolds St., Urbana
WILLIAMS, SAMUEL R., *Physics*...................260 Oak St., Oberlin
WILLIAMS, STEPHEN R., *Biology*..............Miami University, Oxford
WILLIAMSON, E. B., *Entomology*........................Bluffton, Ind.
WILSON, STELLA S., *Geography, Geology*........97 N. 20th St., Columbus
WILTBERGER, P. B., *Entomology, Zoology*....................Orono, Me.
WITHROW, JAMES R., *Chemistry, Mineralogy*.........O. S. U., Columbus
WRIGHT, G. FREDERICK, *Geology*..............................Oberlin
WYKOFF, HARRY S., *Biology, Botany*...........Station A, No. 4, Alliance
YORK, HARLAN H., *Botany*...............Brown Univ., Providence, R. I.
YOST, RALPH, *Genetics, Botany, Bacteriology*..........Box 81, Thornville
YOUNG, A. R., *Botany*..........Dept. of Agriculture, Washington, D. C.
Total Membership 254

Report of the Twenty-Fifth Annual Meeting of the Ohio Academy of Science

Quarter — Centennial Anniversary

The Twenty-fifth Annual Meeting of the Ohio Academy of Science was held at Ohio State University, Columbus, Ohio, on Friday and Saturday, November 26 and 27, 1915, under the presidency of Professor J. Warren Smith, of Columbus.

Eighty members of the Academy were registered as in attendance.

Owing to the anniversary character of the meeting the usual program of volunteer papers was replaced by a series of invited addresses.

GENERAL PROGRAM

FRIDAY, NOVEMBER 26.

8:30 A. M.	Meeting of Committees.
9:30 A. M.	Business Meeting.
10:00 A. M.	Presidential Address, "Agricultural Meteorology," Professor J. Warren Smith, United States Weather Bureau, Columbus.
11:45 A. M.	Address, "Applied Meteorology and the Work of the Weather Bureau," Doctor Charles F. Marvin, Chief United States Weather Bureau, Washington, D. C.
12:30 P. M.	Luncheon at the Ohio Union.
2:00 P. M.	Historical Sketch of the Ohio Academy of Science, Professor William R. Lazenby, Ohio State University, Columbus.
2:30 P. M.	Reviews of Scientific Progress in the Quarter Century.

"Geology," Professor Frank Carney, Denison University, Granville.

"Botany," Professor Bruce Fink, Miami University, Oxford.

"Physics," Professor Frank P. Whitman, Western Reserve University, Cleveland.

4:30 P. M. Social Gathering at the Ohio Union.

5:30 P. M. Supper at Ohio Union, followed by short address by His Excellency, Frank B. Willis, Governor of Ohio, and by Visiting Delegates.

8:30 P. M. Address, "The Relation of the Academy to the State and to the People of the State," Doctor T. C. Mendenhall, Ravenna.

SATURDAY, NOVEMBER 27.

9:00 A. M. Adjourned Business Meeting.

10:00 A. M. Reviews of Scientific Progress in the Quarter Century.

"Zoology," Professor Edward L. Rice, Ohio Wesleyan University, Delaware.

"Chemistry," Professor William McPherson, Ohio State University, Columbus.

"Archaeology," Professor G. Frederick Wright, Oberlin College, Oberlin.

12:30 P. M. Luncheon at the Ohio Union.

2:00 P. M. Inspection of the Grounds, Buildings, and Collections of the University.

VISITING DELEGATES AND GUESTS

His Excellency, Frank B. Willis, Governor of Ohio, had expected to be present and to speak on Friday evening, but was unavoidably prevented at the last moment.

Notice was received of the appointment of the following delegates; those marked with the asterisk were present at the meeting.

American Association for the Advancement of Science—*Professor L. O. Howard, Washington, D. C.

Boston Society of Natural History—*Professor Frederick C. Waite, Cleveland, O.

Chicago Academy of Science—Dr. Frank C. Baker, Chicago, Ill.

Indiana Academy of Science—*Dr. D. W. Dennis, Richmond, Ind.; Mr. E. B. Williamson, Bluffton, Ind.

Iowa Academy of Science—*Professor Herbert Osborn, Columbus, O.; Dr. Charles R. Keyes, Des Moines, Ia.

New York Academy of Science—Mr. Emerson McMillin, New York City; Professor H. P. Cushing, Cleveland, O.

Academy of Natural Sciences of Philadelphia—Dr. Howard Ayers, Cincinnati, O.

Washington Academy of Sciences—*Professor Dayton C. Miller, Cleveland, O.; *Dr. Charles F. Marvin, Washington, D. C.

Cincinnati Section of the American Chemical Society—Dr. Lauder W. Jones, Cincinnati, O.; Dr. Alfred Springer, Cincinnati, O.

Cincinnati Society of Natural History—Dr. DeLisle Stewart, Cincinnati, O.

Columbus Audubon Society—*Professor J. C. Hambleton, Columbus, O.; Miss Lucy Stone, Columbus, O.

Denison Scientific Association—*Dr. George Fitch McKibben, Granville, O.; *Mr. Charles W. Henderson, Granville, O.

Wooster University Scientific Club—*Mr. Frank H. McCombs, Wooster, O.

The Cuvier Press Club—Mr. James W. Faulkner, Cincinnati, O.

Association of Ohio Teachers of Mathematics and Science—*Professor S. E. Rasor, Columbus, O.

Ohio State University Scientific Association—Professor Karl D. Swartzel, Columbus, O.; *Professor James R. Withrow, Columbus, O.

Oxford Science Club—*Professor J. A. Culler, Oxford, O.

Otterbein Science Club—*Mr. Richard M. Bradfield, Westerville, O.

Baldwin-Wallace Science Seminar—*Professor E. L. Fullmer, Berea, O.

In addition to the organizations which appointed delegates, letters of felicitation were received from the following:

Royal Canadian Institute.
California Academy of Sciences.
Southern California Academy of Sciences.
Society of Natural History of Delaware.
Nebraska Academy of Science.
North Carolina Academy of Science.

The following members of the old Tyndall Association, so potent in the scientific life of Columbus and Ohio in the seventies and eighties, were also present by special invitation:

Mr. H. N. P. Dole, Columbus, O.
Mr. Martin Hensel, Columbus, O
Mr. Curtis C. Howard, Columbus, O.
Professor William L. Lazenby, Columbus, O.
Dr. C. L. Mees, Terre Haute, Ind.
Dr. T. C. Mendenhall, Ravenna, O.
Dr. Sidney A. Norton, Columbus, O.
Mr. D. E. Williams, Columbus, O.

A special invitation had also been extended to all past presidents and charter members of the Academy.

The following charter members were in attendance:

Mr. Charles E. Albright, Columbus, O.
Professor A. D. Cole, Columbus, O.
Professor J. S. Hine, Columbus, O.
Professor William Lazenby, Columbus, O.
Professor E. L. Moseley, Bowling Green, O.
Professor A. D. Selby, Wooster, O.

Letters of felicitation and regret were received from the following charter members:

Professor E. G. Conklin, Princeton, N. J.
Mr. Seth Hayes, Cleveland, O.
Mr. William Krebs, Cleveland, O.
Professor John Uri Lloyd, Cincinnati, O.
Professor A. L. Treadwell, Poughkeepsie, N. Y.

The past presidents were represented by
Professor Frank Carney, Granville, O.

Professor W. R. Lazenby, Columbus, O.
Dr. T. C. Mendenhall, Ravenna, O.
Professor E. L. Moseley, Bowling Green, O.
Professor Herbert Osborn, Columbus, O.
Professor Edward L. Rice, Delaware, O.
Professor John H. Schaffner, Columbus, O.
Professor A. D. Selby, Wooster, O.
Professor L. B. Walton, Gambier, O.
Professor Lewis G. Westgate, Delaware, O.
Professor G. Frederick Wright, Oberlin, O.
A letter of regret was received from
Professor C. Judson Herrick, Chicago, Ill.

MINUTES OF BUSINESS MEETINGS

November 26, 1915.

First business session called to order at 9:30 A. M. by President Smith, who read a letter from Mr. Emerson McMillin, to whose continued generosity the Academy is so greatly indebted. Mr. McMillin had expected to attend the meeting, but had been compelled at the last moment to change his plan.

After announcements by Professor Hills, Chairman of Local Committee, the chair announced the appointment of the following committees:

Committee on Membership—F. C. Blake, S. E. Rasor, J. R. Withrow.

Committee on Resolutions—L. B. Walton, E. L. Moseley, F. O. Grover.

Committee on Necrology—W. R. Lazenby, W. C. Mills, A. D. Selby.

The following Auditing Committee was elected by the Academy: C. S. Prosser, J. H. Schaffner.

The following Nominating Committee was elected by the Academy: Herbert Osborn, C. S. Prosser, A. D. Cole.

The following report of the Secretary was read and ordered filed:

Report of the Secretary.

DELAWARE, OHIO, NOV. 26, 1915.

The work of the Secretary has been largely in connection with the work of the Executive Committee, and is for the most part covered by the report of that committee.

The Anniversary Meeting has caused an unusual amount of correspondence; and the secretary wishes to express his gratitude to the President for his very generous and helpful coöperation in this work.

Two letters from the year's file may be of interest to the Academy.

An invitation from the Nebraska Academy of Science to send a delegate to the Twenty-Fifth Anniversary of that organization on May 21 was received by the Secretary and referred to the President for reply.

Last year a letter was reported from the secretary of the Ohio College Association, Dean W. G. Leutner, suggesting an affiliation of the Academy with the College Association. A second letter was received under date of Dec. 15, from which the following paragraph is quoted:—"While I do not believe perhaps that any close affiliation between the two organizations would be of any very special benefit to either, nevertheless a meeting of both societies simultaneously at a place like the State University might be advantageous. A larger number of instructors in Ohio Colleges would thus be brought together than if the two associations met separately. As it is we feel that too few of the members of the Ohio College faculties attend the meetings of the Ohio College Association, and the discussions are apt to confine themselves too largely to questions of administration. At any rate it will do no harm for your Academy to consider the question further." As the Ohio College Association meets regularly in the week preceding Easter, this letter may have a bearing upon the proposition to change the date of the Annual Meeting of the Academy.

The attention of the Vice-Presidents was called to the action of the Academy authorizing the organization of sectional field meetings in the spring; but no such meetings were arranged.

The Academy at the last Annual Meeting authorized the Secretary to revise and reprint the circular concerning the scope of the Academy. It was deemed best by the Secretary, after consultation with the Executive Committee, to delay the revision until after the Anniversary Meeting. The leaflet will be prepared in the near future.

Notices of this meeting have been sent by the Secretary to the important papers in Cleveland, Cincinnati, and Toledo. Also to "Science." The matter of publicity in the Columbus papers was kindly taken over by President Smith.

And, lastly, the Secretary wishes to remind the Academy that notice was given at the last meeting of two amendments to the Constitution to be voted upon at the present meeting,— one to change the time of the Annual Meeting from Thanksgiving to Easter, and the other to do away with the office of Librarian and to provide for a standing Library Committee. These amendments have been drafted and will be presented later in the meeting.

Respectfully submitted,
EDWARD L. RICE, *Secretary*.

The report of the Treasurer was received as follows, and referred to the Auditing Committee:

Report of the Treasurer for the Year 1915

For the year since our last annual meeting the receipts, including balance from last year have amounted to $448.00, and the expenditures to $276.70, leaving a cash balance of $171.30.

RECEIPTS.

Balance from 1914	$85 30
Interest on Endowment	3 00
Sale of Publications	29 70
Membership dues	330 00
Total	$448 00

EXPENDITURES.

220 Subscriptions to The Ohio Naturalist	$165 00
Printing Annual Report	56 00
Cost of Revision of Charter	5 00
Stationery	5 75
Miscellaneous	44 95
Balance December 1915	171 30
Total	$448 00

Respectfully submitted,
JAS. S. HINE, *Treasurer*.

No separate report was presented by the Librarian, the material being included in the report of the Temporary Library Committee.

The report of the Executive Committee was received as follows and ordered filed.

Report of the Executive Committee

DELAWARE, OHIO, NOV. 26, 1915.

Five meetings of the Executive Committee have been held during the year, — Jan. 23, Feb. 13, June 12, Oct. 23, and Nov. 26. In each case except the last all officers of the Academy were invited to meet with the Committee.

At the meeting of Jan. 23, Prof. Mills presented to the Committee the Charter of the Academy. It was voted by the Committee that this be deposited in the Ohio State University Library, together with the Certificate of Amendment of 1914.

In response to a vigorous complaint concerning the irregularity of the time schedule of the last annual meeting, it was voted that in future business sessions shall be limited strictly to the time allotted, and shall not be permitted to encroach upon the time of the scientific sessions.

Since the last Annual Meeting twenty-seven applications for membership have been approved by the Executive Committee. The names will be submitted later for the ratification of the Academy.

As instructed by the Annual Meeting of 1914, the Executive Committee has made a canvass by mail of the sentiment of the Academy membership concerning the proposed change of date of the Annual Meeting from Thanksgiving to Easter. The vote on this question was as follows:

Favoring change	32
Opposing change	25
Neutral	38
Total voting	95

A further question concerning the date of the spring vacation brought usable replies from 48 members. A tabulation of these replies shows two rather distinct periods of spring vacation. Of the members reporting, 17 will be in their vacation on Wednesday, March 29, and 25 on Friday, April 21.

Replies to a question concerning possibility of securing leave of absence to attend the meeting were received from 56 members, 24 of whom would be able to secure such leave, and 17 of whom would not, while 15 are in doubt.

The main work of the Executive Committee has been the arrangement for this meeting. The result of this work is seen in the printed program. In addition it should be stated that invitations to send delegates to the Anniversary have been extended to the American Association for the Advancement of Science, the American Academy of Arts and Sciences, and the National Academy of Sciences; to state academies and similar organizations, so far as the list was available; to academies and scientific societies in a number of the larger cities; and to a selected list of local city and college scientific societies in Ohio. Invitations were also sent to a few Canadian societies.

Personal invitations were also sent to the charter members and past presidents of the Academy, and, so far as their names and addresses could be secured, to the members of the old Tyndall Association of Columbus.

At the meeting of November 26 it was voted to recommend to the Academy that all addresses of the Anniversary Meeting be published by the Academy, and, if practicable, in a single volume.

Respectfully submitted,

EDWARD L. RICE,
Secretary of Executive Committee.

The following report of the Publication Committee was received and ordered filed.

REPORT OF PUBLICATION COMMITTEE

During the year the only report published by the Ohio Academy of Science was the Annual Report of the 24th meeting, "Proceedings of the Ohio Academy of Science, Vol. VI, Pt. 4", consisting of sixty pages, the cost of which was $56.00.

JOHN H. SCHAFFNER,
Chairman Publication Committee.

The report of the Trustees of the Research Fund was received as follows, and referred to the Auditing Committee.

Financial Statement of the Emerson McMillin Research Fund, Ohio Academy of Science, for the Year 1914-15

RECEIPTS.

Cash on hand Nov. 10, 1914	$429 91
Check from Emerson McMillin, Nov. 1914	250 00
Total	$679 91

ASSIGNMENTS.

As no bills were presented last year, and no money paid out, we include the assignments of 1913-1914 with those of 1914-1915.

Jan. 9, 1914.	J. S. Hine	$50 00	
Feb. 10, 1914.	F. B. H. Brown	40 00	
Feb. 20, 1914.	O. W. Pflueger	50 00	
Oct. 25, 1914.	R. F. Griggs	50 00	
Dec. 30, 1914.	S. R. Williams, W. H. Shideler	50 00	
Dec. 30, 1914.	L. B. Walton	50 00	
Feb. 25, 1915.	W. H. Bucher, F. C. Blake	100 00	
Mar. 15, 1915.	Charles Sheard	35 00	
	Total		$425 00

EXPENDITURES.

Dec. 9, 1914.	Robert Griggs for research	$5 40
Sept. 21, 1915.	L. B. Walton for research	19 15
Sept. 29, 1915.	W. H. Bucher for research	93 52
Nov. 13, 1915.	J. S. Hine for research	50 00
Nov. 13, 1915.	L. B. Walton for research	24 30
Nov. 20, 1915.	S. R. Williams for research	33 31
	Total	$225 68
Balance in Capital City Bank, Nov. 25, 1915		$454 23

Of this unexpended balance the sum of $199.32 has been appropriated — but no statements of its use have been presented. This leaves an unappropriated balance of $254.91.

A check for $250 for the year 1915-1916 has been received from Mr. Emerson McMillin. This has been placed to the credit of the Ohio Academy of Science in the Capital City Bank, Columbus.

William R. Lazenby,
Chairman.

For the Temporary Library Committee the following reports were presented by Professor W. C. Mills, Chairman of the Committee, and by Mr. C. W. Reeder, representing the Library of Ohio State University. The reports were received and ordered filed, and Professor Mills was authorized to turn over to the Treasurer the accumulated balance mentioned in his report.

Report of the Committee on Library

At the last annual meeting of the Academy of Science it was decided to transfer the library of the Academy from the library room of the Ohio State Archaeological and Historical Society, to the library of the Ohio State University. This transfer was made about the first of the year, 1915. It is now being carefully cared for in a business-like way in the library and the publications are made available for students of the University and others who may care to consult them.

The committee is most happy to know that the University has decided to pay all postage, etc., upon the publications of the Society. You well know for many years the sales of the various publications would not begin to pay for the postage on the special papers and annual reports, but now the sales will no doubt exceed this expense and we are happy to note that this will be another asset to the Academy to have the use of the funds received in payment of publications.

The amount on hand in the hands of the librarian at the meeting one year ago, was $67.08. During the month of December the amount collected from sales of publications, etc., amounted to $9.37. The amount of expense in postage, etc., amounted to 80 cents, leaving a net balance on hand of $75.65. This sum the chairman will be glad to turn over to the treasurer, or to any one designated by the Academy to receive it.

Respectfully submitted,

W. C. Mills, *Chairman.*

Columbus, Ohio, Nov. 26, 1915.

To the Ohio Academy of Science.

Gentlemen: — On November 26, 1914, the Ohio State University Library and the Ohio Academy of Science entered into an agreement with regard to the deposit of the Library of the Academy with the University Library, and its maintenance. Pursuant to the agreement, the Library moved from the Archaeological Museum the material belonging to the Ohio Academy of Science. This material consisted of two sections: 1st. the library proper, and 2nd, the surplus of publications used for sale and exchange.

The library proper was placed in the newspaper reading room in the Library Building and the collection was arranged in proper order. The stock of annual reports and special papers was stored in the basement in connection with other library property.

During the year the new material which has been sent to the Academy in exchange has been cared for and arranged in the Library in the Academy's collection.

At a meeting of the Library Council of the University, on January 16, 1915, explanation was made of the transfer of the Academy's library to the University Library. At that time it was voted that all express, freight and postage bills incurred in the receipt and exchange of publications and correspondence of the Academy should be paid from the University Library funds.

We take it that such an arrangement would be agreeable to the Academy and therefore Article 12 of the Agreement is null and void.

During the year the Library has conducted the sales business of the Academy, having received $30.45. This amount has been turned over to the Treasurer of the Academy.

During the year the Library bound the volumes of the Academy of Natural Sciences of Philadelphia. This is a set for which there has been some demand and from which several numbers were missing. These parts were secured through the kindness of the Secretary, at Philadelphia.

Only one publication appeared during the year, viz.: the Report of the Twenty-fourth Meeting. This was distributed within a few days after its receipt from the printers. In so doing, the Library has a stenciled list cut for the membership of the Academy, and said list is now on file in the mailing department of the University.

During the year all correspondence which has been received has been answered promptly and is on file in the Library. It consisted largely in requests for publications.

The Library was somewhat surprised to find out how little use is made of the Library of the Academy, as deposited with us. It would seem that the membership of the Academy would find things of value in this collection. We mention this at this time in the hope that during the coming year there will be a more extensive use of the Library of the Academy of Science made, and also of the inter-library loan privileges of the University Library.

Respectfully submitted,

C. W. REEDER,
For the OHIO STATE UNIVERSITY LIBRARY.

Dr. Mendenhall, Committee on the Relation of the Ohio Academy with the State Government and with the National Academy of Sciences, reported orally, referring for a fuller statement to his address of the evening. (See p. 284.) Dr. Mendenhall reported a conversation with Governor Willis in which the Governor expressed interest in the closer relation of State and Academy. Voted that F. C. Waite and Herbert Osborn be associated with Dr. Mendenhall as a Committee on Legislation.

Professor Blake presented a report from the Committee on the Financial Management of the Ohio Naturalist and Journal of Science; after discussion the report was referred back to the Committee for revision and presentation at the adjourned business meeting Saturday morning.

No report was presented by the Committee on Catalog of Scientific Journals in Ohio Libraries. Voted that Mr. C. W.

Reeder, of the Ohio State University Library, be added to the Committee (consisting of E. P. Durrant, Chairman, G. D. Hubbard, W. F. Mercer, and E. W. E. Schear), and that a report be requested for the next Annual Meeting.

Voted that the Constitution and By-Laws be amended, as proposed at the preceding Annual Meeting, to provide for a standing Library Committee in place of a Librarian. (See p. 235.)

Voted that the By-Laws be amended to provide for the presentation by the Nominating Committee of two nominations for each office. (See p. 236.)

The following Nominating Committee was elected by the Academy: C. S. Prosser, Herbert Osborn, A. D. Cole.

Meeting adjourned at 11:00 A. M.

November 27, 1915.

Adjourned Business Meeting called to order by President Smith at 9:00 A. M.

The Nominating Committee, as directed, presented a double list of nominations. The ballot of the Academy resulted in the election of the following officers for 1916:

President—Professor G. D. Hubbard, Oberlin College, Oberlin.

Vice-President for Zoology—Professor F. L. Landacre, Ohio State University, Columbus.

Vice-President for Botany—Professor M. E. Stickney, Denison University, Granville.

Vice-President for Geology—Professor T. M. Hills, Ohio State University, Columbus.

Vice-President for Physics—Professor L. T. More, University of Cincinnati, Cincinnati.

Secretary—Professor E. L. Rice, Ohio Wesleyan University, Delaware.

Treasurer—Professor J. S. Hine, Ohio State University, Columbus.

Elective Members of Executive Committee—Professor L. B. Walton, Kenyon College, Gambier, and Professor C. G. Shatzer, Wittenberg College, Springfield.

Member of Publication Committee—Professor J. H. Schaffner, Ohio State University, Columbus.

Trustee of Research Fund—Professor W. R. Lazenby, Ohio State University, Columbus.

Members of Library Committee—(For three years) Professor W. C. Mills, Ohio State University, Columbus; (for two years) Professor F. O. Grover, Oberlin College, Oberlin; (for one year) Professor J. A. Culler, Miami University, Oxford.

The Membership Committee reported fourteen names for election to membership, marked with * in the following list; twenty-seven additional names, already approved by the Executive committee, were also presented. The entire list were elected as follows:

Albyn, Herbert A., Entomology, Ornithology, Archaeology, Toboso, Licking Co.

Baumiller, G. N., Geology, Chemistry, Zoology, 145 Chittenden Ave., Columbus.

*Bradfield, R . M., Botany, Chemistry, Westerville.

Burton, E. Ray, Zoology, 68 W. Central Ave., Delaware.

Caldwell, F. C., Electricity, Light, O. S. U., Columbus.

Carman, J. Ernest, Geology, University of Cincinnati, Cincinnati.

Colton, Geo. H., Physics, Geology, Hiram.

Dearness, Donald F., Geology, Palaeontology, University of Cincinnati, Cincinnati.

*Detrick, O. J., Geology, Huron.

Devereaux, W. C., Meteorology, Weather Bureau, Cincinnati.

Dietz, Harry F., Entomology, 408 W. 28th St., Columbus.

*Durkee, P. W., Physics, Delaware.

*Elliott, Frank, Botany, Zoology, Wilmington.

Fish, Harold Dufur, Animal and Plant Genetics, Denison University, Granville.

*Guyton, Thomas C., Entomology, O. S. U., Columbus.

*Hanawalt, F. A., Biology, 313 Garfield Ave., Middletown.

*Henderson, Chas. W., Physics, Granville.

*Henderson, Nellie F., Botany, 1567 Worthington St., Columbus.

Hoffmeister, Alex. C., Biology, Ohio University, Athens.

*Holt, W. P., Geography, Geology, Zoology, Botany, Normal College, Bowling Green.

Kauffman, I. S., Physics, Geology, De Graff.

Kirk, Joseph M., Meteorology, Geology, Physics, 321 E. 19th Ave., Columbus.

*Lord, H. C., Astronomy, Mathematics, O. S. U., Columbus.

Lutz, Dexter N., Biology, Agriculture, Meteorology, Spencerville.

Meckstroth, Gustav A., Botany, Entomology, O. S. U., Columbus.

Napper, Charles W., Geology, Greenfield.

Plowman, Amon B., Botany, Physiology, Zoology, Municipal University, Akron.

Pratt, Delbert R., Botany, Zoology, Bacteriology, Granville.

Scott, Edward B., Meteorology, Botany, 1894 Summit St., Columbus.

*Sears, Paul B., Botany, Entomology, O. S. U., Columbus.

Shetrone, H. C., Archaeology, Museum and Library Bldg., Columbus.

Shuman, S. C., Botany, Quaker City.

Thomas, Roy C., Botany, Zoology, Geology, R. D. 5, Mt. Gilead.

*Transeau, Edgar N., Botany, O. S. U., Columbus.

Trott, T. Elmer, Mathematics, Astronomy, 2221 Ridgewood Ave., Alliance.

Van Cleve, M. R., Physical Geography, Botany, Morrison R. Waite H. S., Toledo.

*Vivian, Alfred, Agriculture, Chemistry, O. S. U., Columbus.

Williams, John H., Mathematics, Physics, Chemistry, 227 W. Reynolds St., Urbana.

*Withrow, James R., Chemistry, Mineralogy, O. S. U., Columbus.

Wykoff, Harry S., Biology, Botany, Station A No. 4, Alliance.

Yost, Ralph, Genetics, Botany, Bacterioloby, Box 480, Granville.

The following report of the Committee on Resolutions was adopted by the Academy, and the Secretary was instructed to communicate the action of the Academy to the organizations and individuals mentioned by the report.

Report of Committee on Resolutions

Resolved, That the Ohio Academy express its appreciation to the authorities and to the local committee of the Ohio State University for the excellent arrangements which have made the Twenty-Fifth Anniversary meeting one most enjoyable to those who have been in attendance.

Resolved, That we thank Dr. C. F. Marvin, Chief of the United States Weather Bureau, for his address on Applied Meteorology and the Work of the Weather Bureau.

Resolved, That the Academy express thanks to the various societies sending delegates to the Twenty-Fifth Anniversary meeting.

Resolved, That the Society thank Mr. Emerson McMillin for his continued generosity in the support of science in Ohio.

Resolved, That the Society express its appreciation for the services rendered by the Librarian of the University, Mr. Charles Reeder, in connection with the Academy Library.

Resolved, That we appreciate the long and careful accumulation of phenological data by Mr. Thomas Mikesel of Wauseon, Ohio, as a valuable contribution to agricultural meteorology.

L. B. Walton,
E. L. Moseley,
F. O. Grover.

The following report of the Committee on Necrology was received and ordered filed.

Report of Committee on Necrology

As far as known to our committee, but one member of the Academy has been called to cross the boundary line between this world and the next during the last year. Dr. Charles E. Slocum formerly of Defiance, but more recently of Toledo, died in the latter city June 7, 1915. after a brief illness.

Dr. Slocum, who was one of the charter members of the Academy, was a man of liberal education and well trained faculties. In addition to his calling as a physician he was interested in various lines of study and investigation. His publications include "A History of the Maumee Valley," a treatise on "The Injurious Effect of Tobacco," and a series of articles advocating Phonetic spelling. He was an active member of the Ohio Archaeological and Historical Society and of other State and National organizations. He was a man of energy and enthusiasm, leading a busy and useful life.

His death was not only a loss to the community in which he lived, but is regretted by a wide circle of associates in science.

William R. Lazenby,
W. C. Mills,
A. D. Selby.

Report of Auditing Committee

The Auditing Committee presented the following report, which was received and ordered filed.

Columbus, Ohio, Nov. 26, 1915.

The Ohio Academy of Science:

The Auditing Committee has examined the accounts of the Chairman of the Trustees of the Emerson McMillin Research Fund and of the Treasurer of the Ohio Academy of Science together with the vouchers submitted by each and find that their accounts are correct.

Respectfully submitted,
Charles S. Prosser,
John H. Schaffner.

The following revised report was presented by the Committee on Financial Management of the Ohio Naturalist and Journal of Science.

Report of the Committee on the Financial Management of the Ohio Naturalist and Journal of Science

The committee begs leave to submit the following report:

The Academy has lately considerably enlarged its membership, a new section on Physics having been organized and under way now for three years. New names are constantly being added to the membership — it is not unreasonable to expect that in the near future other sections will be added to the Academy. Manifestly, if the interest of these new members is to be maintained, the journal of the Academy must be enlarged to provide for the new material that would naturally be published there. There is no question but that the Academy should eventually finance and manage its own journal.

However, it was made clear last year, after lengthy discussion from the floor of the Academy, that the Academy was in no position at present to finance the journal. Until such time as the Academy should find a way to do this other methods had to be sought. The committee at a meeting held last Spring received a verbal statement from the Biological Club of the Ohio State University to the effect that it would gladly transfer the management of the Ohio Naturalist and Journal of Science, now the Ohio Journal of Science, to any organization that could assure the Biological Club that an efficient financial management would be provided for the journal. Remembering the discussion last year from the floor of the Academy to the effect that the Academy was in no position at present to give such assurance, the committee decided after careful discussion, to recommend to the Biological Club that a new general science club be organized at the Ohio State University and that this new club should assume control of the magazine until such time as the Ohio Academy of Science could successfully do so. This new club is now organized under the name of the Ohio State University Scientific Society and is financially responsible at present for the publication of the Ohio Journal of Science. For the current year a close estimate of the cost of publication is eight hundred dollars, the cost of the Naturalist in late years being about four hundred and fifty dollars.

The committee accordingly recommends:

1. That the present arrangement of the Academy with the Biological Club of Ohio State University be continued, slightly modified, with the Ohio State University Scientific Society; the modification to be that one dollar of the dues paid to the Academy by each member is to go to the support of the journal. This arrangement is to terminate at the request of either party.

2. That the publication committee of the Ohio Academy of Science is to constitute the Academy representation in the Editorial Board of the Ohio Journal of Science.

3. That a new committee of five be appointed by the President, which shall investigate carefully possible ways and means whereby the Academy can successfully take over the Ohio Journal of Science and how soon this can be done, the committee to report back to the Academy at its next annual meeting. This new committee should co-operate with the committee on the relation of the Academy to the State.

Respectfully submitted,

F. C. Blake,
Jas. S. Hine,
L. B. Walton,
Committee.

After an extended discussion the report was adopted, and the incoming President was instructed to appoint the Committee called for in the third recommendation of the report. President Hubbard appointed the Committee as follows: J. Warren Smith, Chairman, Frank Carney, J. S. Hine, C. G. Shatzer, F. C.

Waite. On the resignation of Professor Smith, Professor L. B. Walton was added to the Committee and Professor Carney made Chairman.

Voted that the Constitution and By-Laws be amended, as proposed at the preceding annual meeting, to transfer the date of the annual meeting from fall to spring. (See p. 236.)

Voted, further, that the next annual meeting shall be held in the spring of 1916, the date and place to be arranged by the Executive Committee.

Voted that the addresses presented at the Anniversary Meeting be printed in the Proceedings of the Academy, if, in the judgment of the Executive and Publication Committees, this action is financially practical.

Meeting adjourned at 10:00 A. M.

AMENDMENTS TO CONSTITUTION AND BY-LAWS

(Adopted at Annual Meeting, 1915)

CONSTITUTION.

ARTICLE IV. OFFICERS, COMMITTEES, ETC.

SECTION 1. Amended to read: — The officers of the Academy shall be a President, a Vice-President of each Section organized, a Secretary, and a Treasurer.

SECTION 5*a* (to be renumbered when Constitution is reprinted). New, to read: — The Library Committee shall consist of three members, elected in accordance with the provisions of Section 15.

SECTION 11. Omitted. (Referred to duties of Librarian.)

SECTION 14*a* (to be renumbered when Constitution is reprinted). New, to read: — The Library Committee shall advise with the Librarians of Ohio State University on all questions arising in connection with the management of the Library of the Ohio Academy of Science, deposited with the Ohio State University Library, and in connection with the distribution of the publications of the Academy.

SECTION 15. Amended to read: — *Terms of Office.* The President, Vice-Presidents, Secretary, Treasurer, and Elective Members of the Executive Committee and Publication Committee, shall be elected annually at the annual meeting, and shall be eligible to reelection without limitation, with the exception of the President, who shall not be elected for successive terms. The Trustees of the Research Fund and the members of the Library Committee shall be elected for a term of three years, one Trustee and one member of the Library Committee being elected each year.

ARTICLE VI. MEETINGS.

SECTION 1. Amended to read: — *Annual Meeting.* The Annual Meeting shall be held during March or April, the place and exact date being determined by the Executive Committee and announced by circular at least thirty days before the meeting. The details of the daily session of each meeting shall be arranged by the Executive Committee, and announced in the official program immediately before the meeting.

BY-LAWS.

CHAPTER I. MEMBERSHIP.

SECTION 3. Amended to read: — Non-payment of annual dues shall deprive a Resident Member of taking part in the management and receiving the publication of the Academy. An arrearage continuing over two years shall be construed as notification of withdrawal. The Secretary and Treasurer shall be exempt from the payment of dues during the year in which they hold office.

CHAPTER IV. ELECTION OF OFFICERS.

SECTION 2. Amended to read: — The Academy shall select by ballot a Nominating Committee consisting of three members who shall nominate two candidates for each office, including elective members of the Executive Committee, the Publication Committee, the Trustees of the Research Fund and the Library Committee. Additional nominations may be made by any member of the Academy.

CHAPTER VIII. ORDER OF BUSINESS.

SECTION 1. Amended to read: — The order of business at the Annual Meeting shall be as follows:

1. Opening.
   a Call to order by the Presiding Officer.
   b Statements by the President.
   c Appointment by the chair of a committee of three on membership. To secure nominations of new members.
   d Appointment by the chair of a committee of three on resolutions.
2. Reports of officers.
   a Secretary.
   b Treasurer.

3. Appointment by the Academy of an Auditing Committee of two members.
4. Reports of Standing Committees.
   a Executive Committee.
   b Publication Committee.
   c Program Committee.
   d Trustees of Research Fund.
   e Library Committee.
5. Reports of Special Committees.
6. New Business.
7. Election of Nominating Committee.
8. Report of Nominating Committee and Election of Officers.
9. Election of Members.
10. Report of Committee on Resolutions.
11. Report of Auditing Committee.
12. Unfinished Business.
13. Adjournment.

PRESIDENT'S ADDRESS

Agricultural Meteorology

J. WARREN SMITH

CONTENTS.

INTRODUCTION

Agricultural Meteorology is defined as meteorology conducted in the interest of agriculture. It considers the effect of the weather conditions upon the development and yield of the different crops. It is a branch of phenology.

Phenology is defined as the branch of meteorology or of biology that treats of animal or plant life and development as affected by climate.

Agricultural climatology is that branch of agricultural meteorology which shows the effect of climate upon the geographical distribution of vegetation and the adjustment of farm activities. This is the science that is considered in classifying the vegetation of the globe into great botanical groups or belts, as it is affected by the varying intensities of temperature, sunshine, and rainfall.

Natural vegetation has adjusted itself to these climatic factors through long ages of selection, until it is possible to refer to certain well defined locations where any certain tree or shrub maintains its best development, other sections where it has a constant struggle for existence, and still others where it is never found.

CULTIVATED PLANTS

While man is constantly trying to grow crops in regions not indigenous to them and indeed not well adapted to them, it will be found that the main standard crops are grown in the region and in the manner best suited for their best development.

The great law of the survival of the fittest applies in crop management as in everything else, and the farmer has unconsciously adjusted his activities to the best crop and applies his labor on it in the proper season for producing the largest yield in the best condition. This relates, of course, to the staple crops in a district that has been occupied long enough to have the crop distribution properly adjusted.

In a comparatively new country where transportation facilities are not well established certain varieties of crops will be grown which later it will be found can be produced more economically elsewhere and the ground devoted to some better paying crop. For example, flax and wheat were at one time extensively raised in New England, while now both crops are very rare there.

There is sometimes an unconscious shifting of farm activities that will not be noticed for a number of years and then can be explained only on the ground of proper adjustment due to climatic influence.

