SIXTH REPORT
OF
THE MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, MARCH 31, AND APRIL 1, AND 2, 1904.

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY
CHARLES E. MARSHALL
SECRETARY

BY AUTHORITY

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LETTER OF TRANSMITTAL

TO HONORABLE A. T. BLISS, *Governor of the State of Michigan*

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

Respectfully,
CHARLES E. MARSHALL,
Secretary of The Michigan Academy of Science.

Agricultural College, May 14, 1904.

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

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

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

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

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

The constitution provides for a summer or field meeting and a winter or annual meeting. At present the summer meetings have been discontinued by common consent. The winter meetings have been continued with increasing importance and value. At the second field meeting held at the Michigan Agricultural College, June 13, 1896, permission was granted to organize a section of agriculture. In 1902 sections in geography and geology, also in science teaching were established; so that the Academy at the present time consists of six sections, those of zoology, botany, sanitary science, agriculture, geography and geology, and science teaching.*

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

meetings of the Academy at the expense of the State. The sections read as follows:

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

* * * * * * *

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

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

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

*The history of the Academy will be found in full in the First Annual Report.

MEMBERS-ELECT.

Carrie A. Lyford, Agricultural College.
Jennette C. Carpenter, Agricultural College.
Thomas F. Marston, Bay City.
Floyd W. Robison, Agricultural College.
Ira O. Johnson, Grand Rapids.
Winifred K. Wright, Agricultural College.
Henry W. Berger, 1224 Washtenaw Ave., Ann Arbor.
Florence Hagle. 618 Packard St., Ann Arbor.
Florence G. Dillon, 432 Cadillac Ave., Detroit.
Jean Dawson, 2098 Ingalls St., Ann Arbor.
A. G. Ruthven, Jr., 821 East Ann St., Ann Arbor.
James E. Duerden, Ann Arbor.
Francis J. Dunbar, 322 S. Fifth Ave., Ann Arbor.
Harriet W. Thompson, Port Sanilac.
Fred A. Loew, Agricultural College.
Thomas B. Cooley, Ann Arbor.

OFFICERS ELECTED.

President—Dr. A. C. Lane, Lansing.
Vice-President:
- Section of Agriculture—Prof. W. J. Beal, Agricultural College.
- Section of Botany—Prof. J. B. Dandeno, Agricultural College.
- Section of Geography and Geology—Prof. M. S. W. Jefferson. Ypsilanti.
- Section of Sanitary Science—Dr. T. B. Cooley, Ann Arbor.
- Section of Science Teaching—Prof. W. B. Sherzer, Ypsilanti.
- Section of Zoology—Dr. Raymond Pearl; Ann Arbor.

Librarian—Dr. G. P. Burns, Ann Arbor.
Secretary-Treasurer—Dr. Charles E. Marshall, Agricultural College.
Editing Committee of Bulletin—Dr. A. C. Lane; Dr. H. L. Clark; Dr. C. E. Marshall.

COUNCIL.

The Council is composed of the above named officers and all Past-Presidents, who are as follows: Prof. W. J. Beal, Agricultural College; Prof. W. H. Sherzer, Ypsilanti; Mr. Bryant Walker, Detroit; Prof. V. M. Spalding, Ann Arbor; Dr. Henry B. Baker, Lansing; Prof. Jacob E. Reighard, Ann Arbor; Prof. Charles E. Barr, Albion; Prof. V. G. Vaughan, Ann Arbor; Prof. I. C. Russell, Ann Arbor; Prof. F. C. Newcombe. Ann Arbor.

SUMMARY OF TREASURER'S REPORT.

Year's receipts	$179.07
Year's expenses	113.39
Balance on hand	$65.68

Expenses for printing the fourth and fifth reports and outstanding bills will doubtless more than consume this balance.

In order to facilitate business matters of the Academy it was voted to elect the same individual for Secretary and Treasurer.

The Academy decided to issue an occasional bulletin, the size to be identical with the Academy's reprints. The Secretary, President and Prof. H. L. Clark were authorized to issue said bulletin.

PRESIDENT'S ADDRESS. A NATURAL HISTORY SURVEY FOR MICHIGAN.

FREDERICK C. NEWCOMBE.

There is probably no state nor territory in the Union in which something has not been done in the way of determining the flora and fauna. The states of New York, Ohio, Illinois, and California have been for years conducting not only a geological but also a natural history survey, while several other states, such as Massachusetts and Pennsylvania, have published many reports on the natural history of inland waters, forests, etc. In recent years state survey work has received added impetus in the direction of natural history by the formal inauguration of such surveys in Indiana, Illinois, Wisconsin, Minnesota, Iowa, and Nebraska.

The state survey of Michigan began as a geological and natural history survey in 1837 when the State was admitted to the Union. In 1840, for economic reasons, the biological part of the work was discontinued, and with brief exceptions the survey was thenceforth continued as geological.