One of the most interesting examples of this kind is the division of the dairy industry in Wisconsin into definite cheese making and definite butter making districts. This was pointed out by Baker and Whitson in Bulletin 223 of the Wisconsin Agricultural Experiment Station.

At one time butter and cheese factories were scattered over central and southern Wisconsin. Now, however, the commercial cheese factories are concentrated into two well defined large districts in southwestern and eastern Wisconsin, and two smaller centers in the north-central and northwestern portions of the State. The butter industry, on the other hand, occupies southeastern Wisconsin.

By comparing the distribution of these two industries with the climatic maps it develops that the commercial cheese factories are almost exclusively within the region with less than 150 days in the growing season, while the commercial butter factories are where the growing season is more than 150 days in length.

It develops also that south of the mean summer isotherm of 70° F. there are no cheese factories in Wisconsin, and that those between the isotherms of 69° and 70° are not numerous and are mostly small. The mean isotherm of 65° for the cheese making season approximately bounds the cheese regions of the State on the south. This adjustment is thought to be partly due to the effect of the lower temperature on the quality of the cheese product and partly to the effect of temperature upon the vegetation.

Another crop that is largely determined by climate is the sugar beet. The beets will grow well in a warm wet climate, but the sugar content will be high enough to warrant growing them commercially only in a cool region and where the hours of daylight are many. This crop has made its best development commercially, in the United States, not for from the isothermal line of 70°.

The United States Department of Agriculture, through the Office of Farm Management in cooperation with other branches of the Department is now studying in great detail the geographical and climatological distribution of the various farm crops in the United States. The charts and tables will include many phases of climate, crop distribution, dates of planting and harvesting, crop yields, etc. When this is completed it will undoubtedly be one of the most important contributions to agriculture ever made.

CRITICAL PERIODS OF GROWTH

Experiment Station investigators have found that every plant has its optimum temperature and moisture values during which it makes its best development, that this varies in different periods of growth, and that the heat and moisture must be in right proportion.

The plant food is brought to the roots of a plant by the moisture in the soil there to be worked into vegetable tissue by the energy of the solar rays. If there is a lack of plant food part of the solar energy is wasted, while, on the other hand, if there is more food brought to the roots than the solar energy can utilize then the food material is wasted.

In the arid districts of the western part of the United States there is naturally too much energy for the food supply, but when through irrigation a large amount of fuel is made available for the great solar engine, remarkable crops result.

In the highest latitudes there is generally an excess of moisture and a deficiency of heat. These are the conditions that prevail in much of northern Europe, and there the crop yields are largely a question of temperature variations.

In some places where the rainfall is sufficient but the temperature is too low for the best growth of plants, as in Alaska, sunshine becomes the most important factor. In fact we must not try to separate sunshine and heat. Solar energy is the factor that enables the plant to make use of the food brought to its roots by moisture, whether we call this energy degrees or calories.

A value called the "Sunshine-hour degree" has been obtained by multiplying the average daily heat necessary to grow and mature a crop by the total possible hours of sunshine from planting to harvesting. We have worked out the sunshine-hour degree for corn in the United States and find that between latitudes 30 and 35 it is 80,313; between latitudes 35 and 40 it is 65.778, and between latitudes 40 and 45 it is only 47,887.

This shows that the number of sunshine-hour degrees necessary to make a crop diminishes as the latitude increases, and explains why there is a decided difference in the quantity of heat necessary to grow and mature the same crop at different latitudes due to the difference in the quantity of sunlight.

AGRICULTURAL METEOROLOGY

Russia has apparently taken the lead in trying to determine the most critical period for field crops, as well as the weather factor most affecting them, by the inauguration of studies in the field.

The Russian Bureau of Agricultural Meteorology was authorized in 1894 and began its observations in 1896. In 1912 they had observations under way at 81 different experiment stations where meteorological observations were being made as near as possible to the test farms. During each year they have made a detailed study of the effect of the various weather factors upon the development of the plant and the final yield of the crop.

In Canada Mr. R. M. Mills has been placed in charge of similar work, and during the summer of 1915 he has had records made relative to the spring wheat crop at 14 different experiment farms scattered from coast to coast.

Forms were prepared covering 73 different items, among them being the average height of the plants on the plot every

7 days throughout the summer. Mr. Mills has visited the farms and is now correlating the crop data with the temperature, rainfall, and sunshine.

In England systematic phenological observations have been made for a good many years, and frequent studies have been made of the advance of the season, and some of weather and crop development.

The United States Weather Bureau maintains a very elaborate meteorological service in the interest of shipping and agriculture, but there is a dearth of systematic, continued and extended phenological records from which definite studies can be made.

One noted exception to this statement is the splendid and remarkable series of records kept by Mr. Thomas Mikesell of Wauseon, Ohio, part of which have recently been published in Monthly Weather Review Supplement No. 2.

In this report there has been published 13 different items regarding 16 different fruits from the time the buds start until the trees are divested of leaves; ten different items on 20 different field and garden crops; eigth items relative to 48 different forest trees, shrubs and vines, and the dates of blossoming of 114 different plants. These are for a period of 30 years.

For the same period the daily rainfall, and daily maximum, minimum and mean temperatures have been observed by Mr. Mikesell and are published in the same volume. It is believed that this pamphlet contains the most complete local record of the development of plant life to be found in this country, although it represents only a part of the phenological records kept by Mr. Mikesell.

PERSONAL INVESTIGATIONS

While this country has comparatively few records for making extended field studies of weather effects as is being done in Russia and Canada, it has seemed to the speaker that we have, in the crop yield and meteorological statistics that are being regularly collected and published, data available for determining the critical periods in the growth of staple crops.

The important thing seems to be to get the data for a period long enough so that accidental coincidences will be eliminated, then to develop a practical method of comparing the yield with definite weather conditions for definite periods of time.

The United States Department of Agriculture and the different State Boards of Agriculture have been collecting crop yield statistics for a good many years. In Ohio the yield figures for the staple crops are available for the different counties for each year since 1850. At the same time the United States Weather Bureau has been keeping daily records of the various weather factors for over 40 years at its regular stations and has been collecting similar data as regards rainfall and temperature at thousands of cooperative stations well distributed over the country.

There have been enough of these voluntary and regular stations in Ohio to give a reliable State average for the temperature for each month from 1850 to date and for the rainfall since 1854. Although not many States have a record to equal this they nearly all have these data for a considerable period of time.

We have used three different methods for determining whether there is a relation between certain weather factors and the yield of crops. These are the plotted curve, the dot chart, and the mathematical calculation for giving the measure of relation between two factors as expressed in the correlation coefficient. The first two are graphical while the third is the method developed by Bravais, Galton, Edgeworth, Pearson, and Yule.

WEATHER AND THE YIELD OF CORN

Inasmuch as 75% of the world's production of corn is grown in the United States, and as this is easily the most important crop in Ohio, this crop was used in our first complete study. These studies have determined that the most important weather factor in varying the yield of corn is rainfall and the most important period, considering calendar months is July.

The average rainfall for Ohio in July is almost exactly four inches while the average yield of corn for the State for the past

60 years is 34.5 bushels per acre. In figure 1 two curves have been charted showing the variations of the corn yield and the July rainfall from the normal for each year from 1854 to 1913.

An inspection of this chart will show that while in a few cases the curves do not run together, in general there is a marked relation between them. This is especially true when there is much variation from the normal.

If the 60 years be grouped by different rainfall amounts the yield figures show some interesting results. This is brought out in table 1 where the July rainfall amounts are grouped for each variation of one-fourth inch, one-half inch, and one inch.

Table 1. Effects of Variations in July Rainfall in Ohio, on the Yield of Corn. 1854 to 1913.

For each increase in the rainfall of	There has been an increase in the corn yield of		
	Per Acre.	*Total Bush.*	*Value.*
¼ inch from 1.75 to 8.0 in.......	0.8 bush.	2,800,000	$1,400,000
¼ inch from 2.0 to 4.0 in.......	1.4 bush.	5,900,000	2,950,000
½ inch from 1.75 to 8.0 in.......	1.2 bush.	4,200,000	2,100,000
½ inch from 2.5 to 3.5 in.......	4.3 bush.	15,050,000	7,525,000
1.0 inch from 1.75 to 8.0 in.......	2.3 bush.	8,050,000	4,025,000
Below 3.0 in. to 5.0 or more......	7.8 bush.	27,300,000	13,650,000

The total amount of land devoted to corn in Ohio averages 3,500,000 acres. The average farm price of corn on December 1 is 50c per bushel.

One of the most important facts brought out in this table is that there is a critical July rainfall value of close to 3.00 inches. For example the first item in the table shows that the average increase in the yield of corn with each increase in the rainfall of one-fourth inch from 1.75 inches to 8.00 inches, is 0.8 bushels per acre, but between 2.00 inches and 4.00 inches, each increase in the rainfall of one-fourth inch causes an increase in the yield of 1.4 bushels per acre.

Again in the 3rd and 4th items the figures show that with each increase of one-half inch in the July rainfall the yield averages to increase at the rate of 1.2 bushels per aere, but when

[1] Figure 1 is omitted because of the size of the chart.

the rainfall passes the 3.00 inch mark the increase in the yield with each variation of one-half inch in rain amounts to over three and one-half times as much, or 4.3 bushels per acre.

These figures mean that near the critical rainfall point a variation of one-fourth inch in July means a variation in the value of the corn crop in Ohio of nearly $3,000,000, and that a variation of one-half inch makes an average variation in the value of the crop of over seven and one-half million dollars.

The last item in the table indicates that when the rainfall for July for the State of Ohio averages over 5.00 inches the probable corn yield will be more than 27 million bushels greater than it would be if the rainfall averages less than 3.00 inches. This is an increase in the value of the corn crop of $3.90 per acre or an increase in the purchasing power of the farmers of Ohio of $13,650,000 due to corn alone. This will allow for the purchase of over 30,000 of the most popular priced automobiles, with a nice little sum left over for repairs.

Four greatest corn States. Of the total acreage of corn in the United States 30% is grown in the four States of Indiana, Illinois, Iowa, and Missouri. Of the total amount shipped out of the County in which it is grown 60% is raised in these four States. The average area devoted to corn in these States is 30,-325,300 and the average yield is 32 bushels per acre.

In these States when the rainfall for July has averaged between 2.0 and 2.5 inches the yield of corn has averaged 23 bushels per acre, and when the rainfall has been between 2.5 inches and 3.0 inches the yield has averaged 33 bushels per acre. This increase of 10 bushels per acre with an increase of only one-half inch of rain means an increase in the value of the corn crop of $5 per acre or the interesting sum of $150,000,000.

When the rainfall for July over the 8 great corn States of the central part of the United State's has averaged more than 4.4 inches the yield of corn has been greater by 500,000,000 bushels than when the rainfall has been less than 3.4 inches.

If corn is King surely rain is the "power behind the throne," and when a variation of this amount in the amount of rainfall in July can be shown to increase the value of the corn crop fully

$250,000,000 it must be true that rainfall in July is the dominating weather factor in the production of corn, in the United States.

In figure 2 the importance of rainfall in July is emphasized and it is made clear that the variations in mean temperature in July do not greatly affect the yields of corn. This is the second graphical method employed and is called the "dot chart." This

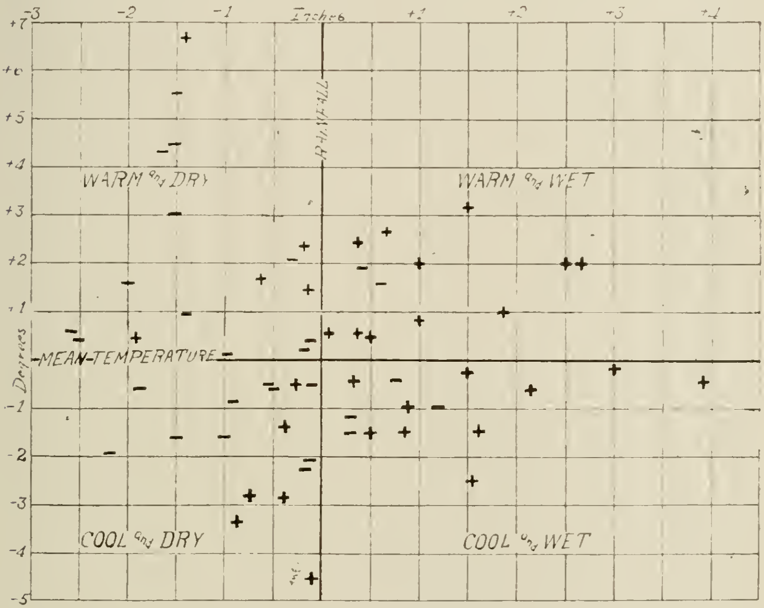

FIGURE 2. Dot chart showing the combined effect of temperature and rainfall during the month of July upon the yield of corn in Ohio, 1854 to 1913.

chart is a most practical method for showing the effect of two factors upon a third.

In this case the combined effect of temperature and rainfall during the month of July upon the yield of corn is indicated. That temperature does not have a material effect is made plain by the fact that there were just as many good yields of corn when the temperature was above the normal as when it was below the normal. On the other hand the plus marks, showing the yield above the normal, are far in excess when the rainfall was above the normal.

If we considered only those years when the rainfall departed one inch or more from the normal it will be seen that when it was wet the corn yield was above the normal 12 times and below only once, and that when it was dry there were 13 poor yields and only 2 good ones. In other words when the rainfall in Ohio for July is more than one inch above the normal

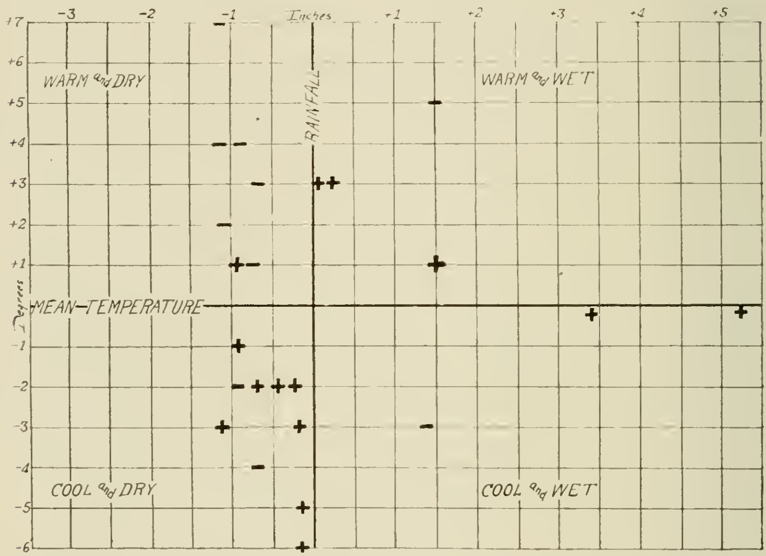

FIGURE 3. Dot chart showing the combined effect of temperature and rainfall during the 10 days following the date of blossoming of corn upon the yield. Wauseon and Fulton County, Ohio. 1883 to 1912.

the probability of a good corn crop is 92%, and when the rainfall is one inch or more below the normal the probability of a good corn crop is only 13%.

THE CORRELATION COEFFICIENT (r).

The importance of the rainfall for July in connection with the yield of corn as compared with other months is made plain in table 2. The two graphical methods heretofore described show the general relation between two factors, but the exact measure of the relation between two variables is best determined by the correlation table as used by statisticians. This measure is shown by the nearness of the correlation coefficient (r) to unity. The values of r have been determined between the yield of corn in Ohio and the rainfall for the different summer months and are shown in table 2.

TABLE 2. CORRELATION OF THE RAINFALL WITH THE YIELD OF CORN IN OHIO. 1854 TO 1913.

Period.	*Correlation Coefficient (r)*	*Probable ± Error.*
June	0.12	±0.09
July	0.59	±0.06
August	0.37	±0.08
June and July combined	0.48	±0.07
July and August combined	0.67	±0.05
June, July, and August combined	0.57	±0.06

This table makes plain that the rainfall for the month of July has a far greater effect upon the yield of corn than either the month of June or August, somewhat greater than for June and July combined, and slightly greater than for June, July, and August combined, but that the rainfall for July and August combined has a greater favorable effect than for July alone. Similar correlation tables made for both the four as well as the eight largest corn States show the same dominating effect of the July rainfall as compared with the other summer months.

In order to ascertain what other or shorter periods than calendar months might have a marked effect upon the corn yield correlation tables have been worked out between the corn yield in central Ohio and the rainfall for each period of 10, 20, 30, 40, and 50 days from June 1 to August 31. The period giving the highest value of r. in each case is given in table 3.

TABLE 3. THE MOST IMPOTANT PERIODS FOR RAINFALL IN THE DEVELOPMENT OF THE CORN CROP IN CENTRAL OHIO. 1891 *to* 1910.

Period.	*Most important.*	*Correlation Coefficient (r)*	*Probable ± Error..*
For 10 days.	August 1 to 10..................	0.52	0.10
For 20 days.	July 21 to August 10...........	0.50	0.10
For 30 days.	July 11 to August 10...........	0.49	0.10
For 40 days.	July 11 to August 20...........	0.60	0.09
For 50 days.	July 1 to August 20...........	0.59	0.09

In making the correlations from which table 3 was obtained, the ten day periods were for each successive ten days, i. e., June 1 to 10, June 11 to 20, etc. In making the 20-day correlations the periods were for each 20 days beginning June 1, June 10, June 21, etc. The longer periods overlapped as in the 20-day grouping.

The correlation coefficient for the 10 days from August 1 to August 10 was considerably higher than for any other 10 days thus showing that this is the most important ten days in the latitude of central Ohio, in the growth of the corn crop. In the longer periods the value of r as indicated in table 3 was not much greater than for one or more nearby groups.

In order to ascertain what relation the above mentioned periods bore to the growth period of corn, table 4 has been taken from the Wauseon, Ohio, phenological data, referred to on page 245.

TABLE 4. PHENOLOGICAL DATES RELATIVE TO CORN RECORDED AT WAUSEON, OHIO. 1883 TO 1912.

Date corn was	*Average.*	*Earliest.*	*Latest.*
Planted	May 14...	April 26...	June 18.
Above ground	May 23...	May 6.....	June 23.
In blossom	July 25....	July 10....	Aug. 6.
Ripe	Sept. 13...	Aug. 30...	Oct. 10.

From these data and the meteorological observations taken at Wauseon tables 5 and 6 have been prepared. The total effective heat or "thermal constants" was determined by getting the sum of the daily temperatures above 43 F.

TABLE 5. THERMAL CONSTANTS FOR CORN AT WAUSEON, OHIO, WITH CORRELATION COEFFICIENT BETWEEN THE TOTAL EFFECTIVE HEAT AND THE CORN YIELD. 1883 TO 1912.

Effective heat for	*Average.*	*Greatest.*	*Least.*	*Correlation Coefficient (r)*
Ten days before planting.....	150	318	—25	—0.03
Planting to above ground....	143	201	36	—0.03
Above ground to blossom....	1,599	1,984	1,232	0.18
Blossom to ripening..........	1,337	1,607	897	0.08
Ten days before blossom.....	296	350	240	—0.003
Ten days after blossom......	286	360	160	—0.28

In table 5 the only value of r that is high enough to receive consideration is for the ten days after blossoming. As this is negative it shows that cool weather is desirable.

TABLE 6. TOTAL RAINFALL FOR CORN AT WAUSEON, OHIO, WITH THE CORRELATION COEFFICIENT BETWEEN THE RAINFALL AND THE YIELD OF CORN. 1883 TO 1912.

Rainfall, inches and tenths.	*Average.*	*Greatest.*	*Least.*	*Correlation Coefficient.*
Ten days before planting.....	0.9	2.6	T	0.01
Planting to above ground.....	1.0	3.3	T	—0.06
Above ground to blossom....	7.4	15.3	2.3	—0.03
Blossom to ripening..........	4.6	13.8	1.1	0.29
Five days before to five days after blossoming	0.8	4.0	T	0.45
Ten days before blossom.....	1.1	3.7	T	0.20
Ten days after blossom.......	1.1	6.4	0	0.74
Twenty days after blossom...	...	...	...	0.57
Thirty days after blossom....	...	...	...	0.46

The results from the correlation in table 6 are very important. It makes plain that there is no relation between the rainfall during the first part of the period of growth of corn and the yield. But it makes equally plain that for the ten days immediately following blossoming rainfall is of great importance to the corn crop. The value of r for this item is 15 times the probable error. It is considerably higher than for either the 20 or the 30 days following the date of blossoming.

In figure 4 the combined effect of rainfall and temperature for the 10 days following the date of blossoming of corn at Wauseon, Ohio, is indicated. This demonstrates that wet weather at this time is nearly always favorable for a good yield of corn and that dry weather is not necessarily unfavorable if it is accompanied by cool weather. But when warm weather accompanies the lack of rain the probability of a poor crop is close to 90%.

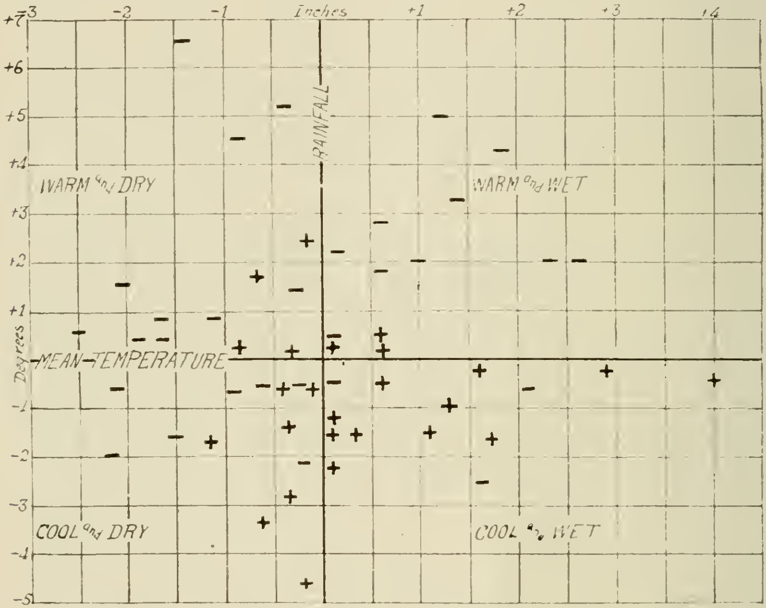

FIGURE 4. Dot chart showing the combined effect of temperature and rainfall during July upon the yield of potatoes in Ohio. 1860 to 1914.

From the above it is shown that the critical period in the growth of corn is for the ten days following blossoming. For 10-day periods it is from August 1 to 10, and for calendar months it for the month of July. If it were practicable to compute the 60-year record of rainfall for the period from July 15 to August 15 this would undoubtedly give the highest value of r in a correlation with the corn yield and thus show this period to be the most critical one in the development of this crop, in the United States.

THE CRITICAL PERIOD FOR POTATOES

For the State of Ohio the most critical calendar month for potatoes is July, as has been shown in an article in the Monthly Weather Review for May, 1915.

Table 7. Correlation Between the Temperature and Rainfall and the Yield of Potatoes in Ohio. 1860 to 1914.

Period.	Correlation Temperature.	Coefficient (r) Rainfall.
April	......	—0.21
May	—0.10	0.06
June	—0.22	0.10
July	—0.51	0.33
August	—0.31	0.22
September	—0.21	—0.13
October	—0.11	0.07
June and July combined	—0.50	......
July and August combined	—0.50	0.37
June, July and August combined	—0.49	......

In table 7 it is shown that cool weather is desirable during each month of the summer to produce the best crop of potatoes, while July is the important month. In fact this is the only month with a correlation coefficient high enough to warrant any decided argument in the matter. When the summer months are combined the results are not far from those for July alone. The higher value of r shows that the temperature has a greater effect in Ohio than rainfall, on the potato crop.

Figure 4 is a dot chart giving the influence of July rainfall and temperature upon the potato crop in Ohio. It covers a period of 55 years. This shows that warm weather in July is nearly always unfavorable for potatoes and that there is seldom a good yield when July is warm and wet. This is in marked contrast to the effect of these conditions on the corn crop.

When the mean temperature in July has averaged more than 1 degree a day higher than the normal the yield of potatoes has been above the normal twice and below the normal 14 times. This is a probability of 88% that the yield will be below the normal if July is very warm. When the temperature has been above the normal and the rainfall more than one inch either greater or less than the normal the yield has always been below the normal. When it has been cool and wet the yield has been above the normal 12 times and below only three times. A cool and dry July has just as many yields above as below the normal.

A similar dot chart made by combining July and August shows that warm and dry weather for the two months is decidedly unfavorable, while cool and wet weather for the two months is decidedly favorable.

Table 8 shows the results of a correlation of the potato yield in central Ohio with the rainfall and temperature for each ten days from June 1 to August 31. This indicates that the period from July 1 to 10 is the most important ten days, for potatoes, as regards both temperature and rainfall.

TABLE 8. CORRELATION OF THE YIELD OF POTATOES IN CENTRAL OHIO WITH TEMPERATURE AND RAINFALL FOR EACH TEN DAYS. 1891 TO 1910.

	Correlation	*Coefficient (r)*
Period.	*Temperature.*	*Rainfall.*
June 1 to 10	—0.12	0.29
June 11 to 20	—0.17	0.32
June 21 to 30	—0.28	0.16
July 1 to 10	—0.44	0.48
July 11 to 20	—0.33	—0.29
July 21 to 31	—0.33	—0.12
August 1 to 10	—0.23	0.06
August 11 to 20	—0.36	0.37
August 21 to 31	—0.38	—0.26

While most of the rainfall values of r are not high, it is interesting to note that part of them are negative and part positive, showing that part of the season rain is needed and part of the time that it is a detriment. This condition persists throughout similar correlations for 20, 30, 40, and 50 day period correlations.

A correlation between the yield of potatoes with the temperature and rainfall constants during the development of the plant, made by using the phenological data at Wauseon, Ohio, shows that the most important period for temperature is for the 10 days following the date of blossoming. Cool weather is necessary to insure a good crop. Rain is necessary during a number of weeks before blossoming.

WEATHER AND WINTER WHEAT

While most spring seeded crops, especially those of rapid growth, have well defined periods when they are greatly affected by the weather, it is much more difficult to find the dominant weather factor as well as the critical period of growth with fall seeded crops or those with a long growing period.

In connection with winter wheat, for example, the general opinion is that particular weather conditions must have a great effect upon the yield. Expressions like the following are common: "The weather of the fall was fine for the wheat crop." "A poor crop of wheat will be harvested because the winter was so severe." "It was so mild in January that a splendid wheat crop is assured."

Correlation coefficients have been calculated showing the relation between the yield of winter wheat in Ohio and the temperature and rainfall conditions, covering periods from 30 to 60 years. Some of these appear in table 9.

TABLE 9. CORRELATION OF THE YIELD OF WINTER WHEAT IN OHIO WITH THE TEMPERATURE AND RAINFALL.

	Correlation	*Coefficient* (*r*)
Period.	*Temperature.*	*Rainfall.*
September	0.16	0.04
October	0.09	0.16
November	0.14	—0.02
December	0.05	—0.17
January	0.21	0.09
February	0.26	0.01
March	0.46	0.06
April	—0.10	0.02
May	—0.11	0.02
Autumn (September to November)	—0.03	0.17
Winter (December to February)	0.17	—0.17
Spring (March to May)	0.19	0.15

The second column in this table shows that there is no appreciable relation between the variations in rainfall in Ohio and the yield of winter wheat. The rainfall is neither too heavy nor too light often enough to have an appreciable effect upon the yield. This is true of individual months as well as for the fall, winter, and spring seasons.

The first column of table 9 also shows that neither the mean temperature for the fall, winter, and spring seasons nor that for individual months except February and March, has a controlling effect upon the yield of wheat. The value of r for March is slightly more than seven times the probable error and as this is preceded by the plus sign it shows that warm weather in March is very important for a good yield.

Figure 5 brings out the influence of the temperature for March upon the winter wheat in Ohio. An inspection of the chart will show that March has been warmer than the normal

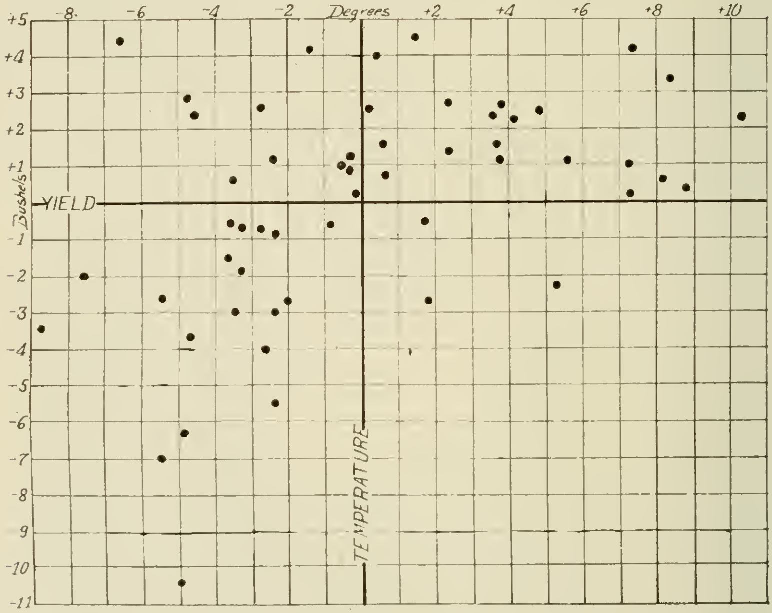

FIGURE 5. Dot chart showing the relation between the mean temperature for March and the yield of winter wheat in Ohio. 1860 to 1913.

24 times during the past 54 years, and that in those years 21 have had a wheat yield above the normal and only 3 a yield below the normal.

On the other hand a cool March usually means a poor wheat yield although the unfavorable effect is not quite so marked as is the favorable effect of a warm March.

If we consider only those years when the departure of the mean temperature has been two degrees a day from the normal then with a warm March the probability of the wheat yield being above the normal is 94% and with a cold March the probability of a poor wheat yield is 75%.

EFFECT OF SNOW COVERING ON WINTER WHEAT

It is common to credit a good snow covering in the winter time with a good yield of wheat, or to say that the lack of a snow blanket is sure to cause a poor yield of wheat. But careful correlations made in Ohio seem to show no beneficial result from snow covering or damage from the lack of it. At least the snow covering does not have a dominating influence. On the other hand the studies seem to show that bare ground with freezing and thawing weather during January is beneficial.

SNOWFALL AND YIELD OF WINTER WHEAT

Further, while a snowfall in January appears to be favorable, it is found, contrary to the usual opinion, that a snowfall in March is decidedly detrimental to winter wheat.

In figure 6 a chart is reproduced showing by one curve the departure of the wheat yield from the normal in Fulton County, Ohio, and by the other the departure of the snowfall from the normal at Wauseon. It will be at once seen that with two or three exceptions the wheat yield is always poor when the snowfall is above the normal and the wheat yield is always good when the snowfall is below the normal.

This curve is substantiated by a correlation between these factors in this and several other counties in Ohio, so that the truth seems to be well established. In fact the correlation coefficients show that this is the most important weather factor in its effect upon the yield of winter wheat in Ohio. Just why this is so remains to be answered along with a great many other similar questions.

A FEW OF THE PROBLEMS

Why are oats grown so extensively in northern Ohio and not in the southern portions of the State? Why is it that head lettuce is grown with such splendid success in the green houses

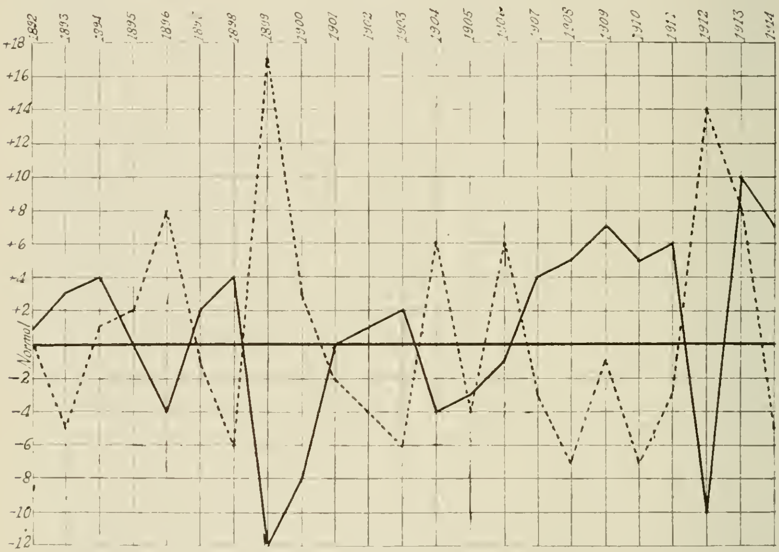

FIGURE 6. Curve chart showing the relation between the snowfall in March at Wauseon, Ohio, and the yield of winter wheat in Fulton County. 1892 to 1914.

about Boston but cannot be grown at all in the vicinity of Cleveland?

What is the length of the growing season of a crop planted at different times and under different climatic conditions? Are crops being planted at such times as will bring that period of their development when they need much water at the season of the year when there is an abundance of rainfall, or does it come when there is little rainfall? Is the value of an early crop great enough to warrant planting so early that it will be killed by frost 25%, 50%, or 75% of the time? If so what are the dates of spring frosts?

If it is true that nitrate of soda has its best effect upon crops in dry and warm weather and sulphate of ammonia produces the best results in moderately wet weather, should not the kind of fertilizer to be used depend upon the climate and the season of the year? Is it true that Agricultural Experiment Station investigators have been carrying on long fertilizer experiments without taking into account the different amounts of heat and rainfall during the different years covered by the tests?

It has been found that the keeping quality of seeds as well as their germinating vigor depends upon the condition of the weather while they are ripening. In Europe it has been found that the weather during the ripening of some crops has more to do with the yield from that seed than that of any similar period during the growth of the plant.

This being the case the exact condition of the weather when seeds of any crop are ripening should be known and those selected from only that district that had the most favorable ripening conditions, even if one has to go a long distance for them. The question will then follow whether we can vary the time of planting, the thickness of the stand, or the kind of fertilizer so that the date of ripening can be brought into that period when weather most favorable for the seed is most apt to prevail?

Why is the keeping quality of onions, for example, different from seed grown in California than that grown in Michigan? Why was it considered necessary for many years to get cabbage and cauliflower seed from Long Island in order to have them head in the most satisfactory manner? Why is it that while spring wheat shows a better yield and quality if the seed is obtained from more northern districts winter wheat seed, on the other hand, gives best results if selected from more southern districts?

If it is true that wheat ripened in a marine climate contains such a low per cent of protein, as compared with that grown in an inland continental climate, that it becomes necessary to increase the consumption of other nitrogenous foods, why do we never inquire as to the locality from which our flour comes or the conditions of moisture under which the wheat is grown?

Some of our investigations in Ohio show that the weather during June of one year has a greater effect upon the apple yield of the *next* year than the weather of any other month of the next fifteen, but is this universally true? We know something of the effect of longer hours of sunshine or of daylight in varying the color of flowers and the texture of fruit and of grain, but we know little of the effect of much sunshine at just the proper period of growth in producing some extraordinary yields.

As I see the matter agricultural meteorology can answer these and a multitude of similar questions by finding the critical period of growth for the different plants in different parts of the country and then correlating this knowledge with the known climatic factors.

The determination of the critical period of the plant and the weather most affecting it can be accomplished in two ways. One by a systematic study of the temperature, rainfall, sunshine, and evaporation at the Agricultural Experiment Stations and the record of the immediate effect of these conditions on the various plants. This is the plan that is in effect in Russia and has just been taken up in Canada.

The other is by correlating the crop yields during past years with the weather conditions that prevailed during each growing season, by means of charts and correlation tables. To accomplish this the tabulating and charting of climatological data under way by the Weather Bureau must be completed and the average and extreme temperature, rainfall, and sunshine data determined, not only for States but for groups of States and for parts of States. These should cover as many years as possible and be tabulated by months and groups of months. In the most important agricultural districts the averages should be determined for 10-day periods or for definite weekly periods.

THE VALUE OF SUCH A SERVICE

The United States Weather Bureau is and has been for years carrying on definite work in the interest of agriculture which is properly placed under the head of agricultural meteorology. I refer to the special corn and wheat region service, the cotton and rice service, its special fruit service, and its weekly and monthly crop bulletins.

But when the critical period for the various plants has been discovered and the information is at hand that will appear in the Agricultural Atlas, then these special activities of the Weather Bureau will take on a special significance and can be made of far greater value to the agricultural interests of the country than they now are.

The value of the knowledge gained from a study of agricultural meteorology cannot be over estimated. Take the irrigated districts of the West, for example, how often one sees crops or even whole fields spoiled by too much water. Grain watered at the wrong time giving a great stand of straw but little grain. Potatoes given too much moisture just as the tubers were setting and the result being many more than the plant could mature. Water used on one plant that did not need it, at a time when the supply was limited, while another crop should have had a maximum supply at this period of its growth.

Even in the humid region of the central and eastern districts a correct knowledge of the importance of water at the right time will make men see the value of being able to supply this moisture through irrigation.

I wonder whether we have even begun to understand the importance of plenty of water in our crop production scheme. Surely there must be something in the old legend of the pot of gold at the end of the rainbow. Only if we but know it it is not necessary to follow the rainbow to its end to find the gold. The gold has fallen from the clouds before the rainbow came into view.

If every summer shower should bring down to the ground dimes and dollars and golden eagles, how eagerly we should watch for each thunderhead as it loomed above the western horizon. If a new land should be discovered where one could go out after each storm and find money lying around on the ground or pick it from the trees and shrubs, there would be a stampede to this new Eldorado such as the days of '49 never knew.

And yet it seems clear that the rains of the growing months of summer leave wealth over every acre of ground just as surely as would be the case if money actually fell from the skies. To be sure we cannot see the real coins, and because so little has been done to measure the actual value of the rain in dollars and cents we have not thought it possible to calculate its worth.

We know, of course, that it has a value, but never have thought it possible to separate this one factor from all of the others that go to control the growth of vegetation and produce the crop.

We believe that this new Agricultural Meteorology when properly developed will enable us to express rainfall in terms of cash value instead of in inches of water, temperature in the ability of the farmers to buy instead of in degrees, and sunshine in the increased number of automobiles and diamond rings instead of in calories.

REFERENCES

1. The Climate of Wisconsin and its Relation to Agriculture, by A. R. Whitson and O. E. Baker, The University of Wisconsin Agricultural Experiment Station Bulletin 223, July, 1912.

2. Phenological Dates and Meteorological Data Recorded by Thomas Mikesell at Wauseon, Ohio, compiled and edited by J. Warren Smith, Monthly Weather Review Supplement No. 2.

3. The Effect of Weather upon the Yield of Corn, by J. Warren Smith, Monthly Weather Review, February, 1914.

4. Correlation. J. Warren Smith, Monthly Weather Review, May, 1911.

5. The Effect of Weather upon the Yield of Potatoes, by J. Warren Smith, Monthly Weather Review, May, 1915.

APPLIED METEOROLOGY AND THE WORK OF THE WEATHER BUREAU

CHARLES F. MARVIN

Mr President, Members and Friends of the Ohio Academy of Science:

It is my first pleasure to try to express to the Academy my sincere thanks and appreciation for the honor and opportunity of attending and taking part in the program of this Quarter-Centennial Meeting. Some of those present already have a more or less intimate knowledge of the rather exceptional conditions that surround my presence here today, but I feel that to many these incidents need to be briefly mentioned in order that all may understand the mingled feelings of pleasure and gratitude that impress me — pleasure because of the opportunity to renew old acquaintances and visit many once familiar scenes — gratitude because whatever attainments I may have reached in later years in the field of science, I owe very largely to the stimulation and inspiration in early life of members of this Academy and others whose labors in the seventies and eighties to give science and education in science a prominent place in Ohio and especially in Columbus culminated first in this great University and later in the Organization of the Ohio Academy. Columbus is the home of my youth, the University my alma mater. Scenes that greet my eyes on every side are tinged with all the romance and color of the past and call up all the memories, the hopes and ambitions of the youth. To be more specific the occasion which brings us together today recalls to my mind the times in the "seventies" when Prof. Mendenhall and others charmed the Columbus audiences in the old Opera House by wonderful exhibitions of scientific apparatus, accounts of the invention of the telephone, and the introduction of courses in manual training in the colleges and educational institutions. On other occasions the Tyndall Association arranged exhibitions of scientific experiments and apparatus drawn from the laboratory of the new University, then known as the Ohio Agricultural and Mechanical College. These events were features of the intellectual activity of the city and served to delight and instruct the enthusiastic boy as well as all who attended. I can not help but associate these memories tinged and colored as they are by all the enchantments of youth, with the Ohio Academy of Science, because the origin of both is to be found in the scientific activities, purposes and ambitions of one and the same body of men. The mention of these thoughts and incidents will I hope help to make you understand something of the seriousness, sincerity and depth of the feelings that impress me on this occasion.

It is my privilege and pleasure also to extend to the Ohio Academy of Science the sincere and cordial congratulations, commendations and felicitations of the Washington Academy of Sciences which I have the honor to represent as delegate for this purpose. It is earnestly hoped that this anniversary may be propitious of many subsequent recurrences and that the hopes and objects of the Academy may be fully realized and attained.

In addition to the incidents I have already mentioned as serving to make my present position somewhat peculiar I find also in the title of this brief address, "Applied Meteorology and the Work of the Weather Bureau" a coincidence and a happy opportunity of gratification to all Ohio scientists. In this I refer to the not widely enough known circumstance that Ohio is the real birthplace of the United States Weather Bureau and its invaluable system of simultaneous meteorological observations telegraphically reported. It seems particularly appropriate at this Quarter-Centennial Celebration of the Ohio Academy of Science to very briefly outline the early work of Prof. Cleveland Abbe while Director of the Mitchel Astronomical Observatory at Cincinnati, during 1867-70. In claiming that the Federal Bureau is the direct outcome of Abbe's initiative, we do not in the least disregard or ignore the splendid work done in the United States by such men as Redfield, Piddington, Maury, Espy, Henry, Ferrel and others who contributed greatly to give Meteorology a place among the sciences nor do we overlook the efforts of Lapham and Paine to secure appropriate legislation but it remained for Abbe to give the country a concrete demonstration of just how a practical meterological Bureau rendering a definite daily service to the community could be organized and conducted. He, it seems, realized in fuller degree than any others the beneficient possibilities of the work and saw ways in which the results could be attained. We Ohioans may well be proud that the little Cincinnati Observatory was the center of this activity, although Abbe himself by birth and education must be accredited to New York. — Prof. M. W. Harrington, a former chief of the Weather Bureau, has given a succinct account of the steps leading to the establishment of the National service from which I may be permitted to quote as follows: —

"In the more detailed plan for the future activity of the observatory which he outlined in his inaugural report, Professor Abbe gave a prominent place to the particular subjects, in connection with which he has won fame. It was his desire, primarily, to extend the field of activity so as to embrace, on the one hand, scientific astronomy, meteorology, and magnetism, and, on the other, the application of these sciences to geography and geodesy, to storm predictions, and to the wants of the citizens and the land-surveyor. In meteorology, he remarked, the observatory ought to keep record of regular hourly observations of all phenomena depending upon observations of the atmosphere: 'The science of meteorology is slowly advancing to that point at which it will begin to yield most valuable results to the general community. Although we can not yet predict the weather for a week in advance, yet we are safe in saying that, with a proper arrangement of outposts, we can generally predict three days in advance any extended storm, and six hours in advance any violent hurricane. This may be effected simply by constituting the observatory a central station, to which telegraphic reports of the weather are regularly daily transmitted. The careful study of these dispatches enables the meteorologist safely to make the predictions mentioned, which can be at once disseminated through the public papers or otherwise. In France, Italy, and England, and on our own eastern coast, such storm-warnings are considered of very great importance.' The co-operation of the Smithsonian observers and those of the army had already been promised; and at the end of the year, in consideration of the fact that the most of our storms appear on this side of the Rocky Mountains and move eastward, observers had been secured at Omaha, Cheyenne, Sherman, and Salt Lake City. * * * *

"The location of the observatory in the smoke-saturated atmosphere of Cincinnati had been for some time recognized as unfavorable for astronomical observations, and efforts were made to secure a more suitable position for it. While this was going on there could be but little heart in such measures as might be proposed for permanent improvements in the building or the fixed apparatus. It therefore seemed evident that the remaining time spent upon Mount Adams could be best improved by paying special attention to meteorology. An hourly record was begun of all important atmospheric phenomena. Monthly reports of meteorological observations were received from observers in other cities. The interest of the Chamber of Commerce was engaged in the organization of a system of daily weather-reports and storm-predictions; the gratuitous co-operation of experienced observers was tendered; and the use of the Western Union telegraph lines was offered at a nominal price. The daily 'Weather Bulletin' of the Cincinnati Observatory was issued first in manuscript form, for the use of the Chamber of Commerce, and a week later in print, as an independent publication. It was supported for three months by the Chamber of Commerce, then passed into the hands of the observatory. Finally, the independent publication was discontinued, and the bulletin only appeared under the same title in the morning papers. Subsequently, the publication, by a manifold process, of a daily weather-chart was undertaken, which, in consequence of the observatory's lack of means, was kept up at the expense of the Cincinnati office of the Western Union Telegraph Company. The National Board of Trade meeting at Richmond, Virginia, united in a memorial to Congress, the fruit of which, with other proceedings of a similar character, among which was Professor Lapham's memorial asking for the institution of signals for Milwaukee and Lake Michigan, was the passage of a joint resolution authorizing the Secretary of War to provide for taking meteorological observations at military posts in the interior of the continent, and on the lakes and seacoasts, for the purpose of giving warning of the approach and probable force of storms.

"The superintendency of these observations, or the 'Weather Bureau,' was put in the charge of General Albert J. Myer, Chief of the Army Signal Service, who appointed Professor Abbe his assistant, or meteorologist."

It is apparent from this brief account that Professor Abbe was primarily imbued with the purpose not only to extend the field of scientific meteorology, but to apply that knowledge to the "prediction of storms and the wants of the citizen." The joint resolution of Congress approved February 9, 1870, and which provided for the establishment of the meteorological work of the Government under the Signal Service of the Army, is as follows:

> That the Secretary of War be, and he hereby is, authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent and at other points in the States and Territories of the United States, and for giving notice on the northern lakes and on the seacoast, by magnetic telegraph and marine signals, of the approach and force of storms.

A study of the origin, as well as of the legislation providing for the establishment and extension, of the Weather Bureau clearly indicates that *practical utility* has always been a dominating consideration. The chief criterion by which the justification of appropriations is determined is the direct benefit to agriculture, commerce and navigation. Such a condition is not highly propitious to the rapid progress of the pure science of meteorology; nevertheless, there is no lack of authority of law permitting the Weather Bureau to engage in research and legitimate investigations in the realms of pure meteorology. In the practical administration of the appropriations, however, by far the greater part is required for the effective maintenance of the regular daily service, while the amount that can be diverted to technical investigations and studies is relatively small. A fair recognition of these conditions is essential to a proper understanding of the work of the Bureau, which, as we see, may well be styled a work of applied meteorology.

While describing these conditions to you, as a matter of information I desire to add that the present policy of the Bureau seeks to maintain its practical service to the public as effective as possible and at the same time to encourage and undertake every species of research and investigation that promise legitimate and useful results and that funds will permit.

The whole fabric of the Weather Bureau work is built upon the foundation of regular meteorological observations over a very extended region. Many of these are made simultaneously and reported telegraphically. In recent times the wireless agencies of communication have made available to us immediate reports, otherwise unobtainable, from vessels at sea. These have been of very great value at times, as, for example, such reports from vessels plying the waters of the Gulf of Mexico and the Caribbean Sea during the occurrence of those terrifying tropical storms known as the West Indian hurricanes. Neither national boundaries nor continental outlines, however, offer any limitations to atmospheric conditions or the study of meteorological problems, and for a number of years before the outbreak of the European war the Weather Bureau obtained telegraphic weather reports from a considerable number of stations scattered over the entire northern hemisphere. With the aid of these it inaugurated on January 1, 1914, the publication of a daily weather map of the northern hemisphere. It is of scientific interest to note that temperature was shown on these maps on the absolute scale and pressure was expressed in absolute units of force. We hopefully look forward to the resumption of this publication so valuable to the student and which was immediately terminated upon the opening of European hostilities.

In the minds of the general public the Weather Bureau is associated, simply, with the daily forecasts of weather and temperature — a work that is relatively not of the highest importance. The great service of the Bureau is found in its numerous warnings of frosts, floods, cold waves, storms dangerous to shipping and in numerous bulletins and advices relating to the current weather conditions and their influence upon all the principal and important crops. I imagine there is scarcely any one here who does not already know a good deal about the frost-warning service in the interest of the horticulturists, especially. This beneficial service is administered throughout Ohio under Professor Smith's very capable supervision, and is known to be the agency through which many enterprising horticulturists are able to protect crops and orchards on occasions when nature, allowed to carry out her own course, would cause great damage, or total loss.

The Bureau's application of the science of meteorology to the welfare of man is not only beneficial to agriculture, commerce and navigation, but at times it is an agency of great beneficence and accomplishes great saving of life by means of its ample warnings of storms, floods, hurricanes and impending danger from atmospheric causes.

A long time might be occupied in reciting examples and instances illustrating our daily work, but I will ask you to allow me time to mention only one or two.

On one occasion our official at Denver saw in advance that unusual flood conditions were certain to occur on the lower Colorado River. This conclusion was reached from a careful analysis of the following contributory conditions: The amount of snow over the mountains and regions constituting the head water's of the main river and its tributaries; the stages of these rivers at various points and their known rates of discharge; the current and prospective weather conditions and other minor factors bearing on the ultimate result. Accordingly, flood warnings were disseminated to the effect that on a certain date, then some ten days ahead, the Colorado River at Yuma, Ariz., would reach a crest stage of 30 feet. Corresponding warnings were sent to Needles, Cal. The tracks of the Santa Fe transcontinental railway cross the Colorado River at this point on a great modern steel bridge, and the receipt of such an alarming warning was attended with more or less of incredulity, especially as little or no tangible evidence in justification thereof was apparent. Nevertheless, the railway company and others concerned took necessary precautions. Rising steadily day after day, the great river on the date specified attained a stage at Yuma of 29.6 feet, just .4 of a foot higher than predicted. Because of the advance warnings and its preparedness the railway company at Needles was able to make a desperate fight against the flood and just succeeded in averting tremendous damage and loss.

Another illustration of how meteorology is being applied in the saving of life and to the benefit of commerce may be drawn from numerous incidents connected with great storms of the past summer. During the latter part of September a West Indian hurricane of unusual intensity traversed the waters of the Caribbean Sea and the Gulf of Mexico and passed inland in the vicinity of New Orleans. Doubtless many of you have read the press reports of the destruction of lives and property caused by this great storm. Ample warnings were disseminated by the Weather Bureau and afforded opportunity of taking every precaution possible. The confidence displayed in the warnings by certain railroad officials responsible for the safety of property and the lives of passengers is shown by a letter sent after the storm to the official in charge of the Weather Bureau station at New Orleans. The letter is signed by the superintendent of the Louisville & Nashville Railway Company. A portion of it reads as follows:

For your information I should say that in each case your warnings were repeated by us to the headquarters of the system and men and material were assembled and held in readiness until the danger had passed.

At threatened points employes were put on the alert, "track walkers" to guard the roadway were increased in number and every precaution taken required by the circumstances.

As a consequence, though every sort of damage was occasioned by the wind and water during the storm of September 29th to the roadway, there was not a single accident to the trains, and, having been prepared in advance for the emergency, the road was reopened for business a month in advance of the possible time predicted by many familiar with the character of the damages which the road sustained.

Our route, as you are aware, is very much exposed as it skirts so closely the sea shore, and no forest or hill range affords protection, hence our great dependence upon the service of your Bureau which has been so well rendered.

I believe you are aware that we gave out your warnings to the people as requested by you on the 28th. Many heeded the warnings and escaped the fate of those unfortunate people who stubbornly refused to believe because "the weather was so fine," and lost their lives when the cataclysm came.

Our bridgemen chained their cars to the track at Rigolets, as the force of the storm increased, and advised by this office of what to expect upon information given by you, actually had to put people in the cars by force.

Upon receipt of your last and conclusive report of Tuesday afternoon I personally notified the people on the coast train and spread the intelligence on the streets of Bay St. Louis. As a result yachts, power boats, and other craft sought refuge up the Jordan and the Wolf rivers and escaped.

Very many persons along the coast from Chef Menteur to Dunbar, inclusive, escaped by getting away when warned, those who were drowned at Lake Catherine and Rigolets lost their lives because they did not heed the warning given in ample time.

The following interesting particulars of the loss of life at Rigolets are furnished by the official in charge at New Orleans:

The loss of life at Rigolets resulted from an absolute disregard of specific warnings and advice to come to New Orleans. Mr. John T. Meehan, of the Times-Picayune, was in the local office, Weather Bureau, when we issued the specific warning at 8:20 a. m., September 29, giving the path which the hurricane would follow and advising that hurricane winds and high tides would prevail over southeastern Louisiana that day and night. He asked me what the result would be at Rigolets, stating that he knew some people there, and I told him he had better telephone them at once, which he did. He spoke with Manuel, the keeper of the club, through his wife, gave him the warning and told him to have everybody come to New Orleans on the next train, which was due to pass that place about 10 a. m. Manuel replied that the train would not stop for them, and Mr. Meehan told him that if the train would not come to a stop for flagging to put a cross tie on the track. The keeper said, "They will put me in jail," to which Mr. Meehan replied, "You would be better off in jail than where you are now. Stop that train at all hazards and come to New Orleans." It has since been learned that Manuel flagged the train and it stopped, but the people were not there to get aboard, the rising tide was jeopardizing the passengers on the train, which could not wait until the people could be collected from the houses. Manuel returned to his companions and when the storm was over his lifeless body, with 23 others of those who were in the club, were found strewn over the marshes. Mr. Meehan, who went to the Rigolets the morning after the hurricane, with a rescue party, assisted in looking after the burial of the keeper, Manuel, and his companions.

These illustrations serve to show what great opportunities exist for the Weather Bureau to render beneficial as well as beneficent services to the public at large, and each year seems to open up some new field of activity. Recently the meteorology of great forest fires became the subject of critical study by the Weather Bureau official at Portland, Ore. Assisted by advices and technical information from representatives of the State and Federal forest services, a method has been developed for forecasting hot, dry winds which are favorable to the inception and spread of forest fires. The tentative efforts in this new line of work have been very beneficial, if we may judge by the reports from the organized agencies occupied with fighting forest fires, and the Bureau is providing for the extension and better conduct of this important work, which can aid so greatly in the conservation of forest reservations.

No one has listened with more interest than myself, I believe, to your President's address on the subject of Agricultural Meteorology, and Professor Smith's prior work in this field has added distinction to himself and credit to the Weather Bureau as well. It has sometimes been reproachfully represented that the Weather Bureau is behind the times and backward because it has not already occupied the field of Agricultural Meteorology. I am not willing to admit the justification of any such view. I realize, however, that the truth about the matter depends a good deal upon the definition we attach to the expression "Agricultural Meteorology."

Those present who may happen to be familiar with the responsibilities of legally disbursing the appropriations made by Congress for the maintenance of a Federal bureau realize how important it is that the work for which money is expended is specifically authorized by the language of the law. As a matter of fact the Weather Bureau is a pioneer in the domain of agricultural meteorology, but the work has not been conducted under that name. Moreover, owing to special statutory limitations and the administrative classification and organization of the work of the Department of Agriculture, it is quite possible the Weather Bureau may be technically disbarred from engaging in certain lines of work that may well fall within the domain of Agricultural Meteorology. Quoting from our organic law, we find these words:

The Chief of the Weather Bureau, under the direction of the Secretary of Agriculture, shall have charge of forecasting the weather * * * ; the reporting of temperature and rainfall conditions for the cotton interests; the display of frost, cold wave, and other signals; the distribution of meteorological information in the interest of agriculture and commerce, and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the

United States, or as are essential for the purpose for the proper execu-
United State, or as are essential for the proper execution of the foregoing duties.

The position we occupy on this question, I believe, is this: From its establishment in 1870 the Weather Bureau has been increasingly engaged in every phase of weather forecasting, the issue of frost and cold wave warnings and the taking of meteorological and climatic observations, all in the interests of agriculture and for the benefit of commerce in live stock and agricultural products. There is supplemental legislation that authorizes "investigations in meteorology, climatology, seismology, evaporation and ærology." In a few words, Agricultural Meteoroolgy may be broadly defined as meteorology applied to the needs and conducted in the interests of agriculture, and from this point of view the Weather Bureau is a pioneer in that field. It behooves us soon to adopt the attractive title for the work, and such a course was recommended in 1913 by a committee of the Weather Bureau, but administrative reasons and technical exigencies have postponed effecting the necessary reorganization to accomplish the desired change. Professor Smith's studies have shown how the work may be extended into fields hitherto but little cultivated, and the fullest practical support and encouragement of his work is assured.

I cannot occupy more of your time on this occasion to discuss the investigations the Bureau is making of ærology by means of kites and balloons or our studies in the measurement of solar radiation, or the investigations and observations we are now authorized to make in seismology. Substantial progress is being made, we believe, along all these lines and in theoretical studies in subjects closely allied to each.

The Bureau welcomes suggestions and friendly criticisms, and urges that specialists and educational institutions devote attention to technical meteorology. Many important problems still await solution, and material differences of view prevail concerning some of the fundamental principles of storm genesis, their maintenance, etc. Meteorology as a science has not yet entered upon its laboratory stage. What is needed is a genuine meteorological laboratory in which experimental work can be undertaken upon the major problems of the physics and dynamics of the atmosphere.

The Bureau is now publishing its Monthly Weather Review promptly and aims to give it the character of a magazine of technical meteorology. All interested in the advance and development of both theoretical and applied meteorology may feel that its pages are open to them for the presentation of contributions to this important literature.

HISTORICAL SKETCH OF THE OHIO ACADEMY OF SCIENCE

William R. Lazenby

Twenty-five years ago the first decisive steps were taken looking toward the organization of an Ohio Academy of Science. At the annual meeting of the Biological Club of the State University held Nov. 3, 1891, the retiring president made a short address in which he said substantially: There is need of one institution in Ohio to the organization of which our club should direct its combined energy and influence. This is a state academy of science. If local clubs and societies of science are beneficial, the reasons that make them so apply with greater force to a state organization. Who can estimate the inspiration, the stimulus to research and investigation that such an institution would provoke. In a great agricultural state like Ohio, a deep, abiding and constantly growing interest will ever be taken in the sciences of geology, botany and chemistry, for these constitute the very foundation, the body and bones of any rational basis of practical knowledge regarding soils and the various crops that grow thereon. But our State Academy would not be confined to the sciences that relate so directly to soils and crops. All branches of biology, as well as physics, chemistry, methematics, anthropology, meteorology, economics, sociology, etc., everything that contributes to the sum total of scientific knowledge should find a place. The initial steps toward the founding of such an academy should be taken by this club, and tonight. This can be done by the appointment of a committee, which should energetically push the matter by preparing a program for a meeting, and issuing a call to all interested, to assist in the organization. In pursuance with this declaration the club appointed a committee consisting of D. S. Kellicott, W. A. Kellerman and the speaker to take such measures as in their judgment were deemed best to carry into effect the wishes of the Biological Club.

The Committee soon secured the promise of hearty co-operation from many of the most prominent scientists in Ohio, and issued a call for a meeting to be held in Columbus, December 31, 1891.

The meeting took place at the date named, and appointed a committee on organization consisting of W. A. Kellerman, of the Ohio State University; E. W. Claypole, of Buchtel College; and Henry Snyder of Miami University.

While the committee just named were preparing a constitution and by-laws, papers were read by Dr. A. M. Bleile, E. E. Bogue, J. N. Bradford, H. E. Chapin, H. J. Detmers, W. A. Kellerman, D. S. Kellicott, H. A. Weber, W. C. Werner, and A. A. Wright.

After the adoption of a brief but comprehensive constitution and a few simple by-laws, the organization was completed by the election of the following officers to serve the first year: President, E. W. Claypole, Buchtel College, Akron; Vice Presidents, A. A. Wright, Oberlin; and Ellen E Smith, Lake Erie seminary, Painesville; Secretary, William R. Lazenby, Ohio State University, Columbus; and Treasurer, A. D. Selby, Columbus, Ohio. Elected as members of the Executive Committee were, E. T. Nelson, Ohio Wesleyan, Delaware; and A. D. Cole, then of Denison University, Granville. It should be noted that of the seven elected officers only two, the Secretary and Treasurer, were residents of Columbus, and connected with the State University. I mention this to show that from the very outset, the Academy has been a state-wide institution and in no way restricted or limited to any one section of the state. Attention is also called to the fact, that the charter members of the Academy, fifty-nine in number, included mathematicians, chemists, physicists in generous proportions.

It was also quite representative of the educational institutions of the state that were interested in science. Besides the State University which naturally had the largest number, the following universities and colleges were represented: Buchtel, Cincinnati, Denison, Miami, Mount Union, Oberlin, Ohio, Ohio Wesleyan, Otterbein, Starling Medical, Western Reserve and

Wilmington. Lake Erie Seminary and the State Experiment Station as well as the High Schools of Alliance, Cincinnati, Cleveland, Columbus, Chillicothe, Dayton, Defiance, Geneva, Kent, Portsmouth, Sandusky and Tiffin were likewise represented.

At the first meeting, the Secretary was instructed to secure articles of incorporation, and to publish the constitution and by-laws, together with a list of the officers and members.

In accordance with the above instructions, a certificate of incorporation was duly filed with the Secretary of State on March 12, 1892. This certificate bore the following names as incorporators of the Ohio State Academy of Science: W. A. Kellerman, *F. M. Webster, A. D. Selby, W. C. Werner, E. E. Bogue and W. R. Lazenby. Of these incorporators Professors Kellerman and Bogue have passed away.

*Died at Columbus Jan. 3rd.

The Academy held its first field meeting in Summit County on June 3 and 4, 1892, the headquarters being at what was then Buchtel College in the city of Akron.

The program for the field day included an excursion by steamer to Long Lake and the day was spent in and about the attractive "Lake District" of Summit county. The botanists observed the rich and varied plant societies of the swamps, and the geologists were interested in the great moraines to which, in part, at least, the swamps, ponds and lakes owe their origin. In the evening a reception was held in the gymnasium of Buchtel college, at which the visitors were welcomed by the mayor of Akron, the President of the College, Dr. O. Cone, and the president of the Akron Scientific Club.

The next day at an early hour the members and visitors set out for Cuyahoga Falls, where they were cordially welcomed. They were conducted some three miles through the post glacial gorge of the Cuyahoga River.

This excursion was equally interesting and profitable. The geologists and botanists and entomologists improved the opportunity and added to their stores of scientific facts.

After the passing of a quarter of a century, I can look back upon this as one of the red-letter days of my life.

What was called on the program the first annual meeting, although in reality the second, was held in Columbus, Dec. 29 and 30, 1892. At this time twenty-five papers were read. They treated for the most part of some phase of botany, geology and entomology. Perhaps the most significant action at this meeting was a brief report of the Committee on Publications, which announced that it had selected the Journal of the Cincinnati Society of Natural History and the technical series of Bulletins of the Ohio Experiment Station, as the official organs of the Academy, until better arrangements can be made. This arrangement continued until the publication of the Ohio Naturalist in 1899, I believe, and since then, or for a period of fifteen years this publication has been the official organ of the Academy. At the end of this year the Ohio Naturalist becomes the Ohio Journal of Science.

At the close of the first year of the existence of the Academy, the total membership was as follows: Annual members, 116 — of which number 59 were charter members, and one life member, Mr. Emerson McMillin, who at this early day became a generous patron.

Having dwelt in some detail upon the founding and early history of the Academy, — I shall treat its subsequent career and accomplishments more briefly.

Statistics are usually wearisome, but in the interests of history they cannot be wholly avoided.

What may be termed the annual membership of the Academy has increased from 59 charter members in 1891 to 234 members in 1915. About one-fifth of the membership resides outside of Ohio, and are found in 15 different states, besides the District of Columbia, Hawaii and Canada. The Ohio residents are found in more than 50 counties of the state.

To illustrate the regularity of growth in numbers, the 5th year the membership was 157; 10th, 173; 15th, 179; 20th, 196; 25th, 234.

As to attendance, one cannot speak confidently for no records have been kept. On the average, I should say that one-third of the resident membership attended the annual meetings. As to place, 14 of the 25 annual meetings have been held in Columbus, 2 in Granville, 2 in Cincinnati, 2 in Cleveland, one each in Oxford, Delaware, Akron and Oberlin.

Summer meetings have been held in well selected places in the following counties: Summit, Hocking, Licking, Erie, Butler, Knox, Montgomery, Franklin, Ottawa, and Wayne. Several of these were joint meetings with other orgainzations. For example, the meeting in Butler County was in connection with the Indiana Academy of Science; in Franklin County the summer of 1899, with the A. A. A. S. The meeting at Put-in-Bay and one at Sandusky with the Ohio State Teachers' Association. These delightful summer meetings were held each year for the first ten years of the life of the Academy. For some reason, unknown to me, they then ceased. Would it not be well to renew them? As summer schools are now held at many points in Ohio, it might be advisable to arrange a meeting of a day or two with the scientific departments of some one of these schools.

The papers presented during the 25 years number 1124, or an average of 45 for each meeting. The range in number is from 10, read at the first meeting to 64 read at the fifteenth. At the twenty-third meeting the number was 61 and at the twenty-fourth it was 58.

Cloud and sunshine, joy and grief are common contrasts in our life. We experienced these contrasts at the eighth annual meeting. The first serious break in the ranks of our membership, had then occurred. Two of our oldest members were missing. We grieved that Dr. Kellicott had been stricken by death, and that Dr. Claypole had left Ohio to spend the remainder of his days in the more genial climate of California.

At the same time we rejoiced that one who had already proven himself a friend, should modestly announce that he had given the Academy $250, to be expended in ways best suited to promote scientific research, with the further statement that such a sum might be given annually, provided the use made of the money was satisfactory, and it proved convenient for the donor to spare it. We may assume that these conditions have been fulfilled, for from that day to this, or for eighteen successive years, this generous gift has been received. It has come to us quietly, promptly and without solicitation during all these years.

It has been administered in the same quiet way, and not one penny has been used for anything except to aid in research, or the publication of its results.

The influence of this gift has been as gentle and persuasive as the spring sunshine or summer shower. Nearly a score of special papers have been prepared and published by the Academy through its aid. As many more have been published elsewhere. All honor to this scholarly, efficient, large-hearted, high-spirited man. I trust he believes that "the reward of a good is to have done it," if not I don't know how he is to be paid.

We are here today in a spirit of congratulation. We congratulate our Academy upon what it has accomplished. We congratulate Emerson McMillin on what he has done for the Academy.

We congratulate the Universities, Colleges and High Schools of Ohio, that so large a number of their instructional force are active workers in our organization. Our annual meetings have confirmed and strengthened a spirit of good will between the educational institutions of the state. They have cultivated the amenities and developed a feeling of brotherhood among our members. Our Academy has stood for good scholarship, good fellowship, and good citizenship. The essentials of a great landscape are unity and variety. These are likewise the great attributes of an association for the promotion of science. Unity in the spirit and ideals of the work to be accomplished, and variety, infinite variety, in the means by which these ideals may be developed. We come together on the basis of commanding interests and diverse experiences. This devotion to the varied phases of science detracts nothing from the pursuit of the older humanities, but adds materially to the effectiveness of any study that puts the student in closer touch with his environment, in closer touch with nature and nature's laws. This spirit was in Orton, and Kellicott and Claypole, who were among the founders of the Academy. What a fine influence these men exerted!

What fine lives they led! It was a happy blending of the strenuous, the simple and the abundant life.

Strenuous, because in addition to the enforced and exacting labors of a teacher were added the self-imposed tasks of the investigator; simple, because they lived close to nature and her laws were the rule and guide of their daily conduct. They had neither time nor means for luxury. And most of all their lives were abundant; abundant in opportunity, abundant in accomplishment, abundant in honors, abundant in friendship. Demanding little, they received much. They are of those who losing their lives save them.

We are together to celebrate an epoch, not alone in the promotion of science but in the attainment of the ideals of education; ideals for which the Academy will stand in the future as it has in the past.

THE RELATION OF THE ACADEMY TO THE STATE AND TO THE PEOPLE OF THE STATE

T. C. Mendenhall

We are celebrating the twenty-fifth anniversary of an institution whose existence is unknown to the great majority of the people of Ohio. Yet it has enjoyed a prosperous life of a quarter of a century during which it has held many meetings in different parts of the state. At these meetings important results of original research on the part of its members were presented, many of which have been published by the academy and in various scientific journals, thus becoming a part of the great store of learning which the world is accumulating.

The academy can not be fairly charged with undue exaltation of its own merit or importance in the past and, as an incorporated institution of the state it has a right to think that some consideration should now be given to the relations which it might and should sustain to that state and to the people of the state.

As a preface to such consideration it seems desirable to refer to the views of a few persons who would naturally be among its most active supporters did they not believe that under present conditions there is no good reason for the existence of such a society as the Ohio Academy of Science, contending that other organizations of a similar character, mostly national in their scope, offer as good or better facilities for the accomplishment of the principal ends the academy has in view. There is enough ground for such a contention to justify a reply.

Of the many remarkable social evolutions that have marked the last quarter of a century none is more curious and interesting than the marvelous increase in the number of societies or groups of people associated together for some special purpose other than what is generally known as "business." It seems to be an accepted theory that if anything is to be done or ought to be done it is only necessary to form an organization of those who think it ought to be done, after which it is often assumed that in some mysterious way the thing will do itself. There is no part of the country however remote or difficult of access that has not been penetrated by and permeated with this malady, and clubs, associations, circles, etc., have been formed in bewildering numbers and perplexing confusion as to origin and *raison d'etre*. Persons cynically inclined have attributed this to the fact that each organization requires a president and other officers and that the universal desire for place-holding is thus gratified. While there is doubtless more truth in this explanation than we would care to acknowledge, the phenomenon is largely the outcome of the modern drift towards specialization in all spheres of human activity. Indeed it is more than a drift; it is a veritable flood-tide and many organizations of recent creation are examples of specialization gone mad.

Scientific men have not escaped this epidemic and during the past twenty years their segregation into groups each of which confines its activities in study and research to a special and often a very narrow field, has gone on with alarming rapidity. Alarming because while there can be no question that science has been and will continue to be greatly advanced by specialization it can not be denied that the man of science has suffered and will continue to suffer from the same cause. Burrowing in a trench, necessary as that operation often is, if persisted in to the exclusion of other occupations, deprives the burrower of that breadth of view and general acquaintance with the topography of the surrounding country which is necessary to the understanding, direction or control of larger operations. It will be admitted that up to the present time the epoch-making generalizations in science have originated with men, who, though profound students of some great subdivision of human knowledge, have not been given to acute specialization. Although we may not expect another Bacon to rise and declare, "I have taken all knowledge to be my province," it is safe to predict that if we are to have in the future discoveries of a magnitude comparable with that ot the Copernican theory of the universe, the law of gravitation, the doctrine of evolution or the conservation of energy, they will come from men whose learning is comprehensive rather than intensive. Indeed the same rule must hold in more restricted fields of research. One who devotes himself exclusively to the study of "the abdominal parasites of the white ant" is not likely to evolve from it a new and important biological principle; nor is it probable that an intensive study of conjugate systems of space curves or years devoted to a revision of the atomic weights of the rare metals would carry one far on the way towards an explanation of the nature and cause of gravitational attraction. I would much regret to be understood as deprecating or disparaging specialization in science. It is of the highest importance even in its narrowest phase for through it the phenomena of nature are revealed. But finding how one phenomenon is related to another; the logical grouping of results of observation and experiment and the derivation therefrom of general principles and laws will always call for intellectual powers of a distinctly higher order.

I conclude, therefore, that an organization like the Ohio Academy is of prime importance to science in Ohio because it is essential to the proper and complete development of the man of science. By mingling with those whose explorations of the mysteries of nature are directed along lines diverging greatly from his own he is better prepared to estimate correctly the comparative and the absolute value of his own work. He has also an opportunity to familiarize himself with methods and instruments of research used in other departments of science which he can often summon to his own service with great profit.

In our own National Academy of Sciences there is no division of members into sections in sessions for the presentation and discussion of scientific papers. Communications of the most diverse character are presented before the entire body and this course is highly commended in a recent volume by Dr. George E. Hale, which is a study of the academies of all nations and their relation to the progress of human knowledge.

Unfortunately the history of scientific organizations in this country during the past quarter of a century shows a strong movement in a direction contrary to that which I have suggested as desirable. Forty years ago the American Association for the Advancement of Science was divided into two sections, one of which included those members who were most interested in the so-called "exact sciences," mathematics, astronomy, physics and chemistry, while the other was made up of students of the "natural history sciences." During the week or ten days of its annual meeting there were daily morning sessions in which both sections participated and there were frequent evening meetings at which addresses and lectures were given by eminent scholars representing both grand divisions of science, each chosen for his skill in presenting his subject in such a way that it was intelligible and interesting to members who were on the other side of the dividing line. In this way the mathematician or physicist might always have a fairly correct knowledge of the more important developments or the larger generalizations in biology or geology. The doctrine of evolution, which came first from that side, was quickly appreciated by students of exact science to which it has since been profitably applied. They, in their turn, gave to the naturalists the great principle of the conservation of energy, of which great use has been made in the study of life in its various forms. The psychological effect of the mingling of these two rather diverse elements of the scientific body was also of great value, and there is not the slightest doubt that both were greatly benefited.