The Michigan Legislature of 1903, in both Houses, passed a bill inaugurating a natural history survey of the State. The bill however, which was passed in the last days of the session, failed to receive the Governor's signature. This partial success gives ground for hope that the survey will be established by the Legislature of 1905. But whether success or failure shall attend the efforts of the Academy to establish a survey next year, we may feel assured that the Academy will relax no effort to carry to a successful end this work to which its members have committed themselves.

THE OLD WAY OF MAKING NATURAL HISTORY SURVEYS.

Looking through the reports of state surveys made during the past century, one finds that from Maine to California nearly every state has published lists of its plants and animals, with brief accompanying descriptions and notes as to habitat, range, etc. In this State, Real and Wheeler's *Michigan Flora* is a worthy example of this kind of work. Such publications are good as a preliminary reconnaissance. They have a scientific value to specialists working on floral and faunal distribution, and to a few systematists in the State. To the general citizen in the State however their worth is relatively small.

A BETTER METHOD FOR NATURAL HISTORY SURVEYS.

The natural history surveys of the future will undoubtedly be ecological. An ecological natural history survey will study plants and animals in relation to their environment. Such a survey will be carried on along two lines: (1) Problems peculiar to special localities or peculiar to special environment will be studied; (2) The plant and animal forms of each district or county will be determined in their relation to climate, soil, and to one another.

Of the two lines of work just noted as included in an ecological survey, that of the study of special problems is just now being most pursued. It has already yielded important results in our own State by the publication of the gratuitous work of Davis entitled Contribution to the Natural History of Marl" (Journal of Geology VIII, 1900; IX, 1901). In Illinois, the 'same method has given us the "Plankton Studies" of the State Laboratory of Natural History (Bulletin Vol. VI, Article II), which are certain to have an effect in promoting the fish industry of that and other states. In Wisconsin and Minnesota several volumes on special problems have recently been issued.

The foregoing method of survey by the study of special problems can, however, never give us a unified and comprehensive result. A well coordinated survey will carry the geological and natural history work along together, and the basic principle will be the exploration of the whole area of the State, county by county, or district by district, so as to learn the natural resources/both geological and biological, throughout the whole extent of the Commonwealth. Every county, besides the resources commonly first thought of, possesses other resources worthy of the highest consideration. The reports of the future geological and natural history surveys will treat not only of the resources of every county in minerals, fuel, agricultural lands, forests, fish and game, but also of the resources in scientific features to furnish a means of instruction to the youth in the schools. The part of the survey which is to be on the side of natural history, in order to work out the economic and education resources of each district must be conducted as an ecological survey. It is to the consideration of such an ecological survey, that I wish to draw your attention.

In making an ecological survey, the surveyor selects a certain district to explore, it may be a county, or a larger or smaller area. This district he examines minutely to determine the plants and animals and their relations to their environment. He must determine the physical characters of the soils, and study the relation of cultivated and uncultivated plants to soil, drainage, light, temperature, etc., and group his plants and animals into societies. If he can have as a basis for his survey a typographic map, and maps showing distribution of soils upon which to construct his map showing distribution of societies, he can start with an excellent background.

This method which is almost new in the world is illustrated by a few pioneer efforts in the surveys of the vegetation and animal life of certain areas. For several years Professor Flahault of the University of Montpellier in France has been using the forest trees as centres about which to group the other plants into societies. He has found that when his plants are grouped the soils are classified also. Professor MacMillen in his “Plant Life of Minnesota" has made a survey of the kind advocated here. The introductory chapters of this book treat of the

rock formations, of the glacial geology, of the soil, the drainage, and the climate. The introduction is followed by a description and general location of the various plant societies, and an enumeration of the members of each society. This book has been placed in every school of the State, in city and country, and no doubt furnishes the basis of much nature study. The area taken for treatment is however too large to give the matter of the hook much local interest, or to allow it to be used in the study of details.

A third example of an ecological survey is that furnished by the work of Dr. Livingston and published by the Geological Survey of Michigan in 1901, under the title, "The Distribution of the Plant Societies of Kent County. Michigan." Of the manner in which Dr. Livingston did his work and the value of his conclusions there is no need of comment here. It is sufficient to say that the plan is good, and, I believe, is certain to be the plan of the future. Dr. Livingston's unit is a county, but unfortunately his map is far too small to be of service except for the most general outline of plant geography, and he has omitted farmland and cultivated plants. He considers however climate and soil and their influence in determining the plant societies.

I need not enumerate the relatively few other attempts at surveys—such as some of the U. S. Government biological surveys—recently made on an ecological basis. I would, however, as a final illustration call your attention to two surveys that have recently appeared in Great Britain, one of the district about Edinburgh and the other of Yorkshire. The first was made by Robert Smith and the second by Mr. G. Smith, and G. E. Moss and W. Munn Rankin (the Geographical Journal, April and August, 1903). In the introduction to the survey of Yorkshire these words are found: "One may set out to And an answer to the question, 'What species occur here?' or to solve 'How are the species arranged with regard to one another, and with regard to soil and climate?' The result in the former case would be a flora; in the latter it would be a connected account of the vegetation."

The survey of Yorkshire is a connected account of the vegetation. The authors find that they can divide the district into *moorland, woodland*, and *farmland*. These three great divisions each have their characteristic vegetation. Each of the three divisions is subdivided into smaller areas. The *woodland*, for example, is subdivided into the *oak*, the *mixed lowland*, and the *pine*. Again these are subdivided, as the oak into the *clough thicket*, *upland oak,* and *lowland oak*. In each of these smallest divisions the species of plants occurring are named, and the species are classed as *dominant*, *subdominant* or *dependent*. The altitude, temperature, rainfall, and soil are given for each plant society. The accompanying map is drawn on the scale of two miles to one inch, and contains 16 different colors to show the distribution of the plant societies. These colors are superposed on a topographic background.

Immediate Uses of Such a Survey.

The advantages to pure science of a state survey, no one will question. Nor need we pause now to predict the economic value to the more distant future of such a survey, but merely cast a glance at that future by repeating the common sentiment, that the pure science of today becomes the applied science of tomorrow. Let us concern ourselves rather with an enquiry as to the immediately practical uses of an ecological state survey.

Every intelligent person has noticed the great awakening within the last few years of the interest in outdoor life. New periodicals devoted exclusively to country life have appeared; established magazines offer in every number descriptions and stories of plant and animal life; nature story books have flooded the market; every town and village has its improvement association; and amateur gardening and landscape architecture are discussed in clubs. These are signs of the times read by everyone. There are other signs less conspicuous and less numerous than the foregoing, but which are to some men still more significant. These are the rehabilitation of many of the old local scientific societies which flourished a generation ago all over Michigan, and the formation at several points in the State of nature study clubs. I remember six to eight years ago a conversation which I had with a friend, in which we expressed regret at the decline of interest in nature study as evidenced by the death of local scientific societies. The impending distribution of the collections of the Kent Scientific Institute of Grand Rapids was the occasion of our remarks. We agreed that these local scientific societies came into existence when the intelligent people in comparatively new settlements found themselves face to face with unknown geological formations, unknown plants and animals. The work of these societies consisted in identifying, collecting and preserving in museums the fossils, plants, and animals of the vicinity. As time passed, the field was worked over, and the interest of the society flagged. In the collections, dust covered the fossils, and the snakes became mummies as the alcohol evaporated. But there has come an awakening. It is perceived that there is a new world to explore containing better treasures than the identifying of plant and animal forms with which the past generation in this territory busied themselves. The search is to be not only for the *what* but for the *how* and *why*. Bow were these hills formed, how these terraces, and how this plain? Why is this plant society characteristic of the sand plains, and this other society of the bogs? How can this stretch of barren land be made to produce, and how should this hillside be cultivated to prevent loss of fertility? These are the questions with which nature study clubs propose to concern themselves.

Of still greater import than the revival of nature study societies is the clear tendency of biological training in the primary and secondary schools, and also in the colleges, toward field work. And who can forsee the demands of the rural schools? The city teacher complains that the country is inaccessible from his school, that he cannot

control his pupils on excursions, that it is impossible to make field work disciplinary; and college professors have written much which seems to demonstrate that boys and girls must learn structure and function in the laboratory before they can understand nature afield. But in spite of the difficulties to be overcome, we all expect to see schools giving more and more of their time to field work. But it will not be the field work of twenty years ago. The pupil must learn the names of plants and animals, but he will understand that his main task is the discovery and perception of relations. The goal is the pupil's intelligent contemplation of nature. He is to look about him to perceive the geology, the climatology, the biology. No doubt the vision will be imperfect, but it will become better defined as time goes on. A physiographic and natural history survey will be the pupil's guide book to the region in which he lives. It will give him the general outline of geological history and of plant and animal societies, leaving untouched many details which he will supply by his own investigation.

Not only should the survey be made for our citizens and our schools, but its results should be so published that they could be used as scientific data in the study of geographical distribution and similar problems.

From these educational and scientific advantages of a physiographic and natural history survey of the State, I turn to consider the advantages which are more economic. The survey should be so conducted that the value of the soils would be known for various kinds of crops. If it should be found, as it certainly would be, that certain lands, now yielding but poor returns in wheat, would yield a more valuable forest crop, the knowledge of that fact would be a clear economic gain. The survey would doubtless lead to the planting of trees over small infertile areas in every county in Southern Michigan. The fertility of soils would have to be related to composition, to temperature, to precipitation, to damage and to vegetation. A collection into one record of such data could not fail to be of great advantage to agriculture, not only in selecting the best location for certain crops, but in the introduction into new regions of fruits, vegetables, and grains.