In this bi-partite classification of its membership the association had followed the example of its English forerunner in a practice which the latter still maintains. In the American Association the disintegration began about thirty years ago and at present it is divided into twelve sections.

In addition to this specialization within the largest scientific body of the country, during the past twenty years an astonishingly large number of other scientific societies have come into existence, each of which is specially devoted to a particular department or, more often, to a subdivision of a particular department of science. Indeed the pressing need of the hour is the organization of a Society for the Prevention of the Organization of Other Societies.

Perhaps the most deplorable consequence of this minute subdivision in the ranks of scientific men is that, because of habitual isolation from all not familiar with its technical vocabulary little or no effort is made by one group to translate the results of original research into a language intelligible to any or all of the others. In spite of the sensational vaporizing about scientific men and scientific discoveries that abounds in the Sunday newspapers and fills the pages of popular magazines, it is absolutely true that at the present day there are almost no attempts to popularize science, that is by men who know what they are talking about. A great journal which for half a century was devoted to the exposition of the results of scientific investigation in the vernacular common to educated men has recently been compelled to suspend further publication for lack of support. It seems to be a case in which both producer and consumer have disappeared.

The Ohio Academy of Science is organized in such a way as to afford, it is hoped, an effective check upon this unfortunate tendency. In its sectional meetings opportunity is offered for the discussion of results of research of the most specialized character, while in its general sessions the more important of such results, when finally accepted, may be presented in a manner intelligible and interesting to all. As an illustration of the latter possibility I may be allowed to refer to the great pleasure and profit with which, as one whose intellectual horizon has always been regretfully restricted, I listened at the last meeting of the academy to a most able, interesting and instructive summary of work done in the suppression of the foot and mouth disease.

I think it fortunate that the academy is never likely to be very great in numbers. Let us hope that there will always be at least one institution whose excellence is not to be measured by a numerical standard.

The American Association for the Advancement of Science with its ten thousand members, its twelve sections and its twenty-three affiliated societies, all meeting at one time and place, is an aggregation of parts not very closely related. It no longer affords, as in the early years of its existence, a great opportunity for that commingling in social and scientific intercourse which counted for so much in both pleasure and profit for its members. The smaller, specialized national societies take its place in large measure in this respect, but these fail in one most important particular. In them a man mingles with his kind; it is mingling with the other kind that he often most needs.

Finally, the Ohio Academy, being a state institution, should appeal to all residents of the state who are interested in the advancement of science or the promotion of scientific discovery. The geographic compactness of the state and the network of transportation lines by which it is covered makes it easy for all to attend its meetings, wherever they may be held, while the national societies are usually in session at such distant points that the burden of expense and time makes them impossible for many.

The academy, therefore should be accepted as a very desirable, indeed necessary adjunct to the scientific activities of the state and it is entitled to the loyal support of all residents of the state, especially of those who are actually engaged in scientific work.

Let us now consider its relation to the state under which it enjoys a corporate existence. In answer to the question "What has the state done for the academy?" a single sentence will suffice. A quarter of a century ago the state gave the academy its charter, in payment for which it received the sum of five dollars; about two years ago when the academy desired to correct a slight and hitherto undetected error in its name as recorded in the charter the state graciously allowed one word to be stricken out, receiving for the stroke another payment of five dollars. That is all. It is not known that the state has in any other way recognized the existence of the academy.

In nearly all enlightened countries there is an organized body of scientific men, existing under a charter which gives it at least a quasi-official standing and the scientific knowledge or technical skill of its members is assumed to be at the service of the government whenever in legislative, administrative or judicial proceedings scientific problems are encountered. In England there is the Royal Society; in France the Academie Francaise; in Italy the Reale Accademia dei Lincei — the "Royal Academy of the Lynx" — of which Galileo and Colonna were early members, and in the United States we have the National Academy of Sciences, which, though not yet utilized by the national government as completely as would be desirable, has furnished the material on which some of the most important and far-reaching legislation of Congress rests. By the terms of its charter the government may call upon the academy to "investigate, examine, experiment and report upon any subject of science or art." The actual expense of such service is to be paid by the government, but members receive no compensation. In some states of the union in which there are chartered academies of science a similar relation exists and state governments have greatly benefited thereby, but in Ohio the state government has never yet asked its academy to "investigate, examine and report" upon any subject of science or art. This apparent lack of appreciation of the merits of the academy and the possibilities of its usefulness must be attributed to an indifference or ignorance on the part of state officials for which the members themselves may be largely responsible. Believing that it has thus far failed in this, one of its most important functions, I shall dwell a little on what I conceive should be its proper relation to the state in this respect.

I would have the academy act, through its properly constituted committees, as the adviser and counsellor of the state in all matters relating to science or the arts. The necessity for such advice and counsel is becoming more and more evident every year because the sciences and the arts are every year playing a more and more important part in all things affecting the wellbeing of both the state and the people of the state. Eager to secure the benefits of applied science, state and municipal governments as well as private individuals have been guilty of wasteful extravagance in their unreasoning haste to do good to themselves before they know what really is good. During the past few years we have expended many millions of dollars in the building of what we hope will prove to be good roads. Bad grades, lack of drainage, collapsed foundations and crumbling bricks already show that in many instances we shall be grievously disappointed. That the greater part of the enormous loss resulting from such failures might have been avoided is apparent to any one possessing even a slight knowledge of the principles of highway construction.

Several years ago laws were enacted affecting the sanitation of our dwellings and public buildings, fixing in great detail the methods by which connection shall be made with public water supply, sewers, etc. These were supposed to be in the interest of the individual as well as that of the community at large, as a protection against the spread of disease, and the importance of many of them can not be denied. But within a few years it has been proved that many of the restrictions put upon us by our boards of health are quite useless and unreasonable. We now know that sewer gas is not poisonous and that much of the cost of a system of so-called "sanitary" plumbing may be avoided, as is already done in countries where legislation follows information in such matters. As our sanitary legislation is much of it largely in the interests of a trade union it is rigidly enforced and the unnecessary burden upon the people is by no means light.

Much the same may be said of our laws and regulations relating to the ventilation of school and other buildings. They add greatly to the cost of construction and maintenance but they are far from being in accord with the more recent results of scientific investigation.

The people of Ohio pay, annually, many millions of dollars for a commodity for the measure of which, as it passes from producer to consumer, the state has made no provision whatever. The assumed honesty of the producer is the consumer's only protection.

Many other examples of wastefulness and burdensome legislation and administration might be cited, but these alone, resulting in a single year in a loss many times enough to endow an academy of science in perpetuity, should be convincing evidence that there is great need of wise counsel whenever laws relating to the applications of scientific discovery are under consideration by a legislative body whose members must of necessity be largely ignorant of the basic principles involved.

It will probably be suggested that the state already has at its command a body of scientific and technical advisors in the several faculties of the state universities and that these, being already in its employ, can more appropriately be called upon for service. But there are numerous other institutions of learning, in the faculties of which are to be found men of high scientific attainments and great technical knowledge and skill, men who are recognized by the members of the State University faculties as their peers in every respect, and the state should be glad to be able to avail itself of their accomplishments. Besides these, with whom science or technology is a profession, there will always be other citizens of Ohio (and may their tribe increase) who, though not connected with any educational institution, are lovers of learning and successfully engaged in research in some department of science. Their knowledge and experience may also be made available through the academy, of which they are almost certain to be members. Aside from the fact that the academy will constitute a much larger group than the faculties of the state universities from which expert counsellors may be chosen there can be no doubt that its advice would always have a higher value on account of its independence of action and freedom from political control or legislative influence. Even college professors are not wholly exempt from the weaknesses of human nature and conditions might arise in which it would go hard with them to oppose in report or recommendation a strong movement of the majority of a body of men to whom they must look for appropriations necessary to their continued existence. Instances in which such influence was successfully exerted would be, of course, extremely rare, but suspicion of its presence might be much less so.

There is a weakness in the third of the three great divisions of our governmental system which has long been deplored by all thoughtful people, to the cure of which a state academy of sciences might make a large contribution.

I refer to the use, or rather the abuse of expert testimony in courts of law. Such testimony is generally summoned in trials in which questions arise involving some department of science or some one of the technical arts. It must be frankly admitted that the scientific expert himself is responsible, more than any one else, for the humiliating fact that courts and juries often have little respect for him and little confidence in the evidence which he furnishes. This unfortunate and unnatural condition is the result of a system which is a disgrace to all who are responsible for it. The scientific expert has allowed himself to become an advocate. All of his tests, experiments and investigations are made to bolster up a particular theory. Phenomena or results of experiments that tend to discredit this theory are excluded from his testimony unless brought out by the skillful questioning of the attorney on the other side. who has been coached by another expert whose tests, experiments and investigations have been made for the purpose of breaking down this particular theory or establishing a different one. Often both of these men know the real truth of the controversy and if locked up in a research laboratory or isolated from outside influence would come to substantial agreement as to every important fact bearing upon it, for two trained observers can never differ long as to the phenomena present in any investigation.

But they have discredited themselves and the great body of scientific men whom they temporarily represent by selling their services as advocates rather than as experts skilled in ascertaining facts.

It has long been recognized that the remedy for this evil lies in the selection of expert witnesses by the court. Attorneys on both sides should be allowed to suggest questions to the court for the experts to answer if the court considers them proper but never to examine or cross-examine the witness directly. The compensation of the witness should be fixed by the court and paid by the state. The court would often find the academy the best source of information regarding the qualifications of experts and would gladly transfer to it the responsibility of making a selection, precisely as some years ago the officers of our national government charged with the administration of the internal revenue laws shifted the responsibility in an important case to the National Academy of Sciences and adopted the recommendations of its committee.

During the past few years there has been much talk (and not much besides talk) about the importance of conserving our resources, state and national. I need hardly say that the membership of the academy includes men who have studied these resources for many years; who are better informed regarding them than any or all others. Whenever the state shall seriously undertake legislation to secure their conservation it will be a reckless administration that does not apply to them for advice and counsel.

At the risk of being charged with grossly exaggerating the merits of my fellow academicians and others of their kind I venture to refer to one other function of our complex social and industrial life for which I have long thought to be especially well fitted, those men who are thoroughly trained in scientific methods and who have shown their capacity for the original investigation and solution of difficult scientific problems. I mean for service as arbitrators, especially in those cases in which both sides declare there is nothing to arbitrate, each believing, often with perfect sincerity, that his own position is absolutely right and the other absolutely wrong.

Arbitration, in theory the best method of settling disputes, in practice has more often failed than not. It could hardly be otherwise under the prevailing system. The ordinary procedure is for each side to choose a representative, generally a lawyer, who is pledged to do his best as an advocate, not as a judge. These two after much difficulty, and sometimes by the tossing of a coin, select a third who is often secretly known to favor one side or the other and thus the case is won before it is begun. In the more favorable case of the third arbitrator being open minded and anxious for a correct decision, the points in dispute are confused and obscured by the pleadings of his legal colleagues whose trade is "to make the worse appear the better reason."

In their place put men who have had much training and long experience in discriminating between appearances and realities, whose life work is the ascertainment of facts, the discovery and announcement of truth regardless of consequences, and arbitration would no longer mean a mere temporary expedient or an illogical and unsatisfactory compromise.

Much of the history of modern civilization might be summoned in support of my contention that training and discipline in the methods of scientific investigation may be depended upon above all other processes to give men power to distinguish between the true and the false; to analyze and reconcile confusing and contradictory evidence, and to extract therefrom whatever of truth it may conceal. For such men are guided by the sentiment that inspired Galileo when, in speaking of the Copernican system of the universe and other scientific doctrines which the Pope had condemned he had the courage to say:

> while there can be no doubt that his holiness has absolute power either to admit or condemn, *it is not in the power of any creature to make them to be true or false otherwise than in their own nature and in fact they are.*

Omitting further consideration of the many ways in which the academy might serve the state, and ignoring entirely the intrinsic value of contributions to science which its existence might make possible, I must refer briefly to the reciprocal obligation of the state to the academy.

In the beginning the question was asked, "What has the state done for the academy?" and the answer was, "nothing." My answer to the question what *should* the state do for the academy is almost as brief. It is, "not much." Its usefulness to the state will depend largely on its being free from state control or departmental influence. At the same time their mutual relations should be close enough to justify the state in calling upon it at any time for services of the kind I have indicated. The provision in the charter of our National Academy already quoted seems to be quite satisfactory. In return for services which in time will become both numerous and valuable the state should do two things for the academy. It should undertake the publication of its annual reports, including monographs, memoirs and other contributions to its proceedings which are judged to be of sufficient interest and importance to the people of the state. This is already the practice of several states in which academies of science flourish and it is done by the national government for the National Academy. It should also provide a suitable building in which the regular meetings of the academy could be held, where its archives and collections could be stored and where its special committees could hold their meetings and prepare their reports. This is certainly a modest demand if the members of the academy pledge themselves in return to give to the state without cost, in the form of advice and counsel, the full benefit of their scientific training and technical skill.

During the past few years in public and private speech, in books, newspapers and magazines the word "efficiency" has been heard and seen almost *ad nauseam*. The better the horse the more we are inclined to ride it to death, but that phase of the meaning of this word which implies making full and economic use of all our varied resources must in the end enjoy a useful survival. From the awful calamity which has fallen upon the world in the form of a general European war there are many lessons to be learned, not the least important of which is to discover the origin and cause of the marvelous efficiency of the military forces of one of the great nations involved, or rather, of the people of that nation, or still more accurately, of the nation as a whole, which has displayed a capacity for the immediate and complete utilization of every available resource, animate and inanimate, that has commanded the admiration of even its most bitter foes.

For one of the principal sources of this efficiency we have not far to look.

In 1893, when every nation of the world was collecting the best examples of its material resources and industrial products for exihibition at the great World's Fair held at Chicago in celebration of the four hundredth anniversary of the discovery of America, an old man in Berlin was commanded to present himself at the Royal Palace for an interview with the Emperor of Germany. To him spoke the Kaiser, saying:

We are sending to America the finest products of our factories, our mills, our fields and our mines; some of our choicest works of art will be there, but above all of these Germany is most proud of the men she produces. You are the best we have and you must go to represent us.[1]

The man thus addressed was not a field marshal of the German army, or an admiral of her navy, her most famous diplomat or her richest iron-master. He was Herman Ludwig Ferdinand von Helmholtz, Germany's greatest natural philosopher, at once the most versatile and profound scholar of the nineteenth century.

The incident is well worthy of our attention as a striking illustration of the value which is set upon men of science and their work by the German Empire. During the past fifty years no other nation has so encouraged scientific research and by no other nation have scientific discoveries been so readily accepted and so quickly utilized. In all legislation upon economic questions the man of science has had paramount influence, and in that greatest of all economics, the prevention of unnecessary waste and the getting out of every material thing the last drop of usefulness, the Germans, from prince to peasant, have no rival.[2] The administration of her municipal governments is a model for the rest of the world, because the advice of the scholar has been sought at every turn. All of her foremost industrial enterprises have had their beginning in the laboratory. In many

[1] This is no imaginary interview. I have given as nearly as possible the exact words used by Baroness von Helmholtz in telling me of it afterwards.

[2] A personal experience, amusing but instructive, may be worth relating. While living in one of the largest cities in Germany I ordered a suit of clothes from a good shop on one of the principal streets. On the first trial of the coat I failed to find the small "change" or ticket pocket usually on the right side. When I called attention to its absence the tailor showed me that it had been put in on the *inside* of the larger pocket below, explaining that if he put it where it is usually placed by American or English workmen it would be *impossible to have the coat turned*, as the cut in the cloth would then show on the left side! And when I expressed my preference for the usual location he remarked, "Nearly every gentleman in Germany has his coat turned once."

important lines she has controlled the markets of the world, not on account of her superior business or commercial intelligence but because of the knowledge and technical skill of her chemists.

Whatever we may think of the outcome it can not be denied that it is *applied science* that has enabled the German Empire to suddenly convert itself into a huge engine of destruction, all parts of which seem to have been so delicately adjusted to each other that the awful strain to which the whole is now subjected is distributed among the several members in exact proportion to their ability to bear. Other nations are learning this lesson in the hard school of experience and they are paying tuition in blood and treasure.

Fortunately for us it may be learned by observation as well as by experiment.

THE PROGRESS OF GEOLOGY DURING THE PERIOD 1891-1915

Frank Carney

In every line of science some very important event may have culminated on a particular day. On the other hand, a twenty-five year interval may pass without recording a contribution of note, even though it were always possible to discern the highest merit; epoch making discoveries may not be recognized at once. Thus, as we members of the Ohio Academy of Science pass the first twenty-five year period of our history, and ask what has been accomplished in our individual fields of work, the answer may be sedately prosaic.

Pseudo-geologists. There was a time when one man knew as much as any other man about earth science, and home made geology was the only kind available. The output of this type of revelation has decreased relatively with the increase in the number of trained students, or of men with aptness for interpreting what they see. Nevertheless the last twenty-five years have recorded some extremely interesting specimens of pseudo-geology. The avenues of publication, which embrace a whole gamut of documents from the privately printed book to the widely read Sunday edition, give publicity to matter which finds no place in the documents of learned societies. Possibly we will always have the naive expounders of geological phenomena, men and women whose names may appear "often in paragraphs, seldom in monographs."

Pioneers in Geology. It has been the privilege of many of us to know a very few of these survivors from the early days of American geology, the versatile Patriarchs of a frontier stage. This type of teacher knew something of all sides of his study: as a chemist, he interpreted minerals from that point of view;

he was a zoologist to the extent of knowing fossil forms as analogies or prototypes of living animals; he was a physiographer in recognizing the salient relationships between rock texture and structure and land forms; he was a geomorphologist because expected to account for the grosser anatomy of the continents; he was a meteorologist since at that time no one else in the village communities or on the college faculties was thought to bear a closer relationship to the mysteries of the air; he was an anthropologist because fossils, hence all antiquities, belonged to his domain; and the public decreed that he was also an antiquarian. These men were promethean encyclopedias of facts, inspiring teachers, illuminating but unrecompensed prophets whose real compensation is the host of workers begot by their enthusiasm.

The sons of these pioneers, as is usual with the second generation, did not give disappointment by evincing greater wisdom than the fathers, and their grandsons feel no chagrin in not knowing completely any one of the numerous fields which the grandsires cultivated thoroughly. Thus has geology evolved specialists.

A comparison of the courses offered today and in the year 1890 by the Departments of Geology in our colleges and universities shows the results of specialization. No longer can the student listen to lectures on minerals, and mountain development, and mining, and paleontology, and petrography, given by the same man. The most modestly equipped university now has at least three groups in its geology courses; the more fully equipped have five or six groups. The tendency augurs further subdivision. It is not so long since the department of mineralogy did the work of the petrographer, but now our petrographers are splitting into several particular fields. In this subdivision of its work, geology and the other sciences accord with modern industry; and in the most highly organized industrial plants, the best machine does automatically just one thing. Possibly in the years to come, when all the little parcels of investigation have been thoroughly analyzed, the generations will begin to produce synthetically an end product that may bear some semblance to the pioneer in geology.

Text Books. The extensive geologic text of Eduard Suess, begun in the 80's, was completed a few years ago, not long before his death. This remarkable set of books has inspired emulation in several other countries. The comprehensive text of Geike in two volumes was very completely revised and republished in 1903. In this country a similar feat of scholarship has been accomplished by Chamberlin and Salisbury. It is doubtful whether we will have many more such texts. Geology as a science has become so sub-divided, and so much detail worked out in each field, that a general text book, to be complete, must be encyclopedic in size and would be little used except in libraries.

The last decade has witnessed the appearance of special books, each covering a particular field, as the dynamic, structural, tectonic, glacial, and paleontologic phases of the subject. Furthermore, special parts of these fields are beginning to have their individual manuals. This diversity of texts is to be expected as a result of the growing number of specialists in geology.

Periodicals. Twenty-five years ago, The American Geologist was the only American periodical in this field of science. In the year 1890, the Bulletin of the Geological Society of America began publication. Three years later the Journal of Geology was founded. In 1905, The American Geologist was incorporated with Economic Geology which first appeared in that year. The Bulletin of the Seismological Society of America dates from 1910. This large gain in the list of serials indicates an activity for which ample provision is not found in the publications of the federal and state surveys, or of learned societies.

United States Geological Survey. A national survey is a fair index of the status of geology in a country. Appropriations and men make a survey; an abundance of one can not at once offset a shortage of the other, but may tend to create an ample supply.

From 1890 to 1901 the lowest appropriation allowed the federal Survey any year was $494,640; the highest was $1,000,-159.25; the average for the 12 years was $757,277.90. Since 1901, including 1916, the average annual appropriation was $1,544,048.33. In 1907 the irrigation work was withdrawn from the Survey, and in 1911 the Bureau of Mines was created relieving the Survey of certain technologic duties.

It is a matter of pride to all Americans that the United States Geological Survey now leads the nations in the quality of its topographic maps; but it is unfortunate that this work does not proceed more rapidly. If the rate of the last twenty-five years continues, nearly a century will pass before the map of our national area is completed. The general efficiency of its organization is also the envy of foreign workers. With us, as a general rule, politics, militarism, and geology mutually observe a decorous neutrality.

Progress in Economic Geology. In the early days of our state and federal surveys, the chief reason for their expenditure of public money was the securing of returns through the development of our mineral resources. The results secured did not always satisfy the public. Consequently individuals and companies supported their own investigations. Later the surveys began to give more attention to economic minerals. The federal survey has become the chief authority on the mining and reduction of ores. Evidence of this leadership, is the fact that private corporations are drawing from the federal survey many of their highest salaried investigators.

The vastness of our mineral resources and the ease with which they are turned into wealth has encouraged careless and partial development. This falling short of possible accomplishment is keenly brought to our attention at the present time when the end results of certain hydrocarbon by-products, i. e., dyes, cannot be procured because Germany alone has carried such investigations to the highest industrial use. The same deficiency of development by Americans is also illustrated in the former exportation of radium minerals and other valuable ores which we preferred to sell raw. The present exigency in reference to dyes has aroused Americans, and should lead to a greater industrial independence; and the federal government, in cooperation with the American Radium Institute, an organization endowed for cancer investigation, is already successfully treating radium minerals and isolating the required radium salt. A further result of the present industrial condition in Europe is the hope that Americans may produce their own supply of potash salts and other ingredients in the manufacture of fertilizers; the federal survey is investigating the possibility of securing at least some of these supplies from our own minerals.

Bureau of Mines. The response of the government to the increasing need of assistance in developing and conserving our mineral resources is seen in the organization in 1911 of the Bureau of Mines. Previously this work was one of the lines of activity of the Geological Survey. In addition to investigating problems connected with the reduction of minerals and with non-wasteful methods of mining, this Bureau has attracted much attention through its efforts to avoid, and meliorate the disastrous effects of, mine accidents. Such work is conservation in the highest sense; it is much more excusable to waste minerals than men.

Alaska. In Alaska there is a larger percentage of government lands than in any other of the territories or states. In handling these lands the government can apply, usually without restraint, the most recent findings of its experts. Probably for this reason, the Geological Survey has given special attention since 1896 to the mineral resources of Alaska, increasing the annual amount allowed for this study from $5,000 to $100,000. This field, therefore, offers the survey its freest opportunity for testing its best judgment on the development of mineral wealth. Complete harmony of opinion does not prevail in reference to the management of Alaska's mineral resources. The activity of private corporations in Alaska as well as the advice of experts acting for the government have led to contentions and much unpleasantness. Another generation will estimate more fairly these matters of dispute.

Work in Paleontology. This fundamental side of geology, oldest in popular interest, if not also in the development of the science, has made remarkable progress during the last twenty-five years. A measure of this progress is seen in the organization of the Paleontological Society in the year 1909, which works in cooperation with the Geological Society of America, of which, in reality, it is an out-growth.

The remarkable literature, both in volume and content, accumulated by paleontologists has necessitated the publishing of bibliographic indexes by the Federal Survey and the U. S. National Museum. The high standard of publications, particularly in the great expense required for the plates produced, by both the Federal and State Surveys, attests the sustained interest of the public, and the productiveness of the workers, in this field of geology.

Geological Survey of Ohio. The formation of the Third Survey of this state was almost coincident with the founding of the Ohio Academy of Science. When J. S. Newberry withdrew from the office of state geologist, the survey activities were placed in the hands of Edward Orton, Sr., who completed the work then under way, that is volumes V and VI and "A Preliminary Report on Petroleum and Natural Gas", embracing in all 1931 pages, before proceeding with his own plans as state geologist. Professor Orton in addition to a report on Botany and another on Archeology, published about 1200 pages, divided almost equally between economic subjects, and stratigraphy and paleontology.

The Fourth Survey was formed in 1899 with Professor Edward Orton, Jr., as state geologist. Under his direction the survey published 1825 pages; 79.8% was devoted to economic geology, and of the remainder, 332 pages consisted of a bibliography of geologic papers relating to Ohio, and 36 pages were devoted to the "Nomenclature of geological formations."

In 1906 Professor John Adams Bownocker was appointed State Geologist. During the nine years to date, Professor Bownocker, in addition to a new geological map of Ohio, has published 2872 pages, apportioned as follows: historic, 45.9%; the economic, 51.9%; the remainder, physiographic. It should be noted, however, that other physiographic problems have been under investigation for several years. Under no other State Geologist have the activities of the Survey been more generally distributed among different phases of geology.

A New World Map. Federal geological organizations in the various countries have made it possible to consummate a proposal of the geographers. At a meeting of the Fifth International Geographical Congress at Bern, in 1891, a movement was initiated for the production of a standardized world map, on a scale of one to one million, i. e., about 15.78 statute miles to the inch. This was an optomistic proposal, the realization of which would require the cooperative interest of the several governments which are making maps of their territory. Slowly the idea took root; France, Germany, and England began to publish sheets on this scale. Following the Eighth Geographical Congress, which met in this country in 1904, our government through the Topographic Branch of the Geological Survey, commenced the issue of such sheets.

Uniformity in other respects than scale was insured by an agreement made at the Ninth Congress, which assembled in 1908 at Geneva, to use the polyconic projection, to reckon longitude from Greenwich, to have each sheet cover 4° of latitude and 6° of longitude, and to express altitude in intervals of 200 meters, though variations may be used in very flat and very mountainous regions.

This is a noteworthy example of international cooperation in science. Having a standard map of definite scale and projection, all the continents may be represented in their relative size; and from such standard maps larger or smaller ones may be drawn, giving a true representation, because the land areas will be shown in the same proportion.

Climate of the Geologic Past. Ecology teaches us today's correlation between organisms and their environment. We expect the most successful functioning of life forms only in a suitable combination of light, heat, moisture, food, and neighbors, a favorable habitat. In a dim way, students long ago recognized in the fossil record anomalies when referred to the present physical conditions of the fossil's geographical location. It was inferred, therefore, that in the progress of geologic time there have come changes in climate, or at least in the distribution of mean annual temperature, in particular parts of the earth's surface. A similar inference has been drawn from wide-spread glaciation. Both deductions are rather broad generalizations.

Since 1890 there has been a tendency in these matters to seek the concrete and specific. Wherever possible more exact methods have been applied to the hazy interpretations of the past. This application is limited, for the present at least, to the recent geologic past, and the corroboration of human history, wherever possible, adds welcome conviction. Thus is the field exceedingly limited. However, encouraging results have been secured particularly through the work of Ellsworth Huntington in a study of strand lines, and of the growth made by very old trees, the sequoias; the latter respond to, and, in their rings of seasonal growth, register the conditions of moisture; the former register variations in the level of water bodies in inland basins. Quite recently, Mr. Huntington is attempting to correlate the precipitates of desiccating water with the other two lines of evidence.

This type of investigation is producing results which accord with the deductions made by the paleontologist from the expanding, dwarfing, or disappearance of faunas; it throws light on the origin of gypsum and other locally deposited salts; and helps to elucidate several stratigraphic features.

The Age of the Earth. When one arrays the estimates of this sphere's antiquity, made by workers in various phases of science, he must conclude that mother earth is either a coy maiden, an indifferent matron, or a gibbering old woman. The margin of safety in these guesses is about one billion years.

In 1862 Lord Kelvin, studying the thermal conductivity of the sphere, decided that the earth is at least 20 million and not over 400 million years old. After an interval of 35 years he amended these figures somewhat and stated, in concurrence with Clarence King's assertion, that about 24 million years ago the earth was a molten mass.

Sir George Darwin in 1886 had urged the wisdom of considering "Theories which appear to demand longer periods of time than those which now appear allowable." Ten years ago he suggested again that the physicists may be in error in computing the age of the earth, and said: "The scale of geological time remains in great measure unknown."

From the thickness of sediments, and the rate at which rivers are making deposits, Charles D. Walcott in 1893 reckoned the lapse of time since the beginning of the Archean to be 90 million years.

Professor John Joly in 1899, from computations of the quantity of sodium in the oceans and their annual accession of sodium, stated the probable age of the earth to be from 90 to 100 million years.

Students of biology have preferred a great length of time for the complex results of evolution. The estimates made by physicists, chemists, and some geologists appear inadequate to them.

Since the discovery of radium, and a more general investigation of radio-active minerals and derivatives from radium, the evolutionists have taken hope. No line of investigation has been so profligate with time as that concerning radio-activity. John Allen Harker, the British physicist, says, "a study of the various radio-active elements contained in minerals and rocks has shown that it is possible, in certain favorable cases, to calculate directly their ages in years." Thus calculated, the Archean rocks are from one billion to one billion, six hundred million years old.

Over a hundred years ago, Hutton, speaking as do the poets and the prophets in science, asserted that geologic time had "no vestige of a beginning, no prospect of an end."

Theories of Earth-Origin. Twenty-five years ago one seldom heard any question raised about the satisfactoriness of the nebular hypothesis. More recently certain variations in this hypothesis have been proposed, but the fundamentals of the Laplacian theory have place in all these restatements. Necessarily, modifications should follow upon the findings of the spectroscope and photograph-attachments of the large telescopes, instruments that were scarcely dreamed of in the day of the French savant.

Among the contributions made to geology since the organization of this Academy none is greater than that of T. C.

Chamberlin arising from his critical examination of the various hypotheses for the origin of the solar system. Chamberlin's "Planetesimal Hypotheses", in the estimation of one who has studied his several papers from the related series beginning with, "A Group of Hypotheses Bearing on Climatic Changes" (*Journal of Geology,* Vol. V (1897), pp. 653; Vol. VII, pp. 545-584, 667-685, 751-787.) is largely a by-product of his studies in reference to the origin of the atmosphere. This fact illustrates how interwoven and interdependent are the various phases of truth.

The simplicity of the Laplacian theory, and its accordance with all that was then known about the planetary system, the vastness of its generalizations, and the meager knowledge of the fundamentals in any theory of earth-origin, led to its immediate and almost universal acceptance. So long has this theory been taught that the idea of a once molten sphere has become a premise, almost an axiom, and is made fundamental in explaining mountains, volcanic activity, and in petrographical studies. The dissent from its teachings is still very local, as is a studious interest in any alternative theory. Conservatism is the armor, as well as the embalming fluid, of science.

That the planetesimal theory as now stated, or slightly modified, will in time be generally accepted, is the belief of most men who have made themselves acquainted with the basis of study from which this theory developed. In our generation no greater contribution has been made to theoretical geology.

TWENTY-FIVE YEARS OF ADVANCE IN BOTANY

Bruce Fink

GENERAL CONSIDERATIONS

One can scarcely delimit a science or any subdivision of a science exactly. Moreover, botany has enlarged, shifted position, and advanced so rapidly within recent years that it is not standardized so definitely as some other sciences. It is not strange, therefore, that botanists are not certain regarding the limitations of their science, or those of its various subdivisions. Who can locate a line of demarcation between morphology and taxonomy? Experimental morphology passes into physiology. Physiology grades imperceptibly into ecology, and some workers do not distinguish plant ecology and plant geography. Other illustrations will suggest themselves.

Though the artificiality of all attempts to define the limits of a science is recognized, some analysis of botany and its subdivisions must be made. Following largely the historical order, botanical science may be said to consist of plant taxonomy, morphology, physiology, ecology, and breeding. Plant pathology is botany in so far as it deals with host or with causal organism with respect to taxonomy, ontogeny, and normal or abnormal morphology and physiology. Paleobotany, on its botanical side, considers mainly morphology and phylogeny; when it turns toward stratigraphy, it becomes geology. Bacteriology is botany with respect to its taxonomy, morphology, and physiology; but the limits of our paper preclude special treatment of this subject. Agriculture, horticulture, and forestry are botany in part; but each one contains much that is not botanical, and their consideration would carry us too far afield.

On account of the vastness of modern botany, no botanist attempts to cover the science, except in its broad outlines. It follows that judgments differ regarding what is most fundamental and important in botanical science. In a rapidly advancing and shifting science, one can, in passing judgment, do little more than indicate the trend of his own limited vision. In what follows, the subdivisions of the science will be considered mainly in historical order, without intimation of relative importance.

Before considering the phases of botanical science, let us note some striking evidences of general advance. From 1875 to 1895, many American students were trained partly in Europe; but in recent years, there has been a marked decrease in the proportion of American students who have gone abroad for botanical training.

Twenty-five years ago, the United States was appropriating only $25,000 per annum for botany and allied work in the Department of Agriculture at Washington. By 1905, the appropriations for the bureaus of plant industry and forestry had passed $1,000,000, and in 1915 they were in round numbers, $9,000,000. The number of workers employed for such work by the United States government has increased in the last twenty-five years from about a dozen to 7,000.

Botanical advance is strikingly reflected in the growth and the multiplication of botanical journals. Scarcely an American botanical periodical is a half century old, and nearly all have come into existence within the last twenty-five years. A quarter of a century ago, one could maintain a fair view of American botany by reading two current publications; but botanical journals and phases of botanical activity have multiplied until no botanist can familiarize himself with any large proportion of all that appears.

TAXONOMY

Prior to 1880, American botany was almost exclusively taxonomy; and other phases, except the beginnings of morphology, belong to our quarter-century. In recent years, taxonomy has been displaced in part, by other phases of botanical science; and it no longer occupies the prominent place that it did when the country was new, the flora poorly known, and other lines of botanical study undeveloped. However, the number of taxonomic titles per annum has increased three or four fold within the last two decades, while the quality of work done has improved greatly. At present, no other kind of botanical activity produces one-fourth as many titles as does taxonomy, while all other phases combined scarcely produce twice as many as this one alone. However, we may not judge wholly by increase in output and improvement in quality; for it is well known that the difficulties of taxonomy, at times, threaten to wreck the science.

The species problem is perhaps the greatest difficulty. The main criteria of species are divergence and isolation, but these can be ascertained only by laborious biometric methods. Recent suggestions regarding centers of variation, about which degrees of divergence or isolation may be measured and plotted, look plausible; but most new species are still described without such laborious processes.

Recent studies in physiology, ecology, mutation, Mendelism, experimental morphology, and experimental evolution have proved that there exist in nature distinct forms, perhaps rarely those of our manuals. We know also that many of our descriptions represent compound species. Either we must attempt to treat real species, with great increase in numbers and with attendant difficulty, or we must allow species to stand for compound conceptions and let those who wish to analyze further use third-place names, numbers, or some other manner of designation. Such a method would furnish a stopping place for those who do not care to follow the taxonomist beyond the compound conception. The segregates should then approach true species as nearly as may be. In spite of many suggestions regarding the species problem, taxonomy is holding its course; not because taxonomists do not recognize the need of reform, but because they are not certain that any of the schemes proposed are feasible, or that the theories on which they are based, in part, will stand the test of further research.

Physiological species have been recognized recently among bacteria and certain fungi, and there is some basis for such species where morphological characters are obscure or lacking.

provided that food relations, functioning, or pathologic effects are quite distinct. However, a double practice further complicates the species problem; and it would seem better to adhere strictly to the morphological conception and regard the physiologically distinct forms incipient stages in the evolution of species.

Nomenclature, citation, and synonomy have become great burdens, especially in groups of plants long studied. Codes have multiplied without bringing uniformity or stability. Possibly these ends may be attained when we have reached an agreement regarding what constitutes a species and when many plants have been studied according to this standard; but no legislation can bring final results while the species problem is unsolved and our flora is poorly known. The problems of nomenclature must be left partly to individual judgment, for serious students will exercise discrimination, regardless of any legislation, however conscientiously and carefully done.