At the present time the State needs a careful survey of the northern part of the Lower Peninsula in order to separate agricultural from forest lands, that the State sequestration and reforestation of infertile areas may proceed intelligently, and that the State officers and private companies may do justice to those now being urged to make homes for themselves in that region.

We know that the State is dotted over its whole surface with deposits of peat and marl. A survey is needed to locate these and other valuable surface deposits, such as cement clay, brick clay, and glass sand. By cooperation with the geological survey the extent of these deposits could be measured.

The fish and game have received too little attention. They are a source and can be made a much greater source of wealth to the State. I am told that in one day last spring there left Grand Rapids for the brook trout streams of Michigan 3,000 men. The report of the Commissioners of Fisheries and Game in Maine estimates the amount spent in that State for the year 1902 by those coming from other States to hunt and fish at $6,000,000 to $12,000,000. From data furnished by the railroads, the profits to Michigan from this source are probably not less than 16,000,000 annually. Properly regulated, these sources of wealth can be made lasting. But before they can be properly regulated the life histories of the forms concerned must be determined by careful field and laboratory study. A natural history survey of the State would determine to some extent the location and the quantity of game and fish, and elucidate relations which they bear to their society of animals and of vegetation. Thus would be laid a basis for future determination of the effect on these beings of natural and artificial changes in their environment.

It is believed that the foregoing advantages would result from an ecologically geographical survey. But there are numerous special problems which are not geographical in their nature, and which would necessarily form a part of any complete survey. The State should publish a list of the injurious fungi found within her borders, giving their habits, range, and the means of combating them. The same thing should be done for insects, birds, and other animals. The scattered publications on these subjects should be verified and collected into usable form. The breeding habits and migrations of animals should be well studied that proper laws may be enacted for their protection. Our waters should be studied with a view to making them productive, and our waste lands with a view to clothing them with forests. Michigan with her unusually large areas of water and non-agricultural land will certainly be remiss in her duty if she does not speedily take increased measures to propagate and preserve her forests, game, and fish. The inland lakes of Michigan have been almost neglected as sources of wealth; and yet the experience of European countries proves that a small lake may be made more valuable with its crop of fish than an equal area of farm land. The recent publications of the Illinois State Laboratory of Natural History indicate very clearly that a proper cultivation of bodies of water will increase the fish supply. Our State ought certainly to turn her attention to a study of the fish and fish food of the inland lakes and streams.

The last special problem which I will mention is the study of the plant and animal life in the streams and lakes from which is taken the water supply of cities. But I will not dwell on this and other special problems, for I do not wish to distract the attention from my main proposition, which is, that the natural history survey should be ecological and geographical.

MEANS OF CONDUCTING SUCH A SURVEY.

If we are to plan an ecological survey we must provide not only for the means of studying our plants and animals in their habitats, but we should include the temperature, precipitation, insolation, the soil, and, if possible, the topography and glacial geology. The first three of these factors, the temperature, precipitation, and insolation, can be obtained from data already existing. The U. S. bureaus in cooperation with the Michigan Geological Survey are slowly surveying the soils and topography of the State, and have the materials at hand for mapping the glacial geology. The topographic survey, for which the State made the small appropriation of $500 annually has already produced a map covering an area of about 25 miles by 35 miles with Ann Arbor as the center, and is now being extended over another area in Wayne County. It is probable that within twelve months this cooperative survey by the U. S. and State Geologists will publish the Ann Arbor Folio, which will contain maps showing contour lines, soils, and glacial formations. In the plotting of soils, the Bureau of Soils of the general Government has already produced a map of Allegan County, and is now at work on Oakland County. Besides this work, the State Geologist has published a topographical map of Kent County. It is the intention of the general Government, if a part of the expense is borne by the State, to include the whole State in the topographic and soils survey. It would seem the part of wisdom in beginning an ecological natural history survey to follow the course already covered by the topographic and soils survey. Should the natural history survey be established, it is probable that cooperation could be arranged by which the topographic and soils surveys would cover the same area preparatory to the natural history survey.

There seems to be one objection to spending all the effort of a survey in a territorially progressive exploration. There may be regions or problems to which the need of immediate attention is urgent, such as the determination of a native flora threatened with disturbance or destruction. In the writer's opinion, means must always be reserved for such special problems; but the main work should still be territorially progressive.

As to the survey staff, it would seem advisable that the State Geologist, as provided in the bill of last year, should be the chief, and that he should, call to his aid a botanist and a zoologist, both of whom should be skilled in ecological work. These men might find a means of unifying the scattered individual efforts, of gathering about one center the workers in natural history now making observations, but without guidance, in all quarters of the State, In every graduating class from this University, there are students well trained in botany who beg for topics upon which they may carry on research after leaving their alma mater. Doubtless all college instructors in natural science could tell a similar story. It might be that the supervisor of the survey in botany and the supervisor of the survey in zoology would find here and there in the State persons capable of doing a part of the work of the survey of districts in which they lived. These surveyors would be glad to work without compensation, and they would be aided by correspondence and personal visits from the director or his subordinates. It is not inconceivable that persons partially trained for such work would be willing to spend a summer at some institution, or in the field under direction, in order to prepare themselves for participation in the survey.

If, however, the method just referred to should be thought or should be found to be not feasible, each specialist would probably best form surveying parties for summer work. By having their traveling and field expenses paid, it is probable that several efficient young men could be found each summer who would gladly assist in the survey without farther remuneration. This has been practiced in the survey of Wisconsin now under way.

Should the State appropriation warrant it, the botanist and the zoologist of the survey should give all their time to the work, exploring in the field in the summer, and using the winter to work up their data. On the other hand, should the funds available be insufficient to secure the services of two specialists for the whole year, men, otherwise engaged in the winter, could be employed on the survey for the summer only, and the work would go forward more slowly. The botanist of the survey should be one skilled in plant geography, with a knowledge of soils, and, if possible, with a knowledge of glacial geology. The qualifications of the surveyor in zoology, I will let others formulate.

It would appear to me that for the first two years an annual appropriation of $3,000 would secure the services of a botanist and a zoologist for the whole year, and would leave $300 to $500 a year for the study of special problems. Should the annual expenditure be limited to $2,000 as was contemplated in the bill passed by the last legislature, it could hardly be expected that competent men could be secured for the whole year.

In the latter case it would seem advisable for the State Geologist to have an advisory board composed of at least one botanist and one zoologist, who should serve without compensation. It would be the task of this board to plan for harmony and similarity of methods in the work of the different surveyors. In any case no one should commit the folly of framing a bill which would throw the burden of the planning of the work upon the State Geologist.

It may be asked "What should be the form of the reports of the survey and what matters should be treated therein?" The method of issuing the reports of the Wisconsin survey seem to me admirable. The reports of that State are divided into three series: (1) the economic series, (2) the scientific, (3) the educational. The nature of the first two series will be readily inferred, and I will speak in more detail of the educational reports only. It would seem that the series should be introduced by a volume descriptive of the general geology and natural

history of the State with an elucidation of the general principles of the formation of rocks, soils and topography, and of the general principles of plant and animal ecology. Following this general introductory volume, there should be separate reports published for each county or district. These reports should be guide books to the study of the region, and should contain a map drawn on a scale not less than two miles to the inch, better one mile to the inch. The map should show not only roads, rivers, section lines, and towns, but the topography, the cultivated lands, the distribution of plant and animal societies, and if possible, the soils. Such maps have already been made successfully for the surveys in Scotland and Yorkshire as already stated. There should be an accompanying text written simply, so that all who wish to become acquainted with nature's ways might understand. This text should treat of the geological history of the region; of the sculpturing of glaciers, of streams, and of winds; of the climate, the soils, and of the plant and animal societies. Anything of special interest in the region, in the topography, the natural history, the mineral deposits, or vegetable deposits should receive special attention and elucidation. The schools of the State and the people of the State are beginning to ask for this information, and the State should supply it.

SUMMARY.

The foregoing pages have spoken of three ways in which a survey may be conducted: (1) it may be floristic and faunistic, or (2) it may be a pursuit of special problems, or (3) it may be progressively ecological. In this address the progressively ecological method has been advocated as a basis, with means allowed for the study of special problems. The uses of such a survey have been presented as

1. Furnishing a means by which all lovers of outdoor life might the better understand and enjoy the face of nature;

2. Furnishing to rural and city schools a guide to nature study;

3. Classifying lands according to their agricultural value;

4. Locating the fish and game of the State, and laying the foundation for the study of their habits, which would lead to their better preservation and propagation;

5. Locating the peat and marl and other valuable surface deposits;

6. Providing data for more general scientific studies;

7. Discovering problems for special attention and investigation. Six years ago Professor Spalding stood before you and in his presidential address asked for the inauguration of a biological survey. At that time his vision did not portray an ecological survey, but rather the study of special problems, among which he advocated most strongly a survey for forestry purposes. Since that time, as you know, a preliminary forestry survey has been made, and the forestry work of the State well established with an annual appropriation of $7,500.

A year ago, Professor Russell, in his presidential address before you plead for a topographical survey. The State has answered by making its first appropriation for that work.

Let us from these successes take courage, and with zeal, labor for the establishment of a natural history survey.

F. C. NEWCOMBE, PH. D., Junior Professor of Botany,
Botanical Department, University of Michigan.

FORMATION OF PEAT IN DEAD LAKE.