Some botanists think of taxonomy as merely the art of pigeonholing species in a system constructed for the purpose of tracing them. More broadly considered, this branch of botany is a science which overlaps phylogeny and is intimately related to morphology, physiology, ecology, and evolution. In its larger aspects and in its final object of defining and arranging species, taxonomy contains much that is fundamental; and thoughtful botanists are interested in placing the science on a basis which may render it helpful to all workers. There is need of systematic study of our whole flora by some acceptable method, and the best thought of botanists is needed in order that this end may be accomplished.

MORPHOLOGY.

In 1880, plant morphology had barely appeared in America. Within the last two decades, the subject has reached vast proportions. Beginning with the morphology of mature structures, we have passed to that of the developing organ, to cytology, and to experimental morphology. In the construction of schemes of phylogeny, morphologists were first concerned chiefly with reproductive structures; but with the advent of modern ideas of vascular anatomy, morphology has become vastly more useful in solving phylogenetic riddles. Anatomy, formerly a somewhat isolated and dry subject, has, since its association with taxonomy, physiology, ecology, and phylogeny, taken on new life, while, with the development of modern microtechnique, cytology has become a most useful phase of morphology.

Due to permanence of embryonic tissues and consequent continuation of growth in plants, conclusions regarding homology are rather uncertain when extended beyond closely related groups. Better knowledge of alternation of generations has, in recent years, rendered studies of homology more complex, since we must avoid homologizing structures which have distinct phylogenetic histories. Likewise, recent studies of vascular anatomy have shattered many ideas formerly held regarding probable lines of descent among higher plants. Cytological studies have, at the same time, aided greatly in correcting erroneous notions regarding plant phylogeny in general.

Many ideas regarding homology, phylogeny, and consequent taxonomic disposition, once expressed with confidence, are now known to be improbable or impossible. We cannot assert longer that any pteridophytes arose from *Anthoceros*-like ancestors, if indeed from any bryophyte-like plants. Likewise the ancestry of gymnosperms has been pushed back to the *Cycadofilicales*, and we no longer argue for direct descent of the former from a *Selaginella*-like ancestor. Limits of space prevent further similar discussion, except to state that our ideas concerning the origin of angiosperms and the relationships of monocotyls and dicotyls have been greatly modified by recent studies in vascular anatomy, which show that certain forms of seed-plants formerly supposed to be primitive are degenerate and not entitled to the importance given them in former phylogenetic schemes.

The non-vascular portions of vegetative tracts must receive treatment similar to that which is being given to the vascular tracts before we may have a firm basis for final conclusions regarding ancestry. Among the ascomycetes and other fungi, studies of both vegetative and reproductive areas and whole life histories are rapidly changing our views regarding taxonomic and phylogenetic disposition, and the same is no less true of the algae. Studies in the morphology of plants of all groups with a view to reconstruction of our ideas of homology, taxonomy, and phylogeny will in the future advance botanical science greatly; but past experience indicates that no theories should be accepted without thorough testing.

Paleobotany, which has come to its own within the last two or three decades, is, in its botanical aspect, mainly a phase of plant morphology and phylogeny. Through recent paleobotanical studies, we have been able to throw much light on phylogenetic problems. Comparisons of the minute morphology of living forms with that of fossil plants have enabled us to reach certain conclusions regarding relationships, some of which have been stated above. Recently, such studies have proved the existence, during carboniferous time, of fern-like gymnosperms, which seem to connect modern types with homosporous leptosporangiate ferns more closely than with the *Lycopodiales*. Much argument regarding phylogeny formerly based on modern pteridophytes is now pushed backward to plants of a former geological age. Paleobotany seems to have proved the multiple origin of heterospory, of the seed-habit, and of secondary growth. Yet little is known of fossil plants below the vascular series; and fossil botany is still largely an unexplored field, which is destined to aid vastly more than it has yet done in phylogenetic studies, though we may scarcely hope for much help among lower plants.

Another promising field of botanical research that has engaged the attention of several American botanists in recent years is experimental morphology, which overlaps both physiology and ecology in determining the relations of structure and function to environment. The goal is to ascertain ranges of variation and the factors which determine these variations. The experimental morphologist, therefore, deals with function quite as much as with form. Ordinary morphology might regard the enclosing walls the essential parts of an oogonium, an antheridium, an archegonium, or a sporangium; but the experimental morphologist would look especially to the fertile cells within. Experimental morphology has proved recently that external vegetative tissues are less fixed than was formerly supposed and are of little value, compared with the less plastic reproductive and vascular tracts, as a basis for phylogenetic considerations. Experimental morphologists have recently given attention, also, to the effect of removal of parts, in changes induced in the form and the functioning of other parts, have been able to inhibit development of organs, both vegetative and reproductive, to inhibit or to induce various kinds of reproduction, and have given us the mutation theory with its observation of the origin of new forms called elementary species. The day seems to be at hand when we may accomplish results of great scientific and economic importance through control of the form and the functioning of plant structures and plants as a whole.

PHYSIOLOGY.

Plant physiology began to take form in America about the beginning of our period, 1890, and many of its problems are unsolved. We know a good deal regarding fundamentals such as carbon assimilation, the nature of foods, the chemical elements and compounds necessary for their synthesis, the manner of diffusion and transport of food matérials and foods within the plant, the formation of amides and proteids, nitrogen assimilation, the effects of stimuli on plants, the nature and activities of protoplasm, plant physics and chemistry, and some other problems. About none of these, however, have we complete knowledge, and we know but little regarding some of them.

We know that chlorophyllous plants utilize light in the manufacture of foods; but we do not know whether these or non-chlorophyllous plants make further use of radiant or obscure heat in manufacturing amides and proteids. Nor do we know why certain hydrocarbons have greater food value, others less, and still others perhaps none whatever. The part played by enzymes in breaking down complex hydrocarbons in nutrition is still to be ascertained. In short, few of the problems of photosynthesis, proteinsynthesis, transfer, digestion, or assimilation are finally settled. Nitrogen assimilation is a problem of profound scientific and economic interest, about which there is much to learn.

We do not know exactly how water and salts are taken from the soil, how they pass upward, or whether transpiration is useful or detrimental to the plant. Still less do we know about cell physiology, with reference to protoplasm as a whole, or with respect to its constituent parts. Whether there is cytoplasmic continuity through plasma membranes and through perforations in cell walls, or only continuity of solutions in protoplasm is not decided.

Plant respiration and photosynthesis are still confused in the popular mind, nor does the botanist thoroughly understand either. Whether the katabolism incident to respiration is effected through analysis of protoplasm or of foods is not known. Potential energy may be transformed into active energy through respiration, but we understand completely neither the function of respiration nor the process. It was formerly supposed that plant respiration was a slow process, connected with little general activity of the organism; but recent experiments indicate that it may be as active in plants as in animals. Fermentation is another physiological problem of great importance, which mainly remains to be solved.

The relation between host and parasite is a problem concerning which there is little fundamental knowledge. Whether the parasite penetrates the plasma membrane and comes into contact with protoplasm, and whether it really obtains organic food or merely absorbs undigested materials, which it builds up into food for itself are problems closely related to unsettled views regarding intracellular food relations in general. It is also reasonable to suppose that fungi and bacteria which we suppose to be parasitic may, if they use ready-made foods, kill the organic material, through enzymatic action, before appropriating it. If they build their foods from crude material, their nutritional processes must be more nearly like those of green plants than we have supposed. If they kill organic food before using it, they would seem to be saprophytes rather than parasites.

Irritability and tropisms present a field of vast importance, as yet explored but little. Two decades ago, botanists had scarcely thought of irritability not attended by visible reaction, and we do not yet know the relation between irritability and changes in protoplasmic composition. Nor do we know how impulses travel in plants, though a good deal of attention has been devoted to the subject.

Only recently has root physiology received much attention. For a decade and a half, diligent work has been done respecting soil physics and chemistry, and definite knowledge of root functioning is required before the results can be utilized in agriculture. With the theory of excretion of toxins or other poisonous substances by roots, has arisen the idea that soil sterility is not commonly due to lack of requisite nourishing substances, but usually to the presence of poisonous substances which retard growth, or to unfavorable physical soil composition. Root physiology and ecology, the study of soils, and practice in the use of fertilizers should go forward together. The part played by roots, by soil bacteria, and by fertilizers, in the destruction of poisonous toxins in soils, is a problem, the solution of which is of immense importance.

The physiology of reproduction is an inviting field, possessing many unsolved problems. Sexual fusions probably arose as a nutritional process. With the evolution of sex, may have come a change of function, by which fertilization in higher organisms may act mainly as a stimulus. It would seem from certain experiments that sex may be controlled, at least in certain organisms. Yet some physiologists insist that sex is determined by internal, uncontrollable factors. Sexual purity is questionable, even in gametes, and sexual reversion may be but a reversion of dominance and latency. Whether sexual reproduction aids or hinders variation is not determined; and we know exactly neither what sex is nor what are the advantages and the disadvantages of sexual reproduction.

Though our knowledge of physiology is meager, the outlook is as encouraging as the results to be obtained are important. In place of former notions of vital force and fanciful teleologic and anthropomorphic expressions and explanations, plant, physiology is now based largely on physics and chemistry. On this foundation, with constantly improving methods, advance is certain to be rapid.

ECOLOGY

Plant ecology is a new phase of botanical science, its development extending through little more than two decades. The word, ecology, sounded strange to botanists for several years after the beginning of the quarter-century with which we are concerned, and the science has been taking form throughout the whole period. Evidently, the plant ecology of today is quite different from that of a decade or two ago; but one cannot be quite certain just what this new field of botanical study is at the present moment. The thing that seems most certain is that, in spite of all the chaotic confusion incident to passing through the experimental state, ecology is to survive the various treatments and the applications of terminology and become a useful portion of botanical science.

The ecology of today certainly deals with the relation of plants, plant structures, and plant aggregations to the physical and biotic environment. This makes plant ecology largely a science of reactions. The morphological aspect is concerned with the reactions of plant structures to the surroundings, the physiological with the reaction of plant functions, and the physiographic with the reactions of plant aggregates. It is evident that, in one aspect plant ecology is closely related to morphology, in another to physiology, and in a third to geography. Distribution is largely ecological, and there is some ground for refusal on the part of certain students to distinguish between plant ecology and plant geography. At any rate, plant geography has received little attention in America, except at the hands of those who dispose of it with ecology, and we need give it no separate treatment in this paper.

The close relationship between ecology and morphology on the one side and between ecology and physiology on the other is also apparent. Ecology takes physiology to the conservatory or to the field where experiments may be performed under more natural conditions, instead of artificial conditions of the laboratory, which often vitiate results to such an extent that one can draw no certain conclusions regarding the functioning of plants in nature. Morphological and anatomical studies bring ecology back to the laboratory where the structural relations may be studied best. There can be no doubt that the rise and development of ecology has done much to offset extreme methods in the laboratory and give new life to studies of structure and function. If the field method in physiological ecology can give us adequate knowledge of the functioning of plants in their habitats, many important problems will be solved.

Not many years since, some botanists explained all modifications of plant structures in terms of relationship to environment, but the latest dictum of ecology is that a plant may exist, for at least a limited time, in an environment with which a majority of its morphological and anatomical characters do not accord. Yet the special field of ecology is to study all factors of the environment and all structures and functions of the plants found in a given habitat in order to ascertain what are the influences which decide what plants and what plant aggregates appear and maintain themselves in that habitat. Such studies have been confined largely to vascular plants, but ecological studies of bryophytes, algae, and fungi will become more common as time passes.

Agriculture, horticulture, and forestry are beginning to recognize their partial dependence on ecology. The relation between natural vegetation and agricultural and horticultural possibilities is becoming well understood in all parts of the country, but has been investigated especially in regions recently opened for settlement. It has been demonstrated through recent research that the study of natural vegetation in relation with soil moisture, soil texture, soil chemistry and physics, and various other factors of the environment is a most helpful criterion in determining the availability of certain soils and certain climates for various agricultural and horticultural purposes. Much money has been wasted by using soils and climates for purposes for which they are not adapted, and ecological and physiological methods are certain to be employed extensively in the future in preventing such waste of capital and energy. Such studies must include the hypogean portions of plants as well as the aerial portions, and the recent studies of root ecology and root physiology are suggestive of the large importance of such investigations.

BREEDING

All plants cultivated for any considerable length of time are very different from their wild or their imported progenitors. Most of these results of breeding have been accomplished by empirical practice. Only within the last two decades have such methods given way largely to scientific procedure, based mainly on evolution and heredity.

Artificial hybridization has produced many cultivated plants of great value. By this method, we are breeding larger and more hardy plants, improving the food qualities of plants or plant parts, obtaining plants adapted to certain climates or resistant to disease, and securing desirable tastes and odors. The marked vigor of certain hybrids is now known to be but an extension of the well-known fact that cross-fertilization results in stronger individuals. In hybridizing, we pass beyond the species limit and secure increase in variation and often in strength as well. Recent work on corn, by which stronger plants and better yield are secured by intricate hybridizing is an illustration of the possibilities.

The rediscovery of Mendel's laws a decade and a half ago has given an explanation of the results of hybridizing, has influenced biological thought profoundly, and has resulted in the accumulation of a large amount of unassimilated data. It had been known previously that succeeding generations of hybrids are more stable and often more desirable than first generations, and Mendelism has given the clue to cause. Mendel's view of unit characters in gametes remains much as he promulgated it, but other Mendelian conceptions have been modified considerably in the fifteen years intervening since rediscovery. Breeders admit the validity of Mendelism in a general way, but dominance and recession do not seem to follow Mendel's fixed laws closely in all instances, either in the first generation or in succeeding ones.

The discovery of mutation shortly before our period, together with Mendelism, has awakened biologists as nothing else has done in recent years. Unexpected variants or sports had been recognized as starting points in securing desirable plants, and it is now supposed that they are either mutants or hybrids. Experimental evolution and breeding have to do with both hybridization and mutation, but neither biologists nor breeders have discarded continuous variation as a possible explanation of the evolution of new forms. Much as mutation and Mendelism, both dependent on unit characters, have done for plant breeding, we still believe that there are characters other than unit characters and variations other than those accounted for by the two new theories. Of course useful variations are equally helpful to the breeder, whatever their origin, nor is there certainty that mutation and Mendelism can maintain their prominence indefinitely.

Physiological chemistry may yet aid cytology greatly in solving problems of heredity, even to the extent of helping to determine the role of various elements of the protoplast. Chemistry may help to determine whether chromosomes or ultramicroscopic bodies, as the hypothetical genes, chromioles, or pangens, are the carriers of heredity. However this may be, the recent tendency is away from the view that any theory of carriers of heredity involves a belief in preformation.

Mass selection, commonly practiced under the empirical methods of breeding, is now known to result in composite strains. Consequently, this crude method is gradually giving way to individual selection, by means of which we may obtain desirable pure strains. By individual selection, it has been demonstrated recently that hundreds of types may be segregated from single varieties of cereals. This information places us at the threshold of almost limitless possibilities in breeding certain plants by selection.

Ready facilities in transportation and increase in city populations conspire to make plant breeding more profitable from year to year. The methods of the breeder are being used also by plant pathologists in securing resistant varieties. Individual selection, followed by pedigree cultures, must yet prove invaluable in this respect. The application of breeding methods in securing plants adapted to certain climates has recently reached valuable results. In short, breeding offers profitable employment for skill of the highest order; and it seems that we are to produce in the future, and often on short notice, all that can be desired in way of improved plants and plant products.

PATHOLOGY

Plant diseases have been recognized for centuries; but their study followed animal pathology and bacteriology, and plant pathology is one of the newest sciences. Bacterial diseases of plants were not recognized generally until the beginning of our period; but bacteriological animal pathology was then beginning to lay the foundation for the technique of plant pathology in general. The technique of studying fungi in relation to plant diseases has been developed during our quarter-century, though there was, during the preceding decade, some laboratory study of causal organisms from the pathological point of view. At this time, little was known of resistance and immunity, and agriculturists and horticulturists gave practically no atttention to diseases. The American texts on plant pathology all belong to our period, while the better ones are very recent.

The section of mycology of the United States Department of Agriculture was established in 1885, and several state experimental stations followed within a year or two. The systematic study of plant diseases dates from 1886, following shortly the establishment of the first agricultural experimental station at Geneva, New York. Some papers had appeared earlier, but there was no organized movement. Before 1890, few American workers were giving attention to plant pathology. Though more than one hundred plant diseases were known, few people were interested in the subject or thought it of practical value. From the beginning of our period to the present time, interest has grown until hundreds of plant pathologists and many thousands of citizens are interested, while 600 or 700 plant diseases are known at present, half of which have been studied carefully. In the same time, papers on plant pathology have multiplied until 6,000 or 7,000 have appeared in the United States.

In the early days of plant pathology, a considerable number of botanists gave attention to abnormal morphology, while certain mycologists were directing their efforts toward causal organisms. The greatest advance has been in bacteriological plant pathology, based on the bacteriological methods of animal pathology. Fungal plant pathology has followed, while the physiological aspect is only beginning to attract attention.

It is now recognized that plant diseases may be caused by conditions of environment as well as by parasitic organisms. Even when a causal organism is present, its effects are usually made possible or more dangerous by some unfavorable condition, as lack of sufficient nourishment, over nourishment, error in cultivation, improper water relations, bad soil conditions, or lack of aeration of the soil. Recognition of the fact that any one of these factors may induce plant disease, or may so weaken the hosts that they fall prey to parasites has in the last decade or two, greatly enlarged the scope of plant pathology. It is now known that a plant immune in one environment may not be in another, and that a plant may be immune on a certain soil one year and not the next. This points to a physiological relationship, through which the vigor and the resistance of the plant varies from time to time. In short, plant pathology has, in recent years, passed from the almost exclusive consideration of causal organisms and their effects to a vastly broader and more promising basis.

Conditions produced by insects or other animal organisms are diseases when they result in tissue changes, quite as much as are plum-pockets, club-root, crown-gall, and other hypertrophied conditions caused by fungi or bacteria. Why hypertrophy of host tissues results in some instances, or prolonged life results in one case and early death in another, remains to be thoroughly investigated. These are considerations for the plant pathologist, whatever the nature of the causal organism.

Necessarily, remedial measures received early attention from plant pathologists and have been fairly well developed. In recent years, more attention is being given to prevention of disease, in which inheritance and immunity play a large part. The development, through breeding, of resistant varieties, at the same time desirable in other ways, is the main objective of recent plant pathology. With development in this direction, and with all possible amelioration of conditions of environment, it is hoped that, in the future, remedial measures will need be resorted to much less frequently than at present.

The future plant pathologist must still know thoroughly both mycology and remedial measures, but he must also understand normal functioning and nutrition, water relations, temperature relations, soil relations, oxygen relations, and other phases of botany, physics, and chemistry. Thus equipped, plant pathologists should be able, in the near future, to see to it that plant diseases are much less common and destructive.

CONCLUSION

Though expansion and differentiation of botany have gone on with surprising rapidity in recent years, we are merely at the threshold of advance. The progress of the near future will make the botany of today appear as crude as we regard that of a quarter of a century ago. Coincident with expansion, the feeling that the various sections of botanical science must not be too sharply segregated, or the science as a whole become so thoroughly standardized as to impede progress will be strengthened. With further progress, the close relationship of pure botanical science to human needs and the enlargement of human character will be recognized more fully. Leaving aside the most important problem of all, viz., the broadening of human life by a general study of organisms about us, the demand for the pure and fundamental aspects of the science must keep pace with the great progress in applied phases. Especially is this true since the theoretical and the practical form one great whole, all of which one must know in its broad outlines if he seeks the highest usefulness in any field of botanical activity.

The progress in botany which may be recorded when this

Academy celebrates its semi-centennial will be much greater than that which we have noted for an equal time just past. By that time taxonomy and morphology will have given us a better knowledge of plants and plant structures and will have placed plant phylogeny on a firmer basis. Physiology and ecology will have passed into stages of greater usefulness. Plant breeders will have given us greatly improved economic plants, and plant pathologists will have taught us how to keep these plants in better health. Beyond these things that seem certain enough, prediction regarding future advance in botany would be quite hazardous.

THE PROGRESS OF PHYSICS IN TWENTY-FIVE YEARS — 1891-1915

Frank P. Whitman

Early in the year 1901 Professor T. C. Mendenhall wrote — for the *New York Sun*, I think, — an excellent summary of the progress, or I might almost say, the creation, of physics in the 19th century. He classifies the subject under the familiar rubrics of energy, heat, light and electricity, and summarizes the extraordinary development of each. It is a familiar story, but it brings to the mind in a way that is still impressive the fact that physical science as we know it today, heat and its laws, including the dynamical theory, light with its two huge wings of infra-red and ultra-violet radiation, electricity with its marvelous theoretical development and its two capital discoveries of the electromagnet and the induced current, the extraordinary theoretical structures of the molecular nature of matter on the one side and the all pervading ether on the other, had not only their great development, but with small exceptions their very beginnings within these hundred years. But another thought comes with fully as much force as one reads this record; the familiarity of it all. All these things have been known to us — to the oldest of us — from our youth up. Rumford and Davy, Fourier, Mayer, Helmholtz, Kelvin, Joule, laid the foundations and reared the superstructure of the doctrine of heat by the middle of the century; the great experimental and theoretical bases of optics recall the names long gone by, of Young, Fresnel, Malus, Wollaston, Kirchoff and Bunsen; electricity was brought to its full strength under the hands of Oerstedt, Ampère, Faraday, at a comparatively early period, and the genius of Maxwell welded the two sciences together before the century was three quarters gone. We come up to the period at which our review begins with the great work apparently ended, with progress only in details, rounding out and polishing a fabric which in its fundamental characteristics was finished long before. This was the time when men began to say with sadness that the fundamental facts of physics were probably all or nearly all known, and that the future of the science lay in the sixth place of decimals. And indeed a corroboration of these views might be seen in the exquisite instruments for fine measurements of all sorts which are characteristic of this period. I can only mention without description a few, as the interferometer of Michelson, with the modification, increasing considerably its sensitiveness, added by Chamberlain, the entirely different interferometer of Fabry and Perot, the almost errorless clocks of Riefler, the exquisite balances of Rueprecht, the echelon and the giant diffraction gratings, both of these last two due to Michelson, and the great astronomical instruments developed especially at Mt. Hamilton in California. But despite all appearances the road to the modern physics did not lie that way. In 1890 there was no indication, there was hardly a dream that any new realms could exist comparable to the great regions already explored. Even in the year 1900 Dr. Mendenhall gives fourteen lines, out of an article filling several newspaper columns, to the phenomena grouped about the discovery of Roentgen.

And perhaps it can hardly be said that the advances of the past twenty-five years hold so commanding a place as the monumental achievement of the nineteenth century. They are characterized rather by their unexpectedness, their contravention of accepted ideas. The nineteenth century was constructive, the twentieth is largely revolutionary.

The more important advances cannot be grouped, like those of the preceding period, under the classical divisions, as light, heat, or what not. They occupy new fields, related to all the others, but different, and not their least interest is the manner in which they unravel and disintegrate the web of theory, the weaving of which was begun a hundred years ago by Young and Dalton and Fresnel. They may be included broadly under the head of radiation, and this word, radiation, embracing in itself a wide range of subjects, may be regarded as the general topic of this review.

It is only proper in a meeting like this that reference should be made to the relations which the state of Ohio has held to the progress of discovery, in virtue of work done either within her borders or by her sons. We can no more than refer, among others, to the extended and varied researches of Carl Barus, a native of Cincinnati, the administrative and experimental work of the Mendenhalls, father and son, of which I always like to recall Dr. Mendenhall's ingenious improvements of the pendulum for determining the acceleration of gravity, the brilliant experiments of Millikan, a graduate of Oberlin, and much other sound and careful work done in Columbus, Cincinnati, Cleveland, and elsewhere. Some of the outstanding researches will receive special mention, one of them in its various parts lying at the very basis of our subject of radiation. Two of the most notable recent researches in acoustics belong also in this category. In 1895 the trustees of Harvard University, finding that a recently erected lecture hall could not be used for the intended purpose on account of acoustic defects, asked Wallace C. Sabine, a native of Ohio, and a pupil of Dr. Mendenhall, to devise if possible, some remedy. Considering that acoustic difficulties have interfered with human speech ever since public assemblies began to be held indoors, it is surprising that Sabine found practically no literature on the subject. Apparently it had never come within the range of experimental investigation. Without direct suggestions or data derived from other work, Sabine entered upon his path-breaking research. His patient and skillful experiments, extending now over twenty years, have solved in great measure the problems presented, and have made it possible to design in advance a building which shall have any desired acoustic qualities, or generally to remedy acoustic defects in already existing auditoriums. Especially ingenious and interesting are some of his later methods, in which, having prepared a sectional model of the audience-room under investigation, he produces upon its stage a short, sharp sound from an electric spark, and after the method devised by Toepler and lately improved by Foley, photographs the sound-waves as they progress through the model. Thus are shown in a highly instructive manner the original sound and its behavior after reflection from walls, ceiling and fixtures throughout the room. Since the size of the model bears to the length of the wave from the spark a relation similar to that which the size of the room bears to the average wave from the human voice, the results are directly applicable, and have proved of much value in designing audience-rooms.

The other acoustic research is more widely known. It is not always that a successful experimenter is also a finished lecturer. Many in this room have doubtless heard Professor Dayton C. Miller's admirable expositions of the photography and analysis of sound vibrations. In this case, however, there was a good deal of previous work. To speak only of some which has been done in this country, as long ago as 1878 Professor Blake of Brown University, one of the pioneering workers on the telephone, devised and used an instrument for photographing sound waves, consisting of a mirror attached to a telephone diaphragm, in a manner which while crude by the side of Dr. Miller's refined dispositions, differs but little from them in principle. Bevier of Rutgers College, enlarging the record of a phonograph cylinder, as others also have done, studied several of the vowel-sounds, analysing them by the application of Fourier's theorem. It may therefore be worth while to point out just what Miller has done beyond devising, and using with rare experimental skill, apparatus more delicate and complete than that of his predecessors.

In the first place he has seen, as no one else has seen, that the problem must be attacked in a large way. Most of the earlier workers recoiled from the magnitude and the difficulties of the task, making perhaps a few photographs, or analysing a few curves, pointing out the way to possible results of value, but attaining them to only a small degree. Miller has photographed thousands of waves, and has analysed hundreds of curves, often to thirty partials. The mathematical analysis of such a curve by any of the applications of Fourier's theorem is a matter of hours or days. The mechanical analyser, devised at first by Professor Henrici, put into a commercial form by a Swiss instrument maker, and somewhat rearranged by Dr. Miller to increase the number of partials from ten to thirty, furnishes a complete and precise analysis of a curve in a few minutes, thus making it possible without undue labor to analyse a great number of photographs.

In the second place, Miller has investigated carefully the errors introduced into the curves by the recording apparatus itself. The oscillating mirror, the cavity in which it is placed, the responding diaphragm, the magnifying horn, have each their own natural periods of vibration, and will respond more readily and loudly to sounds or partials which are nearer to these periods than they can to other sounds. The errors thus introduced into the curve are so great that it is hardly stating it too strongly to say that an original sound-curve, either photographed or impressed upon a phonograph roll, is of little or no value for study until it has been freed from these adventitious effects. Miller spent some years of work in determining the errors due to his instrument, and in devising methods to minimize or correct them. The result has been a substantial advance in our knowledge of the nature and composition of the sounds of various musical instruments, including the human voice, and the characteristics of the different vowels.

Without doubt, however, the most important physical development with which Ohio has been connected, and one which is deeply concerned with our general theme of radiation, is contained in the remarkable group of researches which is based on the Michelson interferometer. Seldom or never before has such important and varied work been performed with a single instrument. It was invented by Michelson in 1881, to investigate the hypotheses upon which are based Fresnel's explanation of the aberration of light. These hypotheses are two:

1. That the luminiferous ether, with reference to the earth, is at rest, the earth moving through it without disturbance.

2. That in dense optical media, however, the ether is carried with the medium, not completely, but to an amount depending on the refractive index of the medium. Michelson's well-

known experiment was as follows: A beam of light was divided by a semi-transparent reflector into two, at right angles to each other. Each of these beams fell, at any desired distance, upon a plane mirror, which reflected it back directly to the glass which divided the original beam. These two beams are now in a condition to interfere, forming the familiar rings or fringes, by which the difference in path traveled by the two beams can be exactly measured. One of the two beams was sent out in the direction in which the earth was traveling at the time of the experiment, the other at right angles to this direction. It is evident that they would be differently affected, if the ether was at rest with reference to the earth. The amount of the difference was shown by calculation to be within the measuring capacity of the instrument.

But Michelson found no evidence of measurable difference in the length of path of the two beams, that is, no evidence in favor of Fresnel's first hypothesis. The difficulties, however, were great, and the apparatus was not entirely satisfactory. In 1886 Lorentz pointed out a small error in Michelson's theoretical discussion, which when corrected reduced the effect to be observed to about one-half of what was at first expected, bringing the magnitude of the result perilously near the errors of observation. A little later Michelson, then at the Case school in Cleveland, became associated with E. W. Morley. The two attacked the whole problem again with far more refined and delicate apparatus. They repeated in 1886 Fizeau's experiment, allowing light to pass through pipes through which liquid was flowing with high velocity. The change in speed of the light due to the motion of the liquid was found to be quite in accordance with Fizeau's measurements, made in 1851, and confirmatory of Fresnel's second hypothesis.

In 1887 Fresnel's first hypothesis, that the ether is at rest, was elaborately investigated by Michelson and Morley. The results, so precise now as to admit of no question, were confirmatory of Michelson's earlier experiments. Fresnel's hypothesis was seen to be without foundation, and the theory of aberration, founded upon it, fell to the ground. The importance of this experiment to the progress of optical theory can hardly be overestimated. The luminiferous ether was devised or imagined to explain the phenomena of light. Given, that light is an undulatory motion, there must be some medium which undulates. The properties of this medium can be inferred only from the phenomena themselves, but so well did the properties agree, as deduced from different phenomena, so definite and exact were the explanations which the ether afforded, that most students of the subject had come to look upon it as a fact, not a theory, as one of the basal, fundamental facts of our universe. If the ether is stationary, as postulated by Fesnel, the optically important phenomenon of aberration is completely explained, but the Michelson-Morley experiment appeared to show that this hypothesis is untenable, and left aberration without the shadow of an explanation. It is easy to see that the whole elaborate structure of the ether is shaken and liable to destruction. There was much discussion. Fitzgerald in England, and Lorentz in Holland, nearly at the same time, made the same suggestion, as a possible way out of the difficulty. The mirrors of the interferometer in the Michelson-Morley experiment had been mounted on a block of sandstone, which in its turn was floated in a circular trough of mercury, so that it could be easily rotated in a horizontal plane, in order that the two arms of the interferometer might be brought in turn into the direction of the earth's motion. Fitzgerald and Lorentz suggested that the dimensions of the block of sandstone were altered by its drift through the ether, that in fact, the stone was shorter in a given dimension when that dimension lay in the direction of the earth's motion in space, than when it lay at right angles to this motion.

The difficulty, the very desperateness of the situation is shown in the fact that this extraordinary suggestion was seized upon as not improbable. There was a possibility that it might be tested experimentally. All substances might experience such a deformation as they drifted through the ether, but it was conceivable that they might not be all deformed alike, that a soft and yielding substance like wood might suffer a different amount of shortening from that of stone or iron.

In 1904 Morley and Miller repeated the experiment of 1887, using a very much larger apparatus, the path of each of the interfering beams of light being now 32 metres, instead of about 11, as in the previous experiment. The mirrors were separated by rods of pine, instead of sandstone, and the experiment was carried out as before. But the result was the same. No effect could be discovered which seemed to show that the earth drifts or moves through the ether. The ether appears to be carried along by the earth in its orbit, or else all substances suffer equal dimensional changes when in motion. The Fitzgerald-Lorentz hypothesis apparently takes the question out of the region of experiment.

The mathematicians now took the matter up, and under the leadership of Einstein and Minkowski put forward the principle of relativity in all measurements of space and time, which not only did away with all possibility of raising questions as to a fixed or moving ether, but went far toward doing away with the ether itself. That is, as Lorentz remarks, the chief value of the ether in this discussion is to furnish us with a fixed system of reference-coordinates. Since it does not seem to fulfill this function, many of the relativists abandoned it, sweeping away with the Michelson-Morley difficulty, the hypothetical substance which gave rise to it. And there the matter rests at present.

This solution, however, avoiding one difficulty, raises many others. Some sort of corpuscular theory of light would seem to be necessary. It is interesting to note in this connection, that certain phenomena of radiation, and some in the domain of heat, seem best explained at present by a sort of corpuscular theory of energy, in which the emission of energy takes place not continuously, but in successive steps, or quanta, as Planck calls them, as if energy, like matter, is molecular in its nature. But what is light, if it is not an ether-wave, and what of such phenomena as polarization, interference, and diffraction? This is perhaps the most notable problem of modern physics. Here are two great series of facts, each leaning toward its own hypotheses, which at present seem incompatible with each other. The great reconciling theory is yet to come.

Another great group of researches is that chiefly inspired by the discovery of Roentgen, which has proven as varied and complex in its ramifications, as the other one was simple and direct, and which, starting as the other did in phenomena of radiation, has found its most interesting field in the nature of matter and the structure of the atom. This series really begins before 1860, with the work done by several investigators on electrical discharge through highly exhausted tubes — Crookes' tubes, as they were called in England. It was in 1895 that William Conrad Roentgen, while experimenting at Würzburg with a tube of this type, perceived the lighting up of a fluorescent plate which lay at a distance of two or three metres from his apparatus, and thus, partly by accident (such accidents as are always happening to men who can make use of them), came upon the radiations which bear his name. His brief paper, an admirable example of scientific presentation, represented work so careful and precise, that for nearly ten years little was added to our real knowledge of the X-rays or to the contents of his first article, by the host of workers who threw themselves at once upon the new phenomena.

Roentgen showed that these new rays were generated where cathode rays strike some solid body, and that they spread from this area of impact as from a source. What was their nature? Not electrified particles like the cathode rays, because they were not affected by an electric or magnetic field, not light-waves, for they showed under the ordinary tests, neither reflection, refraction or polarization. It was suggested by Bragg and others that they might be streams of flying particles, different from the cathode rays in that they were neutral doublets, or particles carrying no electric charge. Roentgen guessed that they might be longitudinal ether-waves; Schuster showed that they might be transverse waves like light-waves, if they were only short enough, and it seemed indeed probable that some sort of electromagnetic disturbance, akin to light, might be set up in the region, bombarded by the cathode rays, from which the X-rays come. In 1905 Barkla tended to confirm this view by showing that X-rays could be polarized to some extent.

But their real nature seemed first to be demonstrated in 1912 by Laue, who considering that if X-rays were very short light waves they would be capable of diffraction by very small-meshed screens, and by such only, with rare imaginative insight perceived in the structure of crystals a possible diffraction-screen. He surmised, that is, that the regularly arranged molecules of a crystal, the space-lattice, as Bravais called it, might affect a beam of X-rays somewhat as, for example, a finely meshed silken fabric affects a beam of light. Confirming his hypothesis by mathematical analysis, he, with Friedrich and Knipping, passed a fine stream of X-rays through a thin slab of crystal, behind which at a proper distance he set a photographic plate. He found upon the plate after development an orderly arrangement of spots, forming to all appearance a well defined diffraction pattern. The X-rays behaved in fact, exactly like short light-waves. Laue's apparatus was ingeniously modified by W. Lawrence Bragg (with his father, W. H. Bragg, among the most diligent investigators of such phenomena) who utilizing the known principle of multiple reflections from equally spaced transparent screens, observed the reflection of the X-rays from the crystalline structure, instead of their diffraction on passing through it. He constructed on this principle an X-ray spectrometer by which the Roentgen radiations may be examined almost as readily as one can examine with the ordinary spectroscope the radiations which we call light. The surface of the substance under examination need not be polished, indeed it may not bear any definite relation to the direction in which the X-rays are moving, since the reflections take place, not from the surface, but from the successive layers of molecules within the crystal itself, and it is these layers which must be properly oriented or directed with regard to the beam of rays. A train of waves will not be appreciably reflected from such an arrangement unless the wavelength bears a definite relation to the spacings of the layers of molecules. The effective distance between the layers may be altered at will by rotating the crystal so that the X-ray waves will strike them at a greater or less obliquity. Two types of investigation are evidently possible. If X-rays from the same source are used in the examination of different crystals, the spacings of their molecular structures may be compared, or if the same crystal is used in the examination of X-rays from different sources, the X-rays themselves may be compared. Many substances under the impact of X-rays, are known to emit secondary X-rays characteristic of the substance, depending, probably, on their molecular spacing and arrangement. By comparative experiments the length of an X-ray wave is found to be of the order of one hundred millionth of a centimeter, or about one one-thousandth the average length of a ware of light. The molecular spacings appear to be of approximately the same order of magnitude. This new science of crystallography is yet in its beginnings, but gives much promise for the future.