GEORGE P. BURNS.

(Abstract.)

Dead Lake is located about ten miles north of Ann Arbor, and is one of the numerous glacial lakes found in the valley of the Huron River. The lake is three-fourths of a mile long, running east and west, and one-half a mile wide. A contour map shows that the bottom is divided into four basins, two in the northern part seventy and seventy-two feet deep respectively, and two in the southern part whose greatest depth is thirty and thirty-five feet. The higher ridge runs north and south. This ridge is never more than twelve feet below the surface and in one place comes above, forming an island. This divides the basin into an eastern and western half.

The bottom of the eastern half is much more shallow in general. In one place the greatest depth for several hundred feet is only ten feet. There begins then a sudden dip and within a distance of 200 feet it drops to seventy feet below the surface. Although the lake reaches a depth of seventy feet in this half, the larger part is comparatively shallow. On the other hand, a large part of the western half is under nearly forty feet or more of water.

The shores are rather steep in the south and southwest, but quite level on the other sides.

The eastern half, with the exception of a small "lake" about 400 feet in diameter, is so densely covered with vegetation that only a very few narrow channels are left through which one can force a boat. The clear water in these channels is only about two feet deep. In this are found Nuphar, Brasenia, Utricularia and other water plants. That is, the entire eastern half of Dead Lake is almost entirely filled with peat.

Plants are not distributed all around the lake in concentric zones as is so often the case. The filling began on the south side, and on this side the arrangement of plant zones is as follows:—

I. Oak, hickory, on high gravel bank.

II. Elm, maple, growing in five (5) to ten (10) feet of solid peat.

III. Tamarack, poison sumach, growing in peat from ten to thirty-five feet deep.

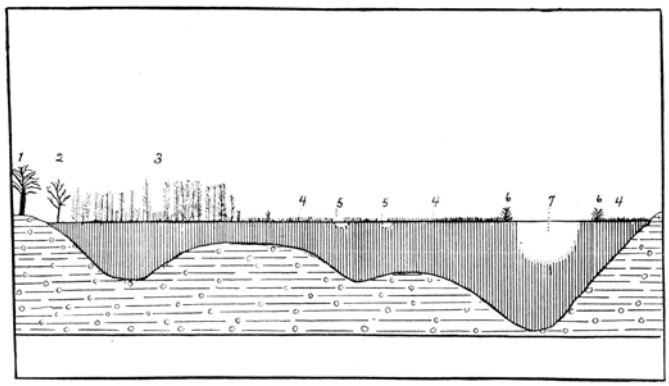
IV. Cassandra and other shrubs bordering the tamaracks.

V. Sedges, largely Carex filiformis, growing in as high as sixty-five feet of very loose peat.

VI. Nuphar, with Peltandra, Brasenia, and Utricularias, which fill up the few remaining channels.

A glance at the profile map gives a good idea of the condition in the eastern part of the lake at the present time. This profile runs north and south through the two basins. The southern one is completely filled; the other will soon be exterminated. It owes its longer existence entirely to its great depth. Carex filiformis is unable to extend into the lake until the lake has been filled within at least twenty-four inches of the surface by the lilies and other water plants.

The western half contains a large area of open water. Vegetation has advanced on the south about one-half the way across the lake, the north shore is destitute of water plants. This side of the lake is filling rapidly on the south and west, but owing to its great depth it will be many years before it will be entirely covered.



EXPLANATION OF FIGURE.

Profile through Dead Lake, running north and south, scale: Vertical, 61 cm. to mm.; horizontal 8 m. to mm.

1. Quercus alba, L.
2. Ulmus Americana, L.
3. Larix Americana.
4. Carex filiformis, L.
5. Channels through sedges, filled largely with Nuphar, Utricularia sp.
6. Salix sp.
7. Remaining lake.

GEORGE P. BURNS, Ph. D.,
Botanical Department, University of Michigan, Ann Arbor.

THE ANTIQUITY OF THE ZOANTHID ACTINIANS.

J. E. DUERDEN.

The zoanthids are a distinct group of actinians found in plenty only in the warm tropical seas, where they are often an important constituent of the luxuriant life of the shallower parts of coral-reefs. They are separated from the two other groups of the Actiniaria—ordinary actinians and cerianthids—chiefly by their method of increase in number of the mesenteries beyond the primary six pairs. In the Zoantheae the new mesenteries arise as bilateral pairs at only two regions of the polyp, one on each side of the ventral directives or axial pair of mesenteries; in the Actiniae, as here restricted, new mesenteries are added in couples within all the six primary interspaces; in the Ceriantheae additional mesenteries arise at only one region of the polyp, which is axial. In addition to this fundamental distinction the mesenteries in the zoanthids form only a single cycle, and are disposed in couples, of which one moiety is large (macrocnemes) while the other is small (microcnemes); further, the tentacles are arranged in only two cycles, an inner and an outer; the polyps frequently give rise by budding to incrusting colonies; a skeleton is generally formed by the inclusion of foreign particles (sand-grains, foraminifera, sponge-spicules, etc.) within the wall; and the stomodaeum is provided with only a single stomodaeal groove or siphonoglyph.