The discovery of the X-rays, with their effect upon a photographic plate, their power of exciting fluorescence and phosphorescence, and their penetrative power, aroused wide interest, especially the latter quality, which made it possible to render visible or to photograph the bones in the hand, or coins in an opaque leather purse. As fluorescence and phosphorescence could be aroused in other ways, it was natural to look for other kinds of radiation, recognisable by their fluorescent or photographic effects. Henri Becquerel in 1896 obtained evidence of such rays from uranium compounds, rays which were continuously emitted without electrical or other excitation, and which were capable of penetrating opaque objects, of affecting a photographic plate, and of discharging electrified bodies, very much as the X-rays do.

The Curies of Paris, passing in review a great variety of substances to discover possible radio-active properties, found in pitchblende, an ore of uranium, radiant powers far greater than that of uranium itself. They succeeded with much labor in isolating several highly active substances, to the most important of which they gave the name of radium.

Rutherford, then at McGill University, showed that radium, as also the other radio-active substances, emits three kinds of radiation, the alpha-rays, which are positively charged particles of atomic size, the beta-rays, which are negatively charged particles many times smaller than an atom, — probably free electrons, like the cathode-ray particles, — and the gamma-rays, which are apparently short ether-waves similar to the X-rays, and very probably are disturbances set up by the impact of the beta-rays on some part of the radio-active body itself. The energy developed during these radio-active changes by a given mass of radium is very considerable, enough to melt its own weight of ice in an hour, and to keep its temperature permanently above that of the surrounding objects by an amount dependent on the circumstances, but often as much as two or more centigrade degrees. It seems probable that a large mass of radium, a kilogram or so, would be permanently red-hot.

Besides these three forms of radiation, all radio-active bodies give off in small quantities substances which are themselves radio-active, but which after a longer or shorter time lose their active properties. The substance given off by radium was called by Rutherford radium emanation. It was itself radio-active, had a characteristic spectrum, and in other respects manifested all the properties of a gas of high molecular weight, chemically similar to the group of inert gases, to which helium and argon belong. It loses 99 per cent of its radio-active power, and practically disappears, or is transformed into something else, in about a month. Ramsay and Soddy showed that the spectrum of this gas, altering from day to day as the gas altered or decayed, became finally the well-known spectrum of the rare gas helium. It cannot be inferred from this, however, that the emanation had turned into helium. Rutherford showed definitely in 1909 that alpha-particles from whatever source, when freed from their positive charges, become simply atoms of helium. The emanation is in all probability an elementary substance (in the ordinary chemical use of that word), though a short lived one, and may be regarded as the residue left when an atom of radium has emitted an alpha particle. The emanation in like manner emits from each atom an alpha particle, changing thereby into another substance called radium A, and so on for a series of transformations.

Thus was shown for the first time that a transmutation of the elements was possible. Radium is apparently one element in a long series, which gradually disintegrating through their own atomic instability, pass by degrees one into another. The disintegration, which during its action gives rise to radio-activity, consists in general of the emission of alpha-rays, that is, of helium. The atomic weight of each sucessive product is generally smaller by 4, the atomic weight of helium, than that of, its predecessor in the series. It has not been found possible by any chemical process to arrest or hasten this disintegrative process; the energy involved is in fact vastly greater, perhaps on the average a million times greater, than the energy connected with the ordinary chemical transformations. It is not to be wondered at that the alchemists were unsuccessful in their attempts at the transmutation of metals.

The element helium plays a remarkable role in all this. Known since 1868, and given its name, only from its brilliant spectrum as observed in the sun and stars, it was discovered, but not recognized, in 1891, in the analysis of some uranium ores for the United States Geological Survey, and some years later was identified by Lockyer through its spectrum. Its atom is now found not merely to be a definite element, but to form a part of many other so-called elementary substances, which on losing it, have thereby all their properties changed, and are transformed into something else.

This gradual disintegration of certain elements suggests the larger question whether all the elements are likewise in process of decay or transformation. It is not improbable. It has been calculated that in about fifty thousand years practically all the radium now in the earth will have ceased to exist as radium. Of course this does not imply that there will be no radium then, for it is in all probability continually produced by the disintegration of some other substance. Since radium occurs always in connection with uranium, it has seemed probable that uranium is in this sense an ancestor of radium, and within three months

Soddy has proved this to be a fact. Again, since lead is always persistently associated, in definite relative quantities, with radium and uranium, it has been plausibly suggested, and the accumulated evidence for the suggestion is becoming very strong, that lead, if not a final disintegration product of the series, is practically such a product, itself disintegrating perhaps, but at a rate which can only be estimated in millions of years.

It is to be remembered that these changes are atomic, not molecular, that they have to do with the nature of the so-called elementary substances. Lord Kelvin, addressing the chemical society in 1907, a few months before his death, suggested that the name atom ought to be abandoned, as inappropriate to a thing which could be broken, and proposed for discussion the question, " when is an atom not an atom?" In fact, the real difference between an atom and a molecule seems now to be that we can break up a molecule into its constituent elements by chemical processes, but that we are not masters of such stores of energy as will enable us to tear apart the atom into its sub-elements.

Before Roentgen's discovery of the X-Rays had drawn universal attention to radiation problems, the passage of electricity through gases had been made the subject of much study, aroused chiefly by the fluorescent and other effects opposite the cathode. Plücker and Hittorf, Goldstein and Crookes had made many ingenious experiments and established many interesting facts, eventuating finally in a lively discussion as to the nature of the cathode rays. It was J. J. Thomson, now Sir Joseph, who in 1897, deflecting the rays for the first time by both an electric and a magnetic field, was able to infer with great probability that he had to do with a stream of electrified particles rather than with a system of ether-waves. He explained their passage through metals, shown by Hertz and Lenard, by suggesting that they were of sub-atomic size, and, by using fields of definite strength found not only their velocity, but the important ratio, m/e, between the mass of the flying particle and the electric charge which it carried. By a daring extension, due to C. T. R. Wilson, of Aitken's method of counting the fog-globules deposited on the dust in the atmosphere, he determined the number of particles in a given volume of air, and so the charge and mass of each particle. These results, especially the value of the ratio, m/e, were confirmed in a variety of ways. The most direct and probably the most accurate, determination of the electric charge was that of Millikan, who in 1911 succeeded in catching electrons on minute drops of oil floating in the air, and in observing with a microscope their behavior in a strong electric field. The charge on each oil-drop was found to be always of a given value or an exact multiple of this value, the amount agreeing in general with the results obtained by Thomson and others. It was evident that electricity was not a continuous fluid, or an ether strain, but existed in discrete separated particles. An atom of electricity became as definite an idea as an atom of matter.

The mass of the particles which in the cathode rays act as carriers for the electric charges could now be determined. It turned out to be always the same, whatever the nature of the cathode from which it was expelled, not a particle or atom of any known element, but a thing sui generis, nearly two thousand times smaller than an atom of hydrogen, the lightest atom known. With regard to this particle a new question now arose. Sir Joseph Thomson had shown years before that the addition of an electric charge to a moving body had the effect of increasing the apparent mass of the body, by an amount dependent on the added charge and the speed of the motion. Since these quantities — charge, mass, velocity, — are all known with regard to the cathode-ray particles (or electrons, as they were now called). Thomson's theory could be experimentally tested. Kaufmann, and afterward Bucherer made the experiments, showing conclusively that the mass of an electron varies with its speed, in a manner exactly concordant with the supposition that the mass is entirely due to the moving electric charge, that is, that the electron is not material at all, but is a free atom of electricity. Since the electrons are obtained, not by means of the cathode rays alone, but by many processes of ionisation, they must be constituent parts of all atoms, which are thus shown to be complex bodies, quite capable under proper provocation of such disintegration as is shown by radio-active substances.

While many well-known phenomena have pointed for years to the probability that the atom, whether it could be broken or not by human power was really very complex, yet we have for the first time a definite constituent separated and isolated, and a first step made toward studying directly the structure of the atom itself. J. J. Thomson, Rutherford, Bohr, and others have devised ingenious models of atoms, which meet more or less perfectly the experimental conditions, and furnish valuable suggestions for future work.

We have been obliged to pass over, almost without mention, various researches which have enlightened one or another side of our subject, such as the work of Hertz on electric waves, which, of great theoretical interest in itself, gave rise to wireless telegraphy, the subject of ionisation in solutions, the behavior of incandescent gases in a magnetic field, known as the Zeeman effect, the whole subject of photo-electricity, the phenomena of positive rays, discovered by Goldstein, from which Sir Joseph Thomson has recently developed his fascinating method of chemical analysis.

But we have passed in review, however hastily and imperfectly, the two lines of physical research which make up by far the most important work of the past twenty-five years. They traverse the most fundamental thinking of the previous century, and lead us farther into the complexities of natural phenomena than we have looked before. Yet it is interesting to compare this modern work, so delicate and minute, so remote from human life, with the great generalizations of the nineteenth century. However striking these phenomena are, they seem rather thin and shadowy by the side of those other powerful and solid achievements. But this shows us how truly we have gone into a new field. These things are yet in their beginnings. Whither they will lead we cannot yet tell, though it seems certain that they will lead far, or whether they will develop as great practical value as that previous work. Faraday's induced current, after all, was but a feeble creature at first. But it matters little at present; in any case the "practical results" are only the by-products of the advance of science. The men who carried on this work were in pursuit of truth. Theirs was the joy of discovery, of the enlargement, in however small a way, of the boundaries of human knowledge, of the ability to say, with Shakespeare's soothsayer

> "In Nature's infinite book of secrecy
> A little I can read."

ZOOLOGY: 1891-1915

EDWARD L. RICE

FOREWORD

Mr. President, Honored Guests, Members of the Academy:

The Executive Committee has honored me with an invitation to attempt a summary of zoological progress during the quarter century covered by the lifetime of the Ohio Academy of Science. The subject comes to me with a special personal appeal because of the coincidence that this period also measures almost exactly my own scientific life. The year of the establishment of the Academy found me a senior in college, and engaged in my first experiments in scientific research, fortunately, perhaps, never published, and in lines somewhat widely removed from my later zoological interests. It is with pleasure, as well as appreciation of the honor conferred upon me, that I accept this invitation.

INTRODUCTORY

A quarter century of zoology in forty minutes! In comparison, the then record-breaking trip of Jules Verne's hero was truly a leisurely stroll! Evidently many phases of the subject must be ruthlessly cut out, or this summary of a great and growing science must be a mere catalog of names and dates. A compromise is probably the wisest course, although a compromise must always face the danger of combining the worst defects of both extremes.

Certain branches of zoology in its broader definition are omitted, confessedly, because of the writer's unfamiliarity,— e. g. physiology and the rapidly developing field of biochemistry; others, like general morphology and classification, lend themselves but poorly to such a summary, and are passed over with but a scanty reference. Paleontology is essentially morphology applied to extinct life, and is accorded no independent consideration, although its wonderful recent achievements justify the enthusiastic affirmation of Henry Fairfield Osborn that "the complete geological succession of the vast ancient life of the American continent was destined to demonstrate the evolution law". Biometrics and explantation and so-called "experimental zoology" are hardly legitimate divisions of zoological science, but rather new methods of attack which have added greatly to the advancement of zoology during our quarter century and promise even greater things to come. The vitalism controversy, newly opened by Driesch, would lead us too far afield. And, finally, an especial apology is due to cytology for the way in which it has been dismembered and treated merely as an auxiliary to other branches of zoology, while some of its most interesting chapters, such as Loeb's experiments on artificial parthenogenesis and Lillie's more recent work on fertilization, are omitted for lack of time.

Even after such radical, perhaps over-radical, limitation, the field of modern zoology is still so enormous that it is a practical impossibility to go back to original sources in such a survey as this; and the writer is frankly availing himself of other summaries and of material furnished by zoological friends in special lines of work other than his own. Especially to Professors Gary N. Calkins, George E. Coghill, Edwin G. Conklin, C. Ross Harrison, H. S. Jennings, Francis L. Landacre, and L. L. Woodruff, and to Doctors E. F. Phillips and C. W. Stiles he would here express his thanks for valuable assistance and suggestion, without, however, making them in any way responsible for any statements of fact or opinion in the following pages.

Without attempting an exhaustive analysis of the underlying causes of the extension of zoology, we may safely mention three as having contributed in marked degree to this result. The lifetime of our Academy has witnessed marked improvement in technique, which has produced vigorous growth in some divisions of zoology; in other lines an economic and practical interest has furnished the efficient motive force in pure as well as applied science; last, but by no means least, we find a renewed emphasis upon the experimental method of research which has almost revolutionized the viewpoint of the science. We shall attempt to trace in rough outline some of the specific contributions of these three underlying causes.

SYSTEMATIC ZOOLOGY AND NOMENCLATURE.

To some of us, of over-specialized morphological and physiological interests, systematic zoology has looked a dry and barren Sahara; to others zoological nomenclature has appealed as a delightful toy for the unscientific amateur instead of a complex piece of apparatus to be used, indeed, by all but to be repaired or modified only by the skilled systematic technician. The very magnitude of numbers and their rapid increase suggest the danger and damage resulting from confusion in this field. Linnaeus knew only four thousand animal species; Ludwig, five years before the founding of our Academy, estimates the known number of species of animals at 273,220, while Pratt, in 1911, raises the number to 522,400. The number of known species of animals has thus approximately doubled since 1891.

And with this enormous complex each tyro has been at liberty to trifle; it is like turning a child loose in the card catalog of the library across the street. No wonder that a friend should exclaim in cynical disgust that he has given up the scientific nomenclature in favor of popular names on the ground that the latter are more definite and less confused.

Here was a loud and insistent demand for improved technique; and the call was answered by the Leyden meeting of the International Zoological Congress in 1895 by the appointment of an International Commission on Zoological Nomenclature. For twenty years this Commission has been working to bring order out of the chaos of the past. The work must needs be slow and conservative, and cannot suit the individual taste of every systematist. But the establishment of an international code of nomenclatorial rules, adopted by the Congress and referred to the Commission for administration, the publication of sixty-six judicial "opinions" on disputed points in nomenclature, and the establishment of a list of officially recognized zoological names mark a great advance over the conditions of a quarter century ago. The gratitude of all working zoologists, whether systematists or not, is due in fullest measure for the immense and otherwise unremunerated labors of the International Commission and its indefatigable secretary, Dr. C. W. Stiles.

MORPHOLOGY

From old-fashioned systematic to old-fashioned morphology is a simple transition. Both are out of style in certain quarters; but both continue to count their faithful devotees, and both continue a healthy, although little realized, growth, just as in our families less note is given to the gradual increase in a child's stature than to an occasional cutting of a tooth or attack of measles.

In our morphological studies the "type method" has reigned supreme, at least in America, — a method whose danger can be recognized by every teacher from his difficulty in convincing the average student that the equation

$$Amoeba + Paramecium = Protozoa$$

does not cover the whole problem of protozoan structure, or that other mollusks may differ from the fresh-water clam. In research work a similar tendency has been shown in rash surmises as to relationships based upon the study of the anatomy, adult or embryonic, of single isolated forms.

A wholesome reaction is seen in such work as that on the embryology of the vertebrate skull, beginning with Gaupp's inaugural thesis on the frog in 1891 and continued in a long series of papers by this master and his pupils. From this detailed and time-consuming comparison of an increasing series of closely related forms it begins to be possible to eliminate the unessential specific and individual features and to establish a broad general foundation for the tracing of homologies and relationships. Here a technical improvement underlies much of the progress, — the wax plate method of Born and Strasser, brought to perfection about 1887. The value of the method comes startingly to the eye if one compares the earlier figures of the skull published by that marvelously skilled technician of the old school, William Kitchen Parker, with those of Gaupp's more recent work.

This healthy progress in skull anatomy and embryology may be paralleled by that in many other lines of morphology less familiar to the writer, while in one branch, at least, of vertebrate anatomy, — the study of the nervous system, — the advance has been little short of revolutionary.

MODERN NEUROLOGY

In 1891 Kölliker, in a presidential address before the Anatomische Gesellschaft in Munich, raised the seemingly isolated question whether a nerve fibre ever exists without direct connection with a ganglion cell. This question he answered in the negative; and his answer was reiterated in the same year by Waldeyer, who gave the name of neuron to this combination of nerve fibre and ganglion cell.

A certain independence of these neurons is argued from experiments upon degeneration and regeneration and from embryological evidence of the origin of the neurons from independent embryonic nerve cells or neuroblasts, — the latter brought to practical demonstration by the brilliant work of Harrison, who in 1907 succeeded in observing the actual development of nerve fibres from isolated embryonic nerve cells cultivated in coagulated lymph. The degree of this independence is still, however, matter of dispute. In 1889 Ramón y Cajal, on the basis of the then new Golgi impregnation methods, had postulated an absolute structural independence and a mere contact connection of neuron with neuron; on the other hand, and with even more delicate technique, Apáthy claims to demonstrate a system of delicate fibrils, neurofibrillæ, which pass without interruption from neuron to neuron and form a marvelously intricate network within the cell body and around its nucleus. Fortunately the decision of this moot question is not essential to the effectiveness of the neuron theory, which finds in the neuron the structural unit and, to a certain extent, the physiological unit of the nervous system, — in fact, the only really nervous element of that system.

Upon the neuron theory is based the science of modern neurology, in the upbuilding of which American investigators have taken such a prominent part, and in which the work of Brookover, Coghill, Herrick, and Landacre may well give the Ohio Academy a special interest. That monumental record of neurological work, the Journal of Comparative Neurology, is also originally an Ohio product and was published in the state until 1907.

The keynote of modern neurology is the physiological analysis of nervous structure. To some of us the cranial nerves are mainly familiar through the classical mnemonic concerning "Monadnock's peaked tops" and the hop-gathering "Finn and German". These nerves, and the spinal nerves as well, the modern neurologist analyzes into their functional components, — somatic afferent and visceral afferent, somatic efferent and visceral efferent; each of these classes is again separated into general and special, and indefinitely further subdivided. (When will some philanthropic and poetic neurologist come to our aid with a revised metrical mnemonic?)

The value of this functional analysis and its difficulty appear from a single illustration. Landacre has collected data from various authors concerning the distribution of the gustatory fibres in fourteen of the chief rami arising from the ganglion mass of the fifth and seventh cranial nerves. In Petromyzon only one of these rami carries gustatory fibres; in Rana two; in Amblystoma, Triton, and Amia three; in Pleuronectes, Gadus, and Menidia five; while Ameiurus marks the extreme, with gustatory fibres in twelve of the fourteen rami. Note that, in the old neurology, these fourteen rami would be homologous throughout the series; the new neurology shows their fundamental difference.

But modern neurology is not content with this progress. Each component must be traced in the one direction until its peripheral distribution is mapped, and in the other to its complex connections in cord and brain. As this is done, it appears that each component, in whatever nerve or nerves distributed, shows a uniform type of peripheral end organ, a fairly uniform size of fibre, a common or homologous central ending in brain or cord, and a uniform embryological origin of its ganglia,— a series of facts justifying the term "functional systems" as applied to nerve components and placing the stamp of approval on this mode of nerve analysis.

PROTOZOOLOGY

In 1675 Leeuwenhoek discovered the protozoa; and from that time to this the group has held a firm grip on the scientific imagination. Aside from their own inherent beauty, the protozoa gain an additional interest as the natural starting point for the evolutionary study alike of physiology and of morphology in the higher animals. The structure of the protozoan cell gives light on the metazoan cell with its more highly specialized nuclear structure; physiological processes are reduced to their lowest terms in the protozoa; the simple tropisms and other reactions of the protozoa may give the clue to the voluntary and conscious psychical activities of the higher animals; in the conjugation of the protozoa we cannot fail to recognize the prototype of the sexual reproduction of the metazoa, complicated in the latter by the sharp separation of somatic and germ cells. It is not surprising that an enormous protozoological literature has sprung up in the last few years, the annual bibliography literally running into the thousands of titles; in one, at least, of our universities an independent professorship of protozoology has existed for nearly ten years.

Let us consider briefly one phase of the discussion of protozoan reproduction. Weismann, during the eighties, had compared the unicellular organisms with the germ cells of the higher forms. While the mass of cells forming the soma or body of a metazoan has a somewhat definite length of life and then, accidents aside, dies a natural death, the germ cells continue as an unbroken series from generation to generation throughout the existence of the species. On the other hand, the protozoan shows no distinction of soma and germ; when division takes place, the new individuals formed are, in one sense, as old as the species, in another, newly born and, according to Weismann, provided with the full potentiality of youth. The logical conclusion is that natural death is a function of the metazoan but not of the protozoan, — that the protozoan is as undying as the germ cells of the metazoan. The conclusion is unassailable if the premises are correct; but the latter have been vigorously questioned by Calkins in a series of papers beginning in 1902. Calkins sees in the protozoan a life cycle divided, like that of the metazoa, into youth, maturity, and senescence, and terminating in natural death. Here it should be emphasized that Calkins finds the equivalent of the metazoan individual not in the individual protozoan cell, but in the entire multitude of cells produced by fission between two conjugation periods. By a very carefully executed series of experiments, in which paramecia were cultivated in sterile hay infusion and isolated at intervals so frequent as to eliminate all possibility of conjugation, the division rate (taken as a measure of general body activity) was shown to fall off rapidly after some two hundred generations. Death would then ensue in the absence of conjugation, unless the protoplasm was artificially stimulated by chemical treatment. Finally, after some 742 geenrations extending through twenty-two months, a condition was reached in which such stimulation was unavailing, and the strain died out. Meantime such individuals as had been permitted to conjugate had established new lines comparable with new metazoan individuals. Death and conjugation would seem to be as necessary in the protozoa and as closely related as death and sexual reproduction in the metazoa.

On May 1, 1907, Woodruff started a similar isolation culture of paramecium, modifying the method of Calkins by the substitution of sterile pond water of varying chemical constitution for the too uniform hay infusion. The results are striking in the extreme. On November 15, 1915, eight and a half years after the beginning of the experiment, the culture was in good condition and had reached the 5375th. generation, — and this without conjugation, without periods of depression, and without artificial stimulation.

In the earlier part of the experiment no conjugation was observed in the mass cultures carried along with the isolation cultures; and Calkins could hold that "Woodruff's Paramaecium aurelia is evidently a Paramaecium Methuselah belonging to a non-conjugating line the life history of which is not known in any case". But two years ago conjugation set in vigorously in the control cultures; and Woodruff replies: "The fact that conjugation has now occurred in mass cultures from my pedigreed race demonstrates that the race is a conjugating race when the proper conditions for its consummation are realized. Therefore there is no evidence extant that a non-conjugating race of Paramaecium exists. One who now would demonstrate its existence must plan to carry a race for far more than 4102 generations without a tendency to conjugation being manifested".

A consecutive cytological study of this strain of paramoecium has shown a remarkable type of nuclear reorganization to which Woodruff gives the name of "endomixis" and to which he attributes the undying character of the protozoa. From these results he concludes: "Paramaecium aurelia can reproduce indefinitely without conjugation under favorable environmental conditions. The so-called life cycle is non-existent * * * From the life history of this race of Paramaecium aurelia we lean toward the view that both endomixis and conjugation in the infusoria, as fertilization in the higher forms, have a double significance — both afford the opportunity for molecular rearrangement which leads to increased physiological activity, and the opportunity for variation. The life of the paramaecium race can proceed indefinitely with endomixis under favorable environmental conditions — conjugation being unnecessary. 'Senile degeneration' and 'physiological death' are not the inevitable result of continued reproduction without conjugation, — the cell has an internal regulatory phenomenon, endomixis, which is self-sufficient for the life of the race".

The last word has, perhaps, not been spoken; but the present evidence seems to point toward the old Weismannian view of protozoan undyingness.

But fascinating as are such theoretical studies, no less fascinating and, perhaps, no less important in establishing the new science of protozoology are the practical applications of protozoan research.

The working up of the malaria case against Plasmodium and Anopheles reads like a Sherlock Holmes detective story. In remote lands investigators of divers nationalities collected their bits of evidence, which have finally been fitted together into an argument of unimpeachable completeness. In 1880 the malarial parasite was discovered and studied in Algiers by a French army surgeon, Laveran, who correctly and unhesitatingly (albeit with very inconclusive evidence) affirmed its causal relation to the disease. As early as 1883 the transfer of malaria by mosquitoes was suggested by King in America, and strongly argued on the basis of the parallel in the occurrence of mosquitoes and malaria. At the time of the establishment of the Academy the problem had not been advanced materially toward a settlement; suspicions were increasing, but the verdict was still "not proven". In 1893 Smith and Kilbourne demonstrated the transfer of Texas fever of cattle by ticks of the genus Boophilus, giving further ground for the suspicion of a similar infection in malaria. Later work by McCallum in America and by Ross in India on a malaria-like disease of birds, and by Ross on human malaria as well, led up to the final complete proof by Grassi in Italy, 1898, that malaria is produced by the sporozoan parasite observed eighteen years earlier by Laveran, and that this parasite is transferred from host to host by mosquitoes of the genus Anopheles. Further work by Grassi and Schaudinn has left no obscure point in the complicated life history of Plasmodium, with its double reproductive cycle in man and mosquito. The disease has been repeatedly produced experimentally by the bite of infected mosquitoes; and the wholesale protective experiments by Grassi, where an entire community has been freed from malaria by protection against Anopheles, are hardly less conclusive. This was the first demonstration of the protozoan nature of a human disease.

Perhaps more dramatic, certainly more tragic, was the investigation of yellow fever, a disease accredited to a protozoan parasite solely on its analogy with malaria, for the actual organism is still unknown, and may probably be of ultra-microscopic size. Even as early as 1881 Dr. Finlay, of Havana, had suggested that mosquitoes might be responsible for yellow fever, but his speculations had met with little approval. Not until the American occupation of Cuba did this theory secure an experimental test by a commission of army surgeons headed by Major Reed. The work of 1900 and 1901 cost the life of Dr. Lazear, but led to an almost perfect demonstration of the agency of mosquitoes of the genus Stegomyia as the bearer of the yellow fever parasite, and made possible the conquest of yellow fever in Havana and the Gulf ports and the building of the Panama Canal.

Since 1900 the number of known protozoan diseases has been increasing at a rapid rate, until the protozoa divide the doubtful honors with their vegetable rivals, the bacteria, as disease producers in man and beast. It may well be that the pendulum has swung too far in this direction and that the protozoa are held responsible for more crimes against life and health than they have really committed. But there can be no question that they are a very important factor in disease production; and it is equally certain that this discovery is one of the greatest practical scientific achievements of the quarter century we are considering. What its future significance to the human race will be we can hardly begin to estimate as yet.

ECONOMIC ENTOMOLOGY

Not all protozoan diseases are carried by insects, but a sufficient number to have furnished a tremendous incentive to the study of bloodsucking insects and their arachnid relatives.

Foreign invasion by insects injurious to crops has proved another important stimulus to entomological study. In 1893 the San José scale was discovered in the eastern part of the United States, already widely distributed through the stock shipments of two New Jersey nurserymen, who had unwittingly brought it from California, where it had gained an earlier foothold. The results were described by Howard in 1900: "In 1897 and 1898 it was seen that there was hardly an important fruit-growing region in the United States which was not directly threatened by the pest. In the meantime there was the greatest activity with regard to the insect on the part of economic entomologists, agricultural and horticultural societies, agricultural journals, and State organizations. * * * It occupied the attention of nearly every meeting of farmers and fruit growers that was held in the United States from 1894 to 1898, from the village club to the great State agricultural and horticultural society. It was the exciting cause of a national convention of fruit growers, farmers, entomologists, and nurserymen which was held in Washington, D. C., in the spring of 1897. It has been the subject of legislation in eighteen states of the nation and its suppression the principal object of two bills which were laid before Congress. The general spread of this destructive insect has worked great hardship to many fruit growers, and was the cause of the loss of many thousands of dollars; but looking at it in another way, the writer is firmly of the opinion that it has already been productive of great good and that its ultimate effect will be shown to have been most beneficial. * * * Much beneficial legislation has been enacted, and no one cause has begun to operate so strongly as this in indicating the economic value of entomological knowledge and of government support to entomological investigation". Similar valuable but expensive contributions to our entomological knowledge have been made by the gypsy moth and brown-tail moth in the East and by the cotton boll weevil in the Gulf States; while our native insects have shown no inclination to leave the field in favor of these foreign immigrants. There seems no immediate danger that economic entomology will run out of material to stimulate its activity.

The response to these insect challenges has been the perfection of an organization of model efficiency, centering in the Bureau of Entomology in Washington and ramifying out through the states in the related work of the experiment stations and universities. It would be a hopeless task to attempt a mere catalog, let alone a discussion, of the serious scientific work accomplished in this line during our quarter century. Particularly interesting to the general zoologist are the systematic campaigns against individual pests, the control of injurious insects through offensive and defensive alliances with their natural enemies, the distribution of such allies from land to land, and the establishment of the Smyrna fig industry in California through the introduction of the Blastophaga required for the transfer of pollen. The extent of the advance is suggested by the following quotation from Parrott's presidential address before the Association of Economic Entomologists in 1914: "In 1899 twenty-five men were listed as entomologists on the staffs of the experiment stations, while in 1912 one hundred and one individuals were recorded as serving in this capcity. * * * Accurate figures exist showing the remarkable development of the national Bureau of Entomology but for the sake of brevity only a few of them have been selected. During the last year of Riley's service, which was concluded in 1894, eleven men served on the permanent staff, while five men were employed for part time. The funds for the support of the work amounted to $29,800. The force in 1912 comprised two hundred fifteen technically trained entomologists besides many other individuals who served as helpers. The budget for 1913-1914 provides for an expenditure of $752,210.00". Note that in each case the years mentioned fall well within the lifetime of the Academy and that the differential statistics must thus be increased in each case to correspond to the quarter century. And these statistics of men and money may well be assumed to correspond approximately with the unattainable statistics of actual scientific accomplishment.

But the claim may be advanced by some that this "applied science" does not merit the same consideration as the more abstract forms of "pure science," — that much of it is mere technology rather than real science. To all such the following passage from a recent personal letter, written by a former student now employed in government entomological work, is commended: "While great advances have been made during the past quarter century in all lines of zoological work, the advance has been greater and of more fundamental importance along economic lines than in any other direction. Certain branches of zoology have really begun to affect the man in the street and it is a hopeful sign to see the staid old science attired in overalls. You fellows who are interested in 'pure' science are a little inclined to poke fun at the economic worker, but there is one little point of difference too often overlooked. If we make mistakes there are dozens of people who are prepared and glad to rise up and correct us and who are vitally interested in the correctness of the observations. On the other hand, if a fellow gets off a freak theory as to the origin of the left hind leg of a starfish, nobody cares whether it is correct or not. It would be a safe bet that there are more incorrect observations published per page in 'pure' scientific zoology than in the economic literature." More informal and, probably, more radical than if intended for printing in a government publication! But none the less suggestive and worthy of consideration. And nowhere, perhaps, is pure science being more mercilessly submitted to the control of practical test and popular criticism than in economic entomology.

EVOLUTION

From this sermonette on applied science we return to theoretical dissipations. Today, as in 1891, biological interest centres around the evolution theory and its two supports, heredity and variation. Of course the theory of evolution was generally accepted by scientific men before 1891, — Huxley's essay on "The Coming of Age of the Origin of Species" was already eleven years old. But civil war among the different schools of evolutionists, and especially between Darwinism and Lamarckism, was in full swing then as now, although with rather a different outlook as to prospective victory.

Variation and heredity are absolute essentials to any theory of the transformation of species; variation without heredity would destroy species, heredity without variation would negate transformation. But the way in which these foundation stones of evolution were treated by Lamarck and Darwin was strikingly different. Lamarck's theory accounts for variation through the influence of environment during the life of the individual animal; heredity was assumed. On the other hand, Darwin assumed not only heredity (Pangenesis was never more than a "provisional hypothesis.") but also variation. This variation, however, was congenital and fortuitous or undirected, — very different from the acquired and directed variation of Lamarck. While the inheritance of Lamarckian variation would in itself be evolution, the inheritance of Darwinian variations would lead to chaos except for the introduction of an additional directive factor, which Darwin found in over-production, struggle for existence, natural selection. Darwin with his usual catholicity had pointed out clearly that these two theories are in no wise logically mutually exclusive and that both may be true; but his followers and Lamarck's had been far less cautious and had established the Neo-Darwinian and Neo-Lamarckian schools, respectively out-Darwining Darwin and out-Lamarcking Lamarck.

In the early Nineties, at least in America, the Neo-Lamarckians were clearly in the ascendancy under the brilliant leadership of Cope, ably seconded by Hyatt, Dall, H. F. Osborn and a score of other lieutenants. Cope's "Origin of the Fittest" appeared in 1887, and his "Primary Factors of Organic Evolution" in 1896. Victory seemed imminent; but the battle was not to be won so easily.

In 1883 Weismann had published an essay entitled "Ueber die Vererbung," which was rapidly followed by a series of writings culminating in "Das Keimplasma" of 1892. This is not the time for a detailed discussion of Weismann's theory; perhaps there is no need even of outlining his sharp distinction of germ-plasm and somatoplasm, — somatoplasm, the protoplasm of the somatic or body cells, carrying on the life of the individual and subject to modification through environment; germ-plasm, or the protoplasm of the germ cells, unused in the individual activity but set apart for the production of the new generation, and so shielded by the soma that it is practically freed from environmental influence. From this the corollary is evident, — only variations in the germ-plasm can affect the new generation, and these variations are not and cannot be the result of environmental influence, — acquired characters are non-inheritable. The contradiction of the Lamarckian theory is absolute. Today, undoubtedly, the trend of opinion is toward the Weismannian school. Says Conklin: — "When one recalls the storm of opposition which was called forth by his book on the 'Germ-Plasm' the present acceptance, at least in principle, of his major propositions can not be viewed in any other light than as a triumph for his theory and a tribute to the insight, foresight and constructive ability of Weismann." And again, while admitting that "it is probable that Weismann underestimated the possible influence of environment in producing changes in the germ-plasm and hence its influence on evolution," Conklin adds: — "Weismann admitted in his later years that the germ-plasm might be modified to a limited extent by certain environmental conditions, but he held that such changes of the germ-plasm led to general and unpredictable changes in future generations which might be wholly different from these somatic changes in the parents which were directly produced by such environment. This view is now widely accepted. Thus while Weismann's views on this subject underwent certain changes in the course of his long life, the opinions of his opponents have undergone so much greater and more important changes that it may be truly said that in the matter of the inheritance or non-inheritance of acquired characters the greater portion of the scientific world has come to Weismann's position".

This is a conservative and rational statement; others are far more radical, and there has been much rash talk about the "omnipotence of selection" (Weismann's own expression). From the other camp has come equally rash talk of the "deathbed of Darwinism". The results of evolution are of tremendous extent and almost infinite in their variety; universal laws in nature are comparatively rare. Scientific opinion, as well as popular opinion, is like a pendulum, swinging first to one extreme and then to the other; but it is likely to come to rest in a middle position. And our final theory of evolution is likely to be neither the extreme of Neo-Lamarckism nor the extreme of Neo-Darwinism, but a golden mean, perhaps not so far removed from the original Darwinism of Darwin.

MUTATIONS

While the evolution theory itself has been evolving, there has also been a great change of view concerning variations. Darwin emphasized minute variations, — infinitesimal variations; but it is also true that he held that sudden conspicuous variations or sports might occasionally lead to the origin of new varieties or species. Bateson, in 1894, collected a vast number of such sudden variations; but it was left for de Vries in his "Mutation Theory" (We trespass on the botanists' domain!) to bring this matter to a position of importance in the thought of botanists and zoologists alike. De Vries distinguishes sharply between "fluctuations" and "mutations". The mutations of de Vries are not necessarily of such extent as the "sports" of Darwin and Bateson; but they are characterized by their infrequency, suddenness, and completeness, as contrasted with the frequent and gradual fluctuations, — in other words, mutations are discontinuous, fluctuations continuous. According to de Vries only mutations are inheritable; therefore only mutations can have evolutionary significance, and this because mutations are due to germinal variation, fluctuations to somatic modification. To this extent, then, the mutations of de Vries are like the congenital variations of Weismann, fluctuations comparable with acquired characters; but the enormous number of minute variations upon which Weismann builds his theory of adaptive evolution would hardly be accepted by de Vries as mutations.