The adventitious skeleton of the zoanthids is constituted of separate particles, and disappears as such when the polyp dies and its soft tissues decay. Consequently there is the greatest improbability that any evidence of the group will ever be found in the rocks, any more than in the case of the altogether soft-bodied sea-anemones. Indeed, as regards the Actiniaria as a whole, it is very unlikely that we shall ever be able to determine their geological antiquity in a direct manner, that is, by finding their actual remains or impressions in the rocks. Indirectly, however, we seem to have good grounds for certain conclusions regarding their past history.

As regards ordinary soft-bodied actinians we have very close represensatives in modern polycyclic hexameral corals. An extended study of the polyps of a large number of species of both groups proves that between the skeletonless actinians and the coral forming polyps there are no morphological differences of any importance, except such as concern the formation of the skeleton; as regards the development and nature of the mesenteries and tentacles the polyps show no divergence. Actinians and hexameral corals have undoubtedly sprung from a common stock; we are justified in regarding them as members of a single group, in the one case provided with a limy skeleton and in the other case devoid of such.

From such a close relationship we seem warranted in concluding that whatever be the geological antiquity of the hexameral corals the hexactinians will have a like ancestry; skeletonless species have probably always

existed alongside of coral-producing forms and would be the first to appear.

With regard to the distribution in time of the Hexacoralla, Zittel, in his Text-Book of Palaeontology (Eng. Ed., page 96), states: "The group *Aporosa* of the *Hexacoralla* appears to have originated from the *Tetracoralla*, and to form the direct continuation of their line. They begin as the latter disappear; they develop a great variety of forms in the Trias, and from the Mesozoic down to the present day they have continued to play a leading part in the construction of coral-reefs. . . . The *Perforata* constitute a. well-defined branch of the *Hexacoralla*, whose ancestry may perhaps be sought in the remarkable *Archaeocyathidae* of the Cambrian. The Eupsammiidae and Poritidae occur sporadically in the Silurian and Carboniferous, while it is not until the Trias that the *Thamnastraeidae* and *Poritidae* develop a large variety of forms; from the Trias to the Tertiary, however, these genera continue to be important reef-builders."

As would be expected there is much uncertainty concerning the true character and relations of many of the earliest-corals. This is especially so as regards the relationships of the Hexacoralla to the Tetracoralla. According to my researches the two groups are each characterized by six equal septa separated by six interseptal chambers during their primary (protoseptal) stage, but beyond this they diverge. Independently of this, however, what seem to be true hexacorallids are found, among the earliest faunae known to us, perhaps in the Cambrian, but more certainly in the Silurian. If these ancient corals be true Hexacoralla their polyps in all essential morphological characters must have resembled the coral polyps of to-day, whether they belong to the perforate or imperforate group. Hexacoralla have been shown to be but skeleton-producing actinians, hence we may with good reason conclude that coral-forming and skeletonless hexactinians have lived together side by side since early Palaeozoic times. Further, the skeleton-producing forms must have had soft-bodied ancestors.

So far as fundamental polypal characteristics are concerned living Madreporaria, notwithstanding their geological antiquity, are really a very homogeneous group; variation and complexity have resulted from the modification of parts which are of small morphological value, namely the skeleton-producing tissues. To the predominance of asexual growth by budding and fission is largely due the great diversity of form of corals as we know them to-day. Soft-bodied actinians on the other hand present a greater variety of polypal modifications. Some, like *Rhodactis*, *Ricordea*, and *Corynactis* suggest the actual colonial types from which corals may have arisen, or possibly they are forms which have relinquished the skeleton-producing habit.

A similar line of argument can now be applied to the zoanthid actinians, though here the conditions are not quite so conclusive. If we find corals whose structure and septa! plan suggest that they were formed by polyps similar to those of zoanthids we have good grounds for assuming that the skeletonless zoanthids have an ancestry like that of the corals.

No living corals, so far as known, have a method of addition of mesenteries and septa which at all suggests the manner already mentioned as characteristic of the Zoantheae. In all living madreporarian corals yet studied the mesenteries and septa follow the hexameral polycyclic plan. However, in a paper recently published (*Ann. Mag. Nat. Hist.*, May, 1902), I have given good reasons for concluding that living zoanthids are closely related to the extinct group of corals known as the Rugosa or Tetracoralla. The increase of mesenteries in the rugose polyps must have followed exactly the method of increase characteristic of the zoanthids, except that in the former the additions took place within four of the six primary chambers or exocoeles, whereas in zoanthids new members are added within only two of the six primary chambers. I have also shown that the single stomodaeal groove or siphonoglyph of the zoanthid polyp, finds its counterpart in the cardinal or ventral directive fossula of the rugose coral.*

As the type of mesenterial increase represented in ordinary actinians and modern corals indicates a common ancestry for these two groups so I conclude that the zoanthids and rugosa had another common ancestry, that the zoanthids are the nearest skeletonless representatives of the. stock from which sprung the skeleton-forming Rugosa.

If this be the true relationship of the rugose corals we shall have to assume that the skeleton-producing habit has been acquired independently by two groups of zoantharian polyps, the Hexacoralla and the Tetracoralla; or, at any rate, that the two separated at the primary six-rayed condition. This double origin, however, is much more likely to have taken place than that the Hexacoralla have been derived from the Tetracoralla, as is frequently assumed. From a knowledge of the development and morphology of the two groups the zoologist can only conclude, that their common ancestry is represented only as far as the primary stage with six septa and six pairs of mesenteries; they diverge from this, that is, with the commencement of the metacnemic stage, along wholly different lines of development.

According to Zittel (l. c., p. 80) the distribution of the Tetracoralla in time is as follows: "The typical Tetracoralla are confined to the Palaeozoic rocks. They are unknown in the Cambrian, and make their first appearance in the Ordovician, where they are sparsely represented in North America and in Europe. . . . The period of maximum development falls in the Silurian, which contains the largest number of genera and species. . . . The *Tetracoralla* are not less conspicuous in the Devonian. . . . According to Frech, the genera *Gigantostylis*, *Pinacophyllum*, and *Coccophyllum*, occurring in the Alpine Trias, belong to the *Tetracolla*."

No one disputes that the tetracorallid or rugose type of coral is wholly extinct to-day. Odd living forms have

been described for which such affinities have been claimed (e. g. *Moseleya*, *Haplophyllia*, *Guynia*) but they have failed to. justify expectations. Even the suggested extension of range of the group beyond the Palaeozoic into the Mesozoic is quite recent.

*Impressed with this relationship it seems not too much to expect that forms of zoanthids may be met with in which new mesenteries are added within four of the six primary chambers, instead of only two; and, on the other hand, I have sought for Tetracoralla in which new septa were developed in only two primary chambers, instead of four, though hitherto without success.

The zoanthids of to-day, therefore, find their nearest coral producing ancestors away back in Palaeozoic times. Though their relationship with the tetracorallids is not quite so close as that of the actinians with the hexacorallids yet the method of mesenterial and septal formation shows that they belong to a common stock, already differentiated to a certain degree in very early Palaeozoic times. Among the early faunae in the earth's history there must have been at least these two well defined types of Actiniaria—zoanthids and tetracorallids, hexactinians and hexacorallids.

As stated at the commencement the zoanthids flourish to-day only in the tropical seas, under conditions similar to those favorable for the growth of reef-building corals. A few species are met with in temperate waters, in the same manner as we find a few scattered species of corals, but they nowhere form the large incrusting colonies which they do in warmer seas. Like the reef-building corals, the skeleton —forming representatives of the zoanthids—the Rugosa—had in past geological times a . . . much wider geographical range. The zoanthid type of coral flourished ill Palaeozoic times, the hexactinian types of coral assumed predominance in Mesozoic times and has continued until to-day; the soft-bodied polyps of both types still live in abundance in the warm tropical seas.

Hitherto the study of fossil corals has shed no light upon the ancestry of, the third group of the Actiniaria, the Ceriantheae. It was hoped that among the many Palaeozoic Actinozoa some forms might have been discovered in which all the metasepta were added axially, at only one region, as are the mesenteries in the cerianthids, but no such types have been encountered. Therefore, so far as present researches go, it must be assumed that the living cerianthids have no skeleton-producing representatives, living or fossil, thus differing in this respect from ordinary actinians and zoanthids which give us the hexacorallids and tetra-corallids.

In all probability, however, the Ceriantheae date back beyond the Actiniae and Zoantheae, for in them the primary mesenteries (protocnemes) are represented by only four bilateral pairs, while in the two other groups there are six primary pairs. Of these six mesenterial pairs the four pairs corresponding with those of cerianthids are early complete, while the additional fifth and sixth pairs remain incomplete either throughout life or become complete only in the later stages of development. In any genealogical scheme of the Zoantharia one would place the, cerianthids with four protocnemic pairs as the lowest members, and above these the actinians (hexacorallids) and zoanthids (tetracorallids) with their six pairs of protocnemes, the two latter groups separating with the commencement of the metacnemic stage.

J. E. DUERDEN, Ph. D., Assistant Professor of Zoology, Zoological Laboratory, University of Michigan, Ann Arbor.