The theory of de Vries is frequently quoted as annulling the Darwinian theory of natural selection, — an utterly illegitimate statement of the over-zealous friends of mutation. Let us hear de Vries himself: — "Darwin discovered the great principle which rules the evolution of organisms. It is the principle of natural selection. It is the sifting out of all organisms of minor worth through the struggle for life. It is only a sieve, and not a force of nature, no direct cause of improvement as many of Darwin's adversaries, and unfortunately many of his followers also, have so often asserted. It is only a sieve, which decides which is to live and what to die. But evolutionary lines are of great length, and the evolution of a flower or of an insectivorous plant is a way with many side paths. It is the sieve that keeps evolution on the main line, killing all, or nearly all that try to go in other directions. By this means natural selection is the one directing cause of the broad lines of evolution". "Only a sieve", — a brilliant figure which would have been welcomed by Darwin; "the one directing cause", — selection carried to an ultra-Darwinian extreme.

No, the mutation theory is an ally, not the opponent, of the main central thought of Darwinian natural selection. But the mutation theory would restrict the material upon which natural selection can work to the occasional discontinuous mutations instead of the ever-present fluctuations. Selection, as applied to the minute variations so universally present in animals and plants, would be unavailing. The striking results which can be reached by selecting from a field crop of beans or a wild aggregate of paramecium is due not to the accumulation of fluctuating variations, but to the isolation of a number of distinct races or "pure lines", of which such a "mixed population" is composed. If a "pure line" (produced by the closest self-fertilization or by asexual reproduction), be taken as the starting point, the results will be different. Johannsen with his beans and Jennings with his parmecia have published similar conclusions, — the progeny of the biggest bean in a given pure line will average no bigger than the progeny of the smallest bean in the same pure line; the offspring of the smallest paramecium will equal in average size the offspring of the largest within the same pure line. Size variation is taken as typical of quantitative variation in general.

Probably all zoologists would agree with de Vries in ascribing an enormous importance to mutations; the majority, perhaps, would follow the theory to its extreme of universal application. But there has always been a respectable minority calling for caution. Castle, for example, has consistently supported the view that many changes of evolutionary value result from the summation of continuous variations, and cites de Vries' own experiments on the buttercup, in which the average petal number was gradually increased through five selections from 5.6 to 8.6, the mode or most frequent number from 5 to 9. Even more striking is the work of Castle and Phillips on the "hooded" rat, in which two divergent and sharply contrasting types have been separated from an original stock, the extreme of each type lying distinctly beyond any known form of the original stock. It is also very significant to note in this connection that recent, as yet unpublished, work by Jennings and his students shows a much greater degree of variation within pure line cultures of the lower animals, and much greater possibilities for selection within such lines, than the earlier experiments by Jennings himself and by other investigators had indicated. Here again zoological opinion is likely to follow a pendulum course and come to rest in a conservative middle position.

MENDELISM

As in the study of variation, so in that of heredity the zoologists must concede that the most conspicuous advance has resulted from the work of a botanist. In 1866 Gregor Mendel published a paper on the hybridization of garden peas, containing the results of eight years' work, in which he had anticipated by a generation the modern method of careful experimentation and accurate statistical record. His essay showed a masterly power of scientific analysis; but it disappeared from sight in the Proceedings of the Natural History Society of Brünn, and was as if unpublished. The time was not ripe. Lost for a generation, independently rediscovered in 1900 by de Vries, Correns, and Tschermak, translated into English by Bateson in 1902, Mendel's work at once received its deserved but long delayed recognition, thus fairly becoming the property of our quarter century. Since its rediscovery Mendelism has assumed the leading position in all study of heredity and has met with general confirmation; in its widespread extension zoologists have been no less active than botanists.

A simple breeding experiment, taken from the zoological field, may serve to illustrate the three principles of Mendel's theory. If a pure bred or homozygous black guinea pig is crossed with a pure bred or homozygous white guinea pig, all of the offspring in the first filial or f_1 generation will be black. While these f_1 blacks look like their black parent, a simple breeding experiment will show that they are really different, — that they are really a mongrel or heterozygous type. This experiment consists in crossing such an f_1 black with a pure bred white; one-half the offspring will be black, one-half white. Returning to the main experiment, suppose the f_1 heterozygous black animals to be bred together; the offspring in the next generation (second filial or f_2 generation), will be in the proportion of three blacks to one white. Testing of the blacks permits the further analysis of this f_2 proportion into one homozygous black : 2 heterozygous blacks : 1 homozygous white.

With this experiment in mind, let us examine briefly Mendel's three main theses.

1. Unit Characters. The total inheritance of an organism may be analyzed into a number of characters each of which is inherited in its entirety (unit character) and independently of other unrelated characters. In our illustration, blackness and whiteness are two contrasting unit characters, and totally independent of other characters such as coat quality or hair length. Recent work on linkage, to be discussed later, shows that this view of independence of characters must be materially modified.

2. Dominance. When contrasting unit characters are inherited from the two parents, only one (the dominant character) appears in the offspring, the other (recessive character) disappearing from sight although remaining in a condition to affect the next generation. In our illustration, blackness is seen to be dominant, whiteness recessive. Later work has shown that the principle of dominance is not of universal applicability; nor is it essential to Mendelism.

3. Segregation and Purity of the Gametes, — the centre and heart of Mendel's work. Even when produced by a heterozygous parent, a germ cell or gamete (egg or spermatozoon) can carry but one of a pair of contrasting unit characters. In fertilization the gametes unite in pairs (egg and sperm) to form the new individual. If like gametes unite, the resulting animal

is homozygous; the union of unlike gametes produces a heterozygous animal. Conversely, a homozygous parent produces like gametes, while a heterozygous parent forms equal numbers of two classes of gametes, bearing respectively the two contrasting characters. In our illustration, the pure bred black of the parental generation produced only "black" gametes (if this strongly abbreviated expression may be permitted), and the homozygous white produced only "white" gametes. The only possible combination of gametes was the union of black with white; hence all the animals of the f_1 generation were heterozygous. When two of these heterozygous f_1 animals were bred together, each produced "black" gametes and "white" gametes in equal numbers. The totality of gametes produced by each animal may be represented by the expression Black+White, conveniently abbreviated to B+W; and the resulting gamete combinations may be represented by the product of the algebraic multiplication of B + W by B + W, — namely BB + 2 BW + WW, which corresponds to the observed proportion of 1 homozygous black (BB) : 2 heterozygous blacks (2 BW) : 1 homozygous white (WW). This is the simplest possible type of Mendelian inheritance, in which but one pair of contrasting characters is considered; the cases with two three , or more pairs of such characters may be worked out on an algebraic basis. Aside from the confusion caused by linkage, the observed results tally remarkably closely with calculated ratios.

Mendel's own work was done years before biology was in position to look within the cell and raise the question as to the material bearers of these hereditary characters. But when his work was rediscovered, the researches of Oskar Hertwig, Strasburger, Kölliker, and Weismann had already turned the attention of the scientific world to the chromatin within the cell nucleus as the probable carrier of hereditary characters. The breaking up of the chromatin, at the period of cell division, into separate bodies or chromosomes, of definite number and form in each species, had already been discovered, as well as the significant fact that the last two divisions in the development of egg and sperm cells lead to the reduction of the chromosomes to one-half the number found in the body cells. The union of sperm and egg, each with its half number of chromosomes, restores the full number in the somatic cells and primordial germ cells of the new organism. The parallel of these chromosome relations with the relations of unit characters could not long escape attention; and today the view is very general that the chromosomes are the bearers of such Mendelian hereditary units.*

Twenty-five years ago biologists stated unhesitatingly that the chromosome number in the somatic cells was always an even number; but, in 1891, Henking published the revolutionary discovery of an odd chromosome number in the male of an insect. Here the spermatozoa are necessarily of two classes, the spermatozoa of one class having one more chromosome than those of the other class. Eleven years later, largely because of the numerical equality of the two classes, McClung suggested the theory that this "accessory chromosome" or "odd chromosome" or "x-chromosome", as it has been variously named, may be correlated with the determination of sex. This view, although in modified form, has now been almost certainly demonstrated for a variety of animals by the careful investigation of E. B. Wilson and other workers.

We may confine our attention to this simplest and most typical case of sex determination, and disregard the complications introduced by the presence of a y-chromosome, paired with the x-chromosome and sometimes visibly indistinguishable from it, or by the substitution of a chromosome group for the single x- or y-chromosome.

In the female the somatic chromosome number is even, including two x-chromosomes, and the eggs are all alike, each containing an x-chromosome. The fertilization of an x-containing egg by an x-containing spermatozoon produces a female animal; the fertilization of an x-containing egg by an x-lacking spermatozoon produces a male. In other words, the female is

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* The existence of any particulate "bearers" of hereditary "units" is totally denied by certain able investigators, who, nevertheless, recognize the correlation in behavior of chromosomes and hereditary characters.

homozygous and the male heterozygous as regards sex. In a few cases the opposite appears to be true, — the eggs are of two classes and the spermatozoa alike; thus the male is homozygous and the female heterozygous. Whether all animal and plant species conform to these two types of sex inheritance it is probably too early to predict; but, at least, the discovery of the sex chromosomes gives a promising clue to the long discussed but hitherto hopelessly tangled snarl of theory in regard to sex determination.

When the chromosomes are mentioned as the bearers of hereditary units, it is not, of course, implied that there is a chromosome for each character, — the very large number of characters and the relatively very small number of chromosomes effectually negative such an idea. Thus in the fruit fly, Drosophila, which has been brought into such prominence through the brilliant intensive researches of Morgan and his students, there are but four chromosome pairs in the somatic cell, four chromosomes in the gamete. If, then, a group of hereditary characters is found in each chromosome, and if, as is generally believed, the chromosomes are somewhat permanent structures, it follows that the characters borne by a single chromosome should be closely associated in heredity, — in technical expression, should be linked. In actual observation this linkage is a recognized fact. It was first observed by Bateson and Punnett in 1906, and its possible relation to the chromosome theory of inheritance was suggested by Lock in the same year. Drosophila, with its rapid breeding and extreme frequency of mutation, affords exceptionally favorable material for the study of linkage; and since 1910 Morgan has recorded about a hundred linked characters. Of these 47 are shown to belong to one great linkage group, 27 to another, 22 to a third, and 2 to a fourth group. The correspondence of four linkage groups and four chromosomes is significant.

But, while there is this very evident tendency to linked inheritance, the linkage is not complete, nor is it equal for all the characters of a group. Thus, while two characters coming from one parent may usually hold together in inheritance, one may sometimes break away or "cross over", to use Morgan's expression, and combine with a character coming from the other parent. Janssens has called attention to the fact that at one stage in the maturation of the germ cells the chromosomes of each pair may be twisted together in a rather close coil and are apparently actually fused at certain points. If in this process the chromosomes should break transversely at a point of fusion in such a way that a part of each chromosome is transferred to the other, we should have, as Morgan has pointed out, a reasonable physical basis for the phenomenon of "crossing over". On the other hand, the retention of chromosome identity would give an equally reasonable basis for the phenomenon of linkage. Further it may be assumed that two characters located in adjacent points of a chromosome will be more likely to remain linked than characters widely separated in the same chromosome. After a careful study of the degree of linkage of character with character, Morgan, Sturtevant, Muller, and Bridges, in their newly published volume on "The Mechanism of Mendelian Inheritance", present a diagram in which they chart the relative positions of some thirty-six unit characters within the four chromosomes of Drosophila. They defend their position in the following words:—"Not only can all the facts of linkage so far studied be explained on this basis, but * * * certain further results can be predicted". Hypothetical; some will say wildly hypothetical; but of fascinating interest, and well worthy of the severe testing that it is sure to receive.

But, granting that certain characters are carried by the chromosomes in heredity, it does not necessarily follow that all hereditary characters are so carried. Thus Conklin, largely as the conclusion from his cytological studies on the egg, affirms most emphatically that "at the time of fertilization the hereditary potencies of the two germ cells are not equal, all the early stages of development, including the polarity, symmetry, type of cleavage, and the pattern, or relative positions and proportions of future organs, being foreshadowed in the cytoplasm of the egg cell, while only the differentiations of later development are influenced by the sperm. In short the egg cytoplasm fixes the general type of development and the sperm and egg nuclei supply only the details. We are vertebrates because our mothers were vertebrates and produced eggs of the vertebrate pattern; but the color of our skin and hair and eyes, our sex, stature, and mental peculiarities were determined by the sperm as well as by the egg from which we came. There is evidence that the chromosomes of the egg and sperm are the seat of the differential factors or determiners for Mendelian characters, while the general polarity, symmetry, and pattern of the embryo are determined by the cytoplasm of the egg".

And, in broader terms, granting that certain characters follow the Mendelian type of alternate inheritance, are all characters Mendelian in heredity? Seemingly we have some startling exceptions. For example, the crossing of Negro and Caucasian gives an f_1 generation of Mulattoes, intermediate in their skin color between the parent stocks. This may be explained in Mendelian terms through the absence of dominance. Numerous parallel cases are known in which the inheritance is otherwise strictly Mendelian. More serious is the recognized fact that the f_2 generation of Mulatto paired with Mulatto does not segregate into the Mendelian proportion of 1 Negro : 2 Mulattoes : 1 Caucasian. Here Mendelian segregation has apparently given way to complete blending; and this is not a solitary case, but can be duplicated alike from plant and animal breeding. Orthodox Mendelians meet the difficulty by the assumption of multiple factors, — several independent factors each of which may produce a given character, although in varying degree of intensity according to the number of the factors present in the individual case. With two such factors for dark color there would be but one pure black and one pure white in sixteen of the f_2 generation, the other fourteen being of intermediate degrees of darkness; with three such characters there would be one pure black and one pure white in sixty-four; while, in the theoretical extreme, an infinite number of such characters would reduce the pure whites and pure blacks of the f_2 generation to more than infinite rarity. This reductio ad absurdum may be an unfair treatment of the Mendelian explanation; but it must suggest the legitimate question whether the Mendelian is not entangling himself in a fatally complex web of theory, and whether the simpler course is not the frank acceptance of the idea that Mendelism, while one of the greatest scientific assets of our generation, may not be of universal applicability. The worst that its friends can do for a theory is to attempt to make it explain too much. "Omnipotence" and "death bed" are likely to be heard simultaneously. The pendulum again gives us a valuable suggestion.

CONCLUSION

Such are some of the elements of the zoological progress of the quarter century which appeal to the writer as deserving consideration. But the account is necessarily incomplete and sketchy; it must also necessarily be marked by a certain personal bias; and many of you will wonder why this has been included and that has been omitted and the other has been treated as it has.

Finally, can we draw any general conclusions? The variety and range of the material covered make this almost impossible; but two points have stood out in impressive relief during the preparation of the review.

First, the future of zoological investigation is bound up with the experimental method. On the title page of de Vries' California lectures stand these three pregnant sentences, which may be taken to mark the progress and suggest the future of all zoology as well as that phase to which they are directly applied:—

The origin of species is a natural phenomenon.—Lamarck.

The origin of species is an object of inquiry.—Darwin.

The origin of species is an object of experimental investigation.—de Vries.

Second, the outlook of zoology is one of intense optimism. The survey of a great and growing science is startling, almost depressing, in its sense of unattainable and almost inconceivable magnitude, but inspiring as the record of the achievement of coördinated and organized human endeavor. The members of the

Academy who were present a year ago have not forgotten the words of warning contained in the closing paragraphs of that memorable presidential address, — the conclusion from a contrast of the rugged conditions of the days of Locke and Mitchell and Sullivant and Newberry and Orton in Ohio with the comfortable and depressing luxury of science at the beginning of the Twentieth Century that "on the whole, conditions are not as favorable for the development of scientific ability of a high order as they were forty or fifty years ago, and that in relative proportion to the number of students of science, then and now, fewer men possessing talent of the first rank are likely to appear during the present century than we know to have lived in the nineteenth".

But the survey of our quarter century of zoology shows an enthusiasm for research, an almost Viking lust for struggle, and a plodding willingness to follow a problem to the last tedious detail of its solution which bid fair to overcome the dangers of luxury as the men of the preceding generation met the difficulties of privation. The type of warfare has changed; but the character of the fighters is the same; and the present drive along the whole broad battle front cannot fail in the next quarter century to penetrate deeply into the trenches of the unknown.

THE PROGRESS OF CHEMISTRY DURING THE LAST QUARTER OF A CENTURY

William McPherson

To give any comprehensive account of the growth of chemical science during the last quarter of a century within the limits of the time assigned me is entirely out of the question. It has seemed to me appropriate, therefore, that under the conditions imposed I should not attempt to follow the many avenues along which the science has progressed but rather select for discussion a few topics which are of primary importance, fully realizing the inadequacy of this method to give any connected or systematic treatment of the subject as a whole.

The Constitution of Matter.—Radioactivity. If not the most important at least the most sensational of the discoveries made during the last quarter of a century lie within that great field of science largely developed in recent years and known as "Physical Chemistry". The development of this line of investigation has effaced all traces of a boundary line between Physics and Chemistry. It follows, therefore, that both the physicist and the chemist are equally interested in many of the facts that have been discovered as well as in the theories that have been developed in this field of investigation.

Included in this field of inquiry is the question of the constitution of matter—a question not only of fundamental importance but one of universal interest. Perhaps the query most often put to the chemist at the present time by workers in other fields of science is "What changes have the results of modern investigation compelled us to make in our ideas concerning the Daltonian atom?" These changes have been largely the outgrowth of the discoveries included in that newly developed region known as "radioactivity".

The beginning of the discoveries included under the head of radioactivity dates back to the year 1896 when Henri Becquerel, Professor of Physics in the laboratory of the Museum of Natural History in Paris, discovered that the element uranium is radioactive; that is, it constantly gives off rays which possess something of the general character of the X-rays. These radiations were found to affect a photographic plate in a manner similar to the X-rays and also to act upon the air and other gases rendering them conductors of electricity as is evidenced by the fact that a charged electroscope is discharged when uranium is brought near it. Later in 1898 Schmidt discovered that thorium, an element resembling uranium in having a high atomic weight, emitted a similar radiation. These discoveries attracted the attention of Monsieur and Madame Curie. The brilliant investigations of these two scientists, culminating in the isolation of the new elements, polonium and radium constitute a story well known even to the layman and need no repetition here. The allurement of the field of work thus opened up naturally drew many investigators, both physicists and chemists, and the discoveries made by these investigators together with the theoretical bearing of these discoveries upon the constitution of matter have held first place in importance in the history of our science during recent years. Naturally there has been much speculation in regard to the discoveries made and many hypotheses have been advanced to account for the phenomena connected with radioactivity. It is recognized, however, that the development in this field is in its infancy and any hypothesis formed at the present time must be a tentative one only and must be advanced with an almost complete assurance that, if not discarded entirely, it will at least have to be modified to meet the conditions that will be imposed upon it by future discoveries.

I shall attempt in as few words as possible a brief survey of the present status of our knowledge of radioactivity so far as it has a bearing on chemical science.

Experiments have shown that the elements, uranium and thorium, are spontaneously disintegrating; that this process is accompanied by, or perhaps it would be better to say that it is the result of the emission of certain rays; that the phenomena of radioactivity are due to the effects produced by these rays. These rays are of three distinct kinds, distinguished from each other by the terms alpha, beta and gamma. The alpha rays consist of particles having an atomic mass of 4 and bearing a double unit charge of positive electricity. The beta rays have a much smaller mass (calculated to be about 1-1800 of the mass of the hydrogen atom) and carry a unit charge of negative electricity. Our conception of the gamma rays is less definite. They have been regarded generally as non-material and due to some peculiar vibration in the ether similar to the X-rays.

Now what are the facts connected with the disintegration of uranium? Experiments show that there is first formed a definite product which is known as uranium X. This product in turn disintegrates forming a second product, probably the substance known as ionium, and this in turn disintegrates forming radium. This process of disintegration continues through a number of subsequent products, the final one being apparently lead. In a similar way thorium is undergoing spontaneous disintegration, giving rise to a series of products. The final product is unknown. From analogy one would expect it to be some unknown element bearing the same relative position to thorium in the periodic arrangement of the elements as lead bears to uranium. Up to the present time some 30 more or less well defined disintegration products have been described. Each of these products has a definite period of average life, varying from millions of years in the case of uranium itself, to a few hours or even minutes in the case of one or two of the disintegration products.

So much for the facts. Now what are the assumptions that best account for these facts. All things considered the assumptions that have met with widest acceptance regard the changes taking place in the formation of one of these products from another as atomic changes. If we accept this view, each of the disintegration products must be regarded as an element so that up to the present date some 30 new elements have been added to our list as a result of the investigations bearing on radioactivity. If these changes are atomic in character it necessarily follows that the atom, at least the atoms of a radio-active element, can not be regarded as made up of indivisible particles. The conception of the atom which seems to be most in accord with modern researches, regards it as made up of a positively charged mass constituting by far the greater portion of the entire mass of the atom, and a limited number of negatively charged particles called electrons, each of which has a mass approximately 1-1800 of the mass of the hydrogen atom. These electrons when expelled, constitute the beta rays to which reference has been made.

Having this conception of the atom before us and recalling that radioactive elements are constantly giving off the alpha, beta and gamma rays referred to above, let us try to get a mental picture of the changes, taking place in the disintegration of a radioactive element.

The atoms of all radio-active elements possess a certain degree of instability. As a result of the unstable character the atom disintegrates forming a new atom. This new atom may likewise be unstable and so in turn it disintegrates; and the process goes on until a final stable product is reached. The disintegration of the atom may consist either in the expulsion of one or more alpha particles or one or more beta particles, or both kinds of particles may be expelled. If the change consists simply in the expulsion of an alpha particle (which particle has an atomic mass of 4 and a double charge of positive electricity) then, the change would be accompanied not only by a decrease of 4 units in the atomic weight but by a change of 2 in valence; for according to our modern conception, the valence of an element is simply a measure of the number of units of electric charge it possesses, a univalent element having a unit charge, a divalent element having a two unit charge and so on. On the other hand if the change consists simply in the expulsion of a beta ray with its unit negative charge, then the change would be accompanied by a decrease in the mass of the atom equal to about 1-1800 the mass of the hydrogen atom and by a change of one in valence. It thus becomes possible in a general way to predict the valence and atomic weights of the successive disintegration products.

Again suppose that the change consists in the expulsion of 1 alpha particle and 2 beta particles. The loss of the alpha particle would carry with it a change of valence of 2 and a consequent shift of 2 places in the periodic arrangement of the elements; but the accompanying loss of 2 beta particles would result in a change of valence of 2 also but in the opposite direction to that caused by the loss of the alpha particle. The product formed therefore would remain in the same position in the periodic arrangement occupied by the parent element.

From such considerations as these Soddy, Russell and Fajans have been lead to conclude that two or more disintegrating elements with practically identical chemical properties but differing slightly in atomic weights may occupy the same position in the periodic arrangement of the elements. It follows, therefore, that some of the substances now regarded as elementary in character may really consist of varying mixtures of closely related elements. For example, lead obtained from a radioactive mineral may really be a mixture of ordinary lead and one or more elementary substances with atomic weights differing slightly from the atomic weight of lead, yet with properties so similar that it is impossible to separate them by any known methods. This prediction was fulfilled in a remarkable way when a year ago (1914) Richards showed that the atomic weight of lead obtained from radioactive minerals is less than the atomic weight of ordinary lead, — the difference amounting in some determinations to as much as 0.75.

It will be observed that in these changes we have an actual transmutation of one element into another. It must be remembered, however, that these transmutations are spontaneous, and that up to the present time at least, no one has found a method whereby such a change can be incited, or altered in velocity if already in progress.

It is often asked whether this disintegration of the atom, attended as it is by a transmutation of one element into another, is a property of all elements. The answer is that up to the present time this property so far as known is confined to uranium and thorium and their disintegration products. Sodium and potassium have been reported as radioactive but there is some doubt as to the accuracy of this report. Ramsey has also reported that lithium is a disintegration product of copper but his experimental results have been strongly questioned and are today, I think, not generally accepted.

Discovery of Argon and its Congeners. It this connection mention should be made of the discovery of the element argon by Lord Rayleigh and Ramsey; also of the elements helium, neon, krypton and xenon by Ramsey and Travers. All of these elements are found in small quantities in the air and are unique in that they are devoid of chemical affinity. Their discovery has made necessary the addition of another group to the table of the periodic arrangement of the elements.

Solutions. The general phenomena attending the formation of solutions as well as the properties of the solutions themselves have been the subject of extended investigations. As our ideas concerning the composition of substances developed it was observed that solutions differed from mixtures in that they were homogeneous; and from chemical compounds in that their composition could be varied within wide limits. It was also observed that solutions possess certain fundamental properties in common. For example, the freezing point of a solution is lower than that of the pure solvent while the boiling point is higher; moreover, each individual solution possesses a certain definite osmotic pressure. More recently it was discovered that the magnitude of the changes in the boiling points, the freezing points and the osmotic pressure is in each case a function of the number of molecules of the dissolved substances present in the solution. In order, therefore, that solutions of different solids in the same liquid may have the same boiling points, the same freezing points and the same osmotic pressure, it is essential that the solutions contain not equal masses of the solids but masses proportional to the molecular weights of the solids.

It was known, however, that certain compounds (acids, bases and salts) when dissolved in water form solutions that conduct the electric current (electrolytes), and that in all such solutions the numbers representing the increase in boiling points and the lowering in freezing points, are abnormally great. Finally Arrhenius in 1887 advanced his now classical theory, known as the Theory of Ionization or of Electrolytic Dissociation, which endeavors to account for the abnormalities of such solutions upon the assumption that the molecules of acids, bases and salts, when dissolved in water tend to dissociate or ionize into electrically charged particles called ions. Each molecule dissociates into at least 2 ions, the electric charges of the two being equal but opposite in character. The ability of these solutions to conduct the electric current is assumed to be due to the actual passage of these ions with their charge of electricity through the solution. The abnormally high boiling points and the abnormally low freezing points of these solutions are explained upon the assumptions that each ion has the same effect as a molecule upon these values. The dissociation of a molecule into 2 ions would therefore have the same effect as doubling the number of molecules. The number of molecules dissociated in any solution increases with dilution reaching a maximum only in very dilute solutions. In ordinary solutions of electrolytes we are dealing, therefore, not only with the molecules of the dissolved substances, but also with the ions formed by the dissociation of a definite number of the molecules present. It was at first supposed that the chemical reactions of these solutions depend entirely upon the properties of the ions present. We now know, however, that the molecules themselves as well as the ions influence the course of the reaction.

The theory of Arrhenius has been strongly contested by a few investigators. Yet it must be said for it, that better than any other theory yet brought forward it furnishes an acceptable basis in accounting for the properties of electrolytes. As one writer puts it, "This theory gives us a working picture of the peculiarities of the class of substances known as electrolytes. This picture has already been considerably modified since it was first drawn and will no doubt be further modified in the future. At many points it is unsatisfactory for it has to do with one of the most complicated provinces of chemistry. It has, however, stimulated a vast amount of research, has greatly extended our knowledge and at the present time gives us by far the most satisfactory conception of solutions that we have."

The significance of the term "solution" has been greatly extended in recent years so that now no restrictions are placed on the physical state of the solution or its constituents. It is logical therefore, to speak of solutions of gases in gases or of solids in solids. Members of the latter type are known as solid solutions and the study of their characteristics from the standpoint of solutions has thrown much light upon a number of intricate problems. For example, certain varieties of iron and steel may be regarded as solid solutions of different carbides of iron as well as of graphite in the pure iron — a view which has been of great value in accounting for the characteristic properties possessed by various grades of iron and steel.

Colloids. Graham, for a long time Professor of Chemistry in the University College of London, as an outcome of his studies on diffusion divided all substances in solution or apparent solution into two classes; the one class, termed the *crystalloids,* easily crystallize and rapidly diffuse through porous membranes; the other known as *colloids* do not crystallize and diffuse only at a very slow rate. Graham's work was published in 1862. For a long time but little attention was given to it. The discovery, however, that many of the constituents of living organisms are colloidal in character drew a large number of workers into this field of investigation. The results obtained are of the greatest interest both from a theoretical and practical standpoint.

A study of the so-called colloidal solutions showed that the properties of many of these could only be accounted for upon the supposition that in them we are dealing not with true solutions but rather with suspensions; in other words, the colloid present is not in solution but in a very fine state of division — so fine that not only is it invisible under ordinary conditions but that it may remain suspended in the liquid indefinitely. We now know that no sharp line can be drawn between colloids and crystalloids since even the same substance can often be obtained in all transition stages from the distinctly colloidad state to the distinctly crystalloid.

Experiments have also revealed the fact that the finely divided particles present in a colloidal suspension often bear an electric charge — a charge which causes the particles to mutually repel each other and hence acts to prevent the precipitation of the particles. It is often possible to discharge these particles with the result that they will then precipitate and this principle is turned to practical account when, for example, it is desired to cause the precipitation of finely-divided solids suspended in water.

In discussing colloids, however, we have to deal not only with the colloidal suspensions known as "sols" but also with the solids known as "gels" which are formed by their precipitation or by the setting of the liquid when cooled. Mere mention of the fact that many of the questions connected with the processes of dyeing, of tanning, of purification of sewage, of the working of rubber are questions pertaining to the character of colloids shows something of the importance of this subject in the industrial world. Some of the most important constituents of the soil are colloids and the application of the principles of colloid chemistry to this study has been of great service. Finally in the study of biology we are often dealing with questions connected with colloid chemistry.

The Synthesis of Organic Compounds. Among the important problems that present themselves in the field of Organic Chemistry is that of gaining some insight into the structure and properties of those carbon compounds that appear to be most closely associated with the life of the organism; also, the problems of ferreting out nature's way of building up the compounds, often highly complex, that are found in the living organism. The problem is as difficult as it is alluring and not much progress has been made. It is true that chemists have succeeded in synthesizing some of these compounds, but it is certain that the methods used by chemists in accomplishing these syntheses are not the methods which nature employs. The chemist uses high temperature, strong acids and alkalies, and conditions that would at once destroy the life of any organism and put an end to its synthetic powers. Nature accomplishes the same end working between very narrow limits of temperature and so far as we know with the use of comparatively simple substances. Apparently not one of the large number of compounds synthesized in the laboratory has been prepared under the exact conditions that obtain in the living organism and its environment. Nevertheless, it must not be inferred that no progress has been made. The theory of Bæyer advanced in 1870, to the effect that the first step in the synthesis of starch and sugars found in the vegetable world consists in the interaction of water and carbon dioxide to form formaldehyde which then polymerizes into a sugar, has received some confirmation in the discovery that traces of formaldehyde actually exist in some plants while other plants are apparently able to assimilate it with the resulting formation of carbohydrates. Moreover the synthesis of a sugar from carbon dioxide and water has actually been accomplished in the laboratory under conditions of temperature that obtain in nature although the first step is accomplished through the action of a catalytic agent that does not exist in nature in the form in which it is employed. It is certain that before much progress can be made some insight must be gained into a number of fundamental reactions, such as the action of catalytic agents. We know but little of the composition and structure of that class of bodies known as enzymes which play such an important part in so many of the reactions of the living organism.

A great deal of work has been done especially by Ciamician and Paterno on the influence of light in effecting chemical changes and some enthusiasts even claim that the great chemical laboratory of the future will be in the Desert of Sahara or in other lands where sun-light may be had for the asking. Considerable advancehas also been made by Willstäter in our knowledge concerning the composition of chlorophyll and of other colored compounds existing in plants.

But the most brilliant worker in this field of synthetic chemistry is Emil Fischer, Professor of Chemistry in the University of Berlin. In his researches on the sugars he was able not only to determine the structure of many of these compounds but to effect their syntheses and in other ways to greatly extend our knowledge of this important group — although sucrose itself has not been synthesized and the constitution of the starch molecule still remains a mystery. Later Fischer began the study of that group of compounds found in the living organism which includes such substances as uric acid, caffeine, theobromine, xanthine, and hypoxanthine and showed that all of these may be considered as derivatives of one parent substance to which he gave the name purine.

More recently Fischer began work upon that highly complex series of compounds known as the proteins, which form the basic material of the living cell. His results in this field are of so much importance that a brief resumé of them must be included in any discussion of recent advances in chemistry.

At present some 40 or 50 natural proteins have been isolated and their properties studied. Their composition is wonderfully complex. It is possible to decompose these complex molecules, or in chemical terms to hydrolyze them into a number of simpler molecules. The resulting products belong to the class of compounds known as the amino acids of which 17 have been isolated and studied. These acids may be regarded as the building stones out of which the protein molecule is constructed. After making an extensive study of these amino acids Fischer began the work of re-combining these parts of the protein molecule in an effort to build up the original molecule. In this way he succeeded in building up more than 200 compounds, the most complex one having a molecular weight of 1213. The compounds obtained in this synthetic process have the general properties of proteins but even the most complex molecule synthesized is still far short of the molecules of natural proteins, the molecular weights of which lie probably around 5000. While some progress is being made in this field of investigation, nevertheless, the task of building up a molecule identical with that of any definite natural protein, would seem to be almost insuperable; for the molecule must be formed by the union of a very large number of amino acid residues. These residues may combine, however, in perhaps hundreds of different ways and if we are to synthesize any natural protein then this combination must take place in only one of the hundreds of ways possible. Since this particular combination is unknown it can readily be seen that the task of building up the molecule of natural protein is to say the least one of prodigious labor. Fischer has temporarily given up the study of the proteins for the reason that no way has been found for purifying the more highly complex synthetic products and is now devoting himself largely to a study of the natural compounds known as the tannins. In this field he has developed methods for building up tannin-like bodies, some of them of great complexity. One of the compounds so prepared has the formula $C_{220} H_{142} O_{58} N_4 I_2$ (molecular weight, 4021). This is the most complex compound so far prepared synthetically and obtained in a pure condition.

In connection with the study of synthetic organic chemistry one can without injustice scarcely avoid mentioning the work of Ehrlich and his associates in building up compounds that have proven to be of great worth in the treatment of certain disease — discoveries that have led to the development of that field of science known as chemo-therapy. These substances seem to act not by directly destroying the micro-organisms causing the disease but by inciting the organ to secrete an anti-body.

Of no less importance is the work of numerous investigators in building up the organic dyes. If one were to select any one achievement that stands out in this line of investigation it would probably be the synthesis of indigo and its development into a commercial process. Bæyer, in his investigations carried on between 1860 and 1880 succeeded not only in establishing the structural formula of indigo but in synthesizing the compound. The amount produced however was small and the method of production in no sense a commercial one. The Germans, however, recalling the successful production of the natural dye alizarin on a commercial scale, saw in Bæyer's discovery a great possibility. After 17 years of chemical investigation and the expenditure of over $5,000,000 the synthetic production of indigo on a commercial scale was finally realized (1897). The synthetic product is not only superior to the natural indigo in that it is pure but it can be sold at a lower price than the natural product. A nation whose faith in chemistry is such that it is willing to spend $5,000,000 in an effort to solve such a problem as the synthesis production of a dye is likely to continue in the future as in the past to maintain a monopoly in the production of synthetic dyes.

Caoutchouc identical with the natural product has also been made in the laboratory and in such amounts that it has been possible to test its properties even to the extent of equipping a motor car with tires of the synthetic product. The outlook for the production of this at a price which will enable it to compete with the natural product is far from encouraging. Whether or not this achievement will ever be realized — who can say.

Asymmetrical Syntheses. Another important problem connected with the study of the compounds associated with the living organism is one that has to do with the subject of stereoisomeric compounds; that is, compounds in which the isomerism is due not to different chemical groups but to the different arrangement in space of the same groups. The work of Pasteur (1848) upon tartaric acid and later that of Wislicenus (1873) upon the lactic acids showed that in each of these cases two acids were known having the same chemical formula but differing from each other in their action on polarized lights. As a result of the study of these investigations Van Hoff and LeBel working independently advanced theories practically identical in their assumptions which satisfactorily account for the existence of these acids. They observed that in tartaric acid as well as in lactic acid the molecule contains at least one carbon atom joined to four radicals or elements all different from each other. Such a carbon atom is known as an asymmetric carbon atom. Now it is very easy to show that in all compounds containing an asymmetric atom it is possible to have two different arrangements of the molecule containing the same groups of atoms but related to each other as object and image or as the right hand is to the left. These two isomers are known as stereo- or space isomers because their isomerism is due not to different groups but to the different space arrangements of the same groups. Since such compounds are so closely related in constitution it is natural to expect that their properties would be very similar. It is found that the only important difference is in their action upon polarized light. The one form known as the dextro form, rotates the plane of polarized light to the right while the other known as the levo, rotates it an equal amount to the left. Mixtures containing equal weights of the two forms would therefore be inactive towards light.

Now if we synthesize a compound containing an asymmetric carbon atom we always obtain the dextro and levo forms in equal amounts and hence the product is optically inactive, the action of the one form upon polarized light being neutralized by the action of the other. This is just what we should expect for in combining the different groups to form the molecule the chances for the groups to combine in the one form are just the same as their chances to combine in the other form. The remarkable fact, however, is that when a compound containing an asymmetric carbon atom is found in nature it is (with only two or three exceptions among the hundreds of such compounds known) always one of the active forms and not the mixture of the two. This striking difference between the natural and the laboratory synthesis has naturally attracted a great deal of attention and led to very extended research with the hope of accounting for this difference between nature's method and the laboratory method. The fact still remains, however, that no one has ever yet succeeded in building up in the laboratory from its elements or from optically inactive materials an optically active compound — and yet this is just what nature is doing all about us constantly. The striking difference between the natural and artificial synthesis has been strongly urged as a valid argument in favor of the principle of vitalism, the adherents of this view claiming that this difference forces us to the conclusion that the phenomena of life are not explicable in terms of physics and chemistry, but that they point to "the existence of a directive force which enters upon the scene with life itself and while acting through the laws of the kinetics of atoms determines the course of their operations within the living organism."

The study of synthetic organic chemistry, however, has not been confined to the mere building up of compounds. More and more attention is being given to the study of the mechanism of the reactions employed and to the transformations of energy accompanying these reactions. The chemist is not satisfied in simply knowing, for example, that sugar decomposes into alcohol and carbon dioxide. He wishes to follow the course of the reaction and to learn the answers to such questions as whether the reaction takes place in steps and if so what conditions bring about each of these changes, what is the mechanism of the changes and what transformations of energy attend them. In the study of these questions much assistance has been rendered by the principle known as the Phase Rule which was advanced by one of our countrymen, J. Willard Gibbs.

In connection with this line of investigation, mention may be made of the development of the respiration calorimeter which has made it possible to follow with precision all the energy changes involved in metabolism. In this way it has been shown that the changes in matter and energy which take place in the human body are in accord with the laws of the conservation of mass and of energy.

Fermentation. The work of Buchner upon fermentation has given us some insight into this highly intricate process. At the time of the discovery (1897) Buchner, now Professor of Chemistry at the University of Wurzburg, was engaged in studying the effects of yeast extract upon animals. In order to secure this extract Buchner first disrupted the cell walls by grinding the yeast with fine sand an then subjected the resulting mass to a high pressure. In this way he obtained the yeast extract entirely free from the cells of the living organism. In order to prevent putrefaction Buchner used sugar as a preservative. The resulting liquid on standing was found to evolve a gas. Investigation soon showed that this was the result of the change of sugar into alcohol and carbon dioxide. By a lucky incident, therefore, Buchner had succeeded in accomplishing what so many others had attempted and failed, namely, the fermentation of sugar in the absence of living cells. In the light of these results the role that the yeast plant plays in the process of fermentation lies in the secretion of an enzyme (to which the name zymase has been given) and it is this enzyme which acts upon the sugar decomposing it into alcohol and carbon dioxide. The process of fermentation, therefore, can no longer be considered as the result of any vital force, but is a purely chemical process. While this discovery is one of great importance as is evidenced by the fact that it gained for Buchner the Nobel Prize, nevertheless, the mechanism of the reactions involved in fermentation is still largely a mystery. It seems certain that phosphates in some way enter into the change and that the production of alcohol is preceded by the formation of intermediate compounds. Ehrlich has shown that the higher alcohols produced in small amounts along with the ethyl alcohol are not the products of yeast juice fermentation but are formed by the action of yeast on the animo acids which result from the hydrolysis of the proteins present in the yeast cells.

The Indestructibility of Matter. The construction of balances of extreme sensitiveness has made it possible to test with much greater accuracy than ever before the principle expressed in the law of conservation of mass. In 1906 Landolt published the results of a series of experiments carried out under conditions that enabled him to detect even very minute changes of mass. In general his experiments consisted in placing two substances in separate limbs of a glass vessel which was then sealed and weighed with extreme care. By tilting the vessel the two substances were then brought in contact with each other and after the interaction of the two was complete and the conditions had become normal the vessel was again weighed. The greatest difference that Landolt detected in the weights of substances before and after interaction amounted to about one part in 10,000,000 — a difference well within the limits of experimental error.

Practical Applications. I have time only to barely mention a few examples of the progress made through the application of chemistry to the industrial development of the nation. It is only natural that such progress should result, for certainly a great number of manufacturing operations are primarily chemical in their nature. The chemist co-operating to be sure with the workers in other fields of science has transformed products that formerly were not only useless but often a source of expense to the manufacturer into products of great commercial value — as illustrated, for example, in the development of the cottonseed oil industry, the last phase of which consists in transforming the oil into solid fats of high food value. He has devised methods for extracting the rare metals from their ore and has brought them into the service of mankind as illustrated in the revolution brought about in our methods of artificial lighting through the use of cerium and thorium in the construction of gas mantles and of tungsten in the construction of the filaments used in incandescent lights. By utilizing the electric current as a means for producing high temperatures as well as for effecting chemical changes he has been able not only to lower the cost of the production of certain metals from their ores but he has also greatly improved the processes for the manufacture of such important products as caustic soda, chlorine, graphite, calcium carbide and carborundum. He has devised processes by means of which nitrogen is taken from the air and built up into compounds that can be assimilated by plants thus making us independent of nature's supply of nitrates. He has produced alloys possessing almost any desired properties and dyes and pigments of every imaginable color. He has contributed his share to the solution of the problem of preserving health in various ways, such as by devising methods for purifying water supplies, for disposing of sewage, by pointing out the kinds and amounts of foods that are best adapted for the different conditions of life, by substituting the non-poisonous materials for the poisonous and by synthesizing compounds of the greatest service for combating diseases. In these and in hundreds of other ways the chemist has contributed his share to the development of the arts of peace. However, he has also played his part in the development of the arts of war. The different alloys of steel that have made the modern engines of war possible, the high explosives, the poisonous gases — for these and many other engines of destruction we have to thank the chemist. There is hope that ere long his contribution to the arts of war will be such as to make war impossible because of the mighty destructive agencies that may be brought into action.

In conclusion if you ask me, "What is the most important of the problems that present themselves for solution in the domain of chemistry," I answer without hesitation, it is the problem of the chemistry of the living organism. What are the processes by which the organisms are built up; what are the energy changes involved in these processes; what is the relation of these changes to the life of the organism, — such questions as these have to deal with that highest of all problems, the problem of life itself. Today I am able to give you only glimpses into this wonderful region. At your half centennial celebration the speaker who narrates to you the advances in chemistry and the allied sciences will have a more wonderful story to tell.

OHIO'S CONTRIBUTIONS TO ARCHÆOLOGY

G. Frederick Wright

The position of Ohio midway between the East and the West gives it a conspicuous place in the development of human history on the American Continent. At the time of the discovery of America by Europeans, Ohio seems to have been neutral territory, being largely a battleground between the Iroquois Confederacy of Indians known as the six nations, whose center was western New York, and the Eries and Andastes who with their allies held the entire country to the south and west of the central portion of the State. One of the most interesting evidences of this is found in the neutral territory of two square miles which existed at Fremont, Ohio. This has been described by General Lewis Cass, from which it appears that at this point there existed something like the cities of refuge in Palestine, a place where members of the warring tribes on either side could meet in safety to carry on barter and exchange ideas. It was through this neutral territory that the main north and south Indian trail, leading from the Great Lakes to the Ohio, passed. Indian traders and warriors coming down from the upper lakes, on reaching the shore of Lake Erie opposite the head of Sandusky Bay, preferred to make a short portage at Port Clinton rather than make a long detour around Marblehead Peninsula to reach the head of the bay. So low is this pass at Port Clinton that at high water it was frequently flooded to a small depth. From the head of Sandusky Bay the trail followed up Sandusky River, passing in Fremont through Spiegel Grove occupied by the residence of the late President Hayes. This has now become the property of the State Archæological and Historical Society, which has taken pains to preserve some of the original traces of this great trail. Following up the Sandusky River the trail passed through the Tymochtee pass into the Scioto Valley a little above Marion, whence it continued down that river to Portsmouth on the Ohio. It is interesting to note, also, that General Harrison in the Campaign of 1812 followed this trail with his army from Columbus to Port Clinton, and that his ammunition wagons had much to do in deepening the marks of the trail where it passes through Spiegel Grove.

Two other important north and south trails connected the lake region with the Ohio. One leaving the Maumee River at Defiance passed up the Auglaize valley into the valley of the Great Miami near Loramie Reservoir and reached the Ohio near Cincinnati. Another leaving Lake Erie at Cleveland followed up the Cuyahoga River to Akron where it passed over into the valley of the Tuscarawas, reaching the Ohio River at Marietta. The east and west trails were in general less direct, except that which led along the south shore of the lake. The trail next south of this, leading from the upper Ohio, followed the Mahoning River to Warren and thence westward through Ravenna, Cuyahoga Falls, Medina, and Norwalk, and passed on thence to Toledo and Detroit. Another passing through Columbiana Co., turned southwesterly down the Tuscarawas River to Coshocton and thence to Circleville where it joined a northwest and southeast trail leading from Mercer County to Gallipolis. These and other trails have now been pretty thoroughly traced out and it is interesting to note that the Indians had by instinct discovered the lines of least resistance which have been brought to light by our modern civil engineers in locating the canals and railroads of the State.

The most striking objects of archæological investigation in Ohio are found in the prehistoric mounds and earthworks of the State, which are numbered by the thousand, — no less than 5,396 being enumerated in the archæological atlas of Ohio recently published by our Society. Of these 587 are enclosures, 354 village sites, 714 ordinary interments, 39 cemeteries, 17 stone graves, 5 effigy mounds, 109 flint quarries, and 6 caches, while burial mounds number 3,513, furnishing altogether material for archæological investigation unrivalled in any other state of the

Union. From the earliest settlement of the State these mounds and earthworks have attracted the attention not only of antiquarians but of the people in general. The first considerable description of them was given by Caleb Atwater in The Journal of the American Antiquarian Society in 1820, a work which it is still important to consult. In 1839 General William Henry Harrison gave in the Transactions of the Historical and Philosophical Society of Ohio the results of a careful survey of "The Miami Fort," situated a little south of North Bend, on the promontory just above the junction of the Ohio and the Great Miami rivers. In this he made the first attempt to estimate the antiquity of the Ohio earthworks, relying chiefly upon the fact that the forest trees covering the site included a great variety. To attain this variety would in his opinion have required a long lapse of time, but he did not undertake to estimate it in years. Similar evidence of great antiquity of the mounds was adduced by him from the condition of the earthworks when he first observed them on the terrace upon which Cincinnati stands. This he says was literally covered with low lines of embankments which had evidently been reduced in size and often nearly obliterated by the cultivation of people that occupied the region subsequent to the mound builders; for, he reasons, "the people who erected them would not themselves destroy works which had cost them so much labor * * * and the probability is that that people were the conquerors of the original possessors."

More definite attempts to determine the age of various mounds were made by Locke, Squier and Davis, Newberry and others from the measurement of trees growing upon the prehistoric earthworks. On Fort Hill in Highland County the stump of a tree was found which was estimated to be 400 years old, while in some places trees of corresponding age were found to be standing over and growing from the decomposed remains of predecessors of equal size and longevity.

A curious estimate of the age of the mound builders was made by the late Professor W. N. Shafer, (American Naturalist, iv. 3), who attributes the decay of the mound builders to the appearance of the buffalo in this part of the country, which he thinks was not more than 1000 years ago. "The coming of this creature coincided with the change of these peoples to a more barbarous condition. This plenitude of meat appears to have had a debasing effect on all the people of the Ohio Valley. They no longer tilled as much; their settlements, with their mounds and forts, were abandoned as far as this epoch-making beast extended his march. The Indians of the south, where the dense forests and the swamp-margined streams presented a barrier to the migration of the buffalo, remained principally soil-tillers as did the Indians of New York, while other western tribes became nomadic." This inference was partly dependent upon the supposition that the remains of the buffalo had not been found in any of the mounds. Evidence, however, has accumulated since, showing that buffalo bones have been found, though rarely, in some of the mounds. Professor Putnam speaks of a "pendant made of buffalo horn" found on an altar in the Turner mounds explored by him in the valley of the Little Miami.

Limitations to the age of some of the most extensive prehistoric earthworks are pretty clearly set by the small amount of erosion which has occurred since their construction. This can be seen to best effect in Fort Ancient, in Warren County, where the fortification for a long distance follows the exposed edge of a promontory which at two or three places is cut into by small streams of water which conduct the drainage from the inclosed plateau into the surrounding depression of the river valley. A thousand years would seem to be more than ample for the actual erosion, across the earthworks accomplished by these streams. Thus does geology come in as an important factor in estimating the age of these prehistoric remains.

As to the ethnographic relations of the mound builders evidence enough seems to have been accumulated to prove that they belonged to the tribes which occupied the southern part of North America, which are brachycephalic or short headed, whereas the Indians of the northern part of North America are dolycocephalic or longheaded. Out of 1400 skulls found at Madisonville by Professor Putnam's colaborers more than 1200 were brachycephalic but in some of the burial places both brachycephalic and dolycocephalic forms were found together. On the whole the evidence supports the theory that the prehistoric earthworks of Ohio represent the outposts occupied by invaders from the south who brought into our fertile valleys a civilization higher than that attained by the tribes farther north, but that their occupation was cut short by pressure of the more warlike dolycocephalic tribes. But it is no longer necessary to maintain with Lewis Morgan that the mound builders were invaders from the far southwest and even from Mexico, who vainly attempted to maintain here their village habits and organizations, but found the natural conditions so unfavorable that they at length abandoned the region. All the facts are sufficiently satisfied if we connect them, as Cyrus Thomas was confident we should, with the Cherokees of the southern states.

It is of more interest to note the facts bearing upon the actual stage of civilization that had been attained by the mound builders. Some of these facts have been known from the first comprehensive explorations of the field by Squier and Davis and others, who noted all the principal mounds and earthworks and gave details of their form and size. Such is their size and extent that they could have been constructed only by an organized society of large extent. The largest mound in Ohio is that at Miamisburg, which is 68 feet in perpendicular height with a circumference at the base of 852 feet, which would give as much as 1,300,000 cubic feet of material necessary for its construction. As there is no ditch around it, or depression near it from which the material could have been obtained, it must have been gathered from a wide spreading surface.

The construction of such a mound involves some interesting calculations concerning the organization of society which could have accomplished it. As the mound builders had no iron implements the dirt required in the construction of the mound must have been obtained and carried in a most primitive way. Allowing that each individual employed would carry a half a cubic foot of soil in his basket and that he would deposit thirty baskets a day, this Miamisburg mound would represent approximately 1,000,000 days' work so that 1000 men would be occupied about three years in its construction, if it could proceed without any interruptions from bad weather and other causes connected with their tribal and domestic economy. There is, therefore, no escaping the inference that the construction of this single mound required a highly organized society in which a large number of individuals were moved by a common impulse and were controlled by centralized authority.

If we consider the construction of Fort Ancient, the evidence is still stronger. The total amount of earth contained in the protective wall of this fortification is estimated at 172,000,000 cubic feet; but as the dirt was taken from the near vicinity we may reasonably assume that each workman could transfer to the fortification 60 baskets of material or 30 cubic feet per day. This would represent approximately 6,000,000 days' work which would occupy 1,000 men about 17 years.

Mr. Gerard Fowke's conservative estimate concerning the entire number of earthworks in the state is equally impressive. "On the estimate of 30,000,000 cubic yards for the prehistoric works of the State, one thousand men, each working three hundred days in a year, and carrying one wagon load of earth or stone in a day, could construct all the works in Ohio within a century." (Archæological History of Ohio, p. 85).

Considerable progress has recently been made in collecting facts bearing upon the religion of the mound builders, and concerning the extent of their commerce and their artistic attainments. We are now happy to announce that through the efforts of our society the facts bearing upon these subjects are open to study in our own state. It has been humiliating to the citizens of Ohio that up to recent times they were compelled to go beyond the borders of the State to study the best collections of the mound builders' relics. The great original collection of Squier and Davis, who were the first ones to explore the mounds, was so little appreciated in our own country that an eminent archæologist of England had no difficulty in purchasing it and spiriting it away to the other side of the Atlantic, this was Mr. Blackmore of Salisbury, England. But it is comforting to know that he took pains properly to install it in his museum at Salisbury where it has always been open to the inspection of American tourists. In this collection there were many objects which until this last summer have never been duplicated in any collection this side of the Atlantic.

The Peabody Museum under the active management of the late Professor F. W. Putnam has expended a large amount of money and well directed effort in the preservation and exploration of the earthworks of Ohio. Enterprising ladies of Boston raised a sum of several thousand dollars to purchase for that society the Serpent Mound in Adams County and to enable Professor Putnam to explore the mound and restore it to its original condition. After the society had completed its work its ownership was generously transferred to the Ohio State Archæological and Historical Society which now has the care of it and has erected on it a tower from which the whole length of the serpent can be surveyed. This mound has long attracted the attention of anthropologists the world over, and has properly been taken as a symbolic work indicating that the mound builders belonged to that large class of human beings who practised serpent worship. This inference has been strongly confirmed by the discovery of a second serpent mound on the Little Miami River in South Lebanon. Local attention had been directed to this mound for many years, but it was not surveyed till about twenty years ago when Dr. C. L. Metz of Madisonville published a careful survey. The convolutions of this figure are still distinctly preserved and the total length of the figure is about 1000 feet. The mound is situated on the south side of the Little Miami River a few miles below the village of Morrow. The location is attractive, and conspicuous from a large surrounding area. The officers of our society have visited the mound and confirmed the description of Dr. Metz, and published the results in their proceedings. This addition of a second serpent mound greatly strengthens the argument for the symbolic significance of the structures.

Altogether Professor Putnam has expended $50,000 or $60,000 in the exploration of Ohio earthworks. The most of this expenditure has been in the exploration of the Turner group of mounds in the Little Miami Valley, not far below Lebanon, and of the prehistoric burial places about Madisonville. It is needless to say that the rich collections made during these investigations have been transferred to the Peabody Museum in Cambridge, Massachusetts, where they are open to inspection.

In 1893 the directors of the Columbian Exposition in Chicago appropriated several thousand dollars for the exploration of the Hopewell group of mounds in the Paint Creek Valley near Chillicothe. The exploration was made by Professor Warren K. Moorehead and resulted in a remarkable collection of relics which were transferred to the Field Columbian Museum in Chicago, where they invite the study of Ohio Archæologists. The Smithsonian Institution in Washington has also been active for many years in gathering relics from the Ohio mounds, and transferring them to the United States National Museum in that city.

But through the work of our Society in the past few years we have now outdistanced all others, both in the amount and the value of our discoveries. By more systematic work we have made the gleanings of the field more important than the first crop. This has been specially noticeable in the exploration of the Harness Mound near Chillicothe, and what had been called the Elephant Mound near Portsmouth. The Harness Mound had been sporadically dug into by Squier and Davis, Putnam, and Moorehead, none of whom, however, had made any very extensive discoveries. But on carefully exploring it from end to end it was found that there was a series of burials near the edge of the mound around its entire distance and that there had been a wooden structure around the whole area. This was brought to light by a series of postholes. In all 130 burials were found in this one mound, together with 1200 implements of copper, a large number of bone implements of rare value, and much rare pottery revealing a special stage of culture. Among the relics deposited with the burial were numerous instruments and ornaments of copper from Lake Superior, of obsidian from the Rocky Mountains, of mica from North Carolina, and of shells from the Gulf of Mexico, points distant 3,000 miles from each other. The existence of the wooden structure brings the mounds of Ohio into an apparent connection with mounds found in Sweden, southern Russia, the Crimea, and Central Asia, where the burials were first inclosed by stone structures and the whole covered with a mound of earth.

The extensive commerce indicated by the relics found in the Harness Mound had, however, been brought to light by Professor Putnam's discoveries in the Turner group of mounds and especially by Mr. Moorehead's investigations of the Hopewell group. Among the discoveries of Mr. Moorehead was a cache of 8,185 flint discs, each weighing on an average a pound. These had been brought from the southern part of Indiana and Illinois and had been only roughly trimmed in the quarry and were waiting in this Ohio mound a convenient opportunity to make them up into perfect implements. The removal of four tons of raw material from distant quarries to a populous center of trade and manufacture in central Ohio presents a vivid picture of the activities of the prehistoric inhabitants of the State. For this heavy load was not brought upon iron rails, or even in primitive carts, but upon the backs of toiling men and women, animated by a highly cherished purpose.

The explorations during this past summer of the mound near Portsmouth has been specially productive of results. In the first place it has dissipated the conjecture that it was an effigy mound representing an elephant or a turtle. On the contrary it was found to be surrounded by a series of postholes such as occurred in the Harness Mound, indicating the existence of a long narrow wooden structure, 250 feet long by 50 feet wide. On clearing off the debris from one end of the area there were brought to light various crematories on which the bodies of the dead had been burned. A little farther along were sunken receptacles in which the ashes and crumbled bones from these crematories had been deposited. But as yet there were no other relics. On clearing off the area a little farther, however, a cache of relics was found exceeding in interest anything else that had been anywhere discovered. At one swoop we were able to find duplicates of all the animal pipes which Squier and Davis had disposed of to Mr. Blackmore, and a great number of even more interesting types. There were pipes in the shape of almost every annual known to the Indian, including a dog who was baying the moon with his tail turned up upon his back. There were figures of owls in various attitudes with pearls set in their eye sockets. Most of these were skilfully made from the pipe clay of the vicinity, but there were some designs skilfully carved in hard rocky material. Altogether the artistic work revealed a skill far beyond that shown by any of the North American tribes of Indians. This mound will hereafter be known as the "Tremper Mound," after its owner, Senator Tremper, who graciously permitted its exploration by our Socety.

An interesting revelation of the fact that the mound builders possessed the traits of human nature in general was made in the disocvery by Dr. Mills, while excavating the Baum Mound, of a great number of carefully selected pearls which had evidently been fastened together upon a string. Mr. Kuntz, the expert of the Tiffany firm in New York, estimated that these would have a market value at the present time of $10,000 if they were fresh and that it would probably require several generations of Indians to collect them from the mussels sparingly found in the Ohio streams. But a still more striking discovery was that the market for pearls was greater than the supply, and that the deficiency was made up in part by counterfeiting the genuine article. Clay was modelled into the shape of pearls and hardened in the fire, when they were skilfully covered with mica, rendered malleable by heat, whose lustre closely resembled that of the genuine article.

Thus in the extent of the mounds and the earthworks of Ohio, (when taking into consideration that all the work of their construction was done by most primitive methods); in the symbolism appearing in the serpent mounds; in the wide range of commerce indicated by the objects collected in single mounds; in the vast amount of material that had been carried to distant places from the flint quarries; in the rare skill shown in the manufacture of their weapons; and in the sculpture of their ornaments; and in their ingenuity in the imitation of nature in counterfeit pearls — in all these respects the mound builders are brought before us as numerous, highly organized, religious committees animated by all the desires and passions of ordinary humanity.

PALÆOLITHIC MAN IN OHIO

Indications of the presence of man in Ohio at a time far antecedent to that of the mound builders have been found at three places in undisturbed glacial deposits. These are of so much interest and have elicited so much criticism that it will be profitable to restate the facts in some detail. As far back as 1875 Dr. C. C. Abbott reported finding implements of palæolithic type in the glacial gravels at Trenton, New Jersey. Having visited this region in 1880 and gone over the field in company with Professor Boyd Dawkins, Professor Haynes, Mr. H. Carvill Lewis, and Dr. Abbott, the evidence of the occupation of the Atlantic coast by man during the Glacial period was such as to perfectly satisfy my own mind. On completing my survey of the glacial boundary in Ohio, in 1883, I called attention at a meeting of the Boston Society of Natural History, March 7, 1883 (reported in Science, vol I, pp. 269-271) to a number of places in Ohio where glacial gravels had accumulated in the same manner and approximately at the same date as those at Trenton had done, and suggested that similar indications of man's presence in Ohio during the Glacial period might be looked for, provided the reported discoveries at Trenton were genuine.

This drew out from Dr. Abbott a communication to *Science* on the 13th of April, 1883, suggesting that the failure to find implements of glacial origin in Ohio might not detract from the evidence which he adduced from the Delaware Valley, because, he writes, very likely, "palæolithic man was essentially a coast ranger, and not a dweller in the interior of the continent. If we associate these early people with the seal and walrus rather than with the reindeer, and consider them essentially hunters of these amphibious mammals rather than of the latter, it is not incredible, I submit, that they did not wander so far inland as Ohio." But it was not long before the expected evidence came. First on November 4, 1885, Professor Putnam showed at a meeting of the Boston Society of Natural History an implement of palæolithic type, closely resembling one of Dr. Abbott's, found by Dr. C. L. Metz, in undisturbed gravel of glacial age, eight feet below the surface in Madisonville, Ohio (see Proceedings B. S. N. H., vol xxii, p. 242). This was accompanied by the announcement that Dr. Metz had found another implement of similar character in the undisturbed glacial gravel of the Little Miami Valley at Loveland, a few miles above Madisonville. Subsequently, in the spring of 1887, Dr. Metz reported another implement of the same character from an excavation in the glacial gravel on the west side of the Little Miami opposite Loveland. In the near vicinity to this latter discovery "mastodon bones were found in a deposit of sand underlying the coarse gravel and pebbles." This implement was found about thirty feet below the surface.

Secondly, in October, 1889, Mr. W. C. Mills, for many years past the accomplished curator of the museum of the Ohio State Archæological and Historical Society, found a flint implement of palæolithic type in undisturbed gravel fifteen feet below the surface of the glacial terrace at Newcomerstown, Ohio, on the Tuscarawas River.

Thirdly, in 1892, Mr. Sam Huston of Steubenville discovered, projecting from the face of a fresh gravel pit at Brilliant, Ohio, a well fashioned flint implement beneath eight feet of crossbedded sand and gravel, in the glacial terrace bordering the Ohio River. On my exhibiting this implement at the Springfield meeting of the American Association for the Advancement of Science in 1885, Professor F. W. Putnam, Mr. F. H. Cushing and Miss Alice Fletcher all recognized it as an indubitable relic of great antiquity. Mr. Cushing asserted that this was indicated by the patina with which it was covered, and by the fact "that the form was antique, being intermediate between that of palæoliths and that of modern Indian implements."

Various attempts have been made to discredit the glacial age of these relics, by throwing doubt upon the competence of the discoverers to determine whether the gravel was undisturbed, and their possible failure accurately to observe and report facts. In answer to these objections it would seem sufficient to call attention to the high character of all these witnesses. Dr. Metz was for a long period Professor Putnam's main dependence in exploring the earthworks in the vicinity of Madisonville, and no more careful observer could anywhere be found. Of Dr. Mills I need say no more than that in his long connection with the work of our society he has established a reputation for carefulness of exploration and accuracy of description second to no other investigator in America or indeed in the world. Mr. Sam Huston was the highly educated county surveyor of Jefferson County and a well-known geological collector of highest reputation. Altogether it would be difficult to find three witnesses more competent to observe and report the facts attested by them.

Furthermore, the implements speak largely for themselves and are open for examination to any one who takes pains to visit the museums which have them in their possession. The implements discovered by Dr. Metz are in the Peabody Museum at Cambridge, the Newcomerstown implement discovered by Dr. Mills is in the museum of the Western Reserve Historical Society of Cleveland, and the implement discovered by Mr. Huston is in the Museum of the Ohio State Archæological and Historical Society. The late Professor N. H. Winchell, who had made special studies upon the patina which had accumulated upon flint implements of various ages made a careful examination of the Newcomerstown implement in Cleveland and pronounced himself as perfectly satisfied with the age that was assigned to it by its connection with the Glacial period. Furthermore it should be said that all doubts about the presence of man in the Delaware Valley during the closing stages of the Glacial period have been settled by Mr. Ernest Volk's discovery in 1899 of a human femur twenty feet below the surface of the glacial terrace at Trenton, beneath a thick deposit of crossbedded coarse gravel.

The stage of culture indicated by these discoveries of human relics in glacial deposits of America, is, so far as we can see, the same as that attained by palæolithic man in Europe, and is primitive in the extreme. As in Europe so in America, glacial man was associated with various animals which have either become extinct or have retired to the arctic regions. Of these the mastodon is specially prominent in the Mississippi Valley, and, on the Atlantic coast, seal and walrus. So far as we can see, the conditions of life here, then closely resembled those found among the Esquimaux of Greenland and the northern part of British America at the present time.

CHRONOLOGY OF THE GLACIAL PERIOD

The connection of man with the closing stages of the Glacial period gives us the best attainable means for estimating his antiquity, though by this method we can reach only the minimum age since man may have existed outside the glacial area for an indefinite period before the time of the deposition of the glacial gravels in which his remains have been found. But it is of great interest to determine approximately this one fixed point. From man's connection with the glacial deposits it follows that all glacial studies have a bearing upon the antiquity of man and upon the many philosophical theories relating to the development of the human race.

It is becoming more and more evident that the current estimates concerning the antiquity of the Glacial period are extravagant in high degree, having no basis in observed facts. The uniformitarian theory advocated by Sir Charles Lyell has been the basis of most of these extravagant calculations, whereas recent investigations clearly show that geological changes do not by any means proceed regularly and by infinitesimal stages; but that long periods of relative quiescence are followed by periods of rapid changes in which catastrophes are by no means absent. The Glacial peroid was itself a catastrophe following upon the slowly accumulated causes of the Tertiary period; and the evidence is now abundant that the close of this period in Europe and America if indeed it has yet closed, did not take place until a high civilization had established itself in Egypt, Mesopotamia, and Turkestan.

It can be only upon the basis of this Lyellian theory of an infinitesimal rate of geological changes that Professor Penck should make bold to assign an age of 100,000 years to the palæolithic implements found in a cavern in Wildkirchli, in the Canton of Appenzell, Switzerland. In reaching this conclusion he estimates the post-glacial period as 30,000 years and that the advance of the ice of the Wurm or Wisconsin period 1,000 feet below the level of the cave, and its continuance and retreat represent periods of 30,000 years each. That this calculation and others like it are purely theoretical without any basis of observation is evident from facts which are now well known. As to the rapidity with which glacial changes may take place it is sufficient to point to the known retreat of the Muir Glacier during the past thirty years. In 1886 when I made the first extended observation of the Muir Glacier in Alaska, the position of the front was established beyond question by the photographs which I obtained at that time. The front of the glacier was fully one mile wide, the height of its precipitous face above the inlet into which it was projecting was 300 feet, and the depth of the water as near as it could be safely sounded was 700 feet, showing thus a precipitous ice front a mile wide and 1000 feet thick pushed forward into the inlet by the united force of nine confluent glaciers coming down from the rear. In 1909, twenty-three years later, the Canadian surveyors found that the front of the Muir Glacier had retreated seven miles and a half, and that its surface had been lowered 700 feet by melting. Here, therefore, is an actual retreat of a living glacier in a quarter of a century exceeding in amount that of the Alpine glacier for which Professor Penck would demand 30,000 years; and that this is not merely temporal and local appears from the evidence which I have adduced and which Professor Reid and the late Professor Russell (the only geologists who have given attention to the evidence) consider ample, that 100 years before my visit, when Vancouver explored the coast, a confluent glacier filled Glacier Bay and extended its front twenty-five miles beyond that of Muir Glacier as it was in 1886, and that the thickness of the glacier in the upper part of the bay was then 3,000 feet. The neglect of such facts as these by European glacialists in their *a priori* speculations concerning the rate of glacial movements is a serious blot upon their scientific reputation.

Coming into the field where more definite evidence of the date of the close of the Glacial period is found, we note that here too there is the same tendency to make exaggerated estimates in defiance of the plainest facts of observation. Instead of its being the case that these points to the close of the Glacial period as 30,000 years distant as Penck and a number of our own geologists would place it, and even to a far more distant period as some would recklessly do, there is any amount of cumulative evidence showing that the Glacial period did not close in Europe and America until about 7,000 years ago. The post-glacial gorge below Niagara Falls would be worn by the forces now in operation in 7,500 years. The post-glacial gorge of the Mississippi River below the falls of St. Anthony would have been worn by the forces in operation before the utilization of the falls for manufacturing purposes, in the same length of time. The post-glacial erosion of the various streams in northern Ohio flowing into Lake Erie could easily have been accomplished by the forces now in operation in ten or twelve thousand years. The accumulation of sediment in the glacial lakes that bordered the ice front in northern Ohio show that they did not continue for more than two or three thousand years before the erosion of the Niagara gorge began. The accumulation of dunes south of Lake Michigan and the erosion from the west shore of Lake Michigan set a similar limit to post-glacial time; while the smallness of the deltas which accumulated in Lake Agassiz at the mouths of such rivers as the Saskatchewan and Assiniboin show that the recession of the ice from the Canadian border to Hudson Bay could not have occupied more than 1000, or at most, 2000 years indicating an average retreat of the ice front of one-half, or at least one-quarter, of a mile a year. Confirmatory of these calculations is the testimony of Gilbert, Russell, Bell, and others concerning the extreme freshness of glacial striæ on the exposed surfaces of rocks in Canada, Utah, and Nevada, showing the absurdity of the extravagant claims so generally made for the antiquity of the glacial period.

And now comes evidence to the same effect from Scandinavia. Dr. Nils Olaf Holst and Baron Gerard De Geer, two of the best informed and most eminent geologists of Sweden have gathered evidence from a variety of sources proving that the ice sheet did not melt away from southern Sweden until 7000 years ago.

Thus we are brought to face the fact that Canada, the northern part of the United States, Sweden, and probably Germany and Central Russia were enveloped in glacial ice while the civilization of Egypt, Mesopotamia, and Turkestan was at its height. And so we must adjust our theories concerning the evolution of history to the limitations of time here set and must allow for periods of rapid changes in political and social conditions and for the existence in the past as in the present of great diversity in the conditions of human existence in different parts of the world.

And now at the last moment there comes to hand a monumental work on the antiquity of man by Dr. Arthur Keith, of London, one of the most eminent comparative anatomists of the world. In this work, which gives the completest summary hitherto made of the discovery of prehistoric human remains, we are startled by conclusions of the most revolutionary sort. Dr. Keith accepts as genuine relics of glacial man those reported by Dr. Abbott and Mr. Ernest Volk from the glacial terrace in the Delaware Valley at Trenton, New Jersey, the Newcomerstown implement discovered by Dr. Mills, and the Lansing skull from the loess deposits of glacial age on the Concannon farm at Lansing, near Leavenworth, Kansas. These he synchronizes with the skeletons found at Combe Capelle in France, and Galley Hill, England, skulls which correspond in almost every respect with those of man in modern Europe, and at the same time with skulls of the Neanderthal type found at La Chapelle, France, and from the Grotto de Spy, Belgium, of early Pleistocene age. The remarkable conclusion is thus reached that the development of the human brain and of the human anatomical frame in general was fully completed early in the Pleistocene period, and that the European races instead of having been developed from the Neanderthal type of man were for a long time in Europe contemporaries of Neanderthal man. The brain capacity, however, both of Neanderthal man and of his contemporaries of the European type was if anything a little larger than that of the average modern European, while the artistic capacity of both was about equally developed and to a high degree. But the differences between the Neanderthal man and his contemporaries of the European type were so great as to compel them to be regarded as different species having their origin, according to the theory of evolution, in a human stem from which they branched off early in the Pliocene period.

The antiquity which Dr. Keith would give to early man is extreme, owing to the fact that he accepts without question the uniformitarain theory of development which still has possession of the majority of geological and biological authorities in Europe. "From what we know," he says, "and what we must infer of the ancestry of Eoanthropus, of Neanderthal man, and of modern man we have reasonable grounds for presuming that man had reached a human standard in size of brain by the commencement of the Pliocene period," which he estimates to cover a period of about one million years. (p. 510).

The type from which the present races of man have been developed is thought by Dr. Keith to be found in some of the lower tribes of Australia whose cranial capacity is less than that of the smallest of the Pleistocene skulls that have been found in Europe, and scarcely larger than that of the *Pithecanthropus erectus* attributed by him to Pliocene deposits of Java. In view of what has already been said it is needless to add that the time estimates of Dr. Keith are needlessly extravagant, especially in view of the abnormal conditions which characterized the passage from the Pliocene epoch to that of the Pleistocene. These time estimates, also, overlook the necessary plasticity of a species in its early history as compared with that of its mature development. For example, the early adventurers of the human race who went from the original center into new regions of the earth were free to develop in any direction of variations that were adapted to the natural conditions, but when the world has become filled with a human population there is no such chance for free development, for, then the average is maintained by means of the prevailing uniformity both of physical structure and of prevailing customs. In this respect as in many others, the present is by no means a measure of the past. To this the Glacial period itself bears indubitable testimony. During the extraordinary changes in physical conditions throughout that period, natural selection itself would act with abnormal rapidity in the production of varieties and species, thus telling against extravagant estimates of human antiquity.

